Reciprocal Vertical Restraints and Retail Competition: Evidence from the U.S. Battery Industry*

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Abstract

We study reciprocal vertical restraints in the alleged Walmart–Energizer agreement. Household purchase data show larger price increases for Duracell at Walmart and Energizer at rival retailers. A model of demand, retail pricing, and wholesale bargaining implies joint profit gains of 9.2% and annual consumer losses of $51 million. Walmart's preferential pricing redistributes gains toward Energizer with little additional consumer harm. Energizer's wholesale terms generate most harm, while costlier replacement offers weaken retailers' bargaining positions with Duracell, raising its wholesale prices, including at retailers not carrying Energizer. A Robinson–Patman-style restriction covering all wholesale terms would avert $39 million annually. **Keywords:** Vertical Restraints, Raising Rivals' Costs, Edgeworth–Salinger Effects, Bargaining, Replacement Threats, Retail Competition

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1 Introduction

Vertical relationships between manufacturers and retailers are key determinants of prices, product availability, and competition in many markets. A longstanding concern in antitrust is that vertical restraints, despite their potential to improve supply-chain efficiency, may foreclose rivals, facilitate coordination, or otherwise harm consumers. Existing empirical studies largely examine individual restraints, yet a retailer–manufacturer relationship may combine restraints on both retail pricing and wholesale contracting. We study the reciprocal restraints alleged in the Walmart–Energizer agreement and quantify their separate and joint effects on prices, profits, and consumer welfare. In the estimated model, Walmart's preferential retail pricing accounts for Duracell's larger price increase at Walmart and shifts gains toward Energizer. Energizer's wholesale restraint generates most of the parties' joint profit gains and consumer harm, while also weakening rival retailers' bargaining positions with Duracell.

In April 2023, consumers and retailers filed proposed class actions against Walmart and Energizer, alleging an agreement to increase disposable battery prices (Portable Power v. Energizer 2023; United States District Court for the Northern District of California 2024). The allegations have two main components: (i) Energizer allegedly raised wholesale prices charged to retailers competing with Walmart, raising rivals' costs and softening inter-retailer competition; and (ii) Walmart allegedly reciprocated by raising retail prices for Duracell, Energizer's main rival manufacturer, softening interbrand competition within Walmart through the Edgeworth–Salinger effect.[1]

We use Numerator's omni-channel consumer panel data on U.S. household purchases from 2018 to 2021.[2] The data provide trip-level information on retailers, product categories, descriptions, quantities, and prices from in-store and online

[1] Legal disclaimer: This paper analyzes the alleged Walmart–Energizer vertical agreement strictly from an economic perspective. The allegations have not been proven in court. As of October 2026, the court had not ruled on the merits. The actions had proceeded beyond the pleading stage, and in September 2026 the court denied the plaintiffs' motions for class certification without prejudice to renewed motions. For the purposes of the analysis, we take the alleged conduct as the object of study and examine whether it is consistent with observed empirical outcomes. We do not take a position on whether the conduct violated antitrust law, and we rely primarily on publicly available case materials and related documents.

[2] We exclude 2022 onward because sharp inflationary price increases make it difficult to separate the effects of the vertical agreement from broader cost and inflation shocks.

receipts. We focus on disposable AA batteries, the largest household battery segment; our final sample contains approximately 1.85 million purchases. The industry is highly concentrated: Energizer and Duracell together account for about 85% of U.S. disposable battery sales (Portable Power v. Energizer 2023), and Walmart is the largest battery retailer.

Beginning in the second quarter of 2019, Energizer's and Duracell's prices rose by approximately 6–7%, while their sales declined by 15–16%, relative to other brands. These changes differ across retailers. At Walmart, Duracell's prices rose by 4.8%, compared with 1.2% for Energizer, and sales shifted toward Energizer. At rival retailers, both brands' prices rose substantially relative to other brands, with a larger point estimate of 9.3% for Energizer, compared with 7.6% for Duracell, while sales shifted toward Duracell. Duracell's prices also rose at retailers with little or no Energizer sales, suggesting that the effects extend beyond within-retailer substitution between the two brands. A retailer that does not carry Energizer may nevertheless use it as a potential replacement supplier when negotiating with Duracell. Costlier Energizer replacement offers would weaken this alternative, allowing Duracell to negotiate higher wholesale prices. These patterns motivate our model-based evaluation of conduct consistent with the allegations and its implications for profits, consumer welfare, and remedies; they do not establish that an agreement existed.

To identify the pricing and bargaining incentives that can rationalize the observed patterns, we develop a conceptual framework with two manufacturers, Energizer and Duracell, and two multiproduct retailers, Walmart and Target. Manufacturer–retailer pairs negotiate wholesale prices through Nash-in-Nash bargaining, and retailers compete in prices under Bertrand competition. We represent vertical coordination between Walmart and Energizer through bilateral profit internalization, governed by a common conduct parameter θ. Walmart internalizes Energizer's profit when setting retail prices, while Energizer internalizes Walmart's profit when bargaining with rival retailers. The parameter captures the strength of these reciprocal incentives without tying them to a particular contractual instrument.[3]

[3]Bilateral profit internalization provides a general representation of the incentives induced by vertical restraints. On the retail side, these incentives may arise from loyalty or market-share rebates; on the wholesale side, they may reflect commitments by Energizer to account for Walmart's interests when negotiating with rival retailers. Relatedly, Crawford et al. (2018) and Yuan (2025)

We identify three mechanisms through which Walmart–Energizer vertical conduct generates asymmetric price increases across brands and retailers and further raises prices by weakening rival retailers' bargaining positions with Duracell.[4] First, Walmart internalizes the effect of Duracell's retail price on Energizer's profit, raising Duracell's relative price and softening within-retailer brand competition through the Edgeworth–Salinger effect. Second, Energizer raises wholesale prices to rival retailers because supplying them reduces Walmart's profits. This raising-rivals'-costs mechanism increases their input costs and softens inter-retailer competition.[5] Third, higher Energizer wholesale prices weaken rival retailers' bargaining positions with Duracell, allowing Duracell to negotiate higher wholesale prices, which in turn raise retail prices.

We extend the conceptual framework into an empirical model of battery demand, retail pricing, and wholesale bargaining, allowing for richer substitution patterns and a larger set of retailers and manufacturers. We model demand at the CBSA-quarter level using a nested logit framework, with consumer utility determined by retail prices, product and retailer attributes, and time effects. The nesting structure allows closer substitution among products sold by the same retailer. On the supply side, manufacturers and retail chains negotiate wholesale prices through Nash-in-Nash bargaining with replacement threats (Ho and Lee 2019; Yuan 2025), while retailers set prices under multiproduct Bertrand competition. Wholesale and retail prices are jointly determined in equilibrium.

We estimate the baseline model in three steps: demand by GMM, retailers' marginal costs from the first-order conditions of Bertrand pricing as proxies for wholesale prices (Berto Villas-Boas 2007), and manufacturers' input costs and bargaining-power parameters from pre-agreement wholesale-price moments.[6]

use profit-internalization weights to model incentives in vertical relationships.

[4]Within our conceptual framework, alternative conduct scenarios, including upstream coordination between Duracell and Energizer and downstream coordination between Walmart and Target, cannot reproduce the full set of observed pricing patterns. Local-market evidence also provides no evidence of hub-and-spoke coordination operating through local retail competition.

[5]Evidence from DecaData, which reports wholesale prices for a limited set of products and retailers, indicates that wholesale prices increased following the alleged agreement. This motivates allowing negotiated wholesale prices to adjust in response to the agreement; see Section 3.4 and Appendix L.

[6]Retailers may incur additional marginal costs for labor and storage. However, these costs are likely small because batteries account for only a small fraction of retailers' assortments and are relatively inexpensive and compact.

Variation across pack sizes distinguishes input costs from bargaining power.

We then introduce the agreement by specifying its retail and wholesale incentives separately, imposing additional structure on the conceptual framework's bilateral profit internalization. On the retail side, a share-based rebate rewards Walmart for selling Energizer batteries while increasing its effective marginal cost of selling competing brands. On the wholesale side, Energizer faces an opportunity cost of supplying Walmart's competitors, raising its negotiated wholesale prices and replacement offers. Two parameters govern these incentives: θ_W captures Walmart's share-based rebate incentive, while θ_E governs Energizer's opportunity cost of supplying rival retailers. We estimate the two agreement parameters by matching the asymmetric post-agreement retail price changes across brands and retailers, holding the pre-agreement cost and bargaining estimates fixed. We assess the estimated conduct against untargeted moments, including changes in market shares, relative price changes across pack sizes at Walmart, and Duracell's price increases at retailers with little or no Energizer sales.

The structural estimates yield several findings. First, the demand estimates indicate stronger within-retailer substitution. Second, the bargaining estimates suggest that retailers capture most of the channel surplus, with Walmart securing the most favorable terms from both brands, and the model matches the recovered pre-agreement wholesale prices for most retailer types, sub-line classes, and pack sizes. Third, the estimated agreement parameters are $\theta_W = 0.31$ for Walmart's share-based rebate incentive and $\theta_E = 0.70$ for Energizer's wholesale opportunity-cost incentive. The model reproduces the main asymmetric post-agreement price changes for both brands at Walmart and rival retailers and broadly matches untargeted changes in market shares and retail prices.

Using the estimated model, we compare equilibria with and without the estimated conduct. The conduct raises Walmart and Energizer's combined battery profits by 9.2% and reduces consumer surplus by approximately \$0.28 per package purchased, equivalent to 3.9% of battery spending. Applied to national AA-battery spending in 2018, this implies an annual consumer loss of approximately \$51 million. An observed-price benchmark, which combines pre-agreement estimates with observed post-agreement price changes and does not use the estimated agreement parameters, yields a similar consumer surplus loss: 6.0%, compared with 6.5% under the estimated conduct. The main results are also robust to

alternative specifications, including direct bilateral profit internalization. Both calculations imply gains for Walmart, Energizer, and Duracell and losses for rival retailers, whose wholesale costs rise for both national brands. Duracell benefits from demand diverted toward it and from improved bargaining leverage.[7]

We decompose the agreement through counterfactuals that isolate its retail and wholesale channels. Energizer's wholesale restraint benefits Walmart by softening competition from rival retailers and generates most of the parties' joint profit gains and consumer harm. Walmart's preferential retail pricing shifts gains toward Energizer by steering sales away from Duracell, at a small cost to joint profit. The two restraints thus create reciprocal benefits while playing distinct roles: wholesale contracting generates most of the gains, while preferential retail pricing primarily changes their division. This finding suggests that observable pricing conduct can serve as a means of exchanging benefits between firms without relying exclusively on unconditional transfers.

We next examine why the agreement is particularly profitable for Walmart and Energizer. Their agreement generates the largest joint profit gain among the retailer–manufacturer pairs considered. Walmart's scale allows it to recapture more sales from rival retailers, while Energizer's relatively weak bargaining power at those retailers allows more of its opportunity cost to pass through to wholesale prices. Replacing Walmart with Target weakens this channel, and the agreement's effects on consumers are much smaller. The division of gains also depends on Duracell's bargaining power with Walmart: stronger bargaining power narrows Walmart's margins on Duracell products and shifts gains toward Energizer, potentially leaving Walmart worse off despite positive joint gains.

We evaluate remedies motivated by the Robinson–Patman Act that restrict incremental wholesale price discrimination while preserving pre-agreement price differences. Restricting Energizer's negotiated wholesale prices limits the increase in its retail prices at rival retailers but leaves Duracell's price increase essentially unchanged. Because Energizer's replacement offers remain costly, Duracell retains its bargaining advantage. Extending the restriction to replacement offers substantially reduces Duracell's price increase as well. The combined restriction would avert approximately $39 million in annual consumer losses nationally, conditional

[7] Re-estimating the model without replacement offers still yields substantial consumer harm but fails to reproduce Duracell's price increase at rival retailers.

on the agreement remaining in place. By contrast, limiting Walmart's preferential retail pricing produces much smaller consumer benefits, consistent with its limited contribution to the welfare loss.

The findings have two broader implications for evaluating vertical restraints. First, a restraint's role in accounting for observed relative prices can differ from its contribution to consumer harm. In our model, preferential retail pricing reproduces the price ordering at Walmart and reallocates profits, while wholesale contracting generates most of the welfare loss. Second, a bilateral restraint can affect prices in other trading relationships by worsening retailers' alternatives to their existing suppliers. Because the relevant replacement terms need not be implemented in equilibrium, remedies that constrain only negotiated wholesale prices may leave this channel of harm intact.

1.1 Literature Review

This paper contributes to the empirical literature on vertical restraints and exclusion. Studies of nonlinear pricing, exclusive dealing, and rebates show how contractual provisions affect prices, markups, and competition (Asker 2016; Bonnet and Dubois 2010; Conlon and Mortimer 2021; Mortimer 2008; Nurski and Verboven 2016). We study an agreement combining retail and wholesale restraints and show that they play distinct roles in generating and distributing gains. Unlike coordination-based explanations (Byrne and de Roos 2019; Clark, Horstmann, and Houde 2024; Miller and Weinberg 2017; Nocke and White 2007), our framework generates market-wide price increases without horizontal coordination.

We also build on empirical studies of vertical integration (Chipty 2001; Hastings and Gilbert 2005; Hortaçsu and Syverson 2007). Most closely related, Luco and Marshall (2020) show that integration with multiproduct downstream firms can lower prices through reduced double marginalization while raising prices for competing brands, and Crawford et al. (2018) quantify foreclosure and raising-rivals'-costs incentives in multichannel television. Whereas these studies examine incentives created by common ownership, we study how a contractual agreement between independent firms can generate similar raising-rivals'-costs incentives. We further show how this wholesale restraint interacts with preferential retail pricing by the partner retailer, with the two restraints playing distinct roles in generating

and distributing gains.

Finally, this paper relates to the empirical literature on bargaining in vertical markets, building on the Nash-in-Nash framework of Horn and Wolinsky (1988) and Collard-Wexler, Gowrisankaran, and Lee (2019), with applications to multichannel television and health insurance (Crawford and Yurukoglu 2012; Ho and Lee 2017). In grocery retail, Noton and Elberg (2018) measures the division of channel surplus between supermarkets and suppliers, while Ellickson et al. (2026) shows how private labels strengthen retailers' bargaining leverage against national brands. Hristakeva (2022) studies replacement threats, while Ho and Lee (2019) and Yuan (2025) incorporate them into Nash-in-Nash bargaining. We show how a bilateral agreement can worsen retailers' replacement options and thereby raise a rival supplier's negotiated prices, even at retailers that do not carry the participating manufacturer.

The remainder of this paper is organized as follows. Section 2 describes the institutional background and data. Section 3 presents empirical evidence on price and market share changes surrounding the alleged agreement. Section 4 develops a conceptual framework to explain the asymmetric pricing patterns and evaluate alternative conduct scenarios. Section 5 outlines the empirical model of demand, retail pricing, and wholesale bargaining absent the agreement, and Section 6 discusses its estimation. Section 7 introduces the agreement into the model and estimates its parameters from post-agreement retail price changes. Section 8 presents the estimation results and counterfactual analyses. Section 9 concludes.

2 Institutional Background and Data

2.1 Institutional Background

2.1.1 Consumer Battery Industry

The types of disposable batteries typically include AA (double A), AAA (triple A), AAAA (quadruple A), C, D, and 9V. Among them, AA and AAA are the most popular and second most popular battery types, commonly used in small electronic devices.

Battery Brands/Manufacturers. Energizer is the leading battery brand, followed by Duracell. According to the plaintiffs' complaint, the two together account for about 85% of U.S. disposable battery sales (Portable Power v. Energizer 2023).[8] Energizer acquired Rayovac, the third-largest brand, through its purchase of Spectrum Brands' battery and lighting division in January 2019. We group Rayovac and Eveready with Energizer in the empirical analysis.

In addition to branded products, a substantial share of battery sales comes from major battery retailers developing their own private-label products, including Walmart (Great Value), Costco (Kirkland Signature), Amazon (Amazon Basics), Target (Up & Up), Dollar General (DG Home), and Dollar Tree (E-Circuit). These private-label batteries are not manufactured by the retailers themselves; instead, production is outsourced to Original Equipment Manufacturers (OEMs). Consequently, these retailers are not manufacturers but large, powerful buyers who order in bulk and set the quality standards, packaging, and branding costs for their private-label products.

Energizer (including Rayovac and Eveready), Duracell, and private-label brands account for the majority of battery sales. The remaining market share is held by smaller brands, including Kodak, ACDelco, and Panasonic. Each of these brands is much smaller in scale compared with Energizer and Duracell and is typically not offered by major retailers, but instead sold through smaller retailers or dollar stores.

Battery Retailers. Walmart is the largest battery retailer, followed by Dollar Tree, Amazon, Dollar General, Costco, and Target. Each accounted for more than 3% of battery sales in 2018, and together they represented over 65% of total sales, as shown in Table 1. The next tier includes Family Dollar, Kroger, Sam's Club, Home Depot, Harbor Freight Tools, Lowe's, Walgreens, CVS, ShopRite, and Menards, each of which accounted for more than 1% of battery sales in 2018.[9]

[8] Smaller brands, including Kodak, ACDelco, and Panasonic, hold only marginal shares.

[9] Family Dollar was acquired by Dollar Tree in 2015 (https://vindyarchives.com/news/2015/jul/07/dollar-tree-acquires-family-dollar/), while Sam's Club is owned by Walmart. We therefore group Family Dollar with Dollar Tree and Sam's Club with Walmart in the analysis. Except at Amazon, battery purchases at these retailers occur primarily in physical stores. Online purchases account for somewhat larger shares at Walmart and Target than at other physical retailers, but remain a small share of their battery sales. We therefore combine physical and online purchases within each retailer.

Battery retailers are typically multi-product sellers, carrying Energizer, Duracell, and private-label products when available. Table 1 reports the within-retailer market shares for each battery brand at major retailers in 2018. Walmart and Target's sales are dominated by Energizer and Duracell, with minimal coverage of private-label or other branded products. Dollar Tree specializes in its E-Circuit private label, which accounts for over 97% of its sales. Amazon's well-known AmazonBasics brand represents roughly half of its sales, with much of the remainder coming from third-party sellers offering less prominent brands such as Indeterminate, ACDelco, Panasonic, Amvolt, EBL, and Maxell. Dollar General's sales are split evenly between branded products and its private label. Costco does not sell Energizer-related brands, relying instead on Duracell and its Kirkland private label.

Dollar stores account for a substantial share of battery purchases. Dollar Tree sells all batteries in our sample for $1, whereas Dollar General and Family Dollar offer branded and private-label products at a range of prices.

	Walmart	Dollar Tree	Amazon	Dollar General	Costco	Target
Market Share	31.65%	15.68%	7.00%	5.66%	4.29%	3.76%
Within-Retailer Market Share						
Energizer (Rayovac, Eveready)						
Energizer	35.15%		23.74%	28.23%		64.36%
Rayovac	32.87%		2.41%			
Eveready	3.89%			15.02%		1.61%
Duracell	27.04%		3.47%	7.51%	72.83%	32.83%
Private Label		97.52%	58.11%	49.23%	27.17%	1.20%
Kodak	1.05%					
Indeterminate		2.48%				
Acdelco			6.29%			
Panasonic			3.15%			
Amvolt			1.64%			
EBL			1.19%			

Notes: The table summarizes the 2018 market share for AA batteries by major retailer, defined as those with a market share greater than 3%, and the within-retailer market share for each major brand. Market share is calculated as the retailer's share of total battery sales. Within-retailer market share is calculated as the share of battery sales for a given brand within that retailer. Brands with less than 1% market share within a retailer are excluded from this calculation.

Table 1: Battery Market Share for Major Retailers and Brands

Battery Product Lines and Package Sizes. Batteries are usually sold in packages. For example, popular products at Walmart include "Energizer MAX AA Alkaline 8 Pk", "Energizer MAX AA Alkaline 16 Pk", "Duracell Coppertop AA Alkaline 8 Pk", and "Duracell Coppertop AA Alkaline 16 Pk", with respective median prices of $6.94, $12.78, $7.47, and $12.78. Energizer MAX and Duracell Coppertop are flagship alkaline battery lines from Energizer and Duracell, respectively, designed for everyday devices.[10] The terms 8 Pk and 16 Pk refer to package sizes containing eight or sixteen AA batteries, with larger packages usually offering a lower price per battery. Common package sizes are 4, 8, and 16, though they can vary by brand and retailer. In the empirical analysis, we define a product as a specific combination of battery line and package size.

2.1.2 Class Actions against Walmart and Energizer

A class action lawsuit was filed against Energizer and Walmart in April 2023 over the companies' allegedly anticompetitive scheme to raise prices for disposable batteries.[11] The plaintiffs include the following three groups: (i) Don Copeland et al., consumers who purchased Energizer batteries from non-Walmart retailers; (ii) Kimberly Schuman et al., consumers who purchased Energizer or Duracell batteries directly from Walmart stores; and (iii) Portable Power, Inc., an online battery retailer that bought directly from Energizer.

From 2018 to 2021, Energizer implemented multiple wholesale price increases of 8–11%, while Walmart correspondingly raised the retail prices of Energizer batteries. Plaintiffs allege that Duracell, Energizer's main rival, also raised its price due to reduced competitive pressure, resulting in inflated prices across the disposable battery market and harming both consumers and retailers.

The plaintiffs point to internal Energizer communications from "Project Atlas," a group created by Energizer that allegedly tracked retailers' prices to ensure Walmart retained a competitive edge (Portable Power v. Energizer 2023). Evidence

[10] Other battery lines for Energizer include its alkaline products Energizer EcoAdvanced and Energizer Industrial, as well as non-alkaline lines such as Energizer Ultimate Lithium, Energizer Advanced Lithium, and the rechargeable Energizer Recharge series. For Duracell, other alkaline lines include Duracell Optimum, Duracell Quantum, Duracell Procell, and Duracell Simply, alongside non-alkaline products such as Duracell Ultra Lithium and the rechargeable Duracell Rechargeable series.

[11] See https://www.classaction.org/walmart-batteries-price-fixing-lawsuit.

cited includes internal emails and sales staff remarks suggesting Walmart pressed Energizer to enforce these pricing practices.

Alleged Vertical Agreement. According to the complaints, the alleged agreement between Walmart and Energizer involved two main elements.[12] First, Energizer allegedly raised wholesale prices to retailers competing with Walmart, inducing higher retail prices and softening competition with Walmart. Second, Walmart allegedly reciprocated by raising Duracell's retail prices, reducing competition with Energizer within Walmart. Under this arrangement, Energizer benefits from higher wholesale revenues at rival retailers and softer competition from Duracell at Walmart.

Evidence from Litigation and Online Enforcement. The Portable Power case provides a concrete example of the alleged enforcement against online retailers. In November 2018, Energizer allegedly raised wholesale prices for certain headlamps sold to Portable Power by 50–85% after it undercut Walmart's prices online. In January 2021, a Project Atlas email identified Portable Power among Amazon sellers violating Energizer's pricing policies, and Energizer allegedly threatened to halt shipments unless it matched Walmart's prices (Portable Power v. Energizer 2023).

The September 2026 court order provides further evidence on the timing of the alleged conduct. Efforts initially directed at preventing online sellers from undercutting Walmart on headlamp prices allegedly expanded to batteries in 2019, broadly consistent with the price increases we document beginning in the second quarter of 2019. The order also indicates that Project Atlas focused primarily on online retailers, particularly Amazon, rather than documenting comparable enforcement across brick-and-mortar retailers.[13] By November 2020, Energizer

[12] Following Starc and Wollmann (2025), we use the term "agreement" to describe the economic arrangement alleged in the complaints rather than any finding of the court, which has not ruled on the merits.

[13] Our data are consistent with this pattern. Comparing each non-Walmart purchase with Walmart's median price for the same product, CBSA, and quarter, we find that the share of Energizer purchases priced more than 2% below Walmart declined online relative to Duracell after the agreement, with no statistically significant relative change in stores. Appendix H reports the estimates.

employees described these efforts as part of their "steady state business" (United States District Court for the Northern District of California 2026).[14]

The litigation remains unresolved on the merits. The court denied the defendants' motions to dismiss in February 2024 and denied class certification without prejudice in September 2026 (United States District Court for the Northern District of California 2024, 2026).

2.2 Data

Our data for the empirical analysis come from an omni-channel consumer panel provided by Numerator, covering the period from 2018 to 2025. We restrict the analysis to 2018–2021, excluding data from 2022 onward due to significant price increases driven by inflation. The data capture households' purchases through receipt submissions across all categories, including both e-commerce and in-store transactions.[15] We define the pre-period and post-period as the periods before and after the vertical agreement, respectively: the pre-period is 2018 to 2019 Q1, and the post-period is 2019 Q2 to 2021.

For each receipt, defined as a "trip," we observe the retailer or online venue (e.g., Walmart, Target, or Amazon), along with the price, quantity, brand, product category, and detailed description of every product listed. We identify battery purchases using the major category "Household Batteries." We also observe consumer characteristics, described in Appendix A. We map each consumer's five-digit ZIP code to the corresponding core-based statistical area (CBSA) and define each CBSA–quarter as a market. This geographic market definition is consistent with the use of metropolitan areas in retrospective studies of retail competition (Clark, Horstmann, and Houde 2024; Hosken, Olson, and Smith 2018).

We use text analysis to extract the battery type (i.e., AA, AAA, or others) and size (i.e., 4-, 8-, or 16-pack) from the product description. For example, "Energizer MAX AA Alkaline 8 Pk" is classified as AA batteries in a pack of eight. We

[14] Our model captures Energizer's incentive to raise wholesale prices at rival retailers but does not explicitly model targeted enforcement against online sellers.

[15] Numerator collects data from users who voluntarily upload their receipts, so households may stop submitting receipts. To capture as many battery transactions as possible, we do not restrict the sample to consumers who remain active throughout the period. Instead, we use all submitted receipts during the sample period. In Appendix A, we compare consumer characteristics before and after the case study period of focus and find no substantial differences.

focus on AA batteries for our main empirical exercises, which account for 43.19% of household battery purchases, while AAA batteries, the second most popular type, account for 29.62% and exhibit similar empirical patterns. We exclude 5.01% of household battery purchases that do not specify battery types. For products with missing pack information on the receipt, accounting for about 29.19% of purchases, we use retailer, brand, and price information to impute the package size. Appendix B discusses this procedure in detail. Between 2018 and 2021, we observe approximately 1.85 million AA battery purchases made by 566,959 households. Most batteries are purchased in physical stores alongside other goods; only 11% of purchases occur online, primarily through Amazon.

	Mean	Median	Standard Deviation
Number of Battery Products per Trip	1.18	1.00	0.81
Batteries per Pack	15.40	8.00	15.73
Price	8.33	7.00	6.15
Number of Products per Trip	18.13	11.00	23.07
Battery Only	0.08	0.00	0.28
Spending per Trip	79.97	42.97	102.89
Online Purchase	0.11	0.00	0.32
Online Purchase (Excluding Amazon)	0.03	0.00	0.18
Total Battery Sales		1,848,318	
Number of Trips		1,562,504	
No. of Consumers		566,959	

Notes: The table summarizes the key variables in the data for trips that include at least one AA battery purchase. A trip is defined as a unique basket or receipt. *Number of battery products per trip* refers to the number of AA battery products purchased in a single trip. *Price* is the retail price per unit of product. *Battery Only* is an indicator equal to one if the trip consists solely of household battery purchases (not limited to AA batteries). *Number of products per trip* refers to the total number of products (including non-battery items) in the basket, while *Spending per trip* refers to the total payment made in a trip. *Online purchase* is a dummy variable equal to one if the basket is an online purchase. *Online purchase (excluding Amazon)* is equal to one if the basket is an online purchase made through a retailer other than Amazon.

Table 2: Summary Statistics

Summary Statistics. Table 2 summarizes the key variables in the data for trips that include at least one AA battery purchase. On average, consumers purchase

1.2 battery products per trip, with a median of 1. These battery products typically contain 15.40 pieces per pack and are priced at $8.33 on average, with a median price of $7.00. Batteries are usually bought alongside other products rather than as the sole purchase in a trip, with only 8% of trips consisting solely of battery products, not limited to AA batteries. On each trip, consumers purchase an average of 18.13 items in total, with a median of 11.00, and the average total spending is $79.97, with a median of $42.97.

Most trips involve visits to physical stores, with 11% occurring online. Of these, the majority are Amazon purchases; excluding Amazon, online transactions account for only 3%. Accordingly, in the empirical analysis we do not separately consider the online channel, as it is primarily captured by Amazon.

3 Empirical Evidence

3.1 Retailer Competition

Battery prices rose beginning in the second quarter of 2019 at every major retailer except Dollar Tree. Figure 1a presents normalized retailer prices from 2018 to 2021 for Walmart, Dollar Tree, Amazon, Dollar General, Costco, Target, and all other remaining retailers. Prices are normalized to each product's price in the first quarter of 2019. Products are defined as a specific combination of brand line (e.g., Energizer Max, Duracell Coppertop) and pack size (e.g., 4, 8, or 12 batteries per pack).[16] The vertical line at the second quarter of 2019 marks the start of the post-agreement period used in the analysis. Dollar Tree, being a fixed-price retailer, kept its battery products at $1 throughout. Dollar General exhibits a particularly large increase, driven primarily by Energizer products.

Figure 1b presents the market shares for Walmart, Dollar Tree, Amazon, Dollar General, Costco, Target, and all other remaining retailers. Walmart experienced a decline in market share, much of which was absorbed by Dollar Tree. Large retailers besides Walmart and Dollar Tree display relatively stable market shares,

[16]For Amazon, because products and product lines are sold by numerous individual third-party sellers rather than a single centralized retailer (as in, e.g., Walmart or Target), we normalize prices using the product identifier in the data rather than our definition of a product, which is a specific combination of battery line and package size. Prices on Amazon are also more volatile, reflecting the decentralized pricing decisions of many individual sellers.

suggesting that substitution occurs more within retailers than across them. Amazon's share has increased since 2020, largely reflecting the broader trend toward online shopping. The remaining smaller retailers show a gradual decline in market share. Appendix C further decomposes retailer shares by brand, showing that Walmart's decline is primarily driven by a reduction in Duracell sales, while Dollar Tree's increase comes mainly from its own brands other than Energizer or Duracell, most notably its private label E-Circuit.

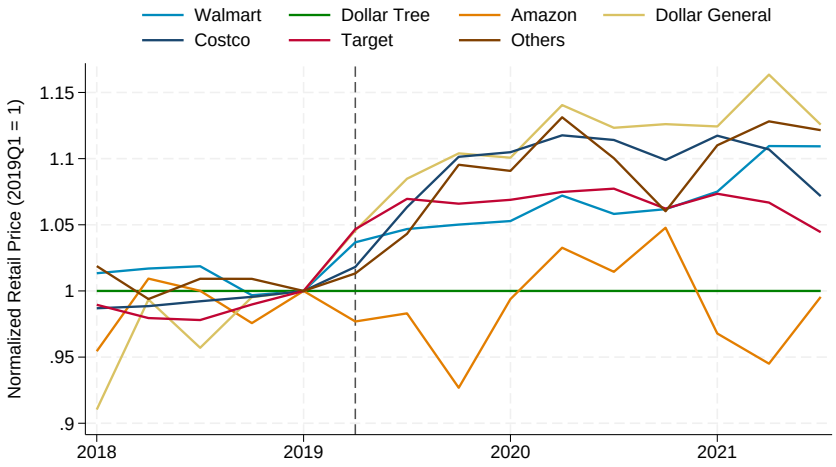
Section 2.2 shows that battery purchases are usually not made as stand-alone purchases but are bundled with other grocery shopping trips. We examine grocery shopping trip patterns by retailer in Appendix D. We find that the overall shares of trips across retailers and the number of other products purchased per trip remain relatively stable over time and therefore do not explain the changes in retailers' shares of battery purchases.

3.2 Retail Prices

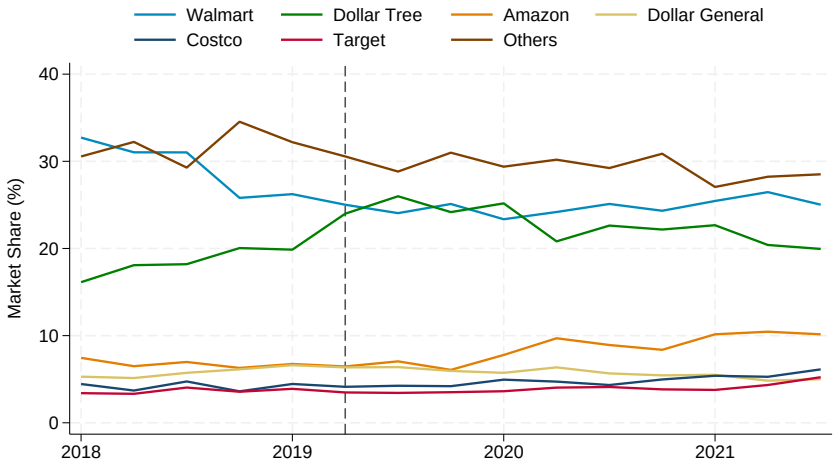
Figure 2a and Figure 2b plot prices at Walmart and other retailers from 2018 to 2021, normalized to each product's price in the first quarter of 2019. At Walmart, both brands' prices increased, with a larger increase for Duracell. At other retailers, the increases were similar across brands, although the regression estimates below are slightly larger for Energizer. Appendix E shows no contemporaneous increase in battery input costs that could explain these patterns. Raw material costs rose sharply only after December 2020, according to the expert testimony summarized in (United States District Court for the Northern District of California 2026, p. 20), consistent with the input-price indices in Appendix E. These cost increases therefore cannot explain the price increases in 2019 and 2020. Appendix F finds no statistically significant increase in private-label prices, providing little evidence that the concurrent tariff increase raised comparison-product prices.

We estimate the following regression to quantify changes in retailer prices for Energizer and Duracell, as well as for other brands. The outcome variable is the log of the retail price of product j from retailer g on trip i in quarter t:

$$\begin{aligned}\log p_{ijgt} = {} & \beta_1 \mathbb{1}\{\text{Energizer}\}_j \times \mathbb{1}\{\text{Post}\}_t + \beta_2 \mathbb{1}\{\text{Duracell}\}_j \times \mathbb{1}\{\text{Post}\}_t \\ & + \beta_3 \mathbb{1}\{\text{Post}\}_t + \phi_{jg} + \tau t + \epsilon_{ijgt},\end{aligned} \tag{1}$$



(a) Retail Prices by Retailer

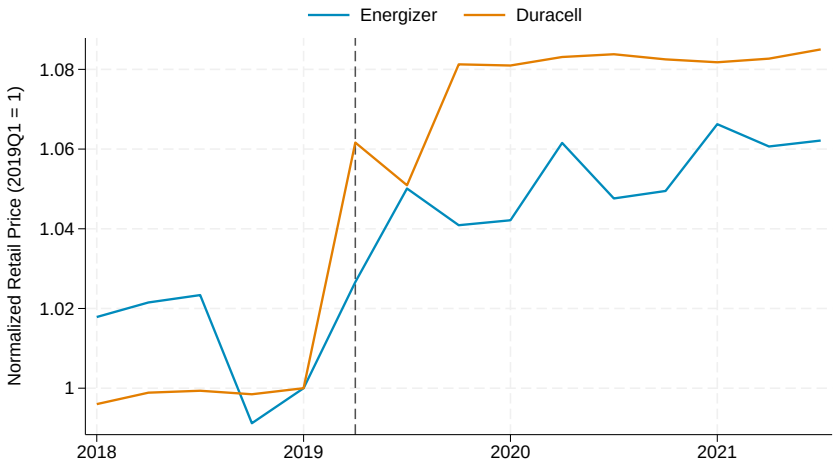


(b) Market Shares by Retailer

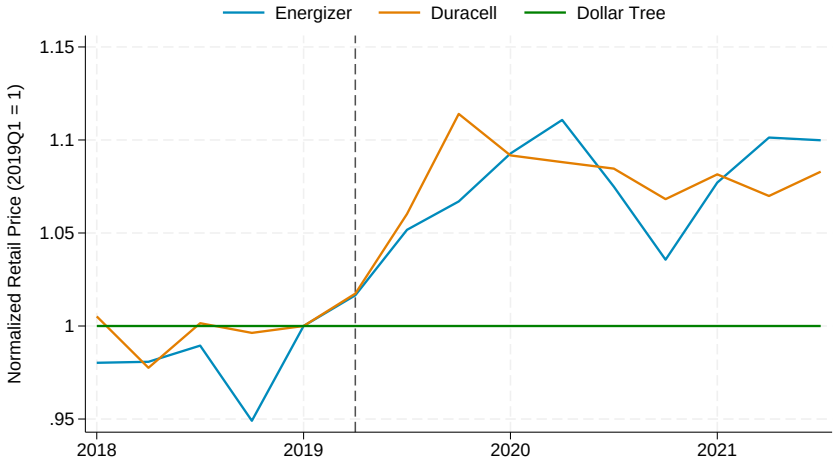
Notes: The figure plots quarterly retail prices and market shares by retailer from 2018 to 2021. Figure 1a displays prices for different retailers, including Walmart, Dollar Tree, Amazon, Dollar General, Costco, Target, and all other remaining retailers, normalized to each product's price in the first quarter of 2019. The vertical line at the second quarter of 2019 marks the start of the post-agreement period used in the analysis. Figure 1b shows the quarterly market shares for these retailers.

Figure 1: Retailer Prices and Market Shares by Retailer from 2018 to 2021

where the specification includes indicators for (i) Energizer brands after the agreement, (ii) Duracell brands after the agreement, and (iii) all products after the agreement. Product-by-retailer fixed effects ϕ_{jg} absorb cross-sectional variation,



(a) Retail Prices at Walmart



(b) Retail Prices at Other Retailers

Notes: The figure plots quarterly retail prices of Energizer and Duracell from 2018 to 2021. Figure 2a shows prices at Walmart for Energizer (including Rayovac and Eveready) and Duracell, normalized to each product's price in the first quarter of 2019. Products are defined as a specific combination of brand line (e.g., Energizer Max, Duracell Coppertop) and pack size (e.g., 4, 8, or 12 batteries per pack). The vertical line at the second quarter of 2019 marks the start of the post-agreement period used in the analysis. Figure 2b shows quarterly prices at other retailers for Energizer, Duracell, and Dollar Tree's battery products.

Figure 2: Retail Prices from 2018 to 2021

while a linear time trend τ_t captures the upward trend in retail battery prices. The common post-agreement indicator absorbs shifts affecting all brands. The brand-by-post coefficients therefore measure the additional pre-post changes in Energizer's and Duracell's prices or sales relative to other brands. We interpret these as effects of the agreement under the assumption that, absent the agreement, Energizer and Duracell would have followed the same trends as other brands.

	All Retailers	Walmart	Other Retailers
$\mathbb{1}\{\text{Energizer}\}_j \times \mathbb{1}\{\text{Post}\}_t$	0.057***	0.012	0.089***
	(0.022)	(0.015)	(0.024)
$\mathbb{1}\{\text{Duracell}\}_j \times \mathbb{1}\{\text{Post}\}_t$	0.070***	0.047***	0.073***
	(0.021)	(0.014)	(0.022)
$\mathbb{1}\{\text{Post}\}_t$	-0.008		-0.005
	(0.018)		(0.017)
τ	0.001*	0.003**	0.001
	(0.001)	(0.001)	(0.001)
p-value: Energizer $\times$ Post $=$ Duracell $\times$ Post	0.204	0.010	0.259
Product-by-retailer fixed effects	Yes	Yes	Yes
No. of observations	1,695,187	514,519	1,180,668
Adjusted R-squared	0.957	0.934	0.956

Notes: The table reports estimates from Equation (1), with log retail price as the dependent variable. Column 1 includes all retailers; Column 2 includes Walmart, Sam's Club, and Walmart Neighborhood Market; and Column 3 includes non-Walmart retailers. In Column 2, we omit $\mathbb{1}\{\text{Post}\}_t$ because Energizer and Duracell account for most Walmart sales. The p-value row reports a Wald test of equality between the Energizer and Duracell post-agreement coefficients within each column. Robust standard errors are clustered at the product-by-retailer level. Significance levels: *($p < 0.10$), **($p < 0.05$), ***($p < 0.01$).

Table 3: Changes in Retail Prices by Brand and Retailer

Price increases exhibit different patterns across retailers. At Walmart, Duracell's prices rise more than Energizer's, whereas both brands experience substantial increases at rival retailers. Across all retailers, Column 1 of Table 3 shows that Energizer's and Duracell's prices rise by 5.9% and 7.3%, respectively, while the prices of other brands show no statistically significant change.[17]

Columns 2 and 3 separate Walmart from other retailers. At Walmart, Duracell's price rises by 4.8%, compared with a statistically insignificant 1.2% for Energizer. The difference is statistically significant, consistent with the alleged agreement to raise Duracell's prices at Walmart. At other retailers, prices rise by 9.3% for

[17] We convert each coefficient b into a percentage change, $\exp(b) - 1$.

Energizer and 7.6% for Duracell relative to other brands, although the difference is statistically insignificant.

Other brands again show no significant price change, consistent with the private-label results in Appendix F. Appendix I obtains similar estimates using Numerator's demographic projection weights to improve the sample's representativeness of the U.S. population.

Price increases extend to retailers carrying only Duracell. Appendix J reports price changes at non-Walmart retailers separately for those carrying both national brands and those carrying only one. Duracell's prices rise even at retailers with little or no Energizer sales. This pattern is difficult to explain through substitution between the two brands within the retailer.

The empirical results are similar to Miller and Weinberg (2017), who document an abrupt increase in retail prices for ABI and MillerCoors following the horizontal merger between Miller and Coors in the beer industry. Our setting, however, differs in several key respects. First, we study a vertical agreement rather than a horizontal merger. Second, the extent of the retail price increases differs across Energizer and Duracell and between Walmart and other retailers. On the other hand, Miller and Weinberg (2017) find broadly similar magnitudes of price increases across firms, with ABI experiencing only slightly smaller increases than MillerCoors.

Conduct Scenarios. Appendix K further shows that post-agreement price increases do not vary significantly with Walmart's or Energizer's pre-agreement local market share. Section 4 examines whether alternative forms of conduct can account for the pricing patterns documented here.

The Rayovac Acquisition. The alleged agreement followed Energizer's acquisition of Spectrum Brands' battery and portable lighting business, including Rayovac, on January 2, 2019. Energizer also acquired Spectrum's auto care business, including Armor All and STP, on January 28, 2019. To examine whether the observed battery price increases reflect broader changes in Energizer's pricing or costs following these acquisitions, Appendix G compares prices of its portable lighting and auto care products with those of competing brands in the same categories. We

find no comparable price increases, suggesting that the battery price changes are unlikely to reflect a firm-wide pricing or cost shock associated with the acquisitions.

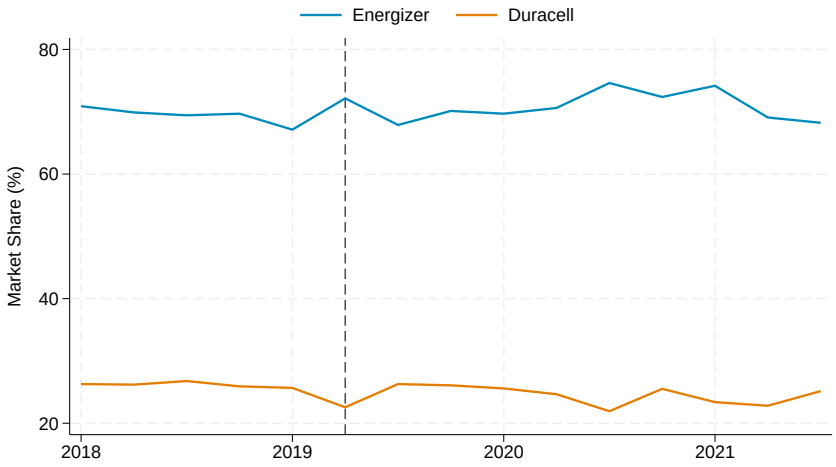
3.3 Battery Sales

Brand shares shift in a direction consistent with the relative price changes: toward Energizer at Walmart and toward Duracell at rival retailers. Figure 3a and Figure 3b present the shares of battery sales for Walmart and other retailers, respectively. At Walmart, Energizer's share of battery sales rises around the second quarter of 2019, while Duracell's share declines. At other retailers, Dollar Tree shows an abrupt increase in market share in the second quarter of 2019, as its price remained fixed at $1, leading much of the demand to be diverted there. Meanwhile, Energizer's share gradually declined, while Duracell's share increased, approaching Energizer's share by the end of 2021.

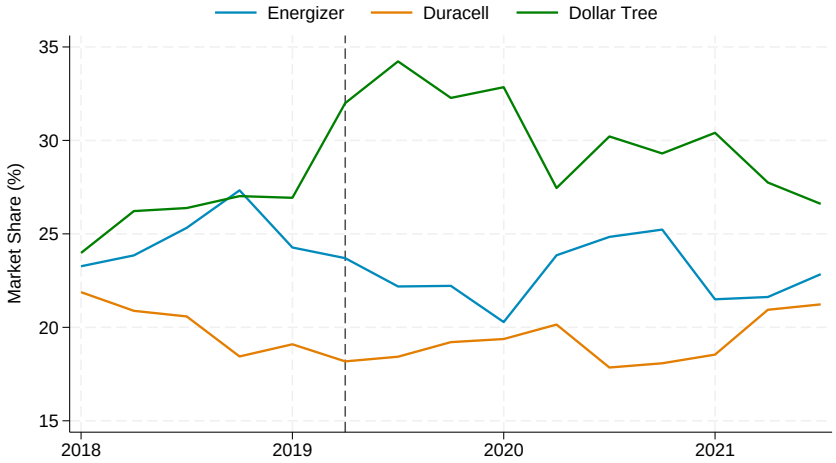
	All Retailers	Walmart	Other Retailers
$\mathbb{1}\{\text{Energizer}\}_j \times \mathbb{1}\{\text{Post}\}_t$	-0.167**	-0.070	-0.156**
	(0.070)	(0.085)	(0.078)
$\mathbb{1}\{\text{Duracell}\}_j \times \mathbb{1}\{\text{Post}\}_t$	-0.175*	-0.304**	-0.021
	(0.105)	(0.126)	(0.082)
$\mathbb{1}\{\text{Post}\}_t$	0.166***		0.179***
	(0.060)		(0.063)
τ	0.017***	0.025**	0.015**
	(0.005)	(0.012)	(0.006)
Product-by-retailer fixed effects	Yes	Yes	Yes
No. of observations	33,897	1,543	32,354

Notes: The table reports estimates from Equation (1) with sales as the dependent variable, estimated using Poisson pseudo-maximum likelihood regressions. Column 1 includes observations from all retailers, Column 2 focuses on observations from Walmart retailers (Walmart, Sam's Club, and Walmart Neighborhood Market), and Column 3 focuses on observations from non-Walmart retailers. For Walmart, we exclude $\mathbb{1}\{\text{Post}\}_t$ in Equation (1) because the majority of its sales come from either Energizer or Duracell. Robust standard errors are clustered at the product-by-retailer level. Significance levels: * ($p < 0.10$), ** ($p < 0.05$), *** ($p < 0.01$).

Table 4: Changes in Sales by Brand and Retailer



(a) Battery Sales Shares at Walmart



(b) Battery Sales Shares at Other Retailers

Notes: Figure 3a plots quarterly battery sales shares at Walmart for Energizer (including Rayovac and Eveready) and Duracell. The vertical line at the second quarter of 2019 marks the start of the post-agreement period used in the analysis. Figure 3b shows quarterly battery sales shares at other retailers for Energizer, Duracell, and Dollar Tree's battery products.

Figure 3: Battery Sales Shares from 2018 to 2021

We next apply Equation (1) to product–retailer–quarter sales, estimating the specification by Poisson pseudo-maximum likelihood.[18] Both national brands lose

[18]Since many smaller brands and retailers record zero sales while larger brands have substantial sales, we follow Chen and Roth (2024) and estimate the regression using Poisson pseudo-maximum

sales relative to other brands, and the losses differ across retailers in the same way as the price increases. Column 1 of Table 4 reports estimates using all retailers. Relative to other brands, Energizer's and Duracell's sales decline by 15.4% and 16.1%, respectively. Sales of other brands rise by 18.1% after the agreement, beyond the linear time trend.[19]

Column 2 shows that at Walmart, Duracell's sales fall by 26.2%, compared with 6.8% for Energizer, consistent with Duracell's larger price increase. At other retailers, Column 3 shows that sales of other brands rise by 19.6%. Relative to other brands, Energizer's sales decline by 14.4%, compared with 2.1% for Duracell, consistent with Energizer's larger price increase. The linear time trend captures the overall growth in battery sales.

3.4 Wholesale Price Increases

Our primary data do not contain information on wholesale prices. Using DecaData for a limited set of products and retailers, we find that wholesale prices increased following the vertical agreement; see Appendix L. This evidence suggests that changes in wholesale terms are an important mechanism to capture. Accordingly, the model developed below allows manufacturer–retailer pairs to renegotiate their wholesale prices after the agreement, thereby generating post-agreement changes in wholesale terms.

4 Conceptual Framework

We develop a simple framework to interpret two central pricing patterns: Duracell's larger price increase at Walmart and higher prices for both national brands at rival retailers. We then compare its predictions with those of the horizontal-coordination benchmarks considered below.

The framework yields three mechanisms. In M1, Walmart raises Duracell's retail price. In M2, Energizer raises its wholesale price at Target. In M3, Duracell's

likelihood.

[19]This increase partly reflects substitution toward other brands, especially Dollar Tree's batteries, whose prices remain fixed at $1. To the extent that the agreement induces this substitution, other brands are also affected by the agreement. Using their sales as a benchmark may therefore overstate the agreement-induced declines in Energizer's and Duracell's sales.

wholesale price rises at Target. M1 reflects Walmart's retail incentive and M2 reflects Energizer's wholesale incentive. M3 is not a separate incentive: it follows from M2 through Target's bargaining with Duracell. In this framework, a common profit-internalization weight represents both incentives. The empirical model in Section 7 represents the same two incentives with a share-based rebate and an opportunity cost.

4.1 Market structure

We simplify the battery market to two manufacturers and two multi-product retailers. Appendix M illustrates this simplified market structure, with two upstream manufacturers, Energizer and Duracell, and two downstream retailers, Walmart and Target. Energizer (E) and Duracell (D) each produce a single brand, while Walmart (W) and Target (T) each carry both brands, yielding four products: Energizer at Walmart (EW), Energizer at Target (ET), Duracell at Walmart (DW), and Duracell at Target (DT).

Manufacturers supply retailers at wholesale prices: Energizer and Duracell charge Walmart w_{EW} and w_{DW}, respectively, and charge Target w_{ET} and w_{DT}, respectively. The multi-product retailers set retail prices for Energizer and Duracell, denoted by p_{EW} and p_{DW} at Walmart, and p_{ET} and p_{DT} at Target.

4.2 Battery Demand

Demand for product EW is linear and given by

$$D_{EW} = a - b\,p_{EW} + \gamma_s\,p_{DW} + \gamma_c\,p_{ET} + \gamma_c\,p_{DT},$$

where $\gamma_s > 0$ captures cross-brand substitution within a retailer, while $\gamma_c > 0$ captures across-retailer substitution. We impose $\gamma_s > \gamma_c$, reflecting stronger substitution within a retailer than across retailers. Demand for the other three products is specified analogously.

Motivated by the empirical observation that total battery sales do not decline with price increases, as well as by the essential nature of batteries, we assume aggregate demand is inelastic. Specifically, total battery demand is fixed at M, so

that

$$D_{EW} + D_{ET} + D_{DW} + D_{DT} = M \quad \forall \mathbf{p}.$$

This condition holds if and only if $b = \gamma_s + 2\gamma_c$, which we impose as a parameter restriction. Under this restriction, consumers only substitute across products; no consumer exits the market in response to a price change.

4.3 Retail and Wholesale Pricing

Each manufacturer–retailer pair negotiates a linear wholesale price w_{ij} through Nash-in-Nash bargaining, and each retailer sets retail prices given its wholesale prices. Manufacturer (E, D) and retailer (W, T) profits are defined as

$$\begin{aligned}
\pi_E &= (w_{EW} - c_E)\, D_{EW} + (w_{ET} - c_E)\, D_{ET}, \\
\pi_D &= (w_{DW} - c_D)\, D_{DW} + (w_{DT} - c_D)\, D_{DT}, \\
\pi_W &= (p_{EW} - w_{EW})\, D_{EW} + (p_{DW} - w_{DW})\, D_{DW}, \text{ and} \\
\pi_T &= (p_{ET} - w_{ET})\, D_{ET} + (p_{DT} - w_{DT})\, D_{DT},
\end{aligned}$$

where c_E and c_D denote the marginal production costs of manufacturers E and D, respectively. For the Energizer–Walmart pair, the Nash product is

$$\mathcal{N}_{EW} = \left(\pi_E - d_E^{-EW}\right)^{\rho} \left(\pi_W - d_W^{-EW}\right)^{1-\rho},$$

where $\rho \in [0, 1]$ denotes the manufacturer's bargaining power, π_E and π_W are the equilibrium profits of Energizer and Walmart, respectively, and d_E^{-EW} and d_W^{-EW} are the disagreement payoffs in the subgame in which product EW is absent from Walmart's assortment.[20] The wholesale price w_{EW} is determined by the first-order condition associated with the Nash product. The wholesale prices for other manufacturer–retailer pairs are determined analogously.

[20] In computing disagreement payoffs, we assume that the parties continue to internalize each other's profits in both on- and off-path states, because the agreement is a structural feature of the relationship rather than an outcome of any individual wholesale-price negotiation. This follows Crawford et al. (2018), where the integration structure is predetermined at the bargaining stage.

4.3.1 Bilateral Internalization

The conceptual framework assesses whether coordination between Walmart and Energizer can reproduce the observed pricing patterns and clarify their mechanisms, without specifying the agreement's contractual form. We represent coordination as bilateral profit internalization: Walmart internalizes Energizer's profit when setting retail prices, while Energizer internalizes Walmart's profit when bargaining with rival retailers. For simplicity, both use the same weight $\theta \in [0, 1]$, with $\theta = 0$ denoting no internalization and $\theta = 1$ full internalization. Walmart's pricing objective is therefore

$$\Pi_{EW} = \pi_W + \theta \pi_E.$$

Symmetrically, Energizer maximizes $\pi_E + \theta \pi_W$ when bargaining with rival retailers. The empirical model preserves these two channels but specifies their incentives separately. Section 7 represents Walmart's retail incentive through a share-based rebate and Energizer's wholesale incentive through an opportunity cost of supplying rival retailers.

These incentives have natural contractual interpretations. On the retail side, internalization resembles a conditional rebate, such as an all-units discount or a market-share rebate, that lowers Walmart's effective cost of Energizer products and encourages it to shift sales away from Duracell (Conlon and Mortimer 2021). We model this incentive explicitly in Section 7.1. On the wholesale side, internalization captures a commitment to account for Walmart's profit when setting terms with rival retailers, addressing the commitment problem in bilateral contracting (Hart and Tirole 1990; McAfee and Schwartz 1994; O'Brien and Shaffer 1992; Rey and Vergé 2004). We model this incentive as an opportunity cost of supplying Walmart's rivals in Section 7.2. Such a commitment could be sustained by Walmart's ability to withdraw shelf space or promotional support, or by contractual terms tied to its battery category's performance, as in a category-captain arrangement.[21]

The framework does not require an explicit restraint, such as RPM, an MFN provision, or a no-undercutting clause; it requires only that Energizer's terms with

[21] In the vertical contracting literature, commitment induces a manufacturer to account for all its retailers' profits, supporting monopoly prices throughout the retail market (Hart and Tirole 1990; O'Brien and Shaffer 1992). The commitment in our setting is selective: Energizer accounts for Walmart's profit when negotiating with rival retailers, but not for their profits when negotiating with Walmart. This generates asymmetric price increases, larger at Walmart's rivals than at Walmart.

rival retailers reflect Walmart's interests.[22]

The agreement operates through two channels: preferential retail pricing (M1) and wholesale contracting, which raises Energizer's wholesale prices at rival retailers (M2), weakens those retailers' bargaining positions with Duracell, and raises Duracell's negotiated wholesale prices (M3).

M1. Walmart raises Duracell's retail price. The first-order condition for Duracell's price at Walmart is

$$\frac{\partial \pi_W}{\partial p_{DW}} + \theta \frac{\partial \pi_E}{\partial p_{DW}} = 0, \qquad \frac{\partial \pi_E}{\partial p_{DW}} = \gamma_s(w_{EW} - c_E) + \gamma_c(w_{ET} - c_E) > 0.$$

Raising p_{DW} diverts demand to Energizer at both retailers. Internalization therefore raises p_{DW}, softening competition between brands within Walmart.

M2. Energizer raises its wholesale price at Target. Energizer's gain from supplying Target is

$$S_{EW}^{ET} = \theta \underbrace{\left(\pi_W - d_W^{-ET}\right)}_{<0} + \left(\pi_E - d_E^{-ET}\right).$$

Supplying Target reduces Walmart's profit, making the first term negative. Internalization thus lowers Energizer's gains from supplying Target and raises w_{ET} and, through pass-through, p_{ET}, softening competition across retailers.[23]

M3. Duracell's wholesale price rises at Target. The higher w_{ET} from M2 also lowers Target's disagreement payoff in its negotiation with Duracell. Without Duracell, Target earns profit only from Energizer:

$$d_T^{-DT} = \left(p_{ET}^{-DT} - w_{ET}\right) D_{ET}^{-DT}, \qquad \frac{\partial d_T^{-DT}}{\partial w_{ET}} < 0, \qquad \frac{\partial w_{DT}^*}{\partial w_{ET}} > 0.$$

[22] Outcome-contingent transfers can generate profit internalization. If Walmart receives a share s_W of Energizer's profit and Energizer receives a share s_E of Walmart's, Energizer maximizes $(1 - s_W)\pi_E + s_E\pi_W$, equivalent to maximizing $\pi_E + \theta_E\pi_W$, where $\theta_E = s_E/(1 - s_W)$. Similarly, Walmart's internalization weight is $\theta_W = s_W/(1 - s_E)$. Equal transfer shares support the common weight imposed in the conceptual framework; the empirical model allows the weights to differ. Lump-sum transfers, such as fixed slotting allowances or marketing payments, affect only the division of joint profit.

[23] For sufficiently large θ, S_{EW}^{ET} may become negative, making it optimal for Energizer to stop supplying Target and resulting in exclusive dealing.

A weaker outside option for Target strengthens Duracell's bargaining position despite its absence from the agreement, raising w_{DT} and, through pass-through, p_{DT}, consistent with Section 3.4. In the empirical model, where most retailers carry only one national brand, this channel also operates through the threat of replacing Duracell with Energizer, as described in Section 5.3.1.

The three mechanisms M1–M3, together with strategic complementarity in retail pricing, generate asymmetric price increases across retailers and higher prices throughout the market.

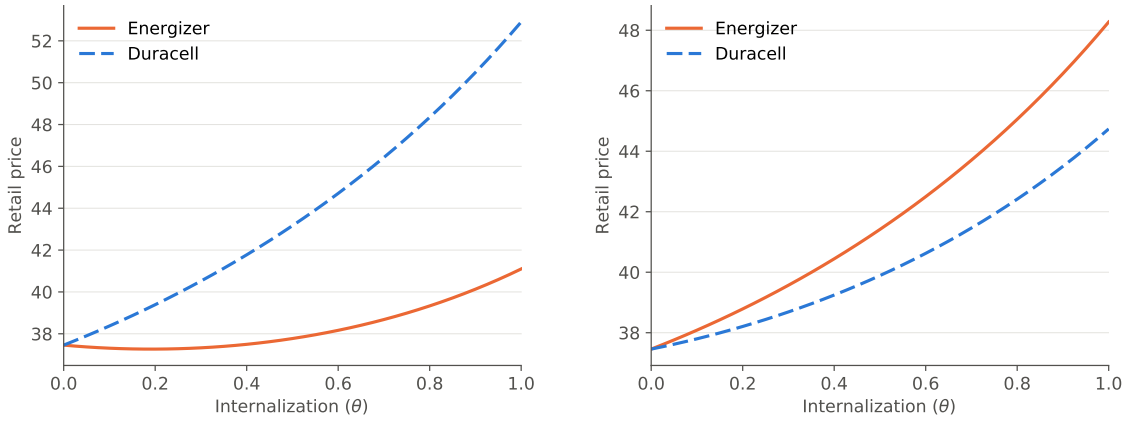
4.4 Equilibrium Retail Prices

The equilibrium consists of wholesale prices $(w^*_{EW}, w^*_{ET}, w^*_{DW}, w^*_{DT})$ satisfying the four Nash bargaining first-order conditions given retail prices, and retail prices $(p^*_{EW}, p^*_{ET}, p^*_{DW}, p^*_{DT})$ satisfying the four retailer first-order conditions given wholesale prices. Prices are determined simultaneously, each optimal given the other, as in Ho and Lee (2017). Following Horn and Wolinsky (1988) and Collard-Wexler, Gowrisankaran, and Lee (2019), disagreement payoffs are evaluated at the equilibrium terms of all other contracts. Energizer's retail price at Walmart reflects two opposing forces: internalization reduces double marginalization, while higher prices elsewhere create upward pressure through strategic complementarity.

Figure 4 illustrates how the balance between these forces changes as θ varies from 0 to 1, for $M = 50$, $c_E = c_D = 1.0$, $\gamma_s = 0.5$, $\gamma_c = 0.3$, $\rho = 0.5$, and $b = 1.1$. At Walmart, Duracell's price rises steadily, while Energizer's price initially falls as internalization reduces double marginalization, then rises as the competitive effects dominate, as shown in Figure 4a. At Target, which represents rival retailers, both prices rise, with a larger increase for Energizer, as shown in Figure 4b. At higher levels of internalization, all four prices exceed their no-agreement levels, with a larger increase for Duracell at Walmart and for Energizer at Target, consistent with the empirical evidence.

4.4.1 Alternative Modeling Choices and Conduct Scenarios

An alternative would be to model the vertical agreement as a shift in Energizer's or Walmart's bargaining parameters rather than as bilateral internalization. We hold bargaining parameters fixed and model the agreement as a change in the parties'



(a) Walmart Retail Prices **(b)** Target Retail Prices

Notes: The figure plots equilibrium retail prices simulated with $M = 50$, $c_E = c_D = 1.0$, $\gamma_s = 0.5$, $\gamma_c = 0.3$, $\rho = 0.5$, and $b = 1.1$, with θ varying from 0 (no internalization) to 1 (full internalization).

Figure 4: Equilibrium Retail Prices Under Vertical Conduct

pricing incentives. Bilateral internalization captures Walmart's incentive to favor Energizer and Energizer's incentive to raise Walmart's rivals' costs, rather than treating the agreement solely as a change in the division of bilateral bargaining surplus. Bargaining parameters are typically viewed as relatively slow-moving structural features reflecting the parties' bargaining positions, whereas internalization more naturally captures a discrete shift in firm objectives induced by the agreement.

We also consider two alternative conduct scenarios: (i) upstream horizontal coordination, in which Energizer and Duracell coordinate wholesale prices, and (ii) downstream horizontal coordination, in which Walmart and Target coordinate retail prices. Within the symmetric benchmarks we consider, neither horizontal coordination scenario reproduces the observed pattern of price increases for both brands with a larger increase for Duracell at Walmart. Appendix N discusses these results in detail. We separately examine hub-and-spoke coordination using local-market variation. Appendix K shows that post-agreement price increases do not vary significantly with either party's pre-agreement local market share. These findings provide no evidence of hub-and-spoke coordination operating through local retail competition, although they do not rule out coordination at the national level.

5 Baseline Empirical Model

We extend the conceptual framework to a larger set of products and retailers, allowing for richer substitution patterns and replacement threats in wholesale bargaining. This section presents the model without the agreement, and Section 6 describes its estimation. Section 7 then introduces the agreement and the estimation of its parameters.

5.1 Demand

A market is defined as a CBSA–quarter combination. Consumer i obtains the following indirect utility in each quarter t from purchasing battery product j at retailer g, where g denotes a CBSA–retailer pair:

$$u_{ijgt} = \alpha p_{jgt} + \phi_j + \zeta_g + \tau_{q(t)} + \xi_{jgt} + \eta_{igt} + (1-\lambda)\varepsilon_{ijgt}, \tag{2}$$

where p_{jgt} is the retail price, ϕ_j captures unobserved product attributes, ζ_g captures unobserved CBSA–retailer attributes, and ξ_{jgt} is an unobserved demand shock for product j at retailer g in quarter t. The quarter-of-year fixed effects $\tau_{q(t)}$, where $q(t)$ denotes the calendar quarter, capture seasonal demand patterns such as holiday purchases, rather than separate effects for each quarter in the sample. The idiosyncratic group preference η_{igt} follows a distribution consistent with nested-logit demand and a Type 1 extreme value marginal distribution for ε_{ijgt}. The nesting parameter $0 \leq \lambda < 1$ captures the correlation in utilities across products within the same retailer. When $\lambda = 0$, the model reduces to standard logit; higher values imply stronger substitution among battery products within the same retailer.

As batteries are a necessity product, we model demand as inelastic: consumers must satisfy their unit demand by purchasing from one of the available retailers. Consumers choose the retailer–product pair that maximizes utility. Because Dollar Tree's private-label batteries are priced at one dollar throughout the sample, we use Dollar Tree as the reference alternative and express all mean utilities relative to it. Dollar Tree's normalized mean utility is therefore zero.[24]

[24]This normalization also implies that Dollar Tree's price is treated as exogenous in the counterfactual, which is consistent with our empirical finding that its E-Circuit batteries remain priced at $1 even after the vertical agreement.

Based on Equation (2), for each consumer i, the choice probability of buying product j from retailer g in quarter t is given by

$$s_{j|gt} = \frac{\exp\left(\frac{\delta_{jgt}}{1-\lambda}\right)}{D_{gt}},$$

where $\delta_{jgt} = \alpha p_{jgt} + \phi_j + \zeta_g + \tau_{q(t)} + \xi_{jgt}$ is the mean utility, $D_{gt} = \sum_{l \in \mathcal{J}_{gt}} \exp\left(\frac{\delta_{lgt}}{1-\lambda}\right)$, and $\mathcal{J}_{gt}$ is the set of products offered by retailer g in quarter t.

For each quarter t, consumers choose from the set of retailers available and Dollar Tree ($g = 0$). We use $\mathcal{G}_t$ to denote the set and define $D_{0t} = \exp\left(\frac{0}{1-\lambda}\right) = 1$. The unconditional probability of buying from retailer g is

$$s_{gt} = \frac{D_{gt}^{1-\lambda}}{\sum_{l \in \mathcal{G}_t} D_{lt}^{1-\lambda}}.$$

The unconditional probability of choosing product j from retailer g in quarter t is given by $s_{jgt} = s_{j|gt} \times s_{gt}$.

5.2 Retailer Pricing

Retailers engage in multiproduct Bertrand price competition. Each retailer g chooses prices to maximize profit:

$$\pi_t^S(\mathcal{J}_{gt}) = \max_{\{p_{lgt}\}_{l \in \mathcal{J}_{gt}}} \sum_{l \in \mathcal{J}_{gt}} \left(p_{lgt} - \omega_{lgt} - \psi_{lg}\right) s_{lgt}(\mathbf{P}_t) M_t,$$

where ω_{jgt} is the wholesale price, ψ_{jg} is a product–retailer-specific retail cost, $\mathbf{P}_t$ collects all retail prices in quarter t, and M_t is market size. The first-order conditions are

$$\mathbf{s}_{gt}(\mathbf{P}_t) + \frac{\partial \mathbf{s}_{gt}(\mathbf{P}_t)^{\mathrm{T}}}{\partial \mathbf{p}_{gt}} \left(\mathbf{p}_{gt} - \boldsymbol{\omega}_{gt} - \boldsymbol{\psi}_g\right) = \mathbf{0}, \tag{3}$$

where $\mathbf{s}_{gt}$, $\mathbf{p}_{gt}$, $\boldsymbol{\omega}_{gt}$, and $\boldsymbol{\psi}_g$ stack market shares, retail prices, wholesale prices, and retail costs across retailer g's products, respectively.

Solving Equation (3) yields the pricing equations. The term ψ_{jg} is a retail cost residual that reconciles the model with observed retail prices. It enters the

retailer's pricing decision but, as a residual, is not part of the bargaining surplus. We describe its recovery in Section 6.

5.3 Wholesale Price Bargaining

Manufacturers and retail chains negotiate product-specific wholesale prices through Nash-in-Nash bargaining. The profit function for retail chain h is therefore

$$\pi_t^S(\mathcal{J}_{ht}) = \sum_{g:\, h(g)=h} \pi_t^S(\mathcal{J}_{gt}),$$

where $\mathcal{J}_{ht}$ denotes the union of product assortments offered by all CBSA–retailers belonging to chain h in quarter t. The profit function for upstream battery manufacturer m is given by:

$$\pi^M(\mathcal{E}_t^m) = \sum_{(j,g)\in\mathcal{E}_t^m} \left(\omega_{jgt} - c_j\right) s_{jgt}(\mathbf{P}_t) M_t,$$

where c_j is the manufacturer's input cost of producing product j, and $\mathcal{E}_t^m = \mathcal{J}_t^m \times \mathcal{G}_t^m$ is the set of all product–retailer pairs for manufacturer m in quarter t. $\mathcal{J}_t^m$ is the set of all products from manufacturer m, and $\mathcal{G}_t^m$ is the set of all market-retailers that sell products from manufacturer m.

Wholesale prices are determined through simultaneous Nash-in-Nash bargaining between each manufacturer and each retail chain. Disagreement between manufacturer m and chain h entails delisting all of m's products from h, holding all other contracts and retail prices fixed. We apply the Nash bargaining rule product by product, allocating the relationship-level disagreement payoffs in proportion to units sold.[25] Let Δ_{jgt}^M denote the manufacturer's profit recaptured at other chains when m is delisted at h, and Δ_{jgt}^S the chain's additional profit on its remaining or replacement products, each allocated to product j at g in proportion to units sold. Each product's wholesale price maximizes the following Nash product:

$$NP_{jgt} = \left[\left(\omega_{jgt} - c_j\right) q_{jgt} - \Delta_{jgt}^M\right]^{\rho_{mh}} \left[\left(p_{jgt} - \omega_{jgt}\right) q_{jgt} - \Delta_{jgt}^S\right]^{1-\rho_{mh}}, \tag{4}$$

[25] Conditional on retail prices and product assortments, a relationship-level bargain determines only the total wholesale payment, leaving its allocation across products and local markets undetermined.

where $q_{jgt} = s_{jgt}(\mathbf{P}_t)M_t$ is the quantity sold and $\rho_{mh} \in [0,1]$ is the manufacturer's bargaining parameter.[26] Here g indexes a CBSA–retailer of chain h: bargaining parameters and disagreement payoffs are determined at the chain level, while wholesale prices vary with local retail prices. The manufacturer's disagreement payoff includes margins recaptured at other chains; the retailer's includes margins on remaining products and, outside Walmart, replacement by the other national brand.

5.3.1 Threat of Replacement

When chain h bargains with national brand m, it can threaten to replace m's products with those of the other national brand m' if negotiations fail. More favorable replacement terms strengthen the retailer's bargaining position without requiring replacement to occur, thereby affecting the negotiated wholesale price. This resembles insurers' threats to replace included hospitals with excluded ones in Ho and Lee (2019); Yuan (2025) studies a similar mechanism for studios and streaming services.[27]

Exclusive arrangements in this industry typically involve one of the two national brands. In our data, Costco and CVS carry almost exclusively Duracell among national brands, while Family Dollar carries almost exclusively Energizer, each alongside its private label. The credibility of replacement is also supported by changes in observed assortments: in DecaData, described in Appendix L, a multi-store retailer that initially carried both national brands stopped carrying Duracell after August 2021 and carried Energizer as its only national brand thereafter. These patterns motivate restricting replacement to the other national brand. This option enters every non-Walmart chain's disagreement payoff in both directions: Energizer can replace Duracell, and Duracell can replace Energizer.[28] Each of m's products is replaced by the other brand's product of the same pack size, and the

[26] Aggregating payments across products and local markets recovers the relationship-level Nash payment. The common ρ_{mh} across products helps distinguish input costs from bargaining power using pack-size variation, as discussed in Section 6.3.1.

[27] Replacement threats also provide bargaining leverage in health care (Ghili 2022) and grocery retail (Hristakeva 2022). See Lee, Whinston, and Yurukoglu (2021) for a review.

[28] Our baseline specification excludes replacement at Walmart and models its relationship with Energizer through the agreement. Walmart carries both national brands in the pre-agreement baseline quarter used for the supply-side counterfactuals.

replacing brand receives its usual bargaining share of the channel margin.[29]

Replacement offers also satisfy the replacing brand's participation constraint: if cannibalization of its existing products makes replacement unprofitable, its share of the channel margin rises until it is indifferent. The chain chooses whether to accept replacement, so its disagreement payoff in Equation (4) is the higher of its profits from delisting m without replacement and from replacing it:

$$D^S_{mht} = \max\left\{\pi^S\left(\mathcal{J}_{ht} \setminus \mathcal{J}^m_t\right), \pi^S\left(\left(\mathcal{J}_{ht} \setminus \mathcal{J}^m_t\right) \cup \mathcal{J}^{m'}_{ht}; \boldsymbol{\tau}^{res}\right)\right\}, \tag{5}$$

where $\boldsymbol{\tau}^{res}$ denotes the replacing brand's wholesale offers. To obtain Δ^S_{jgt} in Equation (4), we subtract the chain's profit on other products under agreement from D^S_{mht} and allocate the difference across products and local markets in proportion to units sold. We treat replacement as a disagreement outcome, following the exogenous-risk-of-breakdown interpretation in Binmore, Rubinstein, and Wolinsky (1986).[30]

5.4 Equilibrium

The equilibrium concept is the same as in the conceptual framework in Section 4.4. An equilibrium is a vector of retail and wholesale prices satisfying two conditions. Given wholesale prices, retail prices satisfy Equation (3). Given retail prices and all other contracts, wholesale prices solve the Nash bargaining problem in Equation (4) for each manufacturer–chain pair. Retail and wholesale prices are thus determined simultaneously, and disagreement payoffs are evaluated at the equilibrium terms of all other contracts.

[29] In Ho and Lee (2019) and Yuan (2025), replacement partners instead receive their reservation payoffs and earn no additional surplus from replacement. This reflects the threatening party's ability to commit to a selective set of partners and use excluded alternatives as bargaining leverage. In our setting, the other national brand supplies the replacement products and receives its usual share of the bargaining surplus. Replacement products carry the replacing brand's estimated brand utility and are sold at the replacement offer plus the replaced product's current retail margin.

[30] By contrast, Ho and Lee (2019) and Yuan (2025) treat replacement as an outside-option constraint, consistent with the treatment in Binmore, Rubinstein, and Wolinsky (1986) of options a party can exercise by withdrawing from negotiations. The constraint binds only when replacement yields a higher payoff than the Nash bargain with delisting as the disagreement point. Our approach allows replacement to affect bargaining whenever it is preferable to delisting, even if the outside-option constraint would not bind. Neither approach requires replacement to occur in equilibrium.

6 Estimation of the Baseline Model

We estimate the baseline model in three steps. First, we estimate the demand system. Second, we recover marginal costs from retailers' pricing first-order conditions and interpret them as wholesale prices (Berto Villas-Boas 2007). Third, we estimate the bargaining model to recover the bargaining parameters and input costs that rationalize the pre-agreement wholesale prices obtained in the second step. The agreement parameters are estimated in Section 7.

6.1 Demand

Based on the method in Berry (1994), we derive the following estimation equation for demand:

$$\ln(s_{jgt}) - \ln(s_{0t}) = \alpha p_{jgt} + \phi_j + \zeta_g + \tau_{q(t)} + \lambda \ln(s_{j|gt}) + \xi_{jgt}.$$

Because prices and within-retailer market shares may be correlated with unobserved demand shocks, we use two sets of instruments to jointly identify the price coefficient α and nesting parameter λ. The first consists of characteristic-based instruments constructed from the sums of pack sizes and squared pack sizes of products sold by the same retailer in other CBSAs within the same quarter. These instruments exploit chain-level assortment decisions that predict local competitive conditions while excluding products in the focal market.

The second set consists of local product-differentiation instruments following Gandhi and Houde (2019). These count competing products whose predicted prices lie within a small neighborhood of product j's predicted price. Predicted prices are obtained by projecting prices on the pack-size instruments and fixed effects. Together, the two instrument sets capture variation in competitive conditions and within-retailer substitution patterns. Their validity requires that the underlying assortment variation be uncorrelated with local unobserved demand shocks, conditional on product, CBSA–retailer, and quarter-of-year fixed effects. Appendix T reports first-stage statistics for both endogenous variables. Our main specification also includes Walmart-by-Energizer and Walmart-by-Duracell fixed effects, allowing preferences for the two national brands to differ at Walmart.

We calculate market size as total battery sales observed in the data within each CBSA–quarter, based on the assumption that aggregate battery demand is inelastic. Market shares are then computed for each product j at retailer g within each market.

6.2 Wholesale Prices

We recover retailers' marginal costs by inverting the pricing first-order conditions in Equation (3) retailer by retailer in the pre-agreement period and use them as proxies for wholesale prices (Berto Villas-Boas 2007).[31]

We parameterize the log wholesale price at the product–CBSA–retailer level as a function of retail chain–product fixed effects, $\omega^1_{h(g)j}$,[32] and a linear time trend, ω^2:

$$\log(\omega_{jgt}) = \omega^1_{h(g)j} + \omega^2 \times t + \nu_{jgt}.$$

We compute the average pre-agreement wholesale price for each product, retail chain, CBSA, and quarter as $\hat{\omega}^*_{jht} = \exp(\hat{\omega}^1_{h(g)j} + \hat{\omega}^2 \times t)$.[33]

6.3 Input Costs and Bargaining Parameters

We parameterize input costs as

$$c_j = mc_{m(j)} \times Q_j,$$

where Q_j denotes the size of battery product j (i.e., the number of batteries per pack), and mc is the marginal cost of producing a single battery, which we allow

[31] We exclude Amazon observations from wholesale-price recovery because changes in the composition of first- and third-party sellers across the two periods complicate the interpretation of its observed pricing patterns. Accounting for these changes would require explicitly modeling seller composition. Amazon remains in the demand system and in the counterfactual equilibria, where its wholesale prices are determined through the same bargaining framework as those of other retailers.

[32] DecaData provides evidence consistent with chain-level wholesale pricing: for the retailer it covers, 94% of shipments have the modal unit cost across stores for the same product and day.

[33] The estimation sample also includes post-agreement observations for non-Walmart retailers, with retail chain–product-specific post-agreement shifts, so that they affect the pre-agreement fitted values only through the common trend. The resulting post-agreement wholesale prices are used only in Appendix P.

to vary across manufacturers and sub-line classes.[34] For Energizer and Duracell, we distinguish premium sub-lines (Energizer Ultimate/Advanced Lithium and e2; Duracell Quantum, Optimum, and Ultra Advanced) from regular sub-lines (e.g., Energizer Max and Duracell Coppertop). Within the Energizer family, we further distinguish value sub-lines (Rayovac and Eveready), except for Eveready Silver, which we group with the regular sub-lines because its recovered wholesale prices track those of the flagship lines.[35] For private labels, we allow marginal costs to differ between the store brands of Walmart and national chains and those of small retailers. Wholesale prices for fringe brands are held fixed at their pre-agreement levels, so we do not estimate their costs or bargaining parameters. Appendix R relaxes this assumption and shows that the main results remain unchanged.

Retailer Classification. We categorize retailers into three types: Walmart, national chains, and small retailers. Walmart, as the largest retailer, forms its own category. Among the remaining retailers, national chains are those with battery sales above the 25th percentile, while small retailers are those in the bottom quartile. We allow the bargaining parameters to vary across retailer types.

6.3.1 Identification

We do not directly observe manufacturers' battery input costs, which creates the main identification challenge: a high wholesale price may reflect either high input costs or strong manufacturer bargaining power. For each brand–retailer–pack-size product, the Nash bargaining outcome implies that the manufacturer recovers its production cost and receives a share ρ_{mh} of the joint surplus. A single wholesale-price moment for each retailer group therefore leaves ρ_{mh} and mc_m jointly underidentified.

[34] We also considered adding an intercept to the cost function, interpreted as a fixed per-package cost capturing packaging and assembly expenses incurred once per pack. The estimated intercepts are generally negligible and mostly converge to zero. This suggests that the observed wholesale-price profiles across pack sizes can already be explained by per-battery production costs and the manufacturer's share of the bargaining surplus. We therefore retain the more parsimonious specification in which cost is linear in pack size.

[35] Although Rayovac and Eveready belong to Energizer, they are priced well below Energizer-branded lines (about \$0.36–\$0.46 per battery for the main Rayovac lines versus \$0.65 for Energizer Max). A common cost parameter would therefore attribute this price gap to bargaining rather than to cost.

Identification exploits quantity discounts across pack sizes. Production costs are proportional to the number of batteries per pack, while retail prices per battery decline from approximately $1 for four-battery packs to $0.30 for 24-battery packs. Small packs have larger per-battery margins, making their wholesale prices more informative about the division of bargaining surplus, ρ_{mh}. Large packs have smaller margins, making their wholesale prices more informative about marginal production costs, mc_m.

6.3.2 Generalized Method of Moments

We estimate 15 parameters, collected in $\boldsymbol{b}$: seven marginal-cost parameters and eight bargaining-power parameters, by matching wholesale prices recovered for the first quarter of 2019, the last pre-agreement quarter.

The marginal-cost parameters cover Energizer's premium, regular, and value sub-lines; Duracell's premium and regular sub-lines; and private labels at national chains and small retailers. The bargaining-power parameters cover each national manufacturer's negotiations with the three retailer types, as well as private-label suppliers' negotiations with national chains and small retailers.

For a candidate parameter vector $\boldsymbol{b}$, the model-implied pre-agreement wholesale price $\hat{\omega}_{jh}(\boldsymbol{b})$ is obtained from the bargaining solution to Equation (4), evaluated at observed pre-agreement retail prices. We construct moments that match these model-implied wholesale prices to the recovered wholesale prices ω_{jh}. For each cell c of observations, defined below by brand, retailer type, sub-line class, and pack size, the wholesale-price moment condition is

$$E\left[\sum_{j\in\mathcal{J}_c} \lambda_{jc}\left(\hat{\omega}_{jh}(\boldsymbol{b}) - \omega_{jh}\right)\right] \;=\; 0,$$

where λ_{jc} is product j's share of the cell's sales.

The vector $\mathbf{g}$ stacks 30 moment conditions, all based on pre-agreement wholesale prices. For Energizer and Duracell, these consist of averages by retailer type, averages by sub-line class (including the value class only for Energizer), and averages by pack-size bin within the regular class. For private labels, the moments consist of averages by retailer type and by pack-size bin within national chains and small retailers. The pack-size-bin moments implement the identification argument

developed in Section 6.3.1.

We estimate the 15 input-cost and bargaining-power parameters by two-step GMM using the 30 pre-agreement wholesale-price moments, with the objective function

$$L(\boldsymbol{b}) = \mathbf{g}(\boldsymbol{b})'\mathbf{W}\mathbf{g}(\boldsymbol{b}),$$

where $\mathbf{W}$ is a diagonal weighting matrix, evaluated at the starting values in the first step and updated at the first-step estimates in the second step. Given these estimates, we recover retail cost residuals ψ_{jg}, which may reflect, for example, handling and storage costs, as the difference between retailers' marginal costs implied by the pre-agreement pricing first-order conditions in Equation (3) and the model-implied wholesale prices, analogous to the non-channel marginal cost in Crawford et al. (2018). By construction, these residuals ensure that the no-agreement equilibrium reproduces observed pre-agreement retail prices.

7 The Vertical Agreement: Model and Estimation

We incorporate the alleged Walmart–Energizer agreement into the model by allowing it to change Walmart's retail pricing incentives and disagreement payoffs in wholesale bargaining. Input costs and bargaining parameters remain fixed across periods.

7.1 Walmart's Pricing

We motivate Walmart's retail incentive using the bilateral profit-internalization benchmark of Crawford et al. (2018). Under this benchmark, Walmart places weight on Energizer's profit when setting retail prices, creating an incentive to favor Energizer over competing brands. Because Walmart and Energizer are independently owned, we represent this incentive contractually through a share-based rebate, with vertical rebates providing a natural mechanism (Asker and Bar-Isaac 2014; Conlon and Mortimer 2021).

In the post-agreement period, Walmart sets retail prices to maximize

$$\begin{aligned} \Pi_t^W &= \pi_t^S(\mathcal{J}_{Wt}) + \theta_W R_t, \\ R_t &= \sum_{l \in \mathcal{J}_{Wt}^E} (\omega_{lWt} - c_l)\, q_{lWt} - \kappa_t\, \bar{m}_t \sum_{l \in \mathcal{J}_{Wt} \setminus \mathcal{J}_{Wt}^E} Q_l\, q_{lWt}, \end{aligned} \tag{6}$$

where $\mathcal{J}_{Wt}^E$ denotes Energizer's products at Walmart, q_{lWt} is the quantity sold of product l, and $\bar{m}_t$ is Energizer's average wholesale margin per battery, weighted by pre-agreement sales. We set $\kappa_t = s_t/(1 - s_t)$, where s_t is Energizer's equilibrium share of Walmart's battery unit sales. Walmart takes both κ_t and $\bar{m}_t$ as given when setting prices, and $\theta_W \in [0, 1]$ governs the strength of the incentive.

The rebate lowers the wholesale component of Walmart's effective marginal cost for Energizer products, while leaving retail costs unchanged, thereby reducing double marginalization. The higher effective margin on Energizer products encourages Walmart to raise competing brands' prices to divert demand toward Energizer, the Edgeworth–Salinger effect in a multiproduct setting (Luco and Marshall 2020; Salinger 1991). The share-based penalty reinforces this incentive by making competing products effectively more costly (M1). Negotiated wholesale prices remain determined by the Nash bargain in Equation (4), and all other retailers continue to follow Equation (3).

We use the share-based form because a per-unit rebate tied only to Energizer sales provides no direct incentive to raise Duracell's prices and underpredicts their observed increase at Walmart. The share-based rebate also predicts larger Duracell–Energizer relative price increases for larger packs, as observed in the data. Profit sharing, under which Walmart internalizes Energizer's profit at all retailers, fits the aggregate price changes similarly well, but would tie Walmart's compensation to Energizer's profits at rival retailers rather than to Walmart's own sales. Appendix O compares these alternatives.

7.2 Energizer's Wholesale Bargaining

We motivate Energizer's wholesale incentive using the bilateral profit-internalization benchmark of Crawford et al. (2018) and Yuan (2025). When bargaining with rival retailer h, Energizer internalizes a share θ_E of Walmart's battery profit. If h delists Energizer, some demand shifts to Walmart, increasing Energizer's disagreement

payoff by $\theta_E V_{ht}$ per battery lost, where V_{ht} is Walmart's recaptured retail margin per battery lost by Energizer at h. Bilateral internalization therefore creates a retailer-specific opportunity cost of supplying Walmart's rivals.

Our main specification replaces the retailer-specific opportunity cost with its sales-weighted average, $\mu_{Et} = \theta_E \bar{V}_t$, where $\bar{V}_t$ averages V_{ht} across non-Walmart chains. We use this common opportunity cost because Appendix P finds no evidence of the positive relationship between Energizer's wholesale price increases and V_{ht} implied by retailer-specific internalization. For Energizer product j sold to a non-Walmart chain, the opportunity cost reduces Energizer's gain from agreement in Equation (4) by $\mu_{Et} Q_j$ per pack sold. It therefore raises Energizer's negotiated wholesale prices (M2) and replacement offers, with θ_E measuring its average incentive to raise Walmart's rivals' costs. Appendix P reports estimates allowing the opportunity cost to vary with V_{ht}.

The Role of Replacement Threats. The evidence in Appendix J shows that Duracell's retail prices rise by about 7 percent relative to other brands at retailers with negligible pre-agreement Energizer sales. This pattern is difficult to explain solely through margins on existing Energizer products, suggesting a role for replacement threats.

Under the agreement, Energizer's opportunity cost of supplying rival retailers also applies to its replacement offers. Specifically, a replacement offer follows the same surplus-sharing rule as in Section 5.3.1, applied to the current channel margin and including the participation adjustment, and adds the full opportunity cost μ_{Et} per battery. Costlier Energizer replacement offers weaken retailers' bargaining positions with Duracell and can therefore raise Duracell's negotiated wholesale prices even at chains that do not currently carry Energizer (M3), consistent with the empirical evidence.[36] Appendix Q allows the replacement margin to adjust through Nash bargaining over surplus net of the opportunity cost.

The equilibrium conditions in Section 5.4 therefore change in two ways. Given wholesale prices, Walmart's retail prices maximize Equation (6) rather than its own retail profit, while other retailers continue to satisfy Equation (3). Given retail

[36] Under Equation (4), negotiated wholesale prices only partially reflect the opportunity cost, whereas replacement offers add it in full on top of the usual surplus share. These offers affect disagreement payoffs without requiring replacement to occur.

prices and all other contracts, Energizer's bargaining in Equation (4) incorporates the opportunity cost, which also enters its replacement offers. Retail and wholesale prices are again determined simultaneously.

7.3 Estimation of Agreement Parameters

We identify and estimate the agreement parameters using the four post-agreement retail price changes in Table 3, holding input costs and bargaining parameters fixed at the values that rationalize pre-agreement wholesale prices. θ_W governs Walmart's relative pricing: it lowers the effective cost of Energizer products and raises the effective costs of Duracell and private-label products. It is therefore identified mainly from the difference between Energizer's and Duracell's price changes at Walmart. θ_E governs prices at rival retailers: it raises Energizer's negotiated wholesale prices through its opportunity cost of supplying these retailers and Duracell's wholesale prices through costlier Energizer replacement offers. It is therefore identified mainly from the price changes for both national brands at non-Walmart retailers. Without replacement offers, the model predicts essentially no increase in Duracell's prices at these retailers, as shown in Appendix Q.

Four moments match the post-agreement retail price changes for Energizer and Duracell at Walmart and at other retailers, estimated in Table 3. Their model counterparts are the sales-weighted average changes in log retail prices between equilibria with and without the agreement, both computed using pre-agreement products and demand, as described in Section 7.2.

Holding the input-cost and bargaining-power parameters and the retail cost residuals fixed, we estimate the two agreement parameters by minimizing the same two-step GMM objective with these four moments, holding product assortments and demand conditions fixed at their values in the first quarter of 2019.[37] Standard errors for the agreement parameters account for first-stage estimation uncertainty.

[37] In principle, all 17 parameters could be estimated jointly. Joint estimation is computationally costly, however, because evaluating the post-agreement moments requires solving equilibria with and without the agreement.

8 Results

We first present the structural estimates, then examine counterfactual equilibrium outcomes and welfare effects. Appendix S details the welfare calculations.

8.1 Estimates

8.1.1 Demand Estimates

Table 5 reports the demand estimates. Our main specification in Column 2 includes Walmart-by-Energizer and Walmart-by-Duracell fixed effects, allowing brand preferences to differ at Walmart. The price coefficient α is -0.34 and the nesting parameter λ is 0.20, implying moderately stronger substitution within retailers than across retailers.[38] The average own-price elasticity is -3.45, while the aggregate elasticity of non-Dollar Tree products is smaller in magnitude, at approximately -0.50. Appendix U reports the distribution of price elasticities.

8.1.2 Input Costs and Bargaining Power

Table 6 shows variation in bargaining positions across manufacturer–retailer pairs. Walmart obtains the most favorable terms from both national brands, consistent with its buyer power. Energizer's bargaining power is 0.06 with Walmart, 0.42 with national chains, and 0.26 with small retailers; Duracell's is 0.17, 0.63, and 0.84, respectively. Because replacement offers use the replacing brand's bargaining share, Energizer's weaker bargaining position at national chains and small retailers makes it a relatively inexpensive replacement for Duracell, disciplining Duracell's wholesale prices.

For private-label products, estimated supplier bargaining power is 0.35 with national chains and 0.26 with small retailers, implying that suppliers capture a larger share of the surplus when bargaining with national chains.

Estimated marginal costs vary across brands and sub-line classes. For regular sub-lines, the estimated cost per battery is \$0.32 for Energizer and \$0.29 for Duracell. Premium sub-lines have higher costs: \$0.73 for Energizer's lithium lines

[38] Without Walmart-by-brand fixed effects, Column 1 yields $\alpha = -0.28$, $\lambda = 0.28$, and an average own-price elasticity of -3.11. Appendix V shows that the agreement's effects are not sensitive to perturbations of the demand parameters around their estimates.

	(1)	(2)
Price coefficient (α)	-0.2785	-0.3354
	(0.0320)	(0.0313)
Within-banner nesting parameter (λ)	0.2773	0.1979
	(0.0400)	(0.0421)
Mean own-price elasticity	-3.11	-3.45
Mean aggregate elasticity	-0.41	-0.50
Product fixed effects	Yes	Yes
CBSA $\times$ Retailer Chain fixed effects	Yes	Yes
Quarter-of-year fixed effects	Yes	Yes
Walmart $\times$ Energizer and Walmart $\times$ Duracell fixed effects		Yes
Number of product-market observations	397,362	397,362

Notes: The table reports nested-logit demand estimates for 5,913 markets with at least 10 inside products and a market size of at least 10. Column 2, the main specification, adds Walmart-by-Energizer and Walmart-by-Duracell fixed effects. λ is the within-retailer nesting parameter. The aggregate elasticity is approximated by the percentage change in total sales of non-Dollar Tree products following a 10 percent increase in all their prices, divided by 10. Standard errors, reported in parentheses, are clustered at the CBSA–retailer–brand level.

Table 5: Demand Estimates

and \$0.48 for Duracell's performance lines. Energizer's value lines, Rayovac and Eveready, cost approximately \$0.23 per battery. Private-label costs are lower, at \$0.21 for the store brands of Walmart and national chains and \$0.14 for those of small retailers.

8.1.3 Agreement Parameters

The estimated agreement parameters are $\theta_W = 0.31$, governing Walmart's share-based rebate incentive, and $\theta_E = 0.70$, governing Energizer's opportunity cost of supplying rival retailers.[39] The estimated θ_E implies that Energizer places a weight of 0.70 on Walmart's average recaptured retail margin when supplying rival retailers, raising its negotiated wholesale prices and replacement offers and strengthening Duracell's bargaining position.

[39]Internalization estimates for vertically integrated firms include 0.79 for multichannel video distributors' internalization of affiliated regional sports networks' profits in Crawford et al. (2018) and 0.63 for studios' internalization of affiliated streaming services' profits in Yuan (2025). These parameters weight affiliates' profits, whereas our parameters govern a share-based rebate and an opportunity cost, so their magnitudes are not directly comparable.

	Energizer	Duracell	Private Label
mc^{prem}	0.733	0.478	
	(0.060)	(0.024)	
mc^{reg}	0.323	0.288	0.211
	(0.011)	(0.024)	(0.001)
mc^{value}	0.229		0.137
	(0.018)		(0.014)
ρ_{mW}	0.059	0.170	
	(0.033)	(0.086)	
ρ_{mL}	0.418	0.632	0.347
	(0.151)	(0.125)	(0.006)
ρ_{mS}	0.258	0.844	0.255
	(0.114)	(0.065)	(0.047)
θ_W	0.312		
	(0.123)		
θ_E	0.695		
	(0.165)		

Notes: The table reports GMM estimates of the bargaining model. For marginal cost, premium refers to performance sub-lines (Energizer Ultimate/Advanced Lithium and e2; Duracell Quantum, Optimum, and Ultra Advanced), value refers to the Rayovac and Eveready lines, and regular refers to the remaining sub-lines (e.g., Energizer Max and Duracell Coppertop). For private labels, regular refers to the private labels of Walmart and the national chains, and value to those of small retailers. The subscript m denotes manufacturer bargaining power; W refers to Walmart, L to national chains, and S to small retailers. Standard errors, reported in parentheses, are computed using the GMM sandwich formula. Standard errors below 0.001 are reported as 0.001.

Table 6: Input Costs, Bargaining Power, and Agreement Parameters

8.1.4 Model Fit

Table 7 reports average wholesale prices per battery by retailer type and sub-line class for each brand before the agreement. Across retailer groups, they range from \$0.19 for private labels at national chains to \$0.56 for Duracell at small retailers. Within each brand, premium sub-lines have higher wholesale prices than regular sub-lines, while value sub-lines have the lowest wholesale prices, consistent with their retail positioning.

Table 7 also reports model-predicted wholesale prices. The bargaining model matches average wholesale prices closely for most sub-line classes and retailer types across brands. The largest discrepancy is for private labels at national chains, reflecting substantial heterogeneity in these products across retail chains.

The model also overpredicts both national brands' wholesale prices at Walmart by about 10 percent per battery; the estimation moments are per-pack averages, which the model matches more closely, so the per-battery averages in the table weight pack sizes differently. Walmart's private-label supplier has no bargaining power in the model, so its wholesale price equals its input cost, and the Walmart private-label moment pins down that cost. The lower panel reports the four post-agreement retail price changes. The model reproduces the larger increase for Duracell than for Energizer at Walmart and the increases for both brands at other retailers. The share-based rebate also generates a prediction not targeted in estimation. Because it penalizes Walmart for each competing battery sold, the model predicts larger post-agreement price increases for Duracell relative to Energizer among larger packs at Walmart. Table A7 shows this pattern in the data: the coefficient on log pack size in the Duracell–Energizer differential price change is 0.012, compared with 0.014 under the share-based rebate and 0.002 under a per-unit rebate.[40] Appendix W evaluates model fit using moments not targeted in estimation.

8.2 Counterfactual Analysis

We use the estimated model to answer three questions: how much the agreement harms consumers, why it is particularly profitable for Walmart and Energizer compared with other retailer–manufacturer pairs, and which remedies would limit the harm. Throughout, "the agreement" refers to the conduct estimated in the model, with effects measured relative to the model's no-agreement equilibrium. All counterfactual equilibria hold product assortments and demand conditions fixed at their values in the first quarter of 2019. Column 1 of Table 8 reports a benchmark that does not use the estimated agreement parameters: it applies the observed retail price changes in Table 3 to pre-agreement prices and lets wholesale prices adjust through the pre-agreement bargaining model. We refer to this calculation as the observed-price benchmark. Comparing it with the estimated agreement shows how far our conclusions depend on modeling the agreement itself.

[40] This pattern is consistent with, but does not uniquely identify, the share-based rebate. A uniform per-battery increase in Duracell's wholesale cost at Walmart can also generate larger proportional retail price increases for larger packs, which have lower prices per battery.

	Energizer		Duracell		Private Label	
	Recovered	Bargaining Model	Recovered	Bargaining Model	Recovered	Bargaining Model
Pre-agreement wholesale prices per battery ($)						
Retailer group						
Walmart	0.312	0.343	0.333	0.374	0.214	0.209
National chains	0.473	0.494	0.438	0.439	0.188	0.262
Small retailers	0.425	0.421	0.555	0.587	0.252	0.247
Sub-line class						
Premium	0.861	0.908	0.596	0.602		
Regular	0.419	0.423	0.404	0.426		
Value	0.220	0.271				
Post-agreement retail price changes (log points)						
	Observed	Model	Observed	Model		
Walmart	0.012	0.003	0.047	0.041		
Other retailers	0.089	0.101	0.073	0.068		

Notes: The table compares the moments used in the GMM estimation with the corresponding model predictions. The upper panel reports sales-weighted averages of recovered wholesale prices per battery and the bargaining model's predictions for the groups that define the wholesale-price moments, which are averages per pack: retailer group and sub-line class (premium, regular, and value). The lower panel reports the post-agreement retail price changes from Table 3 and the model-implied changes between the equilibria with and without the agreement.

Table 7: Model Fit

8.2.1 Profit Gains and the Roles of Reciprocal Restraints

Table 8 reports the observed-price benchmark alongside equilibrium counterfactuals with and without the agreement, holding products and demand fixed at their pre-agreement values. The benchmark in Column 1 and the estimated agreement in Column 2 deliver the same conclusions: Walmart and Energizer gain jointly, Duracell gains, rival retailers lose, and consumers lose. The joint profit gain, the consumer surplus loss, and the total surplus loss differ by about 10 percent or less between the two columns.

Under the estimated agreement in Column 2, Walmart and Energizer's joint profit rises by 9 percent, with Energizer's wholesale profit increasing by 38 percent and Walmart's retail profit by 3 percent. Duracell also gains, and rival retailers lose as wholesale costs rise for both national brands.

	Observed-Price Benchmark	Agreement	Retail Channel	Wholesale Channel
Panel A: Surplus Changes ($10,000 per mil. consumers)				
Consumer Surplus				
ΔCS	-26.170	-28.287	-0.290	-27.822
Agreement-Party Profit				
$\Delta\pi_{\text{Walmart+Energizer}}$	14.671	13.230	-0.128	13.384
Retailer Profit				
$\Delta\pi^{S}_{\text{Walmart}}$	2.764	3.609	-0.401	4.300
$\Delta\pi^{S}_{\text{Others}}$	-11.753	-10.013	0.097	-10.180
Manufacturer Profit				
$\Delta\pi^{M}_{\text{Energizer}}$	11.907	9.622	0.273	9.084
$\Delta\pi^{M}_{\text{Duracell}}$	3.564	4.714	-0.302	5.350
$\Delta\pi^{M}_{\text{Others}}$	2.250	2.474	0.016	2.460
Total Surplus				
ΔTS	-17.437	-17.882	-0.608	-16.807
Panel B: Price Changes (%)				
$\%\Delta p^{\text{Walmart}}_{\text{Energizer}}$	1.207	0.734	-1.757	3.398
$\%\Delta p^{\text{Walmart}}_{\text{Duracell}}$	4.812	4.331	1.810	1.639
$\%\Delta p^{\text{Others}}_{\text{Energizer}}$	9.308	10.670	0.001	10.660
$\%\Delta p^{\text{Others}}_{\text{Duracell}}$	7.573	7.065	0.019	7.037

Notes: The table reports outcomes under the Walmart–Energizer agreement relative to no agreement. Column 1, the observed-price benchmark, applies the price changes from Table 3 to baseline Energizer and Duracell retail prices, with wholesale prices implied by the bargaining model. Column 2 uses the estimated agreement parameters, $\hat{\boldsymbol{\theta}}$. Columns 3 and 4 isolate the retail ($\theta_E = 0$) and wholesale ($\theta_W = 0$) channels, respectively. Panel A reports surplus changes in $10,000 per million consumers; $\Delta\pi^{S}_{\text{Others}}$ denotes the profit change for non-Walmart retailers, and $\Delta\pi^{M}_{\text{Others}}$ the profit change for private-label and other-brand manufacturers. The change in total surplus equals the change in consumer surplus plus changes in retailer and manufacturer profits. Joint-profit subtotals are reported for reference. Panel B reports average percentage retail price changes.

Table 8: Welfare Effects of the Walmart–Energizer Agreement

The Role of Reciprocal Restraints. In the estimated agreement, wholesale contracting creates most of the parties' joint profit gain, while preferential retail pricing reallocates part of that gain toward Energizer. With only the wholesale channel ($\theta_W = 0$, Column 4), Walmart and Energizer's joint profit rises by 9.3 percent, compared with 9.2 percent under the full agreement. With only the retail channel ($\theta_E = 0$, Column 3), joint profit barely changes. Adding the retail channel to the wholesale channel changes how the gain is divided: Walmart's profit gain falls from 3.6 to 3.0 percent, while Energizer's rises from 35.9 to 38.0 percent. Both firms remain better off than without the agreement.

The two channels also leave different footprints in prices. The wholesale channel

raises both national brands' prices at rival retailers and lowers those retailers' profits. On its own, it would also raise Energizer's prices at Walmart by more than Duracell's, reversing the observed pattern. The retail channel steers Walmart's shoppers toward Energizer by raising Duracell's price there, producing Duracell's larger increase at Walmart. As discussed in Appendix S, the net rebate payment is negligible at the estimated equilibrium, but the rebate's marginal incentives still induce Walmart to favor Energizer. The resulting changes in Walmart's relative prices redistribute gains toward Energizer.[41] Relatedly, Klein and Murphy (1988) explain how vertical restraints can support contractual performance by creating quasi-rents that can be lost upon termination. Our decomposition illustrates how a restraint can matter for the allocation of gains even when it contributes little to joint profitability. The reciprocal structure is consistent with the court's characterization of the alleged agreement as an exchange of preferential treatment for restrictions on rival retailers' discounting (United States District Court for the Northern District of California 2024).

8.2.2 Consumer Welfare

Consumer surplus falls by 6.5 percent relative to the no-agreement equilibrium, and by 6.0 percent under the observed-price benchmark. The wholesale channel accounts for most of this harm: consumer surplus falls by only 0.07 percent under the retail channel alone and by 6.3 percent under the wholesale channel alone.

In dollar terms, the loss is $0.28 per package purchased, including purchases at Dollar Tree, equivalent to 3.9 percent of average battery spending per package. Scaling this spending-equivalent loss to national AA-battery expenditure of approximately $1.3 billion in 2018 yields an annual loss of approximately $51 million.[42] We next decompose the increase in consumer expenditure across retailers and brands. Most of the increase in consumer expenditure occurs outside Walmart. Retailers other than Walmart and Amazon account for about three quarters of the increase in consumer expenditure, with prices rising by 6.5 percent on average. Walmart accounts for 16.9 percent of the expenditure increase, with prices rising

[41] Unconditional lump-sum transfers between the parties do not affect pricing and are not identified from the price and quantity data.

[42] We estimate national spending using Numerator's household projection factors, which scale the 2018 battery spending of households in Numerator's 2018 static panel to the number of U.S. households. The national spending and welfare estimates should be viewed as approximate.

by 2.3 percent. Duracell's price increases contribute nearly as much as Energizer's: Energizer and Duracell products at non-Walmart retailers account for 38.4 and 32.9 percent of the increase in consumer expenditure, respectively.

Alternative Contracts. Allowing Walmart and Energizer to eliminate double marginalization through a two-part tariff does not overturn the welfare result. Under this contract, the marginal wholesale price equals Energizer's input cost, while a Nash-bargained fixed fee divides the surplus. Because the fee is independent of quantities and prices, it affects the division of profits without directly changing pricing incentives.[43] As shown in Appendix X, both firms gain under this tariff when Energizer's estimated wholesale restraint at rival retailers is retained, and consumer surplus rises by 1.1 percent without the wholesale restraint but falls by 4.7 percent when the restraint is retained, both relative to no agreement. Eliminating double marginalization between Walmart and Energizer therefore does not eliminate the harm from raising rival retailers' costs. The tariff nevertheless predicts a 2.7 percent decline in Energizer's retail prices at Walmart, compared with an observed increase of 1.2 percent. This comparison leaves open fixed fees combined with other marginal wholesale terms and does not establish why the parties would redistribute gains through pricing.

8.2.3 Why Walmart and Energizer?

We examine which retailer–manufacturer pairs benefit most from the agreement and how bargaining conditions affect each party's incentive to participate. We first apply the estimated agreement parameters to alternative pairs, replacing Walmart with Target, Energizer with Duracell, or both. The agreement parameters are held fixed across pairs, but the rebate rule is allowed to differ. We retain the estimated share-based rebate for the Walmart pairs. For the Target pairs, whose rebate terms are unobserved, we choose the rebate structure that maximizes joint profit, which removes the share-based component.[44] We then vary Duracell's bargaining

[43] We consider an unconditional fixed fee. Transfers whose continuation depends on market outcomes can affect conduct. In Asker and Bar-Isaac (2014), for example, accommodating entry would erode the transfers retailers receive from the incumbent manufacturer, giving them an incentive to deter entry.

[44] The estimated rebate is close to joint-profit maximizing for Walmart–Energizer, but the same rule can induce exclusion that reduces joint profit at Target. Appendix Y retains the share-based

power with Walmart to examine how the gains are divided between Walmart and Energizer. Table 9 shows that Walmart–Energizer generates the largest joint profit gain, most of which comes from raising rivals' costs. Two features explain this result. First, Walmart's large share of battery sales allows it to recapture more demand diverted from rival retailers. Replacing Walmart with Target reduces this profit component by about 77 percent. Second, Energizer's relatively weak bargaining power at rival retailers allows more of its opportunity cost to pass through to wholesale prices. Replacing Energizer with Duracell, which already captures most of the bargaining surplus there, reduces this component by about two thirds. Agreements involving Target have much smaller consumer effects: consumer surplus falls by 0.2 percent with Energizer and rises by 0.3 percent with Duracell, compared with a 6.5 percent loss under Walmart–Energizer. Target's smaller scale weakens the incentive to raise rivals' costs, allowing efficiency gains from lower prices at Target to largely or fully offset the resulting harm.

Joint profitability, however, does not ensure that both parties benefit. Figure 5 varies Duracell's bargaining power with Walmart, $\rho_{DC,W}$, holding all other parameters at their estimates. As $\rho_{DC,W}$ increases, Energizer's profit gain rises, while Walmart's declines and turns negative at approximately 0.57, despite a positive joint gain throughout the range shown. Duracell's stronger bargaining position narrows Walmart's margin on its products, shifting gains toward Energizer and strengthening Walmart's incentive to steer demand away from Duracell. Under the agreement, Duracell's sales at Walmart fall by 9 percent at the estimated $\rho_{DC,W} = 0.17$, by 34 percent at 0.7, and by 61 percent at 0.8. At still higher values, Walmart stops selling Duracell, turning preferential pricing into exclusion. Depending on how the rebate is specified as Duracell exits, the joint profit gain may turn negative, although Walmart already requires transfers from Energizer to participate when $\rho_{DC,W} > 0.57$. Appendix V examines how these gains vary with the demand parameters.

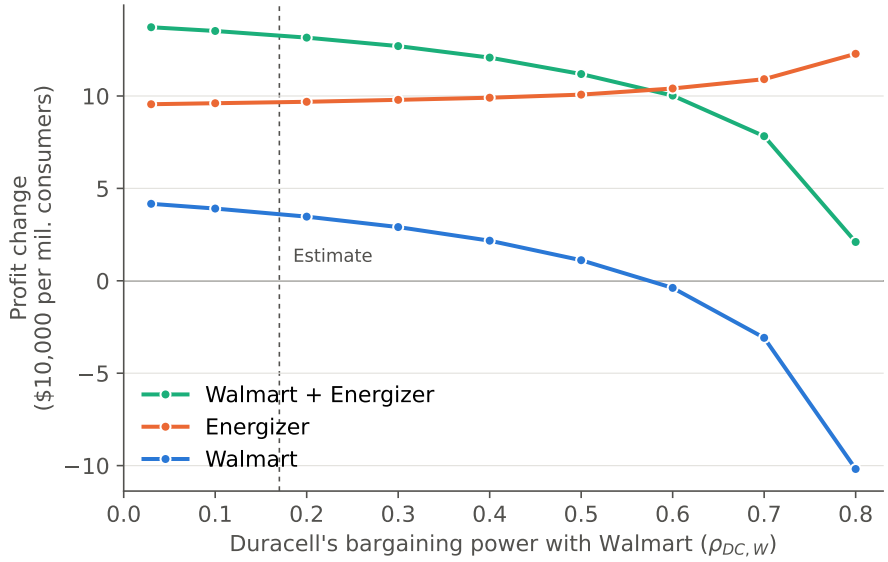
Together, these results indicate that the agreement's profitability and consumer harm are greatest when a large retailer pairs with a manufacturer that has weak bargaining power at rival retailers. The retailer's incentive to participate also depends on its bargaining position with the rival manufacturer.

component subject to Target's participation and finds little change in the consumer welfare results.

	Walmart		Target	
	Energizer	Duracell	Energizer	Duracell
Panel A: Surplus Changes ($10,000 per mil. consumers)				
Consumer Surplus				
ΔCS	-28.287	-12.958	-1.046	1.115
Agreement-Party Profit				
$\Delta\pi_{\text{Retailer+Manufacturer}}$	13.230	5.674	4.612	4.135
Wholesale Channel	13.384	4.878	3.042	1.348
Retailer Profit				
$\Delta\pi^{S}_{\text{Walmart}}$	3.609	2.319	-1.619	-1.460
$\Delta\pi^{S}_{\text{Target}}$	-1.701	-0.484	0.992	1.277
$\Delta\pi^{S}_{\text{Others}}$	-8.313	-4.869	-2.646	-2.022
Manufacturer Profit				
$\Delta\pi^{M}_{\text{Energizer}}$	9.622	2.671	3.621	-0.300
$\Delta\pi^{M}_{\text{Duracell}}$	4.714	3.355	0.317	2.858
$\Delta\pi^{M}_{\text{Others}}$	2.474	1.215	0.103	-0.055
Total Surplus				
ΔTS	-17.882	-8.750	-0.279	1.414
Panel B: Price Changes (%)				
$\%\Delta p^{\text{Walmart}}_{\text{Energizer}}$	0.734	2.723	0.961	-0.212
$\%\Delta p^{\text{Walmart}}_{\text{Duracell}}$	4.331	-2.180	-0.048	0.700
$\%\Delta p^{\text{Target}}_{\text{Energizer}}$	7.900	1.366	-8.213	0.233
$\%\Delta p^{\text{Target}}_{\text{Duracell}}$	5.380	5.829	0.604	-15.207
$\%\Delta p^{\text{Others}}_{\text{Energizer}}$	11.386	2.117	1.382	0.232
$\%\Delta p^{\text{Others}}_{\text{Duracell}}$	7.251	5.905	0.867	0.656

Notes: The table reports outcomes when the estimated agreement parameters, $\hat{\boldsymbol{\theta}}$, are applied to the indicated retailer–manufacturer pair, relative to no agreement. Panel A reports surplus changes in $10,000 per million consumers. "Wholesale Channel" denotes the joint profit change under the wholesale channel alone ($\theta_W = 0$), as in Column 4 of Table 8. $\Delta\pi^{S}_{\text{Others}}$ denotes the profit change for retailers other than Walmart and Target, and $\Delta\pi^{M}_{\text{Others}}$ the profit change for private-label and other-brand manufacturers. The change in total surplus equals the change in consumer surplus plus changes in retailer and manufacturer profits. Joint-profit subtotals are reported for reference. Panel B reports average percentage retail price changes.

Table 9: Vertical Agreements with Alternative Partners



Notes: The figure plots profit changes from the Walmart–Energizer agreement as $\rho_{DC,W}$ varies from 0.03 to 0.80, holding other parameters at their estimates. Changes are relative to no agreement, in $10,000 per million consumers per quarter. The dashed line marks the estimated $\rho_{DC,W}$.

Figure 5: Gains from the Agreement and Duracell's Bargaining Power with Walmart

Effects on the Rival Manufacturer. The effect on the rival manufacturer depends on the balance between the agreement's wholesale and retail channels. Duracell gains substantially under the Walmart–Energizer agreement but only slightly under the Target–Energizer agreement. The wholesale channel benefits Duracell by diverting demand toward it through higher Energizer prices at rival retailers and strengthening its bargaining position through costlier Energizer replacement offers. The retail channel has the opposite effect: internalizing Energizer's wholesale margin induces the partner retailer to lower Energizer's prices, diverting demand away from Duracell.

The relative strength of these channels depends on the partner retailer's scale and Energizer's wholesale margin. Under the Walmart–Energizer agreement, Walmart's scale amplifies the gains from raising rivals' costs, while Energizer's thin wholesale margin at Walmart limits the effect of internalization on Walmart's pricing. The wholesale channel therefore dominates, and Duracell benefits. Under the Target–Energizer agreement, Target's limited recapture of demand from rival retailers weakens the wholesale channel, while Energizer's substantial wholesale margin at Target strengthens the retail channel. Target consequently lowers Energizer's prices by 8.2 percent, diverting demand away from Duracell and offsetting most of Duracell's gains at other retailers.

8.2.4 Remedies

Table 10 evaluates four remedies motivated by the Robinson–Patman Act's restrictions on anticompetitive price discrimination among competing buyers.[45] The first three apply a non-discrimination principle to the raising-rivals'-costs mechanism identified in Table 8 by restricting increases in Energizer's wholesale terms at rival retailers relative to Walmart. Specifically, within each sub-line class, the percentage increase in per-battery wholesale terms cannot exceed the corresponding increase at Walmart. These restrictions allow pre-agreement wholesale price differences, including cost-based quantity discounts, to remain in place. The three remedies

[45]The Federal Trade Commission renewed enforcement with complaints against Southern Glazer's in December 2024 and PepsiCo in January 2025, the latter alleging preferential promotional terms for a large retailer. The PepsiCo action was dismissed without prejudice in May 2025; a proposed settlement in the Southern Glazer's case was filed in October 2026. Our remedies restrict only the incremental discrimination introduced by the agreement, preserving pre-existing price differences.

differ in which terms are restricted. The third, our main remedy, applies the restriction jointly to negotiated wholesale prices and offers to replace a rival brand. The first two restrict negotiated wholesale prices or replacement offers alone. We report these partial restrictions to isolate the two channels rather than as standalone policy proposals, since offers that are never accepted would be difficult to regulate separately.

		Restrictions on Incremental Price Increases			
	Agreement	Negotiated Wholesale Prices Only	Replacement Offers Only	Both Wholesale Terms	Walmart Retail Prices
Panel A: Surplus Changes ($10,000 per mil. consumers)					
Consumer Surplus					
ΔCS	-28.287	-16.685	-17.755	-6.750	-25.416
Agreement-Party Profit					
$\Delta\pi_{\text{Walmart+Energizer}}$	13.230	6.090	9.743	3.063	13.419
$\Delta\pi^{S}_{\text{Walmart}}$	3.609	0.926	1.622	-0.889	4.327
$\Delta\pi^{M}_{\text{Energizer}}$	9.622	5.164	8.121	3.952	9.092
Other Firms' Profit					
$\Delta\pi^{S}_{\text{Others}}$	-10.013	-5.300	-5.650	-1.356	-11.245
$\Delta\pi^{M}_{\text{Duracell}}$	4.714	2.788	2.217	0.501	4.942
$\Delta\pi^{M}_{\text{Others}}$	2.474	1.567	1.375	0.561	2.303
Total Surplus					
ΔTS	-17.882	-11.541	-10.069	-3.981	-15.997
Panel B: Price Changes (%)					
$\%\Delta p^{\text{Walmart}}_{\text{Energizer}}$	0.734	-0.266	0.343	-0.636	1.526
$\%\Delta p^{\text{Walmart}}_{\text{Duracell}}$	4.331	3.664	3.167	2.514	1.293
$\%\Delta p^{\text{Others}}_{\text{Energizer}}$	10.670	2.215	10.224	2.034	10.576
$\%\Delta p^{\text{Others}}_{\text{Duracell}}$	7.065	7.126	1.030	1.114	6.973

Notes: The table reports equilibrium outcomes under the Walmart–Energizer agreement and four remedies, relative to no agreement. Column 1 reproduces Column 2 of Table 8. Columns 2–4 cap Energizer's percentage increases in per-battery wholesale terms at rival retailers at its increase at Walmart within each sub-line class. The cap applies to negotiated wholesale prices in Column 2, replacement offers in Column 3, and both in Column 4. Column 5 similarly caps Walmart's percentage retail price increases for other brands at its increase for Energizer. Panel A reports surplus changes in $10,000 per million consumers; $\Delta\pi^{S}_{\text{Others}}$ denotes the profit change for non-Walmart retailers, and $\Delta\pi^{M}_{\text{Others}}$ the profit change for private-label and other-brand manufacturers. The change in total surplus equals the change in consumer surplus plus changes in retailer and manufacturer profits. Joint-profit subtotals are reported for reference. Panel B reports average percentage retail price changes.

Table 10: Welfare and Price Effects of Alternative Remedies

Restricting only negotiated wholesale prices reduces the increase in Energizer's retail prices at rival retailers from 10.7 to 2.2 percent, but leaves Duracell's retail

price increase essentially unchanged, at 7.1 percent. Energizer's costlier replacement offers continue to strengthen Duracell's bargaining position, so the consumer surplus loss falls only from 6.5 to 3.8 percent. Restricting only replacement offers has the opposite effect: Duracell's retail price increase falls to 1.0 percent, while Energizer's remains at 10.2 percent, and the consumer surplus loss falls to 4.0 percent. Each restriction thus addresses one of the two channels through which the agreement raises rival retailers' costs. Restricting both reduces the consumer surplus loss to 1.5 percent and the parties' joint profit gain from 9.2 to 2.1 percent. Under the estimated terms, Walmart would require compensation from Energizer to participate. The agreement nevertheless remains jointly profitable, leaving scope for such a transfer and a residual consumer surplus loss of 1.5 percent. Conditional on the agreement remaining in place, the combined remedy would avert approximately $39 million in annual consumer surplus losses nationally.

The fourth remedy restricts incremental retail price discrimination at Walmart by preventing it from raising other brands' prices by a larger percentage than Energizer's. The constraint binds, reducing the increase in Duracell's prices at Walmart from 4.3 to 1.3 percent. Nevertheless, the consumer surplus loss declines only from 6.5 to 5.8 percent, and the parties' joint profit gain remains essentially unchanged. The remedy limits Walmart's relative pricing but leaves intact the wholesale channels through which Energizer raises rival retailers' costs. These results indicate that applying the non-discrimination principle to all of Energizer's supply terms is substantially more effective at reducing consumer harm than restricting negotiated wholesale prices or replacement offers alone, or limiting Walmart's preferential retail pricing.

9 Conclusion

Reciprocal vertical restraints can play distinct roles in creating and dividing joint gains. In the alleged Walmart–Energizer agreement, Energizer's wholesale incentive at rival retailers creates most of the parties' joint profit gain and consumer harm, while Walmart's preferential pricing mainly shifts gains toward Energizer. The implied consumer loss is approximately $51 million annually when extrapolated to national AA-battery spending. The distributional role of Walmart's preferential pricing suggests that observable pricing conduct may also serve as a

means of exchanging benefits between firms, although our model does not identify the contractual frictions underlying the choice of restraints. These estimates quantify the implications of the alleged conduct rather than establish that an agreement occurred.

An agreement between two firms can also change the terms on which third parties negotiate. Costlier Energizer replacement offers weaken rival retailers' bargaining positions with Duracell. Duracell, although not a party to the agreement, can then negotiate higher wholesale prices, even at retailers that do not carry Energizer. Rival retailers lose as their wholesale costs rise for both national brands. The size of these effects depends on the participating firms: agreements involving Target have much smaller effects on consumer welfare.

The effectiveness of remedies depends on which wholesale terms are constrained. A non-discrimination principle applied only to negotiated prices leaves much of Duracell's bargaining advantage intact, whereas extending it to Energizer's offers to replace Duracell averts most of the consumer loss. Limiting Walmart's preferential retail pricing does little to reduce consumer harm. These findings show that evaluating vertical restraints requires considering both negotiated prices and the outside options that shape negotiations with other firms.

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Online Appendix

The appendix is intended for online publication.

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A Consumer Composition Comparison

	Pre-Period		Post-Period	
	Mean	Standard Deviation	Mean	Standard Deviation
Female	0.78	0.42	0.80	0.40
Age	38.35	11.90	39.49	12.22
White	0.68	0.47	0.69	0.46
Household Size	3.29	1.55	3.21	1.54
College Graduate	0.75	0.43	0.75	0.44
Full-Time Employment	0.52	0.50	0.52	0.50
High Income	0.12	0.32	0.13	0.34
Medium Income	0.49	0.50	0.51	0.50
No. of Consumers per Quarter	252026.80		167500.10	

Notes: The table summarizes consumer characteristics for cross-sectional observations, with each line representing one consumer and values averaged across all consumers. Age brackets are categorized into the following groups: 18-20, 21-24, 25-34, 35-44, 45-54, 55-64, and 65+, with ages represented by the lowest value within each range. Household sizes above 7 are grouped under the value 8. High-income and medium-income brackets are categorized based on Numerator.

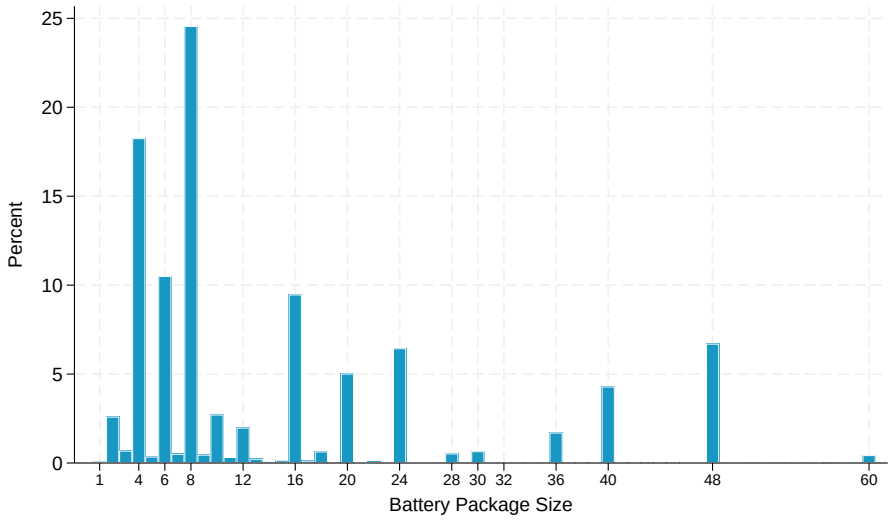
Table A1: Cross-Sectional Comparison of Consumer Composition

Table A1 presents the summary statistics of consumer characteristics for all trips (not limited to trips with battery purchases) during the periods before and after the vertical agreement. While there are more consumers in the pre-period and fewer in the post-period, their characteristics are largely similar.

B Package Size Imputation

We impute missing battery package sizes, accounting for 29.19% of purchases, using the following sequential procedure. At each step, the imputed size is calculated as the average observed pack size for products matching the specified criteria, and then rounded to the nearest whole number after taking the average. If a product's size cannot be imputed using the current criterion because no products with observed size information match it, the product is carried forward to the next step. The criteria, in order, are as follows:

1. Same retailer, same battery brand line, and same retail price (86.8%).



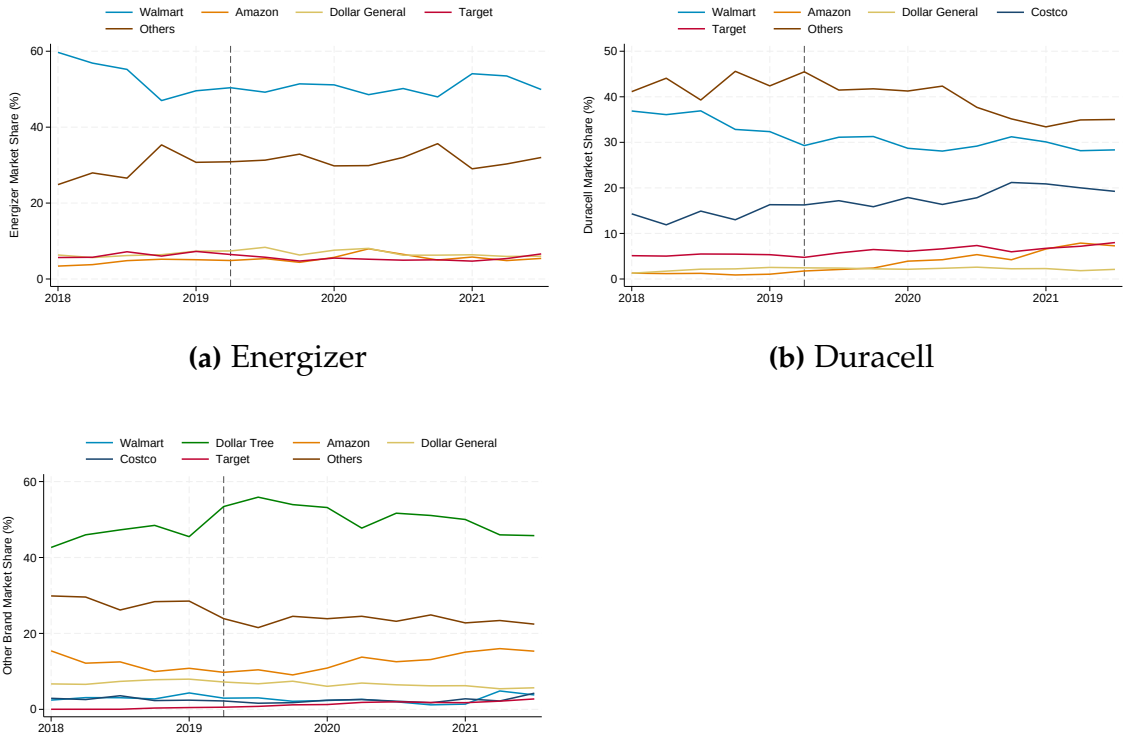
Notes: The figure presents the distribution of battery package sizes after imputation, as described in Appendix B.

Figure A1: Distribution of Battery Package Sizes After Imputation

2. Same battery brand line and same retail price (7.1%).
3. Same retailer and same retail price (3.6%).
4. Same retailer, same battery brand line, and same *rounded* retail price (1.1%).
5. Same battery brand line and same *rounded* retail price (0.17%).
6. Same retailer, same battery brand, and same *rounded* retail price (0.16%).
7. Same retailer and same *rounded* retail price (0.53%).
8. Same battery brand and same *rounded* retail price (0.56%).
9. Same *rounded* retail price (0.01%).
10. All products in the dataset (0.009%).

The numbers in parentheses indicate the percentage share of the total missing-size products that were imputed at each step. Figure A1 shows the distribution of package sizes after imputation, with noticeable bunching at common package sizes such as 4, 6, 8, 16, 24, and 48 per pack.

C Retailer Market Shares by Brand



(a) Energizer

(b) Duracell

(c) Other Brands

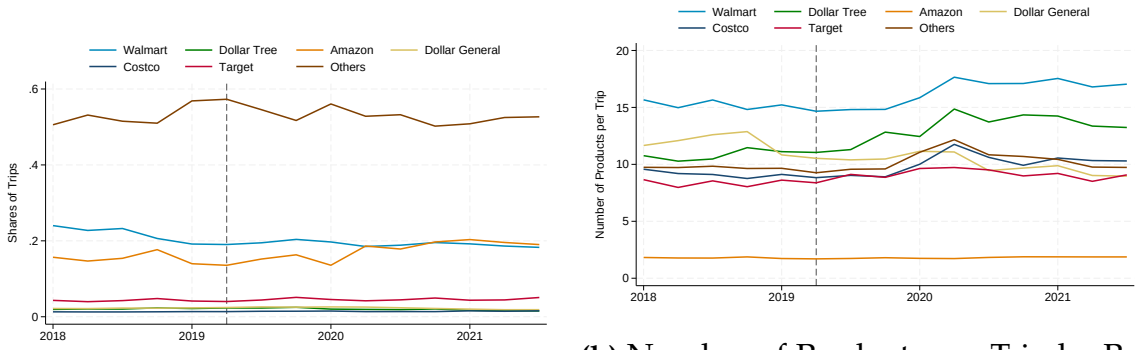
Notes: The figure plots quarterly retailer shares of Energizer, Duracell, and other brands, respectively, from 2018 to 2021 across Walmart, Dollar Tree, Amazon, Dollar General, Costco, Target, and all other remaining retailers. The vertical line at the second quarter of 2019 marks the start of the post-agreement period used in the analysis. Retailers with less than 1% within-retailer market share for a given brand in 2018 are excluded from the corresponding panels, consistent with the definition applied in Table 1.

Figure A2: Retailer Shares by Brand from 2018 to 2021

Figure A2a presents the retailer shares for Energizer, where Walmart's share increases over time while the shares of other retailers decline, indicating that Walmart is the main substitution margin. The remaining retailers display relatively stable shares throughout the period. Figure A2b shows the retailer shares for Duracell, with Walmart experiencing a marked decline that is primarily absorbed by Costco and Amazon. Figure A2c presents the shares for other remaining brands, where Dollar Tree shows a significant increase and Amazon also exhibits

an upward trend, largely capturing sales from other retailers. The other major retailers maintain relatively stable market shares.

D Trends in Shopping Trips



(a) Trip Shares by Retailer

(b) Number of Products per Trip by Retailer

Notes: The figure plots quarterly shopping trips by retailer from 2018 to 2021. Figure A3a displays trip shares for different retailers, including Walmart, Dollar Tree, Amazon, Dollar General, Costco, Target, and all other remaining retailers. The vertical line at the second quarter of 2019 marks the start of the post-agreement period used in the analysis. Figure A3b shows the number of products purchased per trip for these retailers.

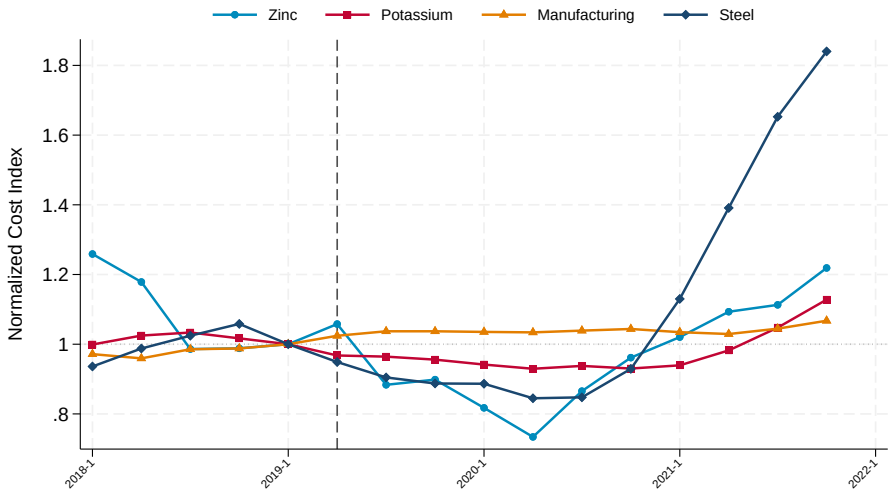
Figure A3: Trip Shares and Number of Products per Trip from 2018 to 2021

Figure A3a displays the quarterly trip shares from 2018 to 2021, which remain relatively stable, except for a sharp increase in Amazon's share that reflects the growing trend in e-commerce during this period. Overall trip shares differ from the battery market shares shown in Section 3.1. With the exception of Walmart and Amazon, most major retailers account for a smaller share of total trips than of battery purchases.

Figure A3b displays the number of products purchased per trip, which has remained relatively stable over time. The growth of e-commerce does not appear to significantly reduce the number of items purchased during in-store trips. After the first quarter of 2020, the number of products per trip increases slightly, possibly due to higher demand or increased travel costs during the pandemic, but the change is modest, about one or two additional products on average.

E Battery Cost Index

Figure A4 displays quarterly average cost indices related to battery manufacturing from 2018 to 2021, normalized such that each series equals 1 in 2019 Q1. We do not observe a sharp increase in input costs that coincides with the rise in retail prices.



Notes: The figure displays quarterly average cost indices related to battery manufacturing from 2018 to 2021, normalized such that each series equals 1 in 2019 Q1. Zinc (IR14260) and potassium (WPU06130302) are key chemical inputs; manufacturing (PCU3359123359120) represents the producer price index for primary battery production; and steel (WPS101) captures packaging and structural costs. All series are sourced from FRED. The vertical line at the second quarter of 2019 marks the start of the post-agreement period used in the analysis.

Figure A4: Battery Cost Index from 2018 to 2021

F Retail Prices of Private-Label Products

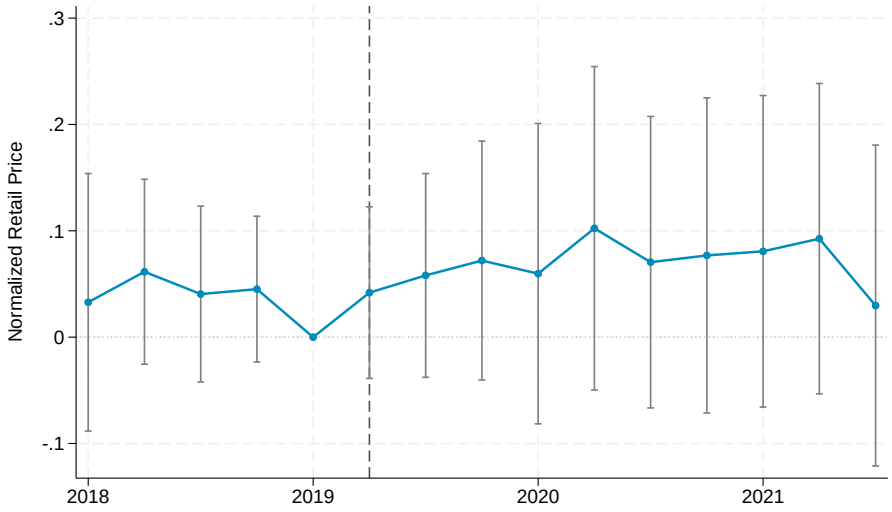
To assess whether private-label prices changed after the agreement, we estimate the following regression. The outcome variable is the normalized retail price of private-label product g from retailer j on trip i in quarter t, where t measures the number of quarters since 2018 and prices are normalized to each product's price

in the first quarter of 2019:

$$\tilde{p}_{ijgt} = \sum_{q=1, q\neq 5}^{15} \gamma_q \mathbb{1}\{t = q\} + \phi_{jg} + \epsilon_{ijgt}, \tag{A1}$$

where the fixed effects ϕ_{jg} absorb cross-sectional variation at the product-by-retailer level. The coefficient for the first quarter of 2019, the last quarter before the vertical agreement, is normalized to zero. Walmart's private-label products are excluded.

Figure A5 reports the estimates of γ_q and their 95% confidence intervals. The post-agreement period also coincides with a tariff increase: in May 2019, the Section 301 tariff on primary batteries imported from China rose from 10 to 25 percent (Office of the United States Trade Representative 2019). To the extent that private-label and smaller brands source batteries from China, higher tariffs could raise comparison-product prices and attenuate the estimated price increases for Energizer and Duracell. The estimates show no statistically significant change in private-label prices after the agreement, although they are imprecise and do not rule out tariff effects.



Notes: The figure presents the estimates of γ_q in Equation (A1) with 95% confidence intervals. Standard errors are clustered at the product-by-retailer level. The vertical line at the second quarter of 2019 marks the start of the post-agreement period used in the analysis.

Figure A5: Changes in Retail Prices of Private-Label Products

G Alternative Explanation: Energizer's Acquisitions

In January 2019, Energizer acquired Spectrum Brands' battery and portable lighting business, including Rayovac, as well as its auto care business, including Armor All and STP. To examine whether the battery price increases reflect broader changes in Energizer's pricing or costs following these acquisitions, we compare prices of its portable lighting and auto care products with those of competing brands. Table A2 reports estimates of Equation (1) for these products, with other brands in the same Numerator categories as the comparison group. In the pooled sample of portable lighting and auto care products, Energizer's prices do not rise relative to competing brands after the alleged agreement, suggesting that the battery price increases are unlikely to reflect a firm-wide pricing or cost shock associated with the acquisitions.

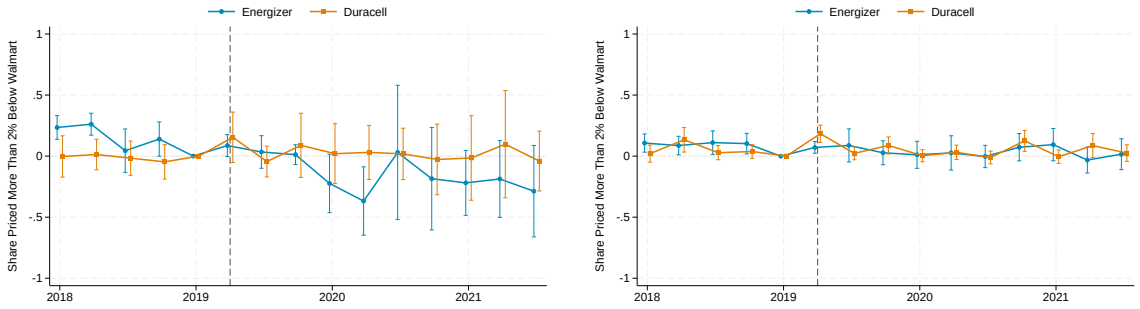
	All Retailers	Walmart	Other Retailers
$\mathbb{1}\{\text{Energizer}\}_j \times \mathbb{1}\{\text{Post}\}_t$	-0.021***	-0.014*	-0.028***
	(0.007)	(0.008)	(0.011)
$\mathbb{1}\{\text{Duracell}\}_j \times \mathbb{1}\{\text{Post}\}_t$	-0.003		0.005
	(0.029)		(0.029)
$\mathbb{1}\{\text{Post}\}_t$	-0.006*		-0.011***
	(0.003)		(0.004)
τ	-0.002***	-0.001**	-0.003***
	(0.000)	(0.000)	(0.001)
Product-by-retailer fixed effects	Yes	Yes	Yes
No. of observations	5,222,146	2,377,483	2,844,663

Notes: The table reports estimates from Equation (1) for portable lighting and auto care products, with log retail price as the dependent variable. Energizer includes Eveready, Rayovac, and the auto care brands Energizer acquired in January 2019. Column 1 includes all retailers; Column 2 includes Walmart, Sam's Club, and Walmart Neighborhood Market; and Column 3 includes non-Walmart retailers. In Column 2, we omit $\mathbb{1}\{\text{Post}\}_t$ as in Table 3, and Walmart does not sell Duracell portable lighting products. Robust standard errors are clustered at the product-by-retailer level. Significance levels: *($p < 0.10$), **($p < 0.05$), ***($p < 0.01$).

Table A2: Changes in Retail Prices of Energizer's Non-Battery Products

H Undercutting Walmart Online and in Stores

We compare each non-Walmart purchase of Energizer and Duracell batteries with Walmart's median price for the same product, CBSA, and quarter, identifying purchases priced more than 2 percent below that median. Figure A6 plots their quarterly shares relative to the first quarter of 2019, separately by brand and purchase channel. After the alleged agreement, Energizer's undercutting share falls online, while Duracell's online share and both brands' in-store shares show no comparable change. This pattern is consistent with enforcement focused on online sellers.



(a) Online Purchases **(b)** In-Store Purchases

Notes: The figure plots quarterly shares of non-Walmart purchases priced more than 2 percent below Walmart's median price for the same product, CBSA, and quarter. Shares are reported separately for Energizer and Duracell from 2018 to 2021 and normalized to the first quarter of 2019. Figure A6a shows online purchases; Figure A6b shows in-store purchases. Energizer includes Rayovac and Eveready. The vertical line marks the second quarter of 2019, the assumed start of the alleged agreement.

Figure A6: Undercutting Walmart: Online and In-Store Purchases

I Robustness to Population Weighting

Our baseline analysis gives equal weight to each observed transaction. Although the Numerator panel provides broad geographic and demographic coverage, it remains a sample of U.S. households rather than a census of purchases. We therefore examine whether differences between the demographic composition of the panel and that of the U.S. population affect our findings. Specifically, we repeat the

entire empirical analysis using Numerator's demographic weights, including the construction of market shares and sales, the price regressions, demand estimation, wholesale-price recovery, the bargaining model, and the welfare decomposition reported in Table 8.

Weight Construction and Application. Numerator collects longitudinal purchase data and provides a rolling static panel, which consists of households with sustained reporting histories and is balanced to approximate the geographic and demographic composition of U.S. households. Numerator reports two weighting components for each household and static panel window. The demographic weight adjusts households' relative representation to better match the U.S. population along dimensions including age, income, ethnicity, and gender. The national factor then projects the weighted static panel to the total number of U.S. households. We define the projection factor as the product of the household's demographic weight and the national factor.

For each transaction, we match its year and month to the static-panel window with the same ending year and month and assign the corresponding household-month projection factor. We multiply transaction quantities and expenditures by this factor before aggregating them to construct product retailer sales and market shares. The resulting weighted data are then used throughout demand estimation, wholesale price recovery, estimation of the bargaining model, and the welfare analysis.

Table A3 re-estimates the price regressions in Table 3, weighting each transaction by its projection factor. The estimates are close to the baseline and exhibit the same pattern of statistical significance. Relative to Table 3, the estimated increase in Energizer prices at non-Walmart retailers is slightly smaller, at 0.086 rather than 0.089 log points, while the estimated increases in Duracell prices at Walmart and other retailers change by at most 0.001 log points.

I.1 Structural Estimates and Welfare Effects

We repeat all estimation steps and counterfactual analyses using the weighted data. Table A4 compares the results with the unweighted specification. Weighting slightly lowers $\hat{\theta}_W$ to 0.30 and $\hat{\theta}_E$ to 0.64. The consumer surplus loss is 6.3 percent,

	All Retailers	Walmart	Other Retailers
$\mathbb{1}\{\text{Energizer}\}_j \times \mathbb{1}\{\text{Post}\}_t$	0.057***	0.013	0.086***
	(0.022)	(0.015)	(0.024)
$\mathbb{1}\{\text{Duracell}\}_j \times \mathbb{1}\{\text{Post}\}_t$	0.070***	0.048***	0.072***
	(0.021)	(0.013)	(0.022)
$\mathbb{1}\{\text{Post}\}_t$	-0.009		-0.006
	(0.017)		(0.017)
τ	0.001*	0.003**	0.001
	(0.001)	(0.001)	(0.001)
Product-by-retailer fixed effects	Yes	Yes	Yes
No. of observations	1,695,187	514,519	1,180,668
Adjusted R-squared	0.958	0.934	0.956

Notes: The table reports the estimates from Equation (1) with the log of retail price as the dependent variable, weighting each transaction by Numerator's demographic projection factor; transactions of consumers without a projection factor receive a weight of one. Column 1 includes observations from all retailers, Column 2 focuses on observations from Walmart retailers (Walmart, Sam's Club, and Walmart Neighborhood Market), and Column 3 focuses on observations from non-Walmart retailers. For Walmart, we exclude $\mathbb{1}\{\text{Post}\}_t$ in Equation (1) because the majority of its sales come from either Energizer or Duracell. Robust standard errors are clustered at the product-by-retailer level. Significance levels: *($p < 0.10$), **($p < 0.05$), ***($p < 0.01$).

Table A3: Changes in Retail Prices by Brand and Retailer, Population-Weighted

compared with 6.5 percent without weighting, and the parties' joint profit gain is 8.8 percent, compared with 9.2 percent.

J Price Changes at Single- and Two-Brand Retailers

Table A5 compares post-agreement price changes at non-Walmart retailers carrying both national brands with those carrying only one before the agreement. We augment Equation (1) with interactions between the post-agreement indicators and a single-brand retailer indicator. Relative to other brands, Duracell's price rises by 0.072 log points at single-brand retailers, with a standard error of 0.028, although its difference from two-brand retailers is imprecisely estimated. Therefore, its prices rise even where Energizer sales are negligible and the increase is unlikely to operate through the retailer's margin on Energizer. Duracell observations at

	Unweighted	Weighted
Panel A: Agreement Parameters		
θ_W	0.312	0.302
	(0.123)	(0.117)
θ_E	0.695	0.638
	(0.165)	(0.176)
Panel B: Effects of the Agreement (%)		
$\%\Delta CS$	-6.45	-6.29
$\%\Delta \pi_{\text{Walmart+Energizer}}$	9.19	8.84
$\%\Delta TS$	-2.26	-2.24
Panel C: Retail Price Changes (%)		
$\%\Delta p^{\text{Walmart}}_{\text{Energizer}}$	0.73	0.56
$\%\Delta p^{\text{Walmart}}_{\text{Duracell}}$	4.33	4.40
$\%\Delta p^{\text{Others}}_{\text{Energizer}}$	10.67	10.23
$\%\Delta p^{\text{Others}}_{\text{Duracell}}$	7.07	6.89

Notes: The table compares the main specification with a specification in which all estimation steps use transactions weighted by Numerator's demographic projection factors. Panel A reports the agreement parameters, with standard errors in parentheses. Panels B and C report the effects of the agreement relative to no agreement, as in Column 2 of Table 8.

Table A4: Robustness: Population Weighting

single-brand retailers come mainly from a few chains: Costco accounts for 54 percent, and five chains account for over 90 percent. The estimate should therefore be interpreted with caution.

K Testing for Local Hub-and-Spoke Coordination

If the observed price increases reflected hub-and-spoke coordination operating through local retail competition, price increases at rival retailers should be concentrated in markets where the hub is a strong local competitor. Alternatively, if wholesale terms are negotiated through national contracts, price changes should be relatively uniform across local markets. We test this prediction as follows.

We compute the hub's local market share in the pre-agreement period, defining each CBSA as a local market and measuring the hub's share of total battery units sold. We define $High_c = 1$ for CBSAs in which the hub's market share is above the

	Log Retail Price
$\mathbb{1}\{\text{Energizer}\}_j \times \mathbb{1}\{\text{Post}\}_t$	0.020
	(0.030)
$\mathbb{1}\{\text{Duracell}\}_j \times \mathbb{1}\{\text{Post}\}_t$	0.016
	(0.028)
$\mathbb{1}\{\text{Energizer}\}_j \times \mathbb{1}\{\text{Post}\}_t \times \mathbb{1}\{\text{Single-brand}\}_g$	0.069*
	(0.041)
$\mathbb{1}\{\text{Duracell}\}_j \times \mathbb{1}\{\text{Post}\}_t \times \mathbb{1}\{\text{Single-brand}\}_g$	0.055
	(0.040)
$\mathbb{1}\{\text{Post}\}_t$	0.069***
	(0.025)
$\mathbb{1}\{\text{Post}\}_t \times \mathbb{1}\{\text{Single-brand}\}_g$	-0.090**
	(0.036)
τ	0.001
	(0.001)
Product-by-retailer fixed effects	Yes
No. of observations	1,179,369
Adjusted R-squared	0.956

Notes: The table augments Equation (1) with interactions between the post-agreement indicators and a single-brand retailer indicator, using the sample in Column 3 of Table 3. A retailer is classified as single-brand if either Energizer (including Rayovac and Eveready) or Duracell accounts for less than 5 percent of its pre-agreement battery unit sales. Robust standard errors, reported in parentheses, are clustered at the product-by-retailer level. Significance levels: *($p < 0.10$), **($p < 0.05$), ***($p < 0.01$).

Table A5: Price Changes at Single- and Two-Brand Retailers

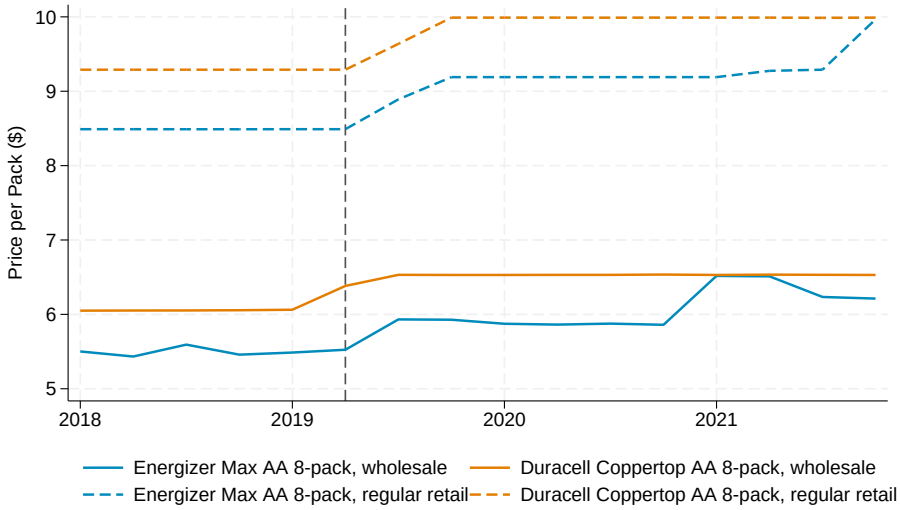
median of the market-share distribution.

We then re-estimate Equation (1), fully interacting the specification with $High_c$, and allow the product-by-retailer fixed effects to differ across the two market groups ($\phi_{jg,High}$). Hub-and-spoke coordination operating through local retail competition would predict larger price increases in markets where the hub has a larger share, implying positive interactions with the high-share indicator in the rival-retailer sample. Table A6 reports the results. The baseline estimates closely match those in Table 3, while the estimated interactions are small and statistically insignificant. We therefore find no statistically significant evidence that post-agreement price increases vary systematically with Walmart's or Energizer's local market share. This pattern is consistent with nationally negotiated wholesale contracts. DecaData provides evidence consistent with chain-level wholesale

pricing: at the retailer it covers, 94% of shipments have the modal unit cost across stores for the same product and day.[46]

L Trends in Wholesale Prices

The main data used in our analysis do not contain information on wholesale prices. To assess wholesale price patterns, we therefore use DecaData (http://decadata.io), which provides wholesale prices for a limited set of products and a small subset of retailers from 2018 to 2021. Figure A7 plots wholesale prices for 8-pack battery products for Energizer Max and Duracell Coppertop and the corresponding retailer prices in those retailers, showing that these prices increase after the vertical agreement.



Notes: The figure plots quarterly retail and wholesale prices for 8-pack battery products for Energizer Max and Duracell Coppertop, respectively. The vertical line at the second quarter of 2019 marks the start of the post-agreement period used in the analysis.

Figure A7: Wholesale Prices from 2018 to 2021

[46]The absence of significant interactions does not, however, rule out hub-and-spoke coordination at the national level, which could produce similar price changes across local markets.

	All Retailers	Walmart	Other Retailers
Panel A: Markets split by Walmart's pre-agreement share			
$\mathbb{1}\{\text{Energizer}\}_j \times \mathbb{1}\{\text{Post}\}_t$	0.062***	0.012	0.089***
	(0.021)	(0.016)	(0.024)
$\mathbb{1}\{\text{Duracell}\}_j \times \mathbb{1}\{\text{Post}\}_t$	0.070***	0.047***	0.074***
	(0.019)	(0.014)	(0.020)
$\mathbb{1}\{\text{Post}\}_t$	-0.003		-0.002
	(0.015)		(0.015)
τ	0.001	0.003**	0.001
	(0.001)	(0.002)	(0.001)
$High_c \times \mathbb{1}\{\text{Energizer}\}_j \times \mathbb{1}\{\text{Post}\}_t$	-0.012	-0.003	-0.005
	(0.012)	(0.006)	(0.018)
$High_c \times \mathbb{1}\{\text{Duracell}\}_j \times \mathbb{1}\{\text{Post}\}_t$	0.000	0.001	-0.004
	(0.010)	(0.006)	(0.012)
$High_c \times \mathbb{1}\{\text{Post}\}_t$	-0.010		-0.007
	(0.009)		(0.009)
$High_c \times \tau$	0.001	-0.000	0.000
	(0.001)	(0.001)	(0.001)
No. of observations	1,361,344	371,527	989,817
Adjusted R-squared	0.959	0.934	0.959
Panel B: Markets split by Energizer's pre-agreement share			
$\mathbb{1}\{\text{Energizer}\}_j \times \mathbb{1}\{\text{Post}\}_t$	0.061***	0.013	0.087***
	(0.021)	(0.016)	(0.024)
$\mathbb{1}\{\text{Duracell}\}_j \times \mathbb{1}\{\text{Post}\}_t$	0.070***	0.047***	0.073***
	(0.019)	(0.014)	(0.020)
$\mathbb{1}\{\text{Post}\}_t$	-0.005		-0.004
	(0.015)		(0.015)
τ	0.001	0.003**	0.001
	(0.001)	(0.002)	(0.001)
$High_c \times \mathbb{1}\{\text{Energizer}\}_j \times \mathbb{1}\{\text{Post}\}_t$	-0.009	-0.005	0.003
	(0.009)	(0.006)	(0.013)
$High_c \times \mathbb{1}\{\text{Duracell}\}_j \times \mathbb{1}\{\text{Post}\}_t$	0.002	0.001	0.002
	(0.009)	(0.006)	(0.011)
$High_c \times \mathbb{1}\{\text{Post}\}_t$	-0.005		-0.003
	(0.007)		(0.007)
$High_c \times \tau$	0.001	-0.000	0.000
	(0.000)	(0.001)	(0.000)
No. of observations	1,361,422	371,536	989,886
Adjusted R-squared	0.959	0.934	0.959
Product-by-retailer-by-group fixed effects	Yes	Yes	Yes

Notes: The table reports estimates of Equation (1) fully interacted with an indicator for CBSAs in which the hub's pre-agreement local market share is above the median. Panel A defines the indicator using Walmart's local market share, while Panel B uses Energizer's local brand share. All specifications include product-by-retailer-by-market-group fixed effects and a linear time trend interacted with the high-share indicator. Robust standard errors, reported in parentheses, are clustered at the product-by-retailer level. Significance levels: *($p < 0.10$), **($p < 0.05$), ***($p < 0.01$).

Table A6: Price Changes and the Hub's Local Market Share

M Market Structure

Figure A8a illustrates the non-internalization baseline. Suppose Energizer enters into a vertical agreement with Walmart, as shown in Figure A8b. Under bilateral internalization, the parties take each other's profits into account in the decisions they control. This setting is analogous to vertical integration, in which Walmart no longer treats the wholesale price w_{EW} as given, but instead takes into account Energizer's marginal cost when determining its retail price.

N Alternative Conduct Scenarios

Following the model setup in Section 4, we consider two alternative conduct scenarios: (i) horizontal coordination in the upstream market, in which Energizer coordinates with Duracell, and (ii) horizontal coordination in the downstream market, in which Walmart coordinates with Target. Each scenario is indexed by a scalar conduct parameter in $[0, 1]$.

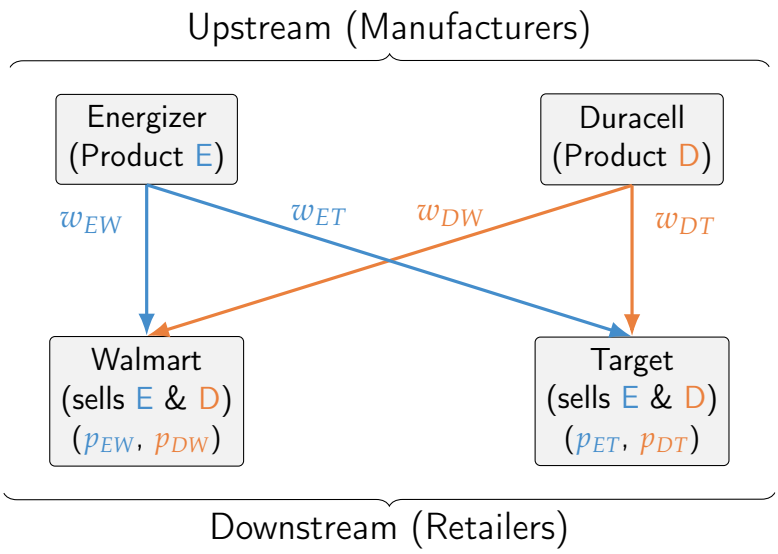
N.1 Upstream Manufacturer Coordination

Under Upstream Manufacturer coordination, Energizer and Duracell coordinate so that each manufacturer's effective bargaining surplus includes a fraction ϕ of the rival's change in profit. For Energizer–Walmart bargaining, the effective manufacturer profit becomes

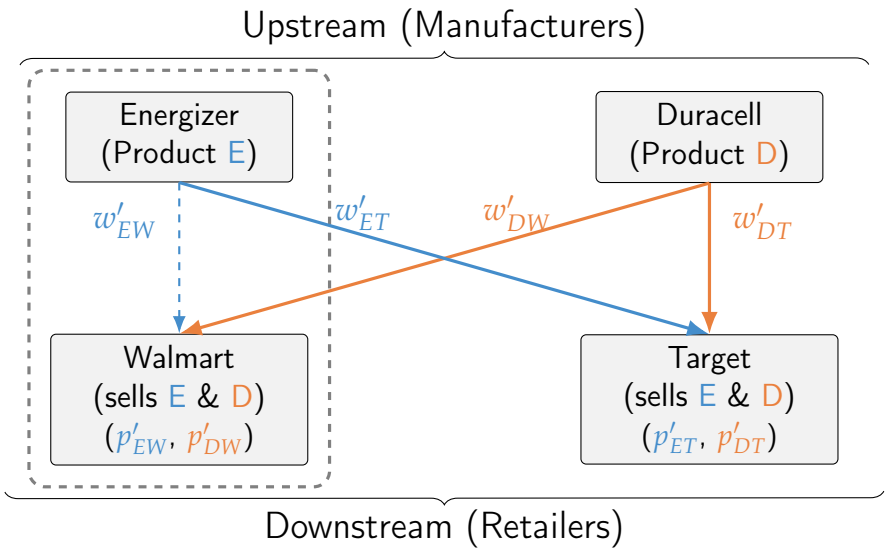
$$S_E^{EW}(\phi) = \left(\pi_E - d_E^{-EW}\right) + \phi \underbrace{\left(\pi_D - d_D^{-EW}\right)}_{<0}, \tag{A2}$$

The second term in Equation (A2) implies that Duracell is worse off when Energizer sells at Walmart due to demand substitution. The same logic applies to all four manufacturer–retailer pairs. Retailer first-order conditions remain unchanged from Section 4, given that $\theta = 0$.

Upstream coordination therefore reduces the manufacturer's profit from each bilateral relationship relative to the non-internalization case, leading to higher wholesale prices across all retailers. As a result, all four retail prices increase monotonically in ϕ, as shown in Figure A9. In this symmetric setting, this pattern



(a) Non-Internalization Baseline

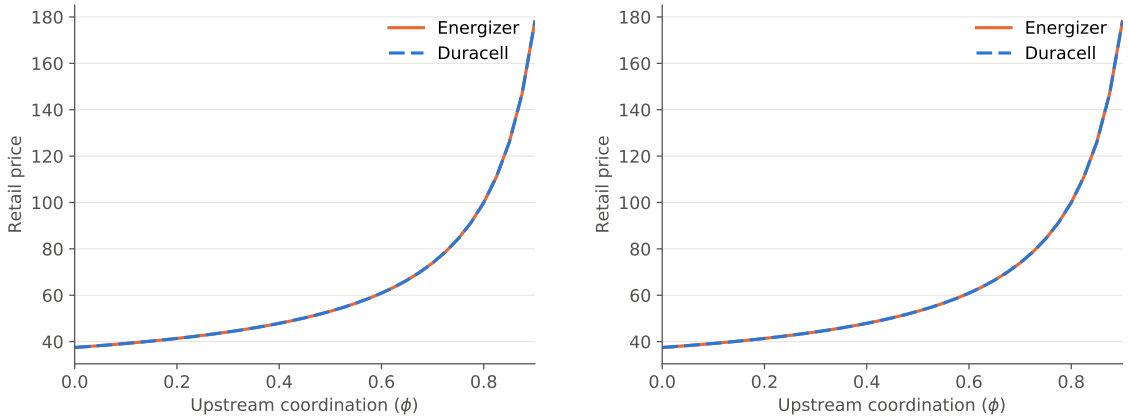


(b) Vertical Conduct

Notes: The figure illustrates the market structure of the conceptual framework. Figure A8a shows the baseline non-internalization case, in which Energizer and Duracell each sell a product through two multiproduct retailers, who then set retail prices. Figure A8b shows the vertical bilateral internalization case, in which Energizer and Walmart internalize each other's margins while also affecting Duracell's retail price at Walmart and Energizer's wholesale price to Target.

Figure A8: Market Structure: Non-internalization Baseline vs. Vertical Conduct

is inconsistent with the asymmetric price changes between Walmart and Target observed in the data.



(a) Walmart Retail Prices **(b)** Target Retail Prices

Notes: The figure plots equilibrium retail prices for $M = 50$, $c_E = c_D = 1.0$, $\gamma_s = 0.5$, $\gamma_c = 0.3$, $\rho = 0.5$, and $b = 1.1$, as ϕ varies from 0 to 0.9. Results for $\phi > 0.9$ are omitted because prices diverge when aggregate demand is inelastic.

Figure A9: Equilibrium Retail Prices Under Upstream Manufacturer Coordination

N.2 Downstream Retailer Coordination

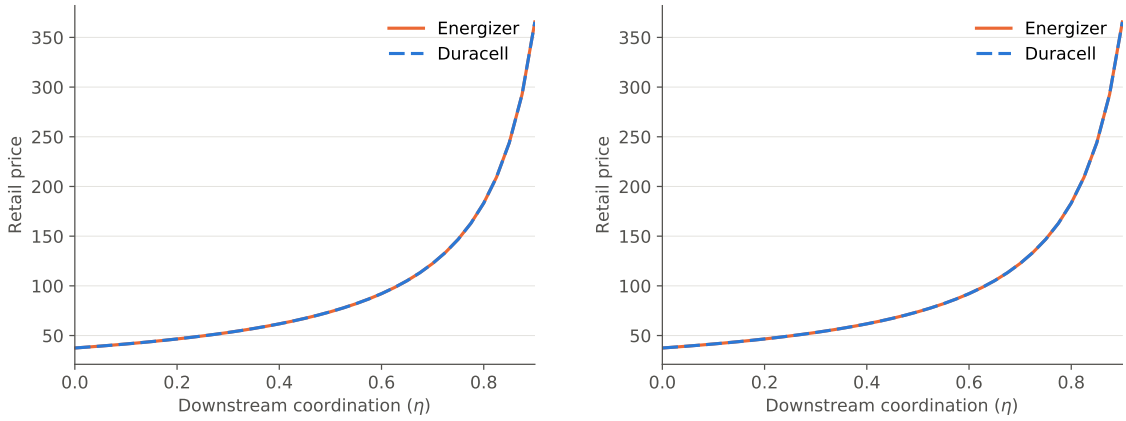
Under downstream retailer coordination, each retailer internalizes the other retailer's profit when setting retail prices. Walmart's first-order condition for p_{EW} becomes

$$\frac{\partial \pi_W}{\partial p_{EW}} + \eta \frac{\partial \pi_T}{\partial p_{EW}} = 0, \qquad \frac{\partial \pi_T}{\partial p_{EW}} = \gamma_c \left(m_{ET} + m_{DT} \right) > 0,$$

where $m_{ET} = p_{ET} - w_{ET}$ and $m_{DT} = p_{DT} - w_{DT}$ denote Target's retail margins. An increase in p_{EW} at Walmart diverts demand to Energizer at Target and to Duracell at Target, both of which benefit Target. Downstream coordination therefore raises all four retail prices simultaneously. The same retail pricing logic applies analogously to p_{DW}, p_{ET}, and p_{DT}. Wholesale Nash–Nash bargaining remains unchanged from Section 4, given that $\theta = 0$.

Figure A10 shows the equilibrium retail prices at Walmart and Target. All four retail prices increase monotonically in η. In this symmetric setting, this pattern

is again inconsistent with the asymmetric price changes between Walmart and Target.[47]



(a) Walmart Retail Prices **(b)** Target Retail Prices

Notes: The figure plots equilibrium retail prices simulated with $M = 50$, $c_E = c_D = 1.0$, $\gamma_s = 0.5$, $\gamma_c = 0.3$, $\rho = 0.5$, and $b = 1.1$, with η varying from 0 to 0.9. Results for $\eta > 0.9$ are omitted, as prices diverge when aggregate demand is inelastic.

Figure A10: Equilibrium Retail Prices Under Downstream Retailer Coordination

O The Form of Walmart's Incentive

Our main specification gives Walmart a rebate tied to Energizer's share of its battery sales, as in Equation (6). We compare this with two alternatives: profit sharing, under which Walmart internalizes a share θ_W of Energizer's wholesale profit across all retailers, and a per-unit rebate, under which it internalizes that share of Energizer's wholesale profit at Walmart only.

All three specifications lower Walmart's effective cost of Energizer products but differ in their incentives to raise Duracell's prices. A per-unit rebate creates only the indirect Edgeworth–Salinger incentive discussed in Section 7.1. Profit sharing additionally rewards Walmart for diverting demand to Energizer at other retailers, while the share-based rebate directly rewards shifting Walmart's own sales toward Energizer.

[47] Because aggregate demand is perfectly inelastic, the joint profit–maximizing retail price is unbounded: coordinated retailers can raise all prices proportionally without reducing total volume. We therefore report results only for $\eta \leq 0.9$.

The observed price changes favor the share-based rebate over the per-unit rebate. After the agreement, Walmart raised Duracell's prices by 4.8 percent but Energizer's by only 1.2 percent. Because a per-unit rebate raises Duracell's prices only through the indirect Edgeworth–Salinger incentive, it predicts an increase of only 2.0 percent in Duracell's prices at Walmart, as shown in Panel B of Table A8. The share-based rebate, which directly rewards Walmart for shifting sales toward Energizer, more closely reproduces the observed price increase.

The share-based rebate also generates a distinct prediction across pack sizes. Because it penalizes Walmart for each competing battery sold, the direct penalty on a Duracell pack increases with the number of batteries it contains. Our estimated model therefore predicts larger post-agreement price increases for Duracell relative to Energizer among larger packs. A per-unit rebate tied only to Energizer sales does not generate this direct incentive. To test this prediction, we augment Equation (1) for Energizer and Duracell products at Walmart with interactions between each brand's post-agreement indicator and pack size, measured by $\log Q_j$ or $\mathbb{1}\{Q_j \geq 16\}$.

Table A7 reports the difference between the Duracell and Energizer interactions, netting out post-agreement price changes across pack sizes common to both brands. Under both measures, Duracell's post-agreement price increase relative to Energizer's is larger for larger packs. The estimates closely match the share-based rebate's predictions, whereas the per-unit rebate predicts little or no differential increase, inconsistent with the observed patterns.[48]

The share-based rebate and profit sharing fit the observed price changes similarly well, and the data provide little basis for distinguishing them. We adopt the share-based rebate because it depends only on Walmart's own sales, which both parties can observe and verify. Such conditional rebates are common in vertical relationships between independently owned firms (Conlon and Mortimer 2021). A literal profit-sharing contract, by contrast, would require Walmart to receive a share of Energizer's profits at rival retailers, which Walmart cannot directly observe and is less natural in the absence of common ownership. The two specifications yield

[48]This pattern is consistent with, but does not uniquely identify, the share-based rebate. A constant per-battery increase in Duracell's wholesale cost at Walmart can also generate larger proportional retail price increases for larger packs, which have lower prices per battery. The evidence therefore favors the share-based rebate over the per-unit rebate within our model, but cannot distinguish it from other sources of a per-battery increase in Duracell's cost at Walmart.

		Model	
	Data	Share-Based Rebate	Per-Unit Rebate
Duracell minus Energizer			
$\log Q_j \times \mathbb{1}\{\text{Post}\}_t$	0.0116***	0.0141	0.0019
	(0.0020)		
$\mathbb{1}\{Q_j \geq 16\} \times \mathbb{1}\{\text{Post}\}_t$	0.0143***	0.0123	-0.0035
	(0.0026)		
Product-by-CBSA fixed effects	Yes		
No. of observations	343,826		

Notes: The table augments Equation (1) for Energizer and Duracell products at Walmart by interacting each brand's post-agreement indicator with pack size, measured by $\log Q_j$ or $\mathbb{1}\{Q_j \geq 16\}$. The outcome is log retail price per pack. Each row reports the Duracell interaction coefficient minus the Energizer interaction coefficient. The data column includes product-by-CBSA fixed effects and a linear quarter trend, with standard errors clustered by CBSA in parentheses. The model columns report sales-weighted regressions of model-implied log retail price changes on the same terms, using the structural sample and the specifications in Columns 1 and 3 of Table A8. Significance levels: *($p < 0.10$), **($p < 0.05$), ***($p < 0.01$).

Table A7: Relative Duracell Price Changes at Walmart by Pack Size

similar effects of the agreement.

Table A8 compares the three specifications of Walmart's incentives in Columns 1–3, each retaining Energizer's common opportunity cost from the main specification. Columns 4 and 5 instead allow Energizer's opportunity cost at each rival retailer to equal $\theta_E V_{ht} Q_j$, as described in Appendix P. Column 4 retains the share-based rebate and thus differs from the main specification only in Energizer's opportunity cost. Column 5 implements bilateral profit internalization, as in the conceptual framework, with Walmart internalizing a share θ_W of Energizer's profit.

The agreement's effects are similar across specifications: consumer surplus falls by 5.7–6.5 percent, and the parties' joint profit rises by 9.0–9.7 percent. These effects remain robust because they arise mainly from Energizer's wholesale terms at rival retailers.

Walmart's incentive	Share-Based Rebate	Profit Sharing	Per-Unit Rebate	Share-Based Rebate	Profit Sharing
Energizer's opportunity cost	Common	Common	Common	$\propto V_{ht}$	$\propto V_{ht}$
	(1)	(2)	(3)	(4)	(5)
Panel A: Estimates					
θ_W	0.312	0.796	0.412	0.306	0.779
θ_E	0.695	0.651	0.739	0.727	0.676
Panel B: Retail Price Changes, Data and Model (log points)					
Walmart, Energizer (data: 0.012)	0.003	0.012	0.005	0.005	0.013
Walmart, Duracell (data: 0.047)	0.041	0.047	0.020	0.042	0.047
Other retailers, Energizer (data: 0.089)	0.101	0.095	0.105	0.101	0.094
Other retailers, Duracell (data: 0.073)	0.068	0.065	0.071	0.069	0.065
Panel C: Effects of the Agreement (%)					
$\%\Delta CS$	-6.45	-6.17	-6.01	-5.95	-5.71
$\%\Delta\pi_{\text{Walmart+Energizer}}$	9.19	8.94	9.72	9.41	9.04

Notes: The table compares specifications of the agreement, each estimated with the same moments. Columns 1 to 3 use Energizer's common opportunity cost per battery from the main specification; in Columns 4 and 5, its opportunity cost varies with V_{ht}. Column 5 corresponds to bilateral profit internalization, in which Walmart internalizes Energizer's profit. Panel A reports the agreement parameters. Panel B reports the post-agreement retail price changes in Table 3 and their model counterparts. Panel C reports the agreement's effects relative to no agreement, as in Column 2 of Table 8.

Table A8: Alternative Forms of Walmart's Incentive

P Energizer's Opportunity Cost and Reduced-Form Evidence

An alternative to our main specification allows Energizer's opportunity cost of supplying chain h to vary with Walmart's recaptured retail margin, $\theta_E V_{ht} Q_j$. It predicts larger wholesale price increases at chains with higher V_{ht}.

We test this prediction using wholesale prices recovered from retailers' pricing first-order conditions. For Energizer products at non-Walmart chains, we regress pre- to post-agreement changes in wholesale prices per battery on V_{ht}, matching observations by CBSA, retailer, product line, and pack size and weighting by sales. We compare the estimated slope with its counterparts from the main and alternative models.

Table A9 reports the results. Energizer's wholesale price per battery rises by \$0.048 on average, compared with \$0.068 in the alternative model. The observed increases, however, do not exhibit the predicted positive relationship with V_{ht}: the

		Model	
	Data	Main Specification	Opportunity Cost $\propto V_{ht}$
Energizer			
Mean change per battery ($)	0.048	0.075	0.068
Slope on V_{ht}	-0.163	0.082	0.770
	(0.213)		
Slope on V_{ht}, with controls	-0.414	-0.076	0.620
	(0.235)		
Duracell (placebo)			
Slope on V_{ht}	0.131	-0.096	0.056
	(0.396)		

Notes: The table regresses pre- to post-agreement changes in wholesale prices per battery at non-Walmart chains on Walmart's recaptured retail margin per battery, V_{ht}, within matched CBSA–retailer–line–pack-size cells, weighted by sales. Controls include retailer type and log pack size. The model columns report corresponding regressions using model-implied wholesale price changes under the main specification and the alternative in which Energizer's opportunity cost equals $\theta_E V_{ht} Q_j$. Standard errors, reported in parentheses, are clustered at the retailer level.

Table A9: Energizer's Wholesale Price Increases and Walmart's Recapture

estimated slope is -0.16, compared with 0.77 under the alternative specification and 0.08 under the main specification. Adding retailer-type and pack-size controls leaves this conclusion unchanged. Duracell's wholesale price changes, used as a placebo, are also unrelated to V_{ht}.

These findings do not rule out raising-rivals'-costs incentives, but do not support the predicted positive relationship between Energizer's wholesale price increases and Walmart's recaptured retail margin across rival retailers. We therefore adopt a common opportunity cost in our main specification. Allowing the opportunity cost to vary with V_{ht} yields similar welfare effects, as reported in Column 4 of Table A8.

Q Alternative Replacement Offers

In the main specification, replacement offers add the opportunity cost in full on top of the replacing manufacturer's usual surplus share. We relax this restriction by determining replacement offers through Nash bargaining over surplus net of

the opportunity cost. The replacing manufacturer then shares this cost with the retailer. For a replaced product k with retail price p_k and pack size Q_k, the offer becomes

$$c_k^{m'} + \rho_{m'h}(p_k - c_k^{m'}) + (1 - \rho_{m'h})\mu_{m't}Q_k,$$

where $c_k^{m'}$ is the replacing manufacturer's input cost for a pack of the same size. This offer also arises from a separate negotiation over replacement, in which Energizer forgoes Walmart's recaptured margin if agreement is reached.

We compare this alternative with the main specification and a model without replacement offers, in which disagreement leads to delisting. Table A10 reports the estimates and the agreement's effects, with each specification re-estimated using the same moments.

The alternative Nash-bargained offers fit the observed price changes less well, primarily underpredicting Duracell's price increase at rival retailers, but yield similar effects on consumer surplus and the participating firms' joint profit. Without replacement offers, Energizer's opportunity cost no longer weakens retailers' disagreement payoffs in negotiations with Duracell, and the model cannot reproduce Duracell's price increase at rival retailers. Nevertheless, the estimated agreement has qualitatively similar effects on consumer surplus and joint profit. These results indicate that replacement threats are important for explaining the observed increase in Duracell's prices, while the broader welfare effects are driven primarily by Energizer's raising-rivals'-costs incentive.

R Fringe Brands in the Bargaining Game

The main specification holds fringe brands' wholesale prices fixed at their recovered pre-agreement levels. We relax this assumption by allowing fringe suppliers to bargain with retailers in the same way as private-label suppliers, using the private-label bargaining parameters for each retailer type and an input cost of \$0.20 per battery, close to the estimated private-label cost. Fringe wholesale prices are then renegotiated in both the agreement and the no-agreement equilibria. All other parameters are held at the main estimates.

Table A11 compares the agreement's effects across the two specifications. Allowing fringe suppliers to bargain barely changes them: consumer surplus falls by

	Main Specification	Nash-Bargained Replacement Offers	No Replacement Offers
Panel A: Estimates			
θ_W	0.312	0.324	0.333
θ_E	0.695	0.756	0.818
Panel B: Retail Price Changes, Data and Model (log points)			
Walmart, Energizer (data: 0.012)	0.003	0.003	-0.019
Walmart, Duracell (data: 0.047)	0.041	0.041	0.030
Other retailers, Energizer (data: 0.089)	0.101	0.108	0.098
Other retailers, Duracell (data: 0.073)	0.068	0.053	0.000
Panel C: Effects of the Agreement (%)			
$\%\Delta CS$	-6.45	-6.09	-3.26
$\%\Delta\pi_{\text{Walmart+Energizer}}$	9.19	8.82	6.37
$\%\Delta TS$	-2.26	-2.08	-1.06

Notes: The table compares three specifications, each re-estimated using the same moments. Column 1 reports the main specification, Column 2 uses Nash-bargained replacement offers, and Column 3 excludes replacement offers so that disagreement leads to delisting. Panel A reports the agreement parameters, Panel B compares observed and model-implied post-agreement retail price changes, and Panel C reports the agreement's effects relative to no agreement, as in Column 2 of Table 8.

Table A10: Alternative Replacement Offers

6.6 percent rather than 6.5 percent, the parties' joint profit rises by 8.7 percent rather than 9.2 percent, and retail price changes differ by at most 0.2 percentage points. Fringe brands account for about 8 percent of batteries sold in the pre-agreement quarter, so their wholesale terms have little effect on the agreement's impact.

S Welfare Calculation

We compute the following welfare measures for a given vector of equilibrium wholesale prices:

Consumer Surplus. Using the nested-logit exact formula, consumer surplus is given by

$$CS = \sum_t M_t \cdot \frac{1}{-\alpha} \ln\left(1 + \sum_g D_g^{1-\lambda}\right),$$

where $D_g = \sum_{j \in g} \exp(U_j/(1-\lambda))$ is the nest-level inclusive value for nest g, and λ is the nesting parameter, as in Section 6.1.

	Main Specification	Fringe Bargaining
Panel A: Effects of the Agreement (%)		
$\%\Delta CS$	-6.45	-6.59
$\%\Delta \pi_{\text{Walmart+Energizer}}$	9.19	8.73
$\%\Delta TS$	-2.26	-2.22
Panel B: Retail Price Changes (%)		
$\%\Delta p^{\text{Walmart}}_{\text{Energizer}}$	0.73	0.54
$\%\Delta p^{\text{Walmart}}_{\text{Duracell}}$	4.33	4.30
$\%\Delta p^{\text{Others}}_{\text{Energizer}}$	10.67	10.61
$\%\Delta p^{\text{Others}}_{\text{Duracell}}$	7.07	7.07

Notes: The table compares the main specification, which fixes fringe wholesale prices at their recovered pre-agreement levels, with an extension in which fringe suppliers bargain with retailers using the private-label bargaining parameters. Both columns use the main parameter estimates. The panels report the agreement's effects relative to no agreement, as in Column 2 of Table 8.

Table A11: Robustness to Bargaining by Fringe Suppliers

Upstream Manufacturer Profits. Upstream manufacturer profit is computed as

$$\Pi^U = \sum_{j,g,t} \left(\omega^*_{jgt} - c_j\right) s_{jgt} \, M_t,$$

where $c_j = mc_{m(j)} \times Q_j$ is the estimated upstream marginal cost.

Downstream Retailer Profits. Downstream retailer profit is computed as

$$\Pi^D = \sum_{j,g,t} \left(p_{jgt} - \omega^*_{jgt} - \psi_{jg}\right) s_{jgt} \, M_t.$$

Walmart's and Energizer's profits exclude the rebate $\theta_W R_t$ in Equation (6). At the estimated equilibrium, R_t is close to zero because $\kappa_t = s_t/(1 - s_t)$, and treating $\theta_W R_t$ as a transfer from Energizer to Walmart would change each firm's profit change by less than 0.01 in the units of Table 8.

The effect of each counterfactual on a given welfare measure is computed as the difference between the counterfactual equilibrium and the model-implied no-agreement benchmark, both solved in the pre-agreement quarter, as described in Section 8.

T First-Stage Instrument Strength

Table A12 reports first-stage statistics for price and the log within-retailer share, the two endogenous variables in the main demand specification in Column 2 of Table 5. The excluded instruments strongly predict both variables, including conditional on the other endogenous variable.

	Price	$\ln s_{j\|gt}$
Partial R^2	0.0016	0.0421
F statistic	158	4365
Cluster-robust F statistic	64.5	451.2
Sanderson–Windmeijer F statistic	210	5807
Number of excluded instruments	4	4
Number of product-market observations	397,362	397,362

Notes: The table reports first-stage statistics for Column 2 of Table 5. Each endogenous variable is regressed on the pack-size and local differentiation instruments, controlling for the fixed effects. Cluster-robust F statistics use CBSA–retailer–brand clusters. Sanderson–Windmeijer F statistics assess instrument strength for each endogenous variable conditional on the other.

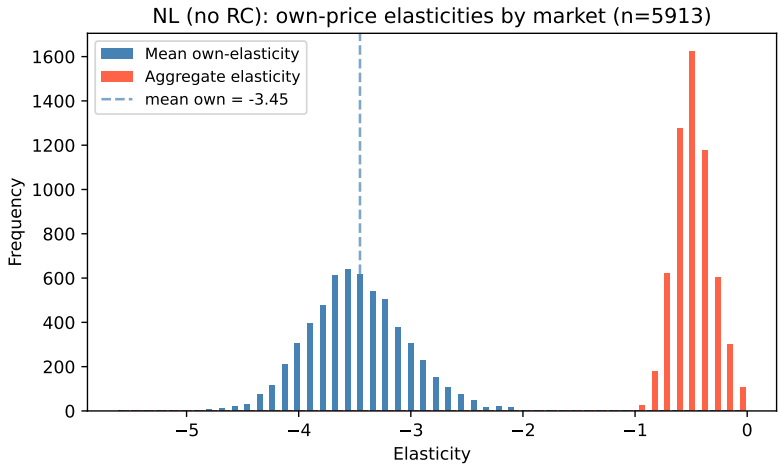
Table A12: First-Stage Instrument Strength

U Price Elasticity

Figure A11 plots the distribution of price elasticities implied by the main specification in Column 2 of Table 5. The average own-price elasticity is around -3.45, while the aggregate elasticity of non-Dollar Tree products is approximately -0.50. Because total battery demand is fixed and Dollar Tree is the reference alternative, the aggregate elasticity measures the response of total sales of all other products to a uniform increase in their prices, reflecting substitution toward Dollar Tree. It is not an elasticity of total battery demand.

V Sensitivity to Demand Parameters

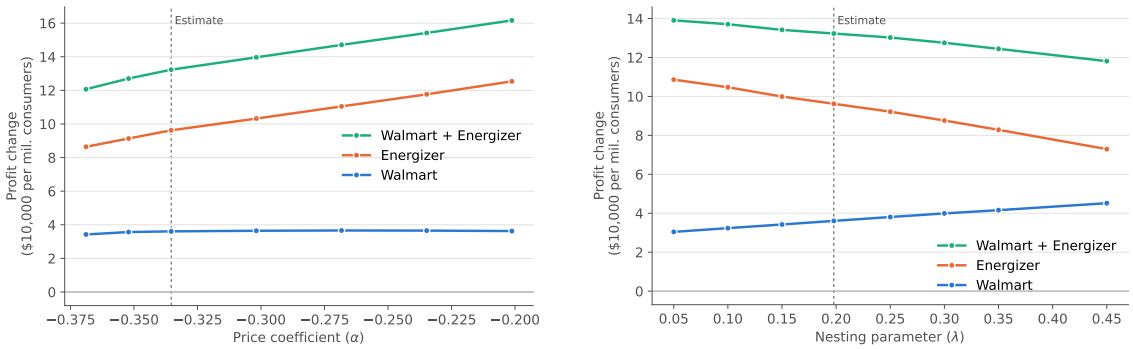
Figure A12 shows how the gains from the agreement vary with demand parameters. At each grid point, we recompute the agreement counterfactual using the



Notes: The figure shows the distribution of price elasticities across markets implied by the main specification in Column 2 of Table 5.

Figure A11: Price Elasticity

corresponding value of α or λ in Equation (2), holding supply-side parameters at their estimates. When varying λ, we also recompute mean utilities to preserve observed market shares.



(a) Price Coefficient α **(b)** Nesting Parameter λ

Notes: The figure plots profit changes from the Walmart–Energizer agreement as the price coefficient α varies from 0.6 to 1.1 times its estimate in Figure A12a and as the nesting parameter λ varies from 0.05 to 0.45 in Figure A12b, holding other parameters at their estimates. Changes are relative to no agreement, in \$10,000 per million consumers per quarter. The dashed lines mark the estimates.

Figure A12: Gains from the Agreement and Demand Parameters

W Untargeted Moment Fit

Table A13 compares model predictions with empirical moments not used in estimation, each related to a mechanism in Section 4. Model counterparts are changes between the no-agreement and agreement equilibria, computed using pre-agreement products and demand. The first row reports the change in Duracell's sales relative to Energizer's at Walmart from Column 2 of Table 4, capturing demand steering (M1). The second reports the change in Walmart's share of total battery sales, capturing higher rival retailers' costs (M2 and M3). We estimate this change using quarterly shares in 2018–2019, controlling for a linear trend and quarter-of-year effects. This estimate therefore differs from the unconditional 2018–2021 patterns in Figure 1b. The third row reports Duracell's price change relative to other brands at single-brand retailers from Appendix J, capturing replacement threats. The final row reports private-label price changes at non-Walmart retailers, which the agreement affects only indirectly.

The model reproduces the direction and approximate magnitude of these moments. It predicts a 0.18 log-point decline in Duracell's sales relative to Energizer's at Walmart, compared with 0.23 in the data, and a 1.0 percentage point increase in Walmart's share of battery sales, compared with 2.1 points. It slightly underpredicts Duracell's relative price increase at single-brand retailers and predicts essentially no change in private-label prices, consistent with the data. Table A7 provides a further comparison using price changes across pack sizes, which are not targeted in estimation.

X Two-Part Tariffs and Lump-Sum Transfers

We examine whether the estimated consumer harm depends on linear wholesale pricing. Under a two-part tariff, Walmart and Energizer can instead set the wholesale price at input cost, eliminating double marginalization, and divide the resulting surplus through a fixed fee F. Because F is independent of quantities and prices, it does not enter the pricing first-order conditions. Its level therefore affects only the division of joint profit, not equilibrium prices, consumer surplus, total surplus, or joint profit.

We determine F through Nash bargaining, using Energizer's estimated bar-

	Data	Model
Duracell minus Energizer sales, Walmart (log)	-0.234	-0.179
	(0.125)	
Walmart's share of battery sales (pp)	2.1	1.0
	(1.2)	
Duracell price relative to other brands, single-brand retailers (log)	0.072	0.063
	(0.028)	
Private-label price, other retailers (log)	0.004	0.005
	(0.038)	

Notes: The table compares untargeted empirical moments with model-implied changes between the no-agreement and agreement equilibria. Shares are based on battery units. The first row reports the difference between the Duracell and Energizer coefficients in Column 2 of Table 4. The second reports the post-agreement coefficient from a regression of quarterly shares in 2018–2019 on a post-agreement indicator, a linear trend, and quarter-of-year indicators, with robust standard errors. The third combines the coefficients in Table A5; the final row estimates Equation (1) for private-label products at non-Walmart retailers. Standard errors in the first, third, and final rows are clustered at the product-by-retailer level. Model price changes are weighted by pre-agreement battery units.

Table A13: Untargeted Moment Fit

gaining power, $\hat{\rho}_{EN,W}$. The disagreement outcome follows Equation (5): Walmart delists Energizer's products, other prices remain fixed, and demand reallocates according to the nested-logit system. Energizer receives its disagreement payoff, the additional margin earned at other retailers from consumers diverted away from Walmart, plus a share $\hat{\rho}_{EN,W}$ of the gains from trade.

Table A14 reports the results. Under a two-part tariff without internalization in Column 2, Walmart lowers Energizer's retail prices by 4.1 percent, and consumer surplus rises by 1.1 percent. The parties' joint profit is essentially unchanged, as stronger retail competition offsets the efficiency gain at Walmart. Retaining the estimated θ_E in Column 3 instead reduces consumer surplus by 4.7 percent, nearly three quarters of the loss under the estimated agreement, because prices at rival retailers rise almost as much. Energizer's low bargaining power with Walmart implies a small Nash-bargained fee, and both parties gain without additional compensation. Under full internalization in Column 4, with $\theta_W = \theta_E = 1$, consumer surplus falls by 8.6 percent.

These results show that the estimated consumer harm persists when the linear-pricing restriction is relaxed. Two-part tariffs improve pricing efficiency at Walmart

by lowering the marginal wholesale price, but do not eliminate the incentive to raise rival retailers' costs, which remains the principal source of consumer harm.

		Two-Part Tariff		Full
	Agreement	$\theta_E = 0$	$\theta_E = \hat{\theta}_E$	Internalization
Panel A: Surplus Changes ($10,000 per mil. consumers)				
Consumer Surplus				
ΔCS	-28.287	4.843	-20.737	-37.569
Agreement-Party Profit				
$\Delta\pi_{\text{Walmart+Energizer}}$	13.230	-0.189	13.014	16.554
Retailer Profit				
$\Delta\pi^{S}_{\text{Walmart}}$	3.609	-0.369	5.294	4.509
$\Delta\pi^{S}_{\text{Others}}$	-10.013	-2.280	-13.237	-13.529
Manufacturer Profit				
$\Delta\pi^{M}_{\text{Energizer}}$	9.622	0.180	7.720	12.044
$\Delta\pi^{M}_{\text{Duracell}}$	4.714	-0.744	4.081	5.579
$\Delta\pi^{M}_{\text{Others}}$	2.474	-0.226	2.052	3.367
Total Surplus				
ΔTS	-17.882	1.403	-14.826	-25.599
Fixed Fee				
F		6.636	8.236	
Panel B: Price Changes (%)				
$\%\Delta p^{\text{Walmart}}_{\text{Energizer}}$	0.734	-4.076	-2.735	1.868
$\%\Delta p^{\text{Walmart}}_{\text{Duracell}}$	4.331	0.865	2.913	7.017
$\%\Delta p^{\text{Others}}_{\text{Energizer}}$	10.670	-0.129	10.395	15.298
$\%\Delta p^{\text{Others}}_{\text{Duracell}}$	7.065	-0.093	6.876	9.810

Notes: The table reports outcomes under alternative Walmart–Energizer contracts relative to no agreement. Column 1 reproduces Column 2 of Table 8. Columns 2 and 3 replace linear pricing with a two-part tariff: Walmart purchases Energizer products at input cost and pays a Nash-bargained fixed fee F. Column 2 sets $\theta_E = 0$; Column 3 retains its estimated value. Column 4 sets $\theta_W = \theta_E = 1$, with Walmart internalizing Energizer's profit across all retailers and Energizer's opportunity cost equal to Walmart's average recaptured margin. Panel A reports surplus changes in $10,000 per million consumers, including F in Walmart's and Energizer's profit changes in Columns 2 and 3. $\Delta\pi^{S}_{\text{Others}}$ denotes the profit change for non-Walmart retailers, and $\Delta\pi^{M}_{\text{Others}}$ the profit change for private-label and other-brand manufacturers; the surplus rows of Panel A sum to ΔTS. Panel B reports average percentage retail price changes.

Table A14: Welfare and Price Effects of Alternative Contracts

Y Alternative Rebate Rules for Target Agreements

For agreements involving Target, our main specification removes the share-based rebate component to maximize each pair's joint profit. This yields an upper bound on joint profit gains across the rebate specifications considered when lump-sum transfers allow partners to redistribute gains freely. Without transfers, the manufacturer may prefer a steeper rebate that induces Target to raise competing brands' prices, subject to Target's participation constraint. We therefore retain the share-based component but cap the rebate slope κ_t at the highest value consistent with Target's participation: 0.84 for Target–Energizer and 0.77 for Target–Duracell.

	Target–Energizer		Target–Duracell	
	Joint Profit Maximum	Target Participation	Joint Profit Maximum	Target Participation
Panel A: Surplus Changes ($10,000 per mil. consumers)				
ΔCS	-1.046	-2.693	1.115	-1.764
$\Delta\pi_{\text{Target+Manufacturer}}$	4.612	4.102	4.135	3.591
Wholesale Channel	3.089	3.091	1.385	1.395
$\Delta\pi^{S}_{\text{Target}}$	0.992	0.005	1.277	0.010
$\Delta\pi^{M}_{\text{Energizer}}$	3.621	4.098	-0.300	-0.803
$\Delta\pi^{M}_{\text{Duracell}}$	0.317	-0.599	2.858	3.582
ΔTS	-0.279	-2.395	1.414	-0.786
Panel B: Price Changes (%)				
$\%\Delta p^{\text{Target}}_{\text{Energizer}}$	-8.213	-8.181	0.233	7.888
$\%\Delta p^{\text{Target}}_{\text{Duracell}}$	0.604	11.175	-15.207	-15.232
$\%\Delta p^{\text{Others}}_{\text{Energizer}}$	1.382	1.426	0.232	0.443
$\%\Delta p^{\text{Others}}_{\text{Duracell}}$	0.867	0.947	0.656	0.729

Notes: The table reports outcomes of the Target–Energizer and Target–Duracell agreements relative to no agreement. "Joint Profit Maximum" removes the share-based component of the rebate, as in Columns 3 and 4 of Table 9. "Target Participation" retains the share-based component but caps its slope at the largest value at which Target does not lose from the agreement. "Wholesale Channel" denotes the part of the joint profit change attributable to the wholesale channel (θ_E). Panel A reports surplus changes in $10,000 per million consumers. Panel B reports average percentage retail price changes; "Others" excludes Walmart and Target.

Table A15: Target Agreements under Alternative Rebate Rules

Table A15 compares the specifications. Under the participation cap, Duracell's price increase at Target under Target–Energizer rises from 0.6 to 11.2 percent. The consumer surplus loss increases from 0.2 to 0.6 percent, while the joint profit gain

falls from 11.5 to 10.3 percent. Under Target–Duracell, consumer surplus falls by 0.4 percent rather than rising by 0.3 percent. The wholesale-channel-only results are unchanged. Under either specification, agreements involving Target have much smaller effects on consumer surplus than Walmart–Energizer.