Vertical Control and Retail Competition: Evidence from Consumer Battery Industry*

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Abstract

This paper examines the impact of a vertical agreement between a downstream retailer and an upstream manufacturer in the context of the U.S. consumer battery industry, using detailed consumer receipt panel data. Following the agreement between Walmart (the retailer) and Energizer (the manufacturer), Walmart increases the retail prices of Duracell, Energizer's main competitor, while Energizer increases the wholesale prices charged to other retailers competing with Walmart. We document a shift in Walmart's sales from Duracell toward Energizer and retail price increases of about 6–7 percent for both brands across major retailers. To interpret these patterns, we estimate a model of consumer demand and retailer–manufacturer bargaining that treats Walmart and Energizer as an integrated party in the post-agreement period. We show that this conduct can be profitable: by altering pricing incentives across brands and retailers, it softens downstream competition and raises rival retailers' costs. Counterfactual analyses indicate that the agreement raises prices market-wide, reduces consumer welfare and downstream profits, and benefits upstream rivals that are not party to the agreement.

Keywords: Vertical Restraints, Coordination, Wholesale Price Bargaining, Consumer Retailing

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1 Introduction

Vertical relationships between firms, such as agreements between manufacturers and retailers, are key determinants of prices, product availability, and competition in many markets. A longstanding concern in antitrust is that these arrangements, including resale price maintenance (RPM), most-favored-nation (MFN) clauses, and other preferential agreements, may facilitate coordination, foreclose rivals, or otherwise harm competition.[1] Yet empirical evidence on how vertical restraints are jointly implemented to sustain coordination remains limited. This paper studies a novel form of vertical conduct that has received little attention in the literature, where a major downstream retailer gives preferential treatment to an upstream manufacturer, which in turn raises wholesale prices charged to rival retailers, in the context of the U.S. consumer battery industry.

The U.S. consumer battery industry is highly concentrated, with Energizer and Duracell together accounting for about 70% of sales. Private-label products from major retailers such as Costco, Amazon, and Dollar Tree capture a significant share of the remaining market.[2] On the retail side, sales are dominated by a small group of retailers, Walmart, Dollar Tree, Amazon, Dollar General, Costco, and Target, which together account for more than 65% of total purchases. While Walmart and Target remain heavily reliant on Energizer and Duracell, retailers such as Dollar Tree and Amazon emphasize their own private-label offerings.

The data for the empirical analyses come from an omni-channel consumer panel provided by Numerator, covering household purchases between 2018 and 2021 across both in-store and online channels in the United States. The data provide detailed trip-level information on retailers, product categories and descriptions, and prices for each product listed on purchase receipts.[3] We focus on household disposable batteries, and because different types of batteries are difficult to substitute, we restrict our analysis to AA (double A) batteries, which account for the majority of household battery purchases (43.23%).[4] In total, our sample consists

[1]These practices are typically evaluated under Section 1 of the Sherman Act, which governs agreements in restraint of trade.

[2]Smaller brands including Kodak, ACDelco, and Panasonic hold only a marginal position relative to the major brands.

[3]We exclude data from 2022 onward due to significant price increases driven by inflation, which makes it difficult to separate the effects of the vertical agreement from those of inflation.

[4]We extract the battery type (e.g., AA, AAA, AAAA, C, D, and 9V) and pack size (e.g., 4, 8, and

of approximately 1.87 million AA battery purchases made by 564,796 households. Most of these batteries are purchased alongside a wide range of other goods, with the majority of transactions occurring in physical stores and only 11% online, primarily via Amazon.

We focus on a case study. In April 2023, consumers and retailers filed proposed class actions against Walmart and Energizer, alleging a vertical agreement to inflate disposable battery prices (Portable Power v. Energizer 2023). The allegations center on two claims: (i) Energizer raised wholesale prices for all retailers except Walmart, forcing competitors to increase their prices and enabling Walmart to charge more than it could in a competitive market; and (ii) in return, Walmart protected Energizer by raising its own prices for Duracell batteries so as not to undercut Energizer, thereby weakening Duracell's competitiveness. This arrangement allegedly allowed Energizer to benefit both from higher wholesale revenues and from reduced competition with its main rival.[5]

We find that this vertical agreement reshaped retailer competition. In particular, the retail battery market experienced a notable increase in prices and shifts in market shares following the agreement. Most major retailers saw an abrupt rise in battery prices, with the exception of the dollar store, Dollar Tree, a national fixed-price dollar-store chain that maintained its $1 price point. Walmart's market share declined, driven largely by a drop in Duracell sales, much of which shifted to Dollar Tree's private-label brand, E-Circuit. On the other hand, other large retailers such as Costco and Target remained relatively stable in market share.[6]

Furthermore, we decompose the price increases and find that the magnitudes differ across brands and retailers. At Walmart, both Energizer and Duracell prices rose, with Duracell experiencing the larger increase. As a result, sales shifted away from Duracell toward Energizer. At other retailers, however, Energizer's price increase exceeded that of Duracell, leading to a relatively larger sales decline for Energizer and a relative gain for Duracell. Overall, Energizer's and Duracell's prices increased by approximately 6–7%, while their sales declined by about

12 pieces per pack) from product descriptions. In the empirical analysis, we define a product as a specific combination of battery line (e.g., Energizer MAX or Duracell Coppertop) and package size.

[5]As of February 2024, although the court had not ruled on the merits, it denied the defendants' motions to dismiss, thereby permitting the litigation to proceed to discovery.

[6]Amazon gradually gained market share from 2020 onward, consistent with the broader trend toward online shopping.

16–17%.[7] These results align with the intended effects of the vertical agreement. The findings parallel those of Miller and Weinberg (2016), though their context involves a horizontal merger, while ours concerns vertical control and highlights how the magnitude of retail price increases differs not only between Energizer and Duracell but also between Walmart and other retailers.[8]

We develop and estimate an industry model of consumers, retailers, and manufacturers to capture the effects of this vertical agreement. First, consumer demand for batteries is modeled using a nested logit framework, where retail prices, product and retailer attributes, and time effects jointly determine indirect utility. The nesting parameter captures within-retailer correlation, allowing consumers to substitute more easily across products offered by the same retailer. Second, because batteries are considered a necessity, we treat demand as inelastic, meaning consumers must purchase from one of the available retailers or the outside option, Dollar Tree.[9] Under this assumption, market size is defined as the battery purchases observed in the data.

Retailers' pricing is modeled as Bertrand competition in the period before the 2019 vertical agreement, where retailers set prices to maximize profits based on marginal costs, which are assumed to equal wholesale prices.[10] For Walmart in the post-period, pricing differs from the pre-agreement period, as Walmart takes Energizer's profit into account and can also set Energizer's wholesale prices for other retailers. This vertical structure effectively lowered Walmart's marginal cost for Energizer products but created incentives to raise Energizer's wholesale prices at competing retailers. This vertical-integration assumption is a modeling device that captures the alignment of incentives between Walmart and Energizer, effectively allowing them to jointly maximize profits, as is standard in models of horizontal

[7] Although prices and sales for other brands also increased, these changes are not statistically significant.

[8] Miller and Weinberg (2016) document an abrupt increase in retail prices for ABI and MillerCoors following the horizontal merger between Miller and Coors in the beer industry. We find that the retail prices of Energizer and Duracell rose sharply after the vertical agreement, which could suggest upstream coordination. However, we test firm conduct using the framework of Duarte et al. (2024), and upstream coordination models are rejected; see Appendix F.

[9] We treat Dollar Tree as an outside option, with its fixed $1 price taken as exogenous. In the counterfactual, we therefore do not consider any strategic pricing response by Dollar Tree to other retailers' or brands' pricing, which is consistent with our empirical evidence in Section 3.1.

[10] In practice, there may be additional marginal costs arising from labor or storage. However, since retailers typically offer a large assortment of other non-battery products simultaneously, and batteries are small in both price and size, these costs can be considered negligible.

coordination. The key mechanism is not formal integration itself, but rather that it allows sales through the favored retailer to be more valuable to the manufacturer. Importantly, the model does not impose any explicit no-undercutting or parity rule on the manufacturer. Instead, retail prices are determined endogenously as wholesale prices and multi-product pricing incentives adjust across retailer–brand pairs, allowing the model to replicate the observed pricing patterns that advantage the parties to the agreement without relying on specific but unobserved RPM or MFN instruments.

We model wholesale prices as being determined through Nash-in-Nash bargaining between manufacturers and retailers, with outcomes driven by input costs (the manufacturing cost per piece of battery), bargaining power, and disagreement payoffs. In the periods after the vertical agreement, the disagreement payoffs for bargaining between non-Walmart retailers and Duracell decrease because Energizer charges them higher wholesale prices. This, in turn, enables Duracell to raise its wholesale prices as well, while holding bargaining power and manufacturing costs constant.

The estimation is carried out in three steps: (i) we estimate the demand system, (ii) we map retail prices to marginal costs, which are also taken as wholesale prices, and (iii) we estimate the bargaining model to obtain bargaining power and input costs that match the observed wholesale prices. First, demand is specified as a nested logit model, and parameters are estimated following Berry (1994), exploiting post-agreement price variation across the five retailers to identify price elasticity. Second, in the pre-agreement period, wholesale prices are obtained from the pricing first-order condition that recovers marginal costs under Bertrand price competition. In the post-agreement period, however, the Walmart–Energizer pricing equation allows us to recover Energizer's input cost.

Third, because high wholesale prices may be driven by either input costs or manufacturer bargaining power, we identify these parameters by assuming they remain constant over the short horizon of the estimation sample (one month before and after the agreement), so that changes in wholesale prices across periods help separate bargaining power from input costs. In particular, input costs are identified from the average level of wholesale prices, while bargaining power is identified from differences in wholesale prices following re-bargaining in the post-agreement period. We solve for input costs and bargaining power such that the implied

wholesale prices match the data. We estimate the input cost and bargaining power for each of the two national brands (Energizer and Duracell), allowing bargaining power to vary across four retailer types (Walmart, large, medium, and small).[11] For private-label products, we allow both input costs and bargaining parameters to vary by retailer category, as these products may be sourced from different Original Equipment Manufacturers (OEMs). Here, we use a coarser retailer classification (medium+large+Walmart combined and small) due to the limited private-label sales for Walmart and large retailers.[12] In addition, since Energizer's input cost is already estimated in the second step, we estimate a total of 14 parameters.

First, the demand estimates suggest that the correlation parameter of utilities among products within the same retailer in the nested logit is approximately 0.33 to 0.49, indicating that consumers are more likely to substitute among products offered by the same retailer. Moreover, the implied average own-price elasticity is around -2.81, while the aggregate price elasticity with respect to the outside option is relatively small, at approximately -0.31.

Second, the estimates from solving the retail pricing equations indicate that wholesale prices increased noticeably in the period after the vertical agreement relative to the period before. This aligns with our empirical finding, based on DecaData, which contains wholesale prices for only a limited set of products and a small subset of retailers. that wholesale prices increased. This pattern helps explain the rise in retail prices following the vertical agreement. This highlights the importance of modeling the rebargaining process to capture these changes.

Third, the estimates from the bargaining model indicate that larger retailers tend to have greater bargaining power with Energizer, Duracell, and private-label manufacturers. The marginal input cost of manufacturing a single battery is approximately 0.25 for Energizer and 0.35 for Duracell. We also show that the bargaining model estimates align closely with the changes in wholesale prices obtained from the retail pricing equations, which are used as empirical moments in the estimation.

We first evaluate the Walmart–Energizer agreement relative to a benchmark

[11]The large, medium, and small retailer categories correspond to battery sales at the 75th percentile and above, the 50th to 75th percentiles, and the 25th to 50th percentiles, respectively.

[12]We exclude modeling bargaining with other small brands, since most retailers offer the three main brands (Energizer, Duracell, and private label), and the remaining brands account for only a small share of the overall market (see Table 1).

with no agreement and find that the vertical conduct is profitable at the expense of consumer welfare: the Walmart–Energizer pair gains jointly, rival retailers lose, and consumers are substantially worse off as retail prices rise across the market. Duracell and other manufacturers also benefit, as downstream competition is softened, allowing them to charge higher wholesale prices.

We then consider three counterfactual equilibria of different retailer–manufacturer pairs in the vertical agreement: (i) Walmart with Duracell instead of Energizer; (ii) Target with Energizer instead of Walmart; and (iii) Duracell with Target.[13] We find that the Walmart–Duracell agreement generates greater consumer harm than Walmart–Energizer because Walmart's smaller share in Duracell gives it stronger incentives to raise Duracell's prices at rival retailers compared to an agreement with Energizer. When Target is part of the agreement instead of Walmart, efficiency gains at Target are outweighed by its weaker market power, which leads to more aggressive wholesale and retail price increases elsewhere. Among these scenarios, the Target–Energizer case results in the largest consumer welfare loss, followed by Target–Duracell, while Walmart–Energizer produces the smallest loss.

These counterfactual results yield three broader policy implications. First, they highlight the incentives of multi-product retailers and manufacturers to coordinate and and be profitable. Second, they show that such vertical conduct can substantially harm consumers. Third, the greatest harm need not arise from the largest firms: agreements involving smaller retailer–manufacturer pairs can also be profitable and may generate even larger price increases and consumer welfare losses.

1.1 Literature Review

This paper contributes first to the literature on vertical restraints and related manufacturer-retailer agreements. Existing theoretical work studies arrangements such as resale price maintenance (RPM), most-favored-nation (MFN) clauses, and related price-parity provisions, highlighting both efficiency rationales and anticompetitive effects through softer competition, facilitated coordination, and reduced entry (Telser 1960; Klein and Murphy 1988; Jullien and Rey 2007; Edelman

[13] Target is chosen as it is the second-largest regular retailer, excluding dollar stores, Amazon (online store), and Costco (bulk purchase).

and Wright 2015; Boik and Corts 2016; Johnson 2017). Empirical evidence likewise shows that vertical contractual provisions can materially affect prices, markups, and market outcomes through nonlinear pricing and RPM (Berto Villas-Boas 2007; Mortimer 2008; Bonnet and Dubois 2010), exclusive dealing (Nurski and Verboven 2016), rebates (Conlon and Mortimer 2021), agency pricing (De los Santos, O'Brien, and Wildenbeest 2018) and price-parity clauses in platforms (Ennis, Ivaldi, and Lagos 2023). Our paper studies a distinct vertical arrangement that combines RPM-like and parity-like features without an explicit resale-price or parity clause. We provide empirical evidence that this conduct can be profitable and soften downstream competition, harming consumers and rival retailers while also benefiting the rival manufacturer.

This paper also contributes to the empirical literature on the competitive effects of vertical integration. Most closely related is Luco and Marshall (2020), who show in a multiproduct downstream setting that vertical integration lowers prices where double marginalization is eliminated but raises prices for other products in the integrated firm's portfolio. Crawford et al. (2018) provide related structural evidence that vertical integration can alter incentives through foreclosure and raising rivals' costs.[14] Our setting differs because it involves a vertical agreement rather than merger or common ownership, but we use the logic of integration to model how partial joint-profit internalization reshapes pricing incentives across products and firms. This yields implications not established in the existing literature: integration-like spillovers can raise prices across a multiproduct firm's entire portfolio and benefit upstream rivals, even as downstream profits and consumer welfare fall.

Finally, this paper relates to the empirical literature on negotiated vertical relationships and wholesale contracting. This work studies how bargaining, wholesale terms, and disagreement payoffs shape prices and welfare in vertical markets, including hospitals and healthcare (Grennan 2013; Gowrisankaran, Nevo, and Town 2015; Ho and Lee 2019; Cuesta, Noton, and Vatter 2024), multichannel television

[14]More broadly, the vertical-integration literature emphasizes the tradeoff between efficiency gains from eliminating double marginalization and anticompetitive harms from foreclosure or raising rivals' costs. Early theoretical work includes Perry (1989), Salinger (1988, 1991), and Ordover, Saloner, and Salop (1990). Empirical studies document evidence of both forces, including price reductions in cement and ready-mixed concrete (Hortaçsu and Syverson 2007) and foreclosure-related harms in cable television (Waterman and Weiss 1996; Chipty 2001; Suzuki 2009) and wholesale gasoline (Hastings and Gilbert 2005).

(Crawford and Yurukoglu 2012; Crawford et al. 2018), e-books (De los Santos, O'Brien, and Wildenbeest 2018), advertising (Donna et al. 2024), and grocery and other consumer markets (Ellickson et al. 2018; Noton and Elberg 2018; Hristakeva 2022; Demirer and Rubens 2025). We use this framework to recover bargaining power and marginal costs from the change in vertical conduct, and to trace how shifts in disagreement payoffs pass through to wholesale terms and market-wide prices. Our contribution is to bring this framework to a new form of vertical conduct, using the change induced by the agreement to identify bargaining power and marginal costs and to quantify how it affects wholesale terms and market-wide prices.

The remainder of this paper is organized as follows. Section 2 describes the institutional background of the consumer battery industry and the data used in the empirical analysis. Section 3 presents empirical evidence on price and market share trends before and after the vertical agreement between Walmart and Energizer. Section 4 outlines the empirical model, and Section 5 discusses the estimation procedure. Section 6 reports the estimation results and counterfactual simulations. Section 7 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. The main battery brand is Energizer, followed by Duracell in second place. Energizer and Duracell have together accounted for approximately 70% of U.S. disposable battery sales over decades.[15] Rayovac is the

[15]See https://natlawreview.com/article/battery-merger-shows-shortcomings-antitrust-policy-critics-say.

third-largest brand; however, it was acquired by Energizer through its purchase of Spectrum Brands' battery and lighting division in 2018. Similarly, Eveready was rebranded as Energizer in 2000. In our empirical analysis, we therefore categorize Rayovac and Eveready as subsidiaries of Energizer.

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 of market share consists of 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. These major retailers each accounted for more than 3% of battery sales in 2018, as shown in Table 1, and together represented over 65% of total battery sales. The next tier, including Family Dollar, Kroger, Sam's Club, Home Depot, Harbor Freight Tools, Lowe's, Walgreens, CVS, ShopRite, and Menards, each has more than 1% of battery sales in 2018.[16] With the exception of Amazon, battery sales for these retailers are primarily from physical store purchases. Walmart and Target record slightly higher online sales compared with other retailers, but these remain a small share of total sales, so we treat physical and online channels as belonging to the same retailer.

Battery retailers are typically multi-product sellers, carrying Energizer, Dura-

[16]Family Dollar was acquired by Dollar Tree in 2015 (https://vindyarchives.com/news/2015/jul/07/dollar-tree-acquires-family-dollar/), and Sam's Club was founded by Walmart. We therefore categorize Family Dollar as part of Dollar Tree and Sam's Club as part of Walmart.

cell, 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, such as Dollar Tree, Dollar General, and Family Dollar, account for a significant share of battery purchases among major retailers. However, Dollar General and Family Dollar do not necessarily sell batteries for one dollar. Dollar General offers both branded and private-label products at lower prices than many competitors, though typically above one dollar. Family Dollar also offers branded products at discounted prices, but not necessarily for one dollar. On the other hand, 99% of battery purchases at Dollar Tree are priced exactly at one dollar.

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, \$11.78, \$6.94, and \$11.78. Energizer MAX and Duracell Coppertop are flagship alkaline battery lines from Energizer and Duracell, respectively, designed for everyday devices.[17] 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

[17]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.

	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

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.[18] 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 by 20% in 2019 and 40% in 2020. 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

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

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

The Portable Power Case. A concrete example cited in the complaint, Portable Power v. Energizer (2023), concerns Portable Power, an online retailer selling via Amazon. The plaintiffs allege that when Portable Power attempted to undercut Walmart's prices in November 2018, Energizer increased its wholesale prices by 50–85%.

According to the complaint, in January 2021 an Energizer sales representative is alleged to have forwarded an email from Energizer's Project Atlas team that identified Portable Power as one of the top ten Amazon sellers "in violation" of Energizer's pricing policies. The plaintiffs further claim that this enforcement was tied to Walmart's demands, citing one internal message that allegedly stated: "This is 1000% about Walmart and wanting the best price."

The complaint also alleges that on February 1, 2021, the same sales representative warned Portable Power that Energizer would halt shipments unless its retail prices matched Walmart's. Later that month, the representative is said to have offered a revised wholesale quote designed to permit a markup only if Portable Power kept its retail prices closely aligned with Walmart's. For additional background on the case, see Portable Power v. Energizer (2023).

Case Proceeds to Discovery Phase. On February 9, 2024, the court denied Walmart and Energizer's motions to dismiss the case and lifted the stay on discovery. It recognized that the plaintiffs' claims, including Walmart's preferential pricing power, Energizer's wholesale increases, Project Atlas enforcement, and market dominance, were plausible at the pleading stage; although not a ruling on the merits, the decision allows the litigation to proceed into discovery phase.

Alleged Vertical Agreement. According to the complaints, the agreement between Walmart and Energizer involves two main points: (1) Energizer raised

wholesale prices for all retailers except Walmart, forcing others to increase prices and allowing Walmart to charge more than in a competitive market. (2) In exchange, Walmart protects Energizer by raising its prices for Duracell batteries so as to avoid undercutting Energizer batteries. In this way, Energizer profits not only from higher wholesale revenues but also by making its main competitor less competitive at Walmart.[19]

In early 2021, there were reports that Energizer punished some retailers who priced below Walmart by first issuing warnings and then raising wholesale prices if they did not comply. Our model did not focus on this conduct, as it occurred later in the data period and appears limited in scale, given that Walmart's prices were usually lower than those of most retailers.

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.[20] 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 visited or online venue (e.g., Walmart, Target, or Amazon), along with the price, quantity, brand, product category, and detailed product description for every product listed. We identify battery purchases based on the major category "Household Batteries." The purchase of batteries is relatively infrequent; overall, trips that include household batteries account for only 0.98% of total shopping trips in our data. We also observe

[19] See https://www.findlaw.com/legalblogs/consumer-protection/a-battery-of-lawsuits-against-energizer-and-walmart-for-price-fixing/.

[20] Numerator collects data from users who voluntarily upload their receipts, so the consumer panel may break if participants stop uploading. 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 receipts recorded during this period, which corresponds to a cross-sectional snapshot of consumer receipts. In Appendix B, we compare consumer characteristics before and after the case study period of focus and find no substantial differences.

consumer characteristics (see Appendix B) and map each consumer's five-digit ZIP code to the corresponding core-based statistical area (CBSA), subsequently defining each CBSA-by-quarter as a market.

We use text analysis to extract the battery type (i.e., AA, AAA, or others) and size (i.e., 4-, 6-, or 12-pack) from the product description. For example, "Energizer MAX AA Alkaline 8 Pk" is classified as AA batteries in a pack of eight. We focus on AA batteries for our main empirical exercises, which account for 43.23% of household battery purchases, while AAA batteries, the second most popular type, account for 30.61% and exhibit similar empirical patterns. We exclude 5.50% of household battery purchases that do not specify battery types. For products with missing pack information on the receipt, accounting for about 23.54% of purchases, we use retailer, brand, and price information to impute the package size. Appendix A discusses this procedure in detail. Between 2018 and 2021, we observe approximately 1.87 million AA battery purchases made by 564,796 households.

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 17.43 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.

	Mean	Medium	Standard Deviation
Number of Battery Products per Trip	1.18	1.00	0.81
Battery Size	15.38	8.00	15.72
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		1,848,310	
Number of Trips		1,562,501	
No. of Consumers		566,960	

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

3 Empirical Evidence

3.1 Retailer Competition

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 pre-agreement level. 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).[21] The vertical line at the second

[21]XXXFor 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.XXX

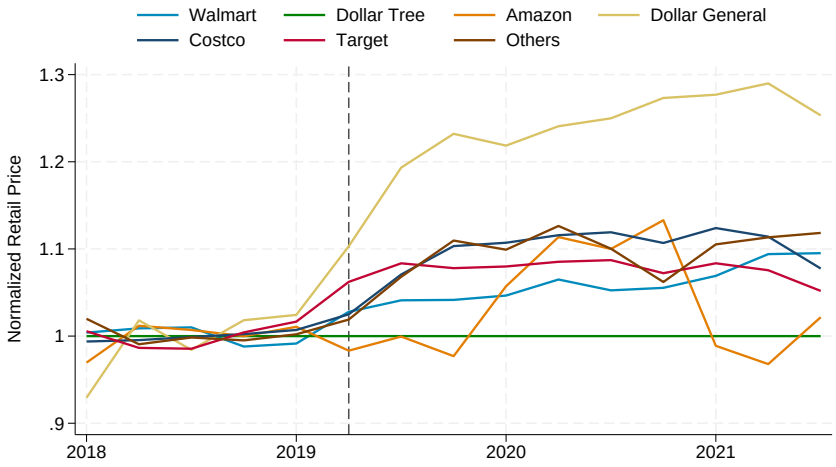
quarter of 2019 marks the timing of the vertical agreement. With the exception of Dollar Tree, all retailers significantly increased their prices after the agreement. Dollar Tree, being a fixed-price retailer, kept its battery products at $1 throughout. Dollar General exhibits a particularly large increase, driven primarily by Energizer products (see the decomposition in Appendix C). Since Dollar General's prices were typically lower than those of other retailers, its battery prices rose more sharply after the agreement to maintain Walmart's competitiveness.

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, 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 D 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.

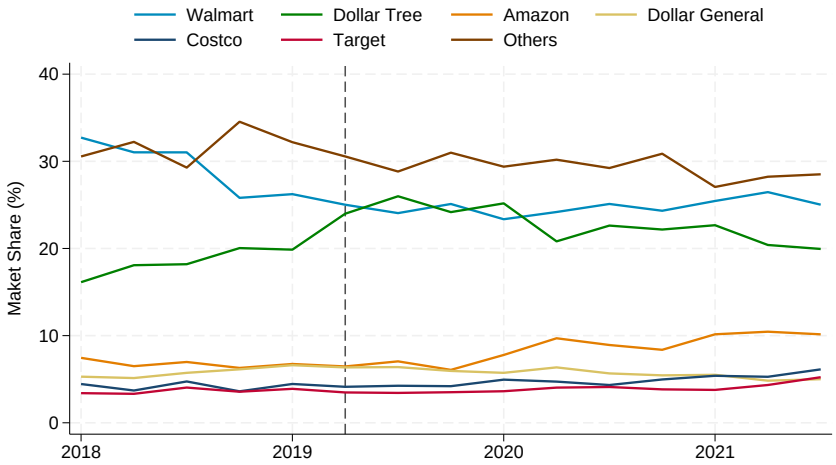
Section 2.2 shows that battery purchases are usually not made as stand-alone purchases but are bundled with other grocery shopping trips. We examine grocery shopping trip patterns by retailer in Appendix E. We find that the overall shares of trips across retailers and the number of other products purchased 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 normalized retailer prices from 2018 to 2021, with prices normalized to each product's pre-agreement level, for Walmart and other retailers, respectively. At Walmart, retail prices of both Energizer and Duracell products increased, with Duracell rising more than Energizer. At other retailers, prices of both brands also increased, but Energizer rose more than Duracell. In Appendix C, we show that private-label batteries do not exhibit a statistically significant increase in prices.



(a) Retail Prices by Retailer

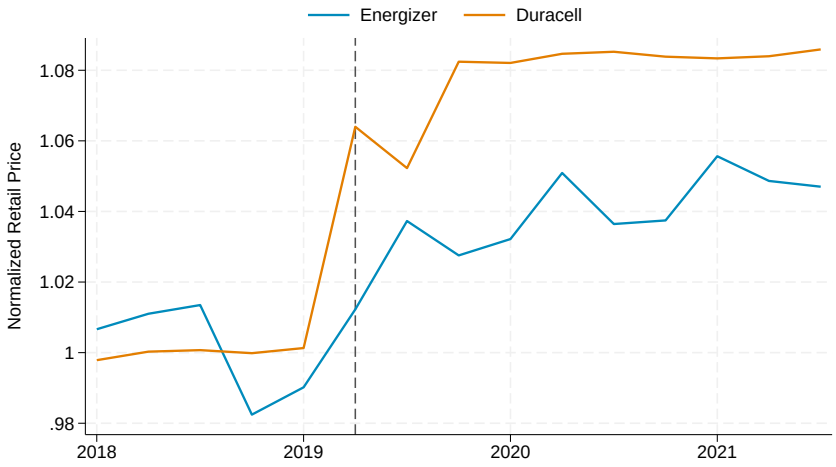


(b) Market Shares by Retailer

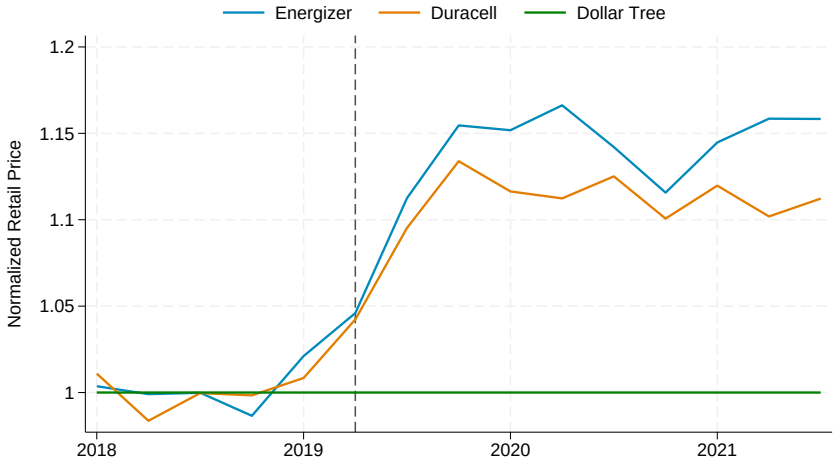
Notes: The upper panel displays quarterly prices from 2018 to 2021 for different retailers, including Walmart, Dollar Tree, Amazon, Dollar General, Costco, Target, and all other remaining retailers, normalized to each product's pre-agreement price. The vertical line at the second quarter of 2019 marks the timing of the vertical agreement. The lower panel shows the quarterly market shares for these retailers.

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

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



(a) Retail Prices at Walmart



(b) Retail Prices at Other Retailers

Notes: The upper panel plots quarterly prices at Walmart for Energizer (including Rayovac and Eveready) and Duracell, normalized to their respective pre-agreement prices for each product. 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 timing of the vertical agreement. The lower panel shows quarterly prices at other retailers for Energizer, Duracell, and Dollar Tree's battery products.

Figure 2: Retail Prices from 2018 to 2021

log of the retail price of product g from retailer j on trip i in quarter t:

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

where the specification includes indicator variables for: (i) Energizer brands in the post-agreement period, (ii) Duracell brands in the post-agreement period, and (iii) all products in the post-agreement period. The fixed effects ϕ_{jg} absorb cross-sectional variation at the product-by-retailer level. We also include a linear time trend τ_t to account for the upward trend in retail battery prices.

		Walmart	Other Retailers
$\mathbb{1}\{\text{Energizer}\}_g \times \mathbb{1}\{\text{Post}\}_t$	0.057***	0.012	0.088***
	(0.022)	(0.014)	(0.024)
$\mathbb{1}\{\text{Duracell}\}_g \times \mathbb{1}\{\text{Post}\}_t$	0.070***	0.047***	0.072***
	(0.021)	(0.014)	(0.022)
$\mathbb{1}\{\text{Post}\}_t$	-0.008		-0.004
	(0.018)		(0.017)
τ_t	0.001*	0.003**	0.001
	(0.001)	(0.001)	(0.001)
Product-by-Retailer Fixed Effects	Yes	Yes	Yes
No. of Observations	1695180	514517	1180663
Adjusted R-squared	0.957	0.934	0.956

Notes: The table reports the estimates from Equation (1) with the log of retail price as the dependent variable. 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. 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

Column 1 of Table 3 reports the regression estimates using all retailer observations. Energizer and Duracell's prices increase by $\exp(0.057) - 1 = 5.9\%$ and $\exp(0.070) - 1 = 7.3\%$, respectively, while prices for other brands do not exhibit a significant change. Columns 2 and 3 of Table 3 separate the estimates for Walmart and other retailers.[22] At Walmart, Energizer's price rises by $\exp(0.012) - 1 = 1.2\%$, although the effect is not statistically significant, whereas Duracell's price increases significantly by $\exp(0.047) - 1 = 4.8\%$, consistent with the agreement that Walmart would raise Duracell's retail prices. At other retailers, Energizer's retail price

[22]For Walmart, we include all Walmart-affiliated retailers, including Walmart, Sam's Club, and Walmart Neighborhood Market. In addition, we exclude $\mathbb{1}\text{Post}_t$ in Equation (1) because the majority of its sales come from either Energizer or Duracell (see Table 1).

increases by $\exp(0.088) - 1 = 9.2\%$, which is larger than Duracell's increase of $\exp(0.072) - 1 = 7.5\%$. Other brands again show no significant change following the agreement, which is consistent with Appendix C, where most of the remaining brands, primarily private-label batteries, do not exhibit a statistically significant increase in prices.

The empirical results are similar to Miller and Weinberg (2016), 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 (2016) find broadly similar magnitudes of price increases across firms, with ABI experiencing only slightly smaller increases than MillerCoors.

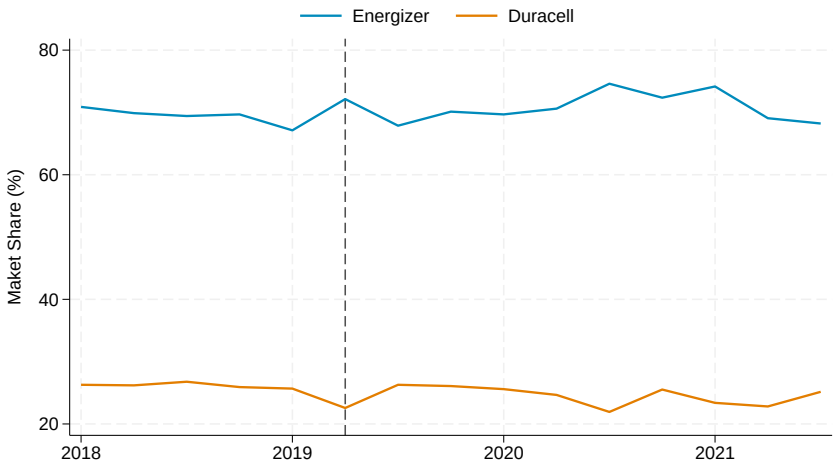
Upstream Coordination. The empirical results may also suggest the possibility of horizontal coordination in the upstream market, or partial coordination between Energizer and Duracell that jointly raises wholesale prices. We therefore test these potential market structures.

We test firm conduct using the framework of Duarte et al. (2024). Specifically, we compare three models: (i) full horizontal coordination in the upstream market, (ii) partial horizontal coordination between Energizer and Duracell in the upstream market, and (iii) vertical integration between Walmart and Energizer. The first two upstream coordination models are rejected. See Appendix F for details on the procedure and results.

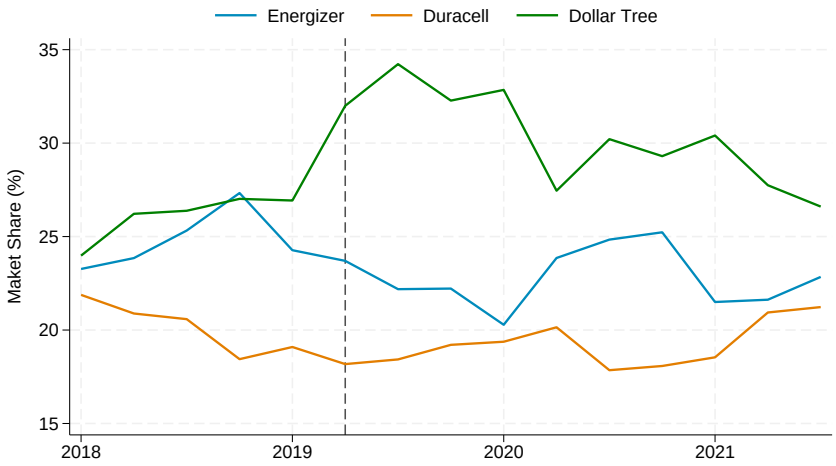
3.3 Battery Sales

Figure 3a and Figure 3b present the shares of battery sales for Walmart and other retailers, respectively. At Walmart, the second quarter of 2019 marks a notable increase in Energizer's sales, accompanied by a decline in Duracell's sales. This shift is consistent with the price changes: within Walmart, sales were steered away from Duracell, which experienced a larger price increase, toward Energizer, which had a smaller price increase. 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 sales gradually declined, while Duracell's share increased, catching up with Energizer by 2022.



(a) Battery Sales Shares at Walmart



(b) Battery Sales Shares at Other Retailers

Notes: The upper panel 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 timing of the vertical agreement. The lower panel 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 estimate the following regression to examine how retailer sales changed

for Energizer, Duracell, and other brands, using Equation (1). The dependent variable is defined as the sales of product g from retailer j in quarter t, and the regression is estimated using Poisson pseudo-maximum likelihood.[23]

		Walmart	Other Retailers
$\mathbb{1}\{\text{Energizer}\}_g \times \mathbb{1}\{\text{Post}\}_t$	-0.177***	-0.069	-0.172**
	(0.069)	(0.085)	(0.077)
$\mathbb{1}\{\text{Duracell}\}_g \times \mathbb{1}\{\text{Post}\}_t$	-0.182*	-0.303**	-0.029
	(0.104)	(0.126)	(0.081)
$\mathbb{1}\{\text{Post}\}_t$	0.170***		0.183***
	(0.059)		(0.062)
τ_t	0.017***	0.025**	0.015**
	(0.005)	(0.012)	(0.006)
Product-by-Retailer Fixed Effects	Yes	Yes	Yes
No. of Observations	33850	1550	32300

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. 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

Column 1 of Table 4 reports the regression estimates using all retailers. Energizer and Duracell's sales decrease by around $\exp(-0.177) - 1 = -16.2\%$ and $\exp(-0.182) - 1 = -16.6\%$, respectively. Column 2 of Table 4 shows that at Walmart, Duracell experiences a much larger sales decrease ($\exp(-0.303) - 1 = -26.1\%$) compared to Energizer ($\exp(-0.069) - 1 = -6.7\%$), which is consistent with the magnitude of the price change. On the other hand, Column 3 of Table 4 shows that at other retailers, Energizer experiences a much larger sales decrease ($\exp(-0.172) - 1 = -15.8\%$) than Duracell ($\exp(-0.029) - 1 = -2.9\%$), consistent with the fact that Duracell's price increase was smaller than Energizer's. Other brands exhibit an increase in sales in the post period, although these increases are

[23]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 likelihood.

not statistically significant. Overall, battery sales show an upward trend, which is captured by the linear time trend.

4 Empirical Model

We build an empirical model of battery demand, retail pricing, and wholesale price bargaining between retailers and manufacturers to capture the patterns of prices and market shares before and after the vertical agreement. We model the agreement as if Walmart and Energizer are vertically integrated, which is a modeling device that captures the alignment of incentives between Walmart and Energizer, effectively allowing them to jointly maximize profits, as is standard in models of horizontal coordination. The key mechanism is not formal integration itself, but rather that it allows sales through the favored retailer to be more valuable to the manufacturer. Importantly, the model does not impose any explicit no-undercutting or parity rule on the manufacturer. Instead, retail prices are determined endogenously as wholesale prices and multi-product pricing incentives adjust across retailer–brand pairs, allowing the model to replicate the observed pricing patterns that advantage the parties to the agreement without relying on specific but unobserved RPM or MFN instruments.

Market Structure. Figure 4a presents the simplified market structure before the vertical agreement, with two upstream manufacturers, A and B, and two downstream retailers, 1 and 2. Each manufacturer is specialized in one brand, which is simplified as a single product in the figure. Both retailers are multi-product retailers, selling both products A and B. Manufacturer A sells its product at wholesale prices c_{1A} and c_{2A} to Retailers 1 and 2, respectively. Similarly, Manufacturer B sells its product at wholesale prices c_{1B} and c_{2B} to Retailers 1 and 2, respectively. Given the wholesale prices, the multi-product retailers then determine the retail prices for products A and B, denoted as p_{1A} and p_{1B} for Retailer 1, and p_{2A} and p_{2B} for Retailer 2.

Figure 4b presents the simplified market structure after the vertical agreement. Suppose Manufacturer A enters into an agreement with Retailer 1. They maximize their joint profit after the agreement; in this case, it is analogous to vertical integration, where Retailer 1 no longer considers the wholesale price c_{1A} but

instead takes into account the input cost of Product A when determining its retail price. Whether p_{1A} increases after integration depends on the trade-off between the efficiency gain from eliminating double marginalization and the additional market power gained by the integrated party. At the same time, the integrated parties can set the wholesale price of Product A to Retailer 2, which may create incentives to raise Retailer 1's Product B prices and increase Retailer 2's costs, that is, to raise both upstream and downstream rivals' costs.

The empirical model incorporates this market structure and allows for incentives to raise downstream or upstream rivals' costs through wholesale or retail prices. We begin with the demand for battery products as follows.

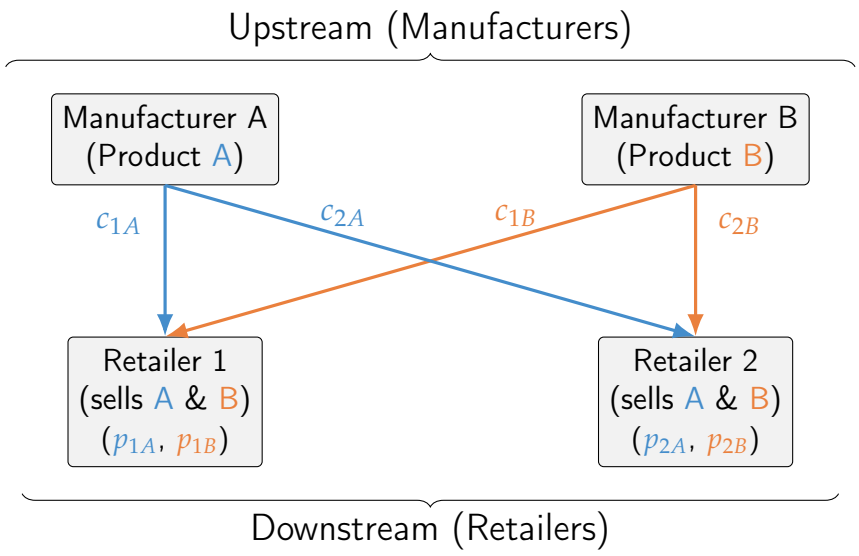
4.1 Demand

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:

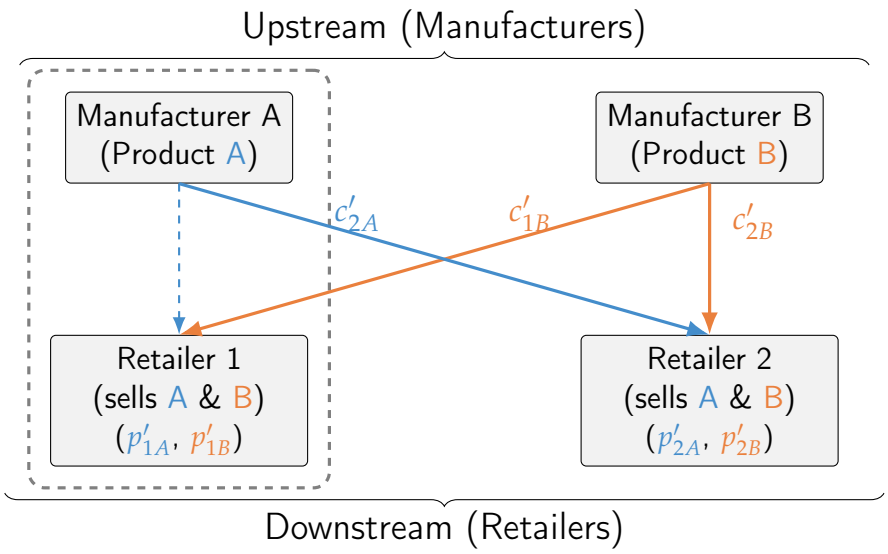
$$u_{ijgt} = ap_{jgt} + \phi_j + \zeta_{h(g)} + \tau_t + \eta_{igt} + (1-\lambda)\varepsilon_{ijgt}, \tag{2}$$

where p_{jgt} represents the retail price, ϕ_j is an index of unobserved product attributes, $h = h(g)$ denotes the retail chain to which county–retailer g belongs, and ζ_h represents an index of unobserved retailer-chain attributes. The term τ_t denotes quarterly fixed effects, and the idiosyncratic group preference η_{igt} follows a distribution such that ε_{ijgt} also follows a Type 1 extreme value distribution. The demand is therefore modeled as a nested logit, where the parameter $0 \leq \lambda < 1$ represents the correlation in utilities that consumers perceive among products within the same retailer. When $\lambda = 0$, the model collapses to the standard logit, and as λ increases, consumers become more likely to substitute toward other battery products within the same retailer.

As batteries are a necessary product, we model demand as inelastic, meaning that consumers must satisfy their unit demand by purchasing from one of the available retailers. Consumers choose the retailer–product pair or the outside option, Dollar Tree, that maximizes their utility. The utility of not purchasing batteries, represented by the Dollar Tree outside option, is normalized to the cost



(a) Pre-Period Market Structure



(b) Post-Period Market Structure

Notes: The upper panel shows the pre-agreement market, where Manufacturers A and B each sell a product to two multi-product retailers, who then set retail prices. The lower panel shows the post-agreement structure, where Manufacturer A and Retailer 1 coordinate pricing and internalize margins. The integrated firm also sets the retail price of Product B and the wholesale price of Product A to Retailer 2.

Figure 4: Market Structure: Pre- and Post-Vertical Agreement

of one dollar ($u_{i0t} = a \times 1$).[24]

[24]This also implies that, in the counterfactual, Dollar Tree's pricing is treated as exogenous,

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 $\delta_{jgt} = ap_{jgt} + \phi_j + \zeta_g + \tau_t + \eta_{igt}$, $D_{gt} = \sum_{l \in \mathcal{J}_{gt}} \exp\left(\frac{\delta_{lgt}}{1-\lambda}\right)$, 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 the outside option ($g = 0$). 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 $s_{jgt} = s_{j|gt} \times s_{gt}$.

4.2 Retailer Pricing

Retail prices follow standard Bertrand price competition, as outlined in Section 4.2.1. For Walmart in the post-period, pricing differs from the pre-agreement period, as Walmart takes Energizer's profit into account and can also set Energizer's wholesale prices for other retailers. We discuss this change in Section 4.2.2.

4.2.1 Pricing Equations

Retailers may offer multiple products and set their product prices to maximize profit:

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

where ω_{jgt} is the wholesale price, assumed here to be the marginal cost to the retailer, $\mathbf{P_t}$ is the set of prices p_{jgt} over all products, retailers and quarters, and

which is consistent with our empirical finding that its E-Circuit batteries remain priced at $1 even after the vertical agreement.

M_t is the market size in quarter t. The first-order condition with respect to p_{jgt} is therefore:

$$\mathbf{s_{gt}}(\mathbf{P_t}) \; + \; \frac{\partial \mathbf{s_{gt}}(\mathbf{P_t})^{\mathrm{T}}}{\partial \mathbf{p_{gt}}} (\mathbf{p_{gt}} \; - \; \boldsymbol{\omega}_{gt}) \; = \; \mathbf{0}, \tag{3}$$

where $\mathbf{s_{gt}}$, $\mathbf{p_{gt}}$ and $\boldsymbol{\omega}_{gt}$ are the vectors stacking all s_{jgt}, p_{jgt} and ω_{jgt} across j respectively.

Solving Equation (3) yields the pricing equations. In practice, there may be additional marginal costs arising from labor or storage. However, since retailers typically offer a large assortment of other non-battery products simultaneously, and batteries are small in both price and size, these costs can be considered negligible. We therefore assume that the retailer's marginal cost of battery products is equal to the wholesale price.

4.2.2 Post-Period Pricing (Walmart/Energizer)

The pricing equation for Walmart and Energizer changes following the vertical agreement. We model this by assuming that Walmart and Energizer jointly choose (i) Walmart's retail prices and (ii) Energizer's wholesale prices to other retailers in order to maximize their joint profits, defined as follows.

$$\begin{aligned} \Pi^{EW} \; = \; & \max_{\{p_{jt}^W\}_{j \in \mathcal{J}_t^W}, \{\omega_{jgt}\}_{j \in \mathcal{J}_t^E, g \in \mathcal{G}_t^E}} \sum_{j \in \mathcal{J}_t^W} \left(p_{jt}^W \; - \; \omega_{jt}^W \right) s_{jt}^W(\mathbf{P_t}) M_t \\ & + \sum_{g \in \mathcal{G}_t^E} \sum_{j \in \mathcal{J}_t^E} \left(\omega_{jgt} \; - \; c_{jgt} \right) s_{jgt}(\mathbf{P_t}) M_t, \end{aligned} \tag{4}$$

where c_{jgt} denotes the input cost, i.e., the manufacturing cost incurred by battery manufacturers to produce batteries; $\mathcal{J}_t^W$ is the set of battery products available at Walmart in quarter t; $\mathcal{J}_t^E$ is the set of all Energizer products; and $\mathcal{G}_t^E$ is the set of retailers except for Walmart that sell Energizer products in quarter t. The first-order conditions are as follows. Note that, for Energizer products sold in Walmart, ω_{jt}^W is replaced by the input cost c_{jt}^W.

(i) For retail prices at Walmart, we have

$$\mathbf{s_t^W}(\mathbf{P_t}) + \frac{\partial \mathbf{s_t^W}(\mathbf{P_t})^{\mathrm{T}}}{\partial \mathbf{p_t^W}} (\mathbf{p_t^W} - \boldsymbol{\omega}_t^W) \; + \; \frac{\partial \mathbf{s_t^E}(\mathbf{P_t})^{\mathrm{T}}}{\partial \mathbf{p_t^W}} (\boldsymbol{\omega}_t^E - \mathbf{c_t^E}) \; = \; \mathbf{0}, \text{ for } \mathbf{p}_t^W = \{p_{jt}^W\}_{j \in \mathcal{J}_t^W},$$

where $\mathbf{s_t^E}$, $\boldsymbol{\omega}_t^E$ and $\mathbf{c_t^E}$ are the vectors stacking all s_{jgt}, ω_{jgt} and c_{jgt} for j$\in \mathcal{J}^E$, $g \in \mathcal{G}_t^E$.

(ii) For Energizer's wholesale prices at non-Walmart retailers, we obtain

$$\frac{\partial \mathbf{s_t^W}(\mathbf{P_t})^{\mathrm{T}}}{\partial \boldsymbol{\omega}_t^E}(\mathbf{p_t^W} - \boldsymbol{\omega}_t^W) \; + \; \frac{\partial \mathbf{s_t^E}(\mathbf{P_t})^{\mathrm{T}}}{\partial \boldsymbol{\omega}_t^E}(\boldsymbol{\omega}_t^E - \mathbf{c_t^E}) + \mathbf{s_t^E}(\mathbf{P_t}) \; = \; \mathbf{0}, \text{ for } \; \boldsymbol{\omega}_t^E = \{\omega_{jgt}\}_{j\in\mathcal{J}_t^E, g\in\mathcal{G}_t^E}.$$

The pricing equations under the vertical agreement may increase efficiency, as they lower the marginal cost of Energizer products at Walmart from the wholesale price to the manufacturer's marginal cost, similar to the effects of vertical integration. On the other hand, the agreement creates incentives for Walmart and Energizer to raise retail prices for non-Energizer products (to shift demand toward Energizer products) and to raise wholesale prices for Energizer products sold at non-Walmart retailers (to shift demand toward Walmart).

4.3 Wholesales Price Bargaining

We model wholesale prices as the outcome of a bilateral bargaining process between battery manufacturers and retailers, with product-specific wholesale prices determined for each product. Bargaining occurs between each manufacturer and each retail chain. 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:

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

where $\mathcal{E}_t^m = \mathcal{J}_t^m \times \mathcal{G}_t^m$ 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 assumed to be determined through simultaneous Nash-in-Nash bargaining between each battery manufacturer and the retailer for a given product. The

Nash product for retail chain h and battery manufacturer m at quarter t is

$$NP(\boldsymbol{\omega_{mht}}, \boldsymbol{\Omega_{-mht}}) = \left[\pi^S(\mathcal{J}_{ht}; \boldsymbol{\omega_{mht}}, \boldsymbol{\Omega_{-mht}}) - d^S(\mathcal{J}_{ht}; \infty, \boldsymbol{\Omega_{-mht}})\right]^{\rho_{mh}} \cdot \left[\pi^M(\mathcal{E}_t^m; \boldsymbol{\omega_{mht}}, \boldsymbol{\Omega_{-mht}}) - d^M(\mathcal{E}_t^m; \infty, \boldsymbol{\Omega_{-mht}})\right]^{1-\rho_{mh}}, \tag{5}$$

where d^S and d^M are the disagreement payoffs, defined as the payoffs when the price of product j is set to infinity, and ρ_{mh} is the bargaining parameter, taking values between 0 and 1. The bargaining outcome is to find $\boldsymbol{\omega_{mht}} = \{\omega_{jht}\}_{j \in \mathcal{J}_{ht} \cap \mathcal{J}_t^m}$, which maximizes the bilateral Nash product in Equation (5), given the wholesale prices between other retailers and manufacturers:

$$\omega_{mht}^* = \arg\max_{\omega} NP(\boldsymbol{\omega_{mht}}, \boldsymbol{\Omega_{-mht}}).$$

Our main data do not contain information on wholesale prices. However, we use DecaData to obtain wholesale prices for only a limited set of products and a small subset of retailers, and we find that wholesale prices increase after the vertical agreement (see Appendix G). Therefore, we allow re-bargaining as occurring after the vertical agreement, leading to changes in wholesale prices in the post-agreement period. For non-Walmart–Duracell pairs, disagreement payoffs decrease after the agreement, as profits from selling Energizer products decline. This reduces the manufacturer's overall payoff and allows Duracell to raise wholesale prices despite bargaining power remaining unchanged.

5 Estimation

The model contains four primitives to be estimated: demand parameters, wholesale prices, battery input costs, and bargaining parameters. Estimation proceeds in three steps. First, we estimate the demand system. Second, we map retail prices to marginal costs, which we also interpret as wholesale prices. Third, we estimate the bargaining model to recover bargaining power and input costs that rationalize the wholesale prices obtained in the second step. We discuss each step sequentially, beginning with the demand side.

5.1 Demand

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

$$\ln(s_{jgt}) - \ln(s_{0t}) = \alpha p_{jt} + x_{jg}\beta + \zeta_{h(g)} + \zeta_t + \lambda \ln(s_{jt|g}) + \xi_{jgt}.$$

As unobserved demand shocks, ξ_{jgt}, may be correlated with price, we use supply cost shocks to zinc, potassium, and steel, key input materials in battery production and components of battery manufacturing costs, which are plausibly orthogonal to unobserved demand shocks, to instrument for prices. These measures include the zinc and potassium price indices, the battery manufacturing producer price index, and an indicator for periods of high steel input costs, defined as a dummy equal to one when the steel price index exceeds its sample median.

We calculate market size as the total number of battery sales in each quarter, since demand is modeled as inelastic. Market share is then calculated for each product j at retailer g in quarter t.

5.2 Wholesales Prices

Based on the pricing first-order condition in Equation (3), we obtain the retailer's marginal cost of battery products in the pre-agreement period, i.e., wholesale prices, using the standard method for estimating marginal costs in Bertrand price competition. For Walmart–Energizer in the post-agreement period, Equation (4) yields wholesale prices for all non-Energizer products and input costs for manufacturing Energizer products.

We parameterize the log of the wholesale price at the product–CBSA–retailer level as a function of retail chain–product fixed effects $\omega^1_{h(g)j}$, a retail chain–product-specific post-agreement shift $\omega^2_{h(g)j}$ capturing changes in wholesale prices after the vertical agreement, and quarterly fixed effects ω^3_t:

$$\log(\omega_{jgt}) = \omega^1_{h(g)j} + \omega^2_{h(g)j} \times Post_t + \omega^3_t + \nu_{jgt},$$

where $Post_t$ indicates quarters following the vertical agreement. We calculate $\hat{\omega}^*_{jht} = \exp(\hat{\omega}^1_{h(g)j} + \hat{\omega}^2_{h(g)j} \times Post_t + \hat{\omega}^3_t)$ as the average wholesale price across CBSA–retailers for each product and quarter, and use these values in the bargaining parameter estimation.

5.3 Input Costs and Bargaining Parameters

We do not observe input costs for manufacturing batteries other than Energizer products, which can be backed out as in Equation (4). This constitutes the main challenge in identification, as high wholesale prices could reflect either (i) high input costs or (ii) strong bargaining power on the part of the manufacturer. Therefore, we require additional variation in the data to separately identify input costs and bargaining parameters..

We employ data from one month before and one month after the vertical agreement, assuming that bargaining parameters and input costs do not vary over this short horizon. Energizer's input costs, estimated from Equation (4), are likewise treated as constant over the estimation window, specifically one period before and after the vertical agreement. Under this assumption, the observed change in wholesale prices can help identify input costs separately from bargaining power. Input costs is identified by the average level of wholesale prices, while bargaining power is identified by differences in wholesale prices following re-bargaining. We parameterize the input costs as

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

where Q_j denotes the size of battery product j (i.e., the number of pieces per pack), and mc is the marginal cost of producing a single battery, which we allow to vary across brands and retail chain groups h' (Walmart, large, medium, and small).

Two-Step Generalized Method of Moments. In the inner loop, we solve for the optimal wholesale prices $\hat{\omega}_{jht}$ for each product that maximize Equation (5) in both the pre-period ($t = 0$) and the post-period ($t = 1$), given a set of marginal costs mc and bargaining powers ρ. In the outer loop, we minimize the distance between the model-predicted wholesale prices and the observed wholesale prices in the data. The moment condition is written as follows:

$$E\begin{bmatrix} \frac{1}{|\mathcal{J}_{h0} \cap \mathcal{J}_0^m|} \sum_{j \in \mathcal{J}_{h0} \cap \mathcal{J}_0^m} (\omega^*_{jh0} - \omega_{jh0}) \\ \frac{1}{|\mathcal{J}_{h1} \cap \mathcal{J}_1^m|} \sum_{j \in \mathcal{J}_{h1} \cap \mathcal{J}_1^m} (\omega^*_{jh1} - \omega_{jh1}) \end{bmatrix} = \mathbf{0}_{2\times 1}.$$

We implement a two-step Generalized Method of Moments (GMM). In the first step, we estimate the model using an identity weighting matrix to obtain the initial estimator and then compute the optimal weighting matrix. In the second step, we obtain the efficient estimator by weighting the moment conditions with the optimal weighting matrix.

For Energizer products, input costs can be recovered from Equation (4) at the product–retailer level. Therefore, we can directly estimate the bargaining power parameter by matching pre-period wholesale prices. The moment condition then becomes

$$E\left[\frac{1}{|\mathcal{J}_{h0} \cap \mathcal{J}_0^m|} \sum_{j \in \mathcal{J}_{h0} \cap \mathcal{J}_0^m} (\omega^*_{jh0} - \omega_{jh0})\right] = 0.$$

Retailer Classification In practice, we categorize retailers into four types: Walmart, large, medium, and small. Walmart represents the top 75th percentile in sales, while the

large, medium, and small categories are defined as retailers whose battery sales fall into the 75th percentile and above, the 50th–75th percentiles, and the 25th–50th percentiles, respectively. We allow input costs and bargaining parameters to vary across retailer types.

For Duracell, we estimate one marginal cost parameter and four bargaining parameters, one for each retailer group. For Energizer, we estimate four bargaining parameters, one for each retailer group, since input costs are estimated separately from the pricing equation.

For private-label brands, both the marginal cost and the bargaining parameter are allowed to vary by retailer group, as these products may come from different manufacturers. Because Walmart's and other large retailers' private-label sales are limited in our sample, we combine Walmart and the large retailer group with the median retailer group for the private-label estimation. We do not consider bargaining with other small brands in the estimation, as most retailers offer Energizer, Duracell, and private-label products, and the remaining brands account for only a small share of the overall market, as shown in Table 1. In total, we estimate a total of 14 parameters.

6 Results

We first present and discuss the structural estimates, followed by the equilibrium outcomes and welfare measures from the counterfactual simulations.

6.1 Estimates

6.1.1 Demand Estimates

Table 5 presents the demand estimates. Column 1 includes product characteristics, such as the number of batteries per pack and brand indicators (Energizer, Duracell, or private label). Consistent with expectations, consumer utility increases with the number of batteries. Consumers also derive similar positive utility from Energizer and Duracell, both of which exceed the utility associated with private label products. Column 2 further controls for product fixed effects, while Column 3 presents our preferred specification, which includes CBSA–retailer chain fixed effects to account for the possibility that some retailers may be more or less likely to be visited due to their geographic location within an CBSA. The estimates of the price coefficient and λ are similar across these different specifications, and we use Column 3 as our main specification in the subsequent stages of the analysis.[25]

[25]We also estimate a random coefficient on price, but the standard deviation was small and not statistically different from zero. Therefore, we use the nested logit model as our main specification.

The estimate of λ ranges from approximately 0.33 to 0.49, indicating a strong degree of correlation in consumer utility across products offered by the same retailer. Appendix H further presents the distribution of price elasticities based on our main specification in Column 2. The average own-price elasticity is around 2.8, while the aggregate price elasticity is relatively small, at approximately 0.31.

	(1)	(2)	(3)
λ	0.486	0.421	0.334
	(0.150)	(0.081)	(0.081)
Prices	-0.208	-0.237	-0.236
	(0.035)	(0.020)	(0.022)
Size	0.018		
	(0.006)		
Energizer	0.372		
	(0.102)		
Duracell	0.443		
	(0.118)		
Private Label	0.076		
	(0.067)		
Retailer Chain FEs	Yes	Yes	
CBSA FEs	Yes	Yes	
Quarter FEs	Yes	Yes	Yes
Product FEs		Yes	Yes
CBSA-Retailer Chain FEs			Yes
No. of Observations	394,082	394,082	394,082

Notes: The table shows the parameter estimates of the demand model. Standard errors (in parentheses) are clustered at the CBSA–retailer–brand level.

Table 5: Demand Estimates

6.1.2 Wholesales Price Estimates

The means of wholesale price estimates by retailer type and manufacturer, for the pre-period and post-period, are reported in Table 6. Average wholesale prices range from \$2.8 to \$6.7, and post-period wholesale prices are consistently higher than those in the pre-period. Appendix J shows the distribution of wholesale prices for Duracell in the pre-period and post-period, with estimated wholesale prices exhibiting a noticeable increase after the agreement. This highlights the importance of the re-bargaining process in capturing Duracell's price increase.

However, for Walmart–Energizer, the post-period estimate corresponds to the input cost (c), which is lower than the pre-period wholesale price. This pattern is consistent with efficiency gains from vertical integration: following the vertical agreement to maximize joint profit, Walmart considers the input cost rather than the wholesale price, thereby eliminating double marginalization.

	Energizer		Duracell		Private Label	
	Pre-Period	Post-Period	Pre-Period	Post-Period	Pre-Period	Post-Period
Walmart	4.456	<u>3.290</u>	5.765	6.169	6.006	6.525
Large Retailers	4.282	4.604	6.099	6.732	6.520	6.756
Medium Retailers	4.786	5.726	5.783	6.207	2.894	3.519
Small Retailers	3.945	4.334	4.453	5.370	2.840	3.298

Notes: The table shows the mean wholesale price estimates (ω) for each retailer–manufacturer combination, except for Walmart–Energizer in the post-period (underlined), where the reported value is the mean input cost (c) instead of the wholesale price.

Table 6: Summary Statistics of Wholesale Price Estimates

6.1.3 Input Cost and Bargaining Power Estimates

Table 7 presents the estimates from the wholesale price bargaining model. Standard errors (in parentheses) are obtained using the sandwich formula.

For Energizer, Walmart's bargaining power is close to 0.94, meaning that a large fraction of the profits is allocated to Walmart. The bargaining power is smaller for the other retailers, with no significant difference between medium and small retailers.

For Duracell, the marginal cost of producing one battery is approximately \$0.35, slightly higher than Energizer's marginal input cost estimated in Appendix I. Regarding bargaining power with Duracell, Walmart and other large retailers hold higher bargaining power, while smaller retailers have less.

For private-label products, we allow the marginal cost to vary across retailer types medium+large+Walmart combined and small), as these products may be sourced from different Original Equipment Manufacturers (OEMs). The estimated marginal costs decrease with retailer size, suggesting that larger retailers use higher-cost, and potentially higher-quality, OEMs. However, we also find that larger retailers have higher bargaining power with OEMs.

Model Fits. We compare the model predictions of wholesale prices with the empirical moments in Table 8 for Energizer and Duracell. As shown in the table, the bargaining

	Energizer	Duracell	Private Label
mc	0.251	0.345	
	(0.024)	(0.029)	
λ_W	0.936	0.915	
	(0.027)	(0.018)	
λ_L	0.442	0.995	
	(0.050)	(0.162)	
λ_M	0.244	0.438	0.999
	(0.046)	(0.073)	(0.360)
λ_S	0.303	0.001	0.024
	(0.043)	(0.180)	(0.029)
mc_M			0.269
			(0.111)
mc_S			0.001
			(0.047)

Notes: The table reports the parameter estimates of the wholesale price bargaining model. W refers to Walmart, L to large retailers, M to medium retailers, and S to small retailers. The estimates of mc for Energizer are derived from the method outlined in Appendix I. Standard errors, shown in parentheses, are computed using the sandwich formula.

Table 7: Input Cost and Bargaining Power Estimates

model can predict the change in wholesale prices before and after the vertical agreement, which plays an important role in rationalizing the price change in the post-agreement period.

	$E[\omega_0]$		$E[\omega_1 - \omega_0]$	
	Data	Model	Data	Model
Energizer				
Walmart	3.180	3.181		
Large Retailers	6.241	6.241		
Medium Retailers	5.581	5.581		
Small Retailers	4.306	4.292		
Duracell				
Walmart	5.602	5.603	0.813	0.813
Large Retailers	9.117	9.117	0.493	0.493
Medium Retailers	5.877	7.340	0.406	1.202
Small Retailers	8.550	8.554	0.920	0.919

Notes: The table displays the model fits from the bargaining model. Columns 1 and 3 report the empirical moments used to estimate the GMM, while Columns 2 and 4 report the model-predicted moments. For Energizers, only the first moment is used.

Table 8: Model Fits

6.2 Counterfactual Simulations

To calculate the counterfactual equilibrium, we simulate the initial counterfactual wholesale prices $\mathbf{wp^0}$ and the corresponding retail prices. Given these values, we iteratively update the wholesale prices to obtain $\mathbf{wp^1}$ and the corresponding retail prices. The iteration is considered to have converged at the nth step when ϵ is set to 0.01 and the condition $|\mathbf{wp^{n+1}} - \mathbf{wp^n}| < \epsilon$ is satisfied.

6.2.1 Retailer–Manufacturer Pairs in the Vertical Agreement

We consider several counterfactual scenarios involving different combinations of retailers and manufacturers: (i) a counterfactual equilibrium in which Walmart has a vertical agreement with Duracell instead of Energizer; (ii) a counterfactual equilibrium in which Energizer has a vertical agreement with Target, the second-largest retailer comparable to Walmart; and (iii) a counterfactual equilibrium in which Duracell has a vertical agreement with Target.[26]

Table 9 summarizes the changes in consumer surplus, retailer profit, manufacturer profit, and percentage change in retail prices, relative to the benchmark scenario with

[26]Amazon is excluded as it is an online marketplace, and Costco is excluded as it operates primarily as a volume reseller.

	Walmart-Energizer	Walmart-Duracell	Target-Energizer	Target-Duracell
Panel A: Surplus change, measured in thousands of USD				
ΔCS	-178.314	-208.885	-271.609	-235.096
$\Delta\pi^S_{\text{Walmart}} + \Delta\pi^M_{\text{Energizer}}$	6.504			
$\Delta\pi^S_{\text{Walmart}} + \Delta\pi^M_{\text{Duracell}}$		8.796		
$\Delta\pi^S_{\text{Target}} + \Delta\pi^M_{\text{Energizer}}$			12.715	
$\Delta\pi^S_{\text{Target}} + \Delta\pi^M_{\text{Duracell}}$				10.530
$\Delta\pi^S_{\text{Others}}$	-1.216	-3.018	-11.116	-7.851
$\Delta\pi^M_{\text{Duracell}}$	1.525		2.996	
$\Delta\pi^M_{\text{Energizer}}$		3.585		5.591
$\Delta\pi^M_{\text{Others}}$	2.069	2.810	3.079	3.415
Panel B: Price Change, measured as a percentage				
$\%\Delta p^{\text{Walmart}}_{\text{Energizer}}$	3.158	4.987		
$\%\Delta p^{\text{Walmart}}_{\text{Duracell}}$	7.952	2.714		
$\%\Delta p^{\text{Target}}_{\text{Energizer}}$			-15.243	5.832
$\%\Delta p^{\text{Target}}_{\text{Duracell}}$			11.292	-5.998
$\%\Delta p^{\text{Others}}_{\text{Energizer}}$	10.929	2.503	17.289	1.544
$\%\Delta p^{\text{Others}}_{\text{Duracell}}$	1.847	17.171	0.953	19.933

Notes: The table displays the counterfactual equilibrium outcomes for different retailer–manufacturer pairs in the vertical agreement. Panel A reports the surplus changes, measured in thousands of U.S. dollars, while Panel B presents the price changes in percentage terms. $\Delta\pi^S_{\text{Others}}$ denotes the surplus change for the remaining retailers, excluding the retailer involved in the vertical agreement. Similarly, $\Delta\pi^M_{\text{Others}}$ denotes the surplus change for the remaining manufacturers, excluding the manufacturer participating in the vertical agreement.

Table 9: Retailer–Manufacturer Pairs in the Vertical Agreement

no vertical agreement. Column 1 of Table 9 presents the model simulation for the Walmart–Energizer agreement. Interestingly, Duracell benefits from this arrangement due to its ability to raise prices following the vertical agreement. This is consistent with the fact that Duracell was not part of the lawsuit. Other manufacturers also benefit on average. On the other hand, retailers other than Walmart are worse off, as they face higher wholesale prices. Consumers are significantly worse off compared to both retailers and manufacturers, primarily due to higher retail prices.

Column 2 presents the case where Walmart has a vertical agreement with Duracell instead of Energizer. Relative to the benchmark, Energizer is still better off, as is the average manufacturer. The overall directional changes are similar to the Walmart–Energizer case. However, since Duracell has a smaller share within Walmart, the retailer has stronger incentives to raise Duracell's price at other retailers. As a result, other retailers and consumers are worse off compared to the Walmart–Energizer case.

Column 3 displays the scenario in which Target, instead of Walmart, enters a vertical agreement with Energizer. Although Energizer benefits from efficiency gains at Target, which leads to lower Energizer prices at Target, Target lacks the same level of market power as Walmart. As a result, to increase battery sales, Target must raise Duracell's prices in its own stores and increase Energizer's wholesale prices at other retailers more than Walmart would. Consequently, consumers are worse off, manufacturers' profits increase further, and the profits of retailers other than Target fall more than in the Walmart–Energizer scenario.

Column 4 shows the case where Target has a vertical agreement with Duracell. Duracell's price at Target decreases due to efficiency gains from vertical integration. However, because Duracell has a larger market share within Target, the retailer raises prices less aggressively than in the Target–Energizer case. As a result, the loss in consumer welfare is smaller than under Target–Energizer. Nonetheless, since Target lacks Walmart's market power, it still raises Duracell's prices more than Walmart would under a Walmart–Duracell agreement. Therefore, overall welfare loss is greater than in the Walmart–Duracell scenario, but less than in the Target–Energizer case.

The results have important implications. Consumer welfare loss is not necessarily the greatest when the largest retailer and manufacturer reach an agreement. Instead, we find that the Target–Energizer agreement results in a greater loss of consumer welfare due to stronger incentives to raise prices on the more competitive brand. Similarly, we find that the Walmart–Duracell agreement leads to a larger consumer welfare loss compared to the Walmart–Energizer case. These findings suggest that relying solely on firms' market shares to evaluate welfare impact may not capture the true extent of consumer welfare loss.

7 Conclusion

This paper studies the market outcomes of a vertical agreement between a multi-product retailer and a manufacturer in the consumer battery industry. We exploit a natural experiment arising from the agreement between Energizer and Walmart and show that battery prices increase significantly across retailers. To rationalize these patterns, we develop an

empirical model of multi-product pricing with wholesale price bargaining. Counterfactual simulations indicate that this vertical conduct reduces consumer welfare and that agreements involving smaller retailers can generate even larger losses. These results highlight that incentives to foreclose rival retailers and to raise their costs are central to assessing the economic effects of such conduct. More broadly, our findings demonstrate how vertical restraints can be jointly implemented to sustain coordination between upstream and downstream firms, with important implications for market outcomes and consumer welfare.

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Online Appendix

The appendix is intended for online publication.

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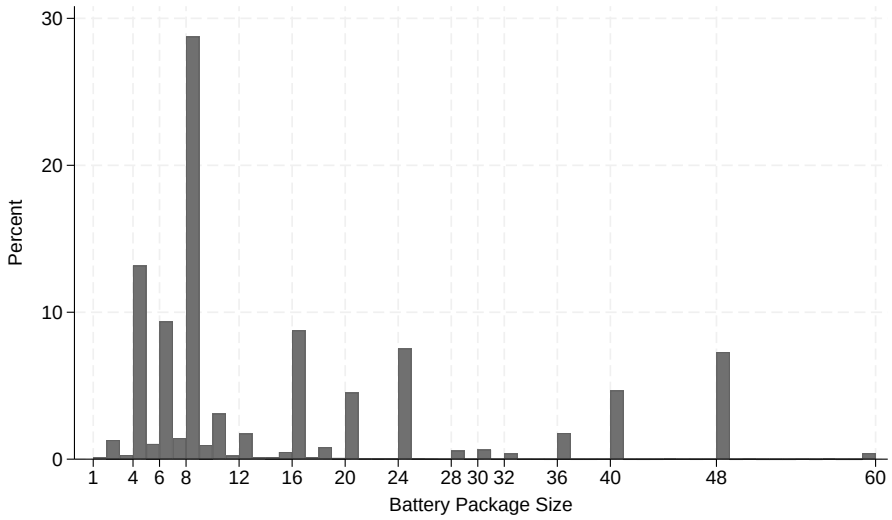
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A Package Size Imputation

We impute missing battery package sizes, accounting for 23.54% 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 (84.2%).
2. Same battery brand line and same retail price (10.2%).
3. Same retailer and same retail price (3.8%).
4. Same retailer, same battery brand line, and same *rounded* retail price (0.8%).
5. Same battery brand line and same *rounded* retail price (0.28%).
6. Same retailer, same battery brand, and same *rounded* retail price (0.25%).
7. Same retailer and same *rounded* retail price (0.19%).
8. Same battery brand and same *rounded* retail price (0.30%).
9. Same *rounded* retail price (0.02%).
10. All products in the dataset (0.006%).

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.



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

Figure A1: Distribution of Battery Package Sizes After Imputation

B Consumer Composition Comparison

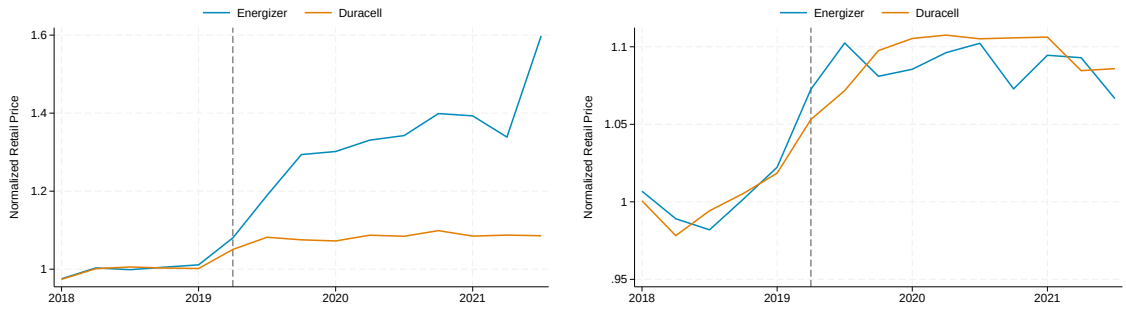
	Pre-Period		Post-Period	
	Mean	Standard Deviation	Mean	Standard Deviation
Female	0.81	0.39	0.83	0.38
Age	42.80	12.07	43.04	12.03
White	0.68	0.47	0.69	0.46
Household Size	3.25	1.52	3.21	1.52
College Graduate	0.61	0.49	0.61	0.49
Full-Time Employment	0.52	0.50	0.52	0.50
High Income	0.16	0.37	0.17	0.37
Medium Income	0.53	0.50	0.54	0.50
No. of Consumers per Quarter	252351.53		167307.94	

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.

C Retailer Prices By Retailer and by Brand



(a) Dollar General **(b)** Target

Notes: The two panels display quarterly normalized prices for Energizer and Duracell, respectively, from 2018 to 2021 across Dollar General and Target, which are major retailers with relatively large shares in both brands, as shown in Table 1. Prices are normalized to their respective pre-agreement prices for each product. 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 timing of the vertical agreement.

Figure A2: Retailer Prices By Retailer and by Brand from 2018 to 2021

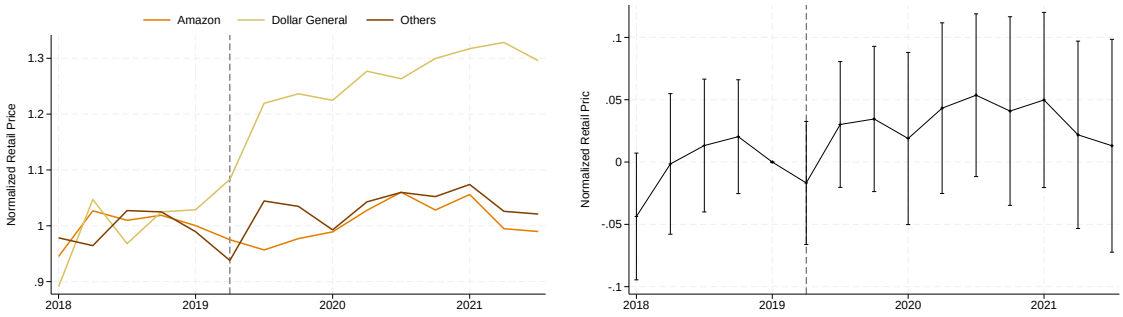
We plot the normalized prices for Energizer and Duracell from 2018 to 2021 at Dollar General and Target, two major retailers with relatively large shares in both brands, as shown in Table 1.

Figure A2a illustrates the retail price trend at Dollar General, where Energizer products experienced a larger increase in prices. As a dollar store that offers discounted (but not $1) Energizer products, Dollar General had to raise its Energizer prices substantially to ensure Walmart's Energizer products remained competitive. On the other hand, Duracell's products saw only a modest price increase.

Figure A2b shows the retail price trend at Target. Unlike Dollar General, the divergence in price increases between Energizer and Duracell is much less pronounced. Both Energizer and Duracell raised prices by a similar magnitude. This is likely because Target has no

other major battery brands besides Energizer and Duracell to serve as substitutes (see Table 1), allowing Duracell to raise prices significantly alongside Energizer.

C.1 Retail Prices of Private-Label Products



(a) Normalized Prices **(b)** Regression Estimates

Notes: The left panel displays quarterly normalized prices for private-label products from 2018 to 2021 across Dollar General and Target, which are major retailers with relatively large shares of private-label sales, as shown in Table 1, as well as for other retailers. Prices are normalized to their respective pre-agreement prices for each product. 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 timing of the vertical agreement. The right panel presents the estimates of γ_q along with their 95% confidence intervals from Equation (A1). Robust standard errors are clustered at the product-by-retailer level.

Figure A3: Retail Prices of Private-Label Products from 2018 to 2021

Figure A3a plots the quarterly normalized prices for Dollar General and Target, two major retailers with relatively large shares of private-label sales, as shown in Table 1, as well as for other retailers. Dollar General's private-label batteries experienced a substantial increase in retail prices, similar to the pattern observed for other brands. At Target and other retailers, retail prices also display an upward trend, though the increases are less pronounced.

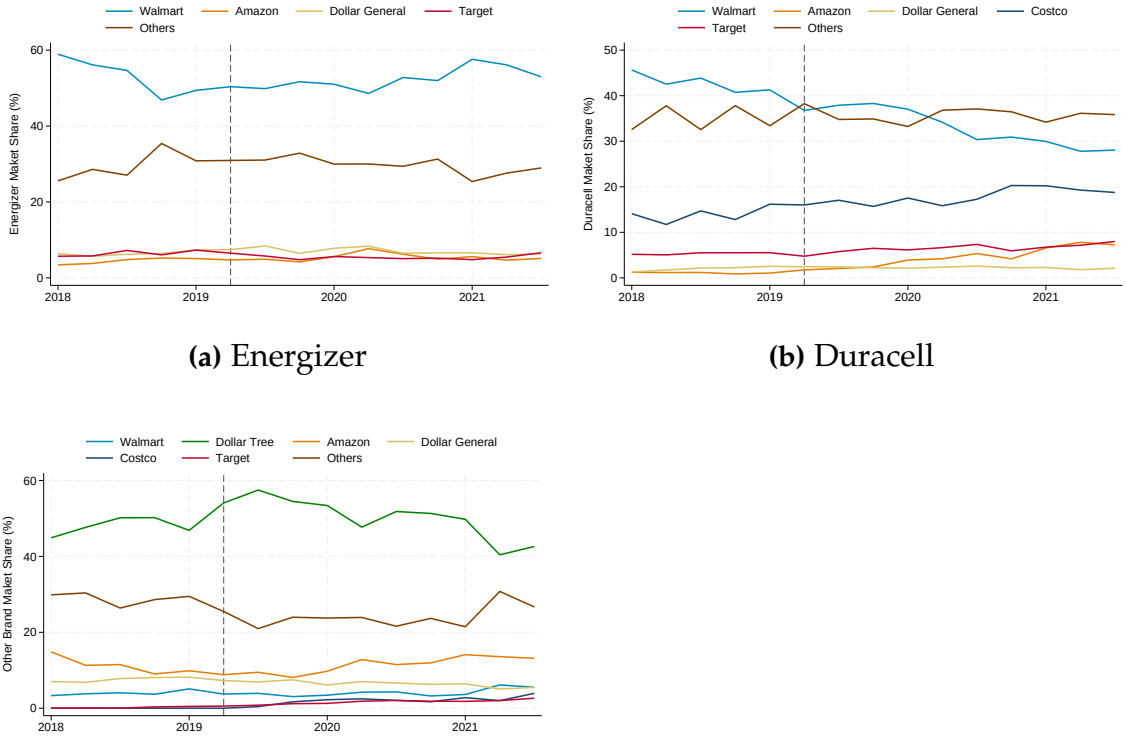
In light of the unclear upward trends outside of Dollar General, we estimate the following regression to assess the statistical significance of private-label product price changes. The outcome variable is the normalized retail price of private-label product g from retailer j on trip i in quarter t, where t measures the number of quarters since 2018:

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

where the fixed effects ϕ_{jg} absorb cross-sectional variation at the product-by-retailer level. The coefficient for the period prior to the vertical agreement (the first quarter of 2019) is normalized to zero.

Figure A3b presents the estimates of γ_q along with their 95% confidence intervals from Equation (A1). While there may appear to be an upward trend in prices, the estimates are noisy, suggesting that the overall changes in prices are not statistically different from zero.

D Retailer Market Shares by Brand



(a) Energizer

(b) Duracell

(c) Other Brands

Notes: The three panels display quarterly retailer shares for 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 timing of the vertical agreement. 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.

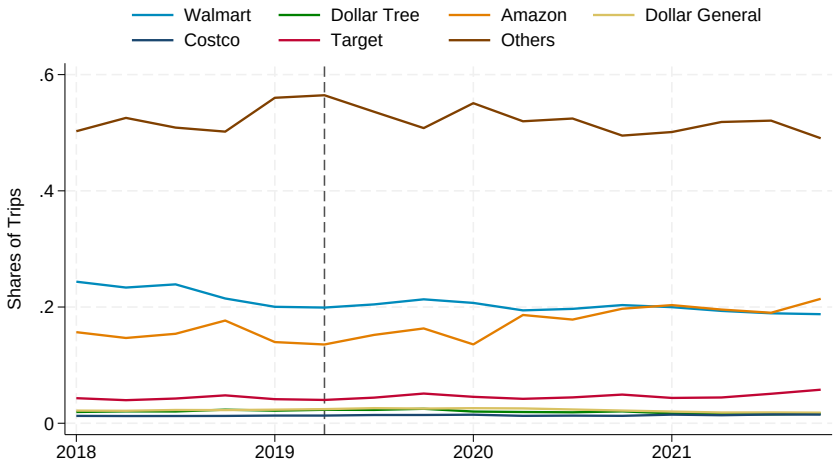
Figure A4: Retailer Shares by Brand from 2018 to 2021

Figure A4a 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 A4b shows the retailer shares for Duracell, with Walmart experiencing a marked decline that is primarily absorbed by Costco and Amazon. Figure A4c 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.

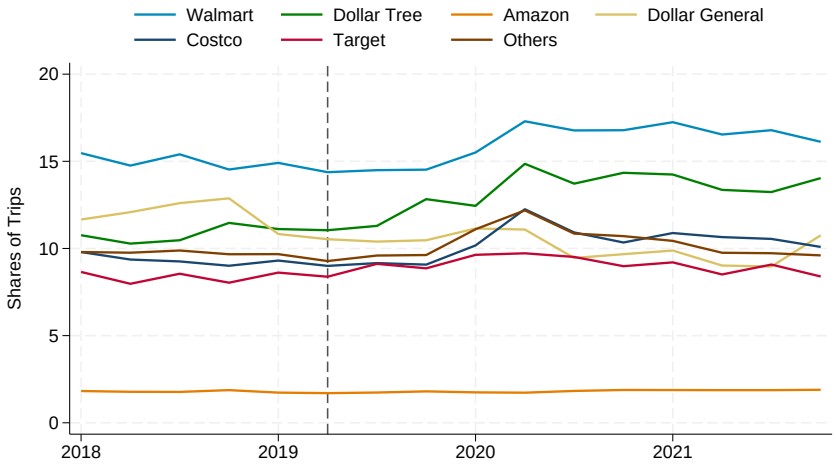
E Trends in Shopping Trips

Figure A5a 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 A5b 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 second quarter of 2022, 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.



(a) Trip Shares by Retailer



(b) Number of Products per Trip by Retailer

Notes: The upper panel displays quarterly trip shares from 2018 to 2021 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 timing of the vertical agreement. The lower panel shows the number of products purchased per trip for these retailers.

Figure A5: Trip Shares and Number of Products per Trip from 2018 to 2021

	P-Values
Model 1: Upstream Coordination (Full)	
IV (zinc, potassium, manufacturing)	0.000
IV (zinc, potassium, manufacturing, aluminum)	0.000
IV (all)	0.000
Model 2: Upstream Coordination (Energizer and Duracell)	
IV (zinc, potassium, manufacturing)	0.000
IV (zinc, potassium, manufacturing, aluminum)	0.000
IV (all)	0.000
Model 3: Vertical Integration (Walmart and Energizer)	
IV (zinc, potassium, manufacturing)	0.539
IV (zinc, potassium, manufacturing, aluminum)	1.000
IV (all)	0.764

Notes: The table reports the p-values from the Model Confidence Set (MCS) for conduct tests. Model 1 represents full horizontal coordination in the upstream market, Model 2 represents partial horizontal coordination between Energizer and Duracell in the upstream market, and Model 3 represents vertical integration between Walmart and Energizer. We test using combinations of five IVs: the price indices for primary battery manufacturing: primary batteries (labeled "manufacturing"), chemicals and allied products: chlorine, sodium hydroxide, and other alkalies (labeled "potassium"), zinc (end use) (labeled "zinc"), alumina and aluminum production and processing (labeled "aluminum"), and metals and metal products: iron and steel (labeled "steel"). "IV (all)" refers to the specification where all IVs are used. Standard errors are clustered at the CBSA–retailer–brand level.

Table A2: Conducting Tests: Model Confidence Set

F Conduct Tests

We test firm conduct using the framework of Duarte et al. (2024).[27] Our demand estimates are obtained using both pre- and post-period data, as outlined in Section 5.1 of the main paper, while the conduct tests focus on the post-period.

Because the demand instruments in Section 5.1 only vary across pre- and post-period observations, we collect additional instruments from FRED for testing. Specifically, we use the price indices for primary batteries (PCU3359123359120, labeled "manufacturing"), chemicals and allied products: chlorine, sodium hydroxide, and other alkalies (WPU06130302, labeled "potassium"), zinc (end use) (IR14260, labeled "zinc"), alumina and aluminum production and processing (PCU3313133131, labeled "aluminum"), and

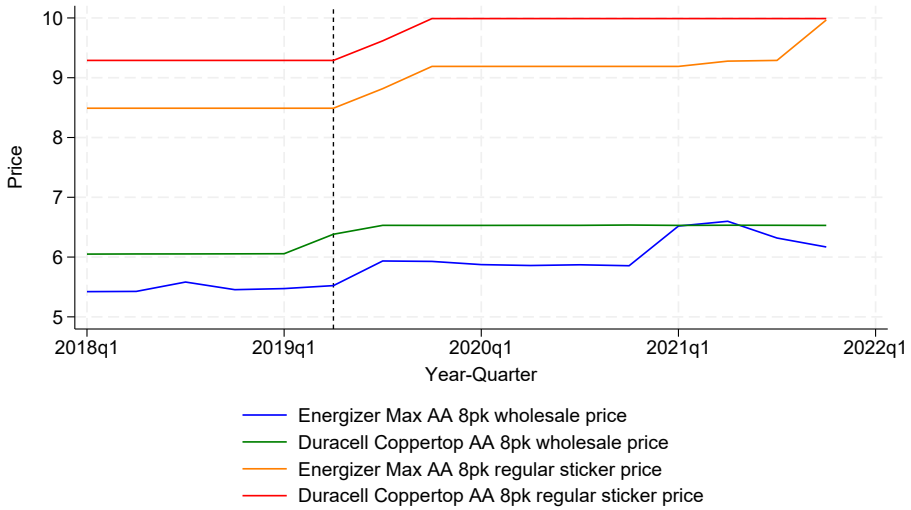
[27]We implement the testing procedure with the estimation package developed by Conlon and Gortmaker (2020) and `pyRVtest`.

metals and metal products: iron and steel (WPS101, labeled "steel"). These indices are intended to serve as cost shocks for battery manufacturing.

Specifically, we compare three models: (i) full horizontal coordination in the upstream market, (ii) partial horizontal coordination between Energizer and Duracell in the upstream market, and (iii) vertical integration between Walmart and Energizer. As shown in Table A2, which reports the p-values from the model confidence set, the results lead us to reject the hypothesis of horizontal coordination in the upstream market.

G Trends in Wholesale Prices

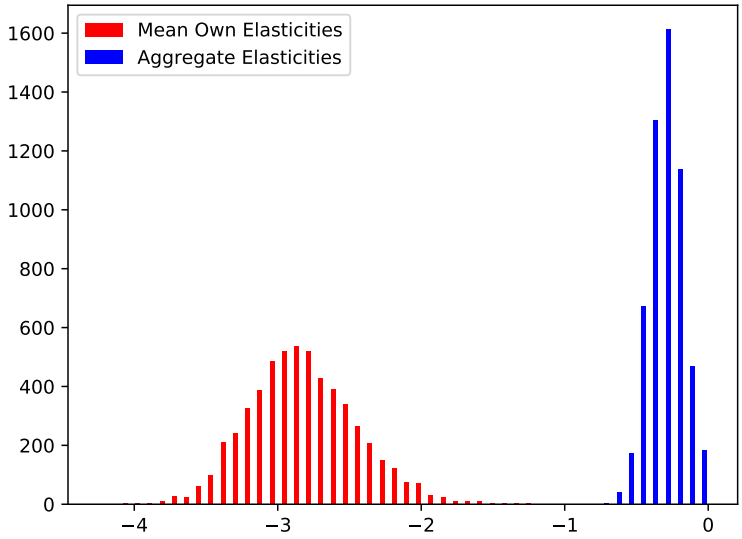
The main data used in our analysis do not contain information on wholesale prices. To assess wholesale price patterns, we therefore use DecaData (http://decadata.io), which provides wholesale prices for a limited set of products and a small subset of retailers from 2018 to 2021. Figure A6 plots wholesale 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 timing of the vertical agreement.

Figure A6: Wholesale Prices from 2018 to 2021

H Price Elasticity



Notes: The figure shows the distribution of price elasticities implied by the demand estimates in Column 2 of Table 5.

Figure A7: Price Elasticity

Figure A7 plots the distribution of estimated price elasticity. The average own-price elasticity is around -2.59, while the aggregate price elasticity is relatively small, at approximately -0.29.

I Energizer's Input Costs

Energizer's input costs c_{jgt} can be obtained from Equation (4). We then use the following regression to estimate the implied s the marginal cost of producing a unit of battery.

$$c_{jgt} = \alpha_0 + \alpha_1 Q_j + \epsilon_{jgt}, \tag{A2}$$

where Q_j denotes the size of battery product (i.e., the number of pieces per pack).

The results are shown in Table A3. The implied marginal cost is approximately \$0.25.

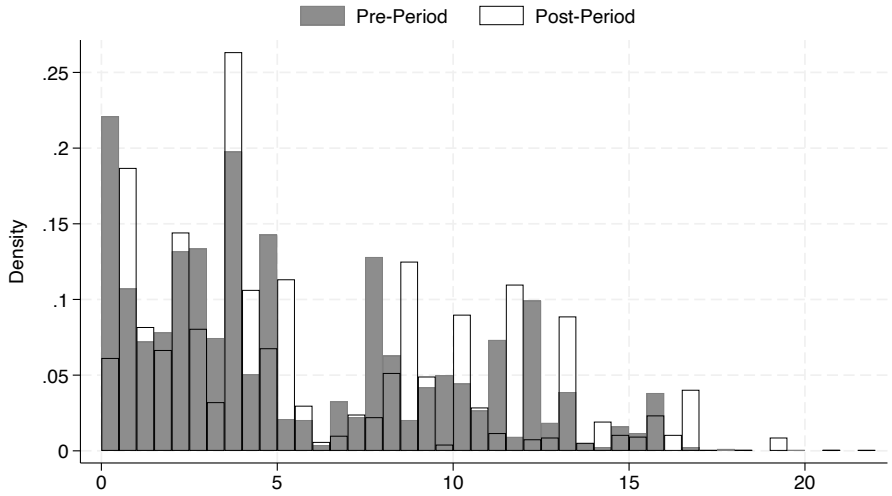
	(1)
Q_j	0.251***
	(0.024)
Constant	-0.150
	(0.437)
Observations	8,600
Adjusted R-squared	0.380

Notes: The table reports the estimates from Equation (A2) with the input cost as the dependent variable. Robust standard errors are clustered at the product-by-retailer level. Significance levels: *(p $<$ 0.10), **(p $<$ 0.05), ***(p $<$ 0.01).

Table A3: Energizer's Input Costs

J Distribution of Duracell's Wholesale Prices

Figure A8 displays the distribution of wholesale prices for Duracell, estimated from the retailer pricing model, for the pre-period and post-period, respectively. The estimated wholesale prices show a noticeable increase in the post-period relative to the pre-period: the average rises from \$5.50 to \$6.07, representing a 10.36% increase. This pattern highlights the significance of the re-bargaining process.



Notes: The figure shows the distribution of wholesale prices for Duracell, estimated from the retailer pricing model, for the pre-period and post-period, respectively. The gray bar represents the period before the vertical agreement between Walmart and Energizer, while the black transparent bar represents the period after.

Figure A8: Duracell's Wholesale Prices