Economies of Scope in Retail Distribution: A Study of Ready-to-Consume Categories

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Abstract

We develop a method to estimate discrete games where firms make a large number of interdependent discrete decisions, based on the optimal-transport inference framework of Li and Henry (2025). We apply it to retail distribution choices in carbonated beverages, tea, and yogurt, where firms decide whether to enter and if so, which products to sell in each local market. Using firms' product-choice decisions, we derive product-level bounds on incremental fixed costs under weak behavioral assumptions. These bounds allow us to estimate a fixed-cost function that accommodates economies or diseconomies of scope, so that the cost of adding a product may depend on a firm's product portfolio. We find evidence for economies of scope, where the incremental fixed cost of adding a product is lower when the firm sells more products in the same local market. Counterfactual simulations show that these scope economies have important implications. First, policies that increase a market's size raise consumer surplus primarily through the increase of incumbent firms' product variety rather than through entry by new firms. Second, counterfactual mergers among small owners lead to fixed-cost savings, which raise product variety and consumer surplus.

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1 Introduction

Many empirical questions require estimating payoff parameters in discrete games where agents choose a large number of interdependent decisions. For example, firms choose which products to offer, which locations to serve, or which technologies to adopt. These choices are fundamental to market structure, competition, and welfare. We can model such a decision as a vector of discrete decisions, where firms make a binary decision regarding each product, technology, or location, and these decisions are interdependent due to their potential complementarity or substitutability. This paper develops a method to estimate such discrete-choice games.

We illustrate our method in the context of retail distribution. Product variety in retail markets depends not only on demand and price competition, but also on the fixed cost of product distribution. These costs are not directly observed and may exhibit economies or diseconomies of scope: the incremental fixed cost of adding a product to a firm's product portfolio in a local market may depend on the size of its portfolio. These scope economies affect how product variety responds to mergers, market growth, and other changes in market conditions.

Estimating these costs is difficult in settings with many potential firms and potential products. Complete-information entry-game approaches, such as Ciliberto and Tamer (2009) and Ciliberto et al. (2021), can accommodate rich fixed-cost specifications because they work with market-level outcomes. Their computational burden, however, increases quickly with the number of firms and products, since the researcher must evaluate many possible product configurations. The product-level bounds of Fan and Yang (2025) and Sabal (2025) avoid this enumeration problem and are therefore scalable to settings with many discrete decisions. These bounds, however, assume fixed costs that are additively separable across products and are not directly applicable to estimating flexible economies of scope.

This paper develops a tractable way to estimate economies of scope in fixed costs of distribution while retaining the scalability of product-level approaches by working with bounds implied by revealed preference: a product is offered only if its incremental variable profit is large enough to cover its incremental fixed cost. A number of papers (Ho, 2009; Pakes et al., 2015; Wollmann, 2018; Park, 2020) directly average over the inequalities and form moment inequalities to estimate the mean components of the fixed costs. We extend these inequalities to account for mixed-strategy equilibria. These inequalities inform the support of unobserved fixed costs. Then, we apply the optimal-transport inference framework of Li and Henry (2025), which set-identifies the fixed cost parameters by minimizing the distance between the support of fixed costs consistent with data and that implied by the model.

We apply the method to three ready-to-consume product categories: carbonated beverages, tea, and yogurt. These categories contain many firms and many products, making them suitable settings for studying product variety and for assessing the empirical importance of scope economies. We use NielsenIQ Retail Scanner data and the NielsenIQ Consumer Panel to estimate a random-coefficient discrete-choice demand model. We then recover marginal costs from Nash-Bertrand pricing first-order conditions and use the resulting variable profits in the product-choice problem for fixed-cost estimation.

The estimates imply substantial economies of scope and a significant market-size effect on fixed costs in all three categories. The incremental fixed cost of adding a product falls sharply with the number of other products the firm offers in the market. We also find that both the level of fixed costs and the dispersion of fixed-cost shocks rise with market size. The estimates therefore point to two offsetting forces in larger markets: higher demand raises the return to offering a product, but fixed costs are also higher in larger markets. More importantly, the net effect of market size on product variety depends on economies of scope in fixed costs: larger economies of scope may amplify a positive effect or exacerbate a negative effect of market size on product variety.

We use the estimated model in two counterfactual exercises. First, we study policies that relax zoning restrictions and increase the connectivity between population centers, which can increase a market's size. We find that such policies raise variable profits and induce firms to expand their assortments, even though they increase fixed costs for a given product portfoio size. In all three categories, average consumer surplus rises mainly because incumbent firms add products, not because many new firms enter.

The second counterfactual considers mergers between small firms. When fixed costs exhibit economies of scope, a merger can reduce distribution costs. We find that the fixed-cost savings dominates the merged firm's incentive to reduce product variety due to its internalization of product-level competition. As a result, mergers increase product variety.

The paper makes two contributions. First, it contributes to the literature on estimating discrete games with multiple equilibria and many discrete choices. Early work on incomplete discrete games, including Tamer (2003), Aradillas-Lopez and Tamer (2008), and Ciliberto and Tamer (2009), develops bounds that are valid without specifying an equilibrium selection rule but require working with market-level outcomes. Related work characterizes identified sets in incomplete models, including Beresteanu et al. (2011), Galichon and Henry (2011), and Chesher and Rosen (2017); de Paula (2013) surveys the econometric literature on games with multiple equilibria. Other approaches use moment inequalities based on necessary equilibrium conditions, revealed-preference restrictions, or support restrictions, including Pakes (2010), Pakes et al. (2015), Eizenberg (2014), Wollmann (2018). We combine these approaches with those in Fan and Yang (2025) and Sabal (2025). We use product-level restrictions to avoid enumerating all possible outcomes of a game, but allow the restrictions to depend on the observed product portfolio of a firm. This method allows us to estimate (dis)-economies of scope in fixed costs.

Second, the paper contributes to the empirical literature on product variety, mergers, and welfare. Several papers study how mergers affect product choice and welfare when firms can adjust their product offerings, including Berry and Waldfogel (2001), Fan (2013), Sweeting (2010), Wollmann (2018), Fan and Yang (2020), and Li et al. (2022). Other work studies entry responses to mergers or policy changes, including Ciliberto et al. (2021). We add to this literature by estimating economies of scope in fixed costs and by quantifying how those scope economies affect merger efficiencies and the response of product variety to market expansion (Ellickson, 2007).

The rest of the paper is organized as follows. Section 2 compares our approach with existing methods for estimating entry games. Section 3 describes the data and the three product categories. Section 4 presents the model of demand, pricing, and product choice. Section 5 describes the estimation of demand and marginal costs and reports the estimation results. Section 6 presents the inequalities used to estimate fixed-cost parameters, describes the inference procedure, and reports the estimation results. Section 7 presents the counterfactual simulations. Section 8 considers several variations of the model, and Section 9 concludes.

2 Entry Games: A Conceptual Comparison

This section compares our estimation approach with existing methods for discrete games. There are often three challenges in estimating discrete games:

1. firms face many discrete decisions (e.g., product entry decisions regarding each potential product of a firm);
2. costs associated with each decision may depend on other decisions (e.g., there may be (dis-)economies of scope in the fixed costs of product entry);
3. researchers need to recover the distribution of these costs (e.g., the distribution of the fixed cost).

Existing approaches address some of these but rarely all three. We use product choice as an example to explain the existing approaches and compare our approach to them.

Market-level bounds. One approach constructs bounds on the probability that an observed market outcome is an equilibrium or satisfies equilibrium conditions. Examples include Aradillas-Lopez and Tamer (2008), Ciliberto and Tamer (2009), Wang (2020), and Ciliberto et al. (2021). These methods can accommodate rich forms of scope economies because they work with market-level outcomes, allowing for cross-product interactions. They can also estimate the distribution of structural entry shocks because the probability bounds depend on the distribution. Their limitation is computational. The number of possible outcomes grows exponentially with the number of firms and the number of potential products of each firm, and evaluating whether each outcome can be supported as an equilibrium becomes infeasible in product markets with many firms or firms with many potential actions.

Product-level bounds. A second approach avoids this enumeration by constructing bounds on product-level choice probabilities. Fan and Yang (2025) show that, under weak behavioral assumptions, the probability that a product is offered can be bounded by the probability that offering the product is either a dominant action or not a dominated action. Sabal (2025) constructs bounds on product-level choice probabilities based on submodularity and private information assumptions. These methods are computationally attractive because they do not require solving the full game or enumerating all market configurations.

The product-level approach is effective when fixed costs are additively separable across products. In that case, the bounds for the probability of a product being offered used in this approach are independent of how many other products a firm also offers. The bounds may no longer be valid when the incremental fixed cost of a product depends on the firm's other products in the market, especially when the sign of the dependency is unknown.[1]

Revealed-preference inequality. A third approach uses revealed-preference inequalities implied by necessary conditions for optimality, as in Ho (2009), Pakes (2010), Pakes et al. (2015), Eizenberg (2014), Wollmann (2018), and Montag (2026). If the observed portfolio of a firm is optimal given other firms' observed portfolios, then unilaterally adding or dropping a product should not increase a firm's total profits. Specifically, the incremental variable profit from adding a product should not exceed the increase of the fixed cost, and the incremental variable profit decrease from dropping a product should exceed the decrease of the fixed cost. These restrictions avoid enumerating all outcomes and allow flexible fixed-cost functions.

The tradeoff is that these approaches usually rely on mean-zero restrictions, support restrictions, or other assumptions on unobservables. They do not generally estimate the full distribution of the structural fixed-cost shocks, which is an important input in counterfactual simulations.

This paper combines elements of the product-level approach and revealed-preference inequalities. We evaluate the implication of adding or dropping one or two products conditional on the firm's observed portfolio, which allows the incremental change of the fixed cost to depend on the number of other products the firm offers in the market. We develop inequalities that are robust to the presence of mixed-strategy equilibria and that allow us to estimate the fixed-cost distribution. We then use optimal-transport inference to infer the fixed cost

[1] Fan and Yang (2025) allow for a limited form of scope economies through a firm-entry component.

parameters by minimizing the distance between the support of the fixed-cost shocks implied by observed product choices and that from the model's fixed-cost distribution as in Li and Henry (2025). We thus obtain the confidence sets for the fixed-cost parameters without solving the full product-choice game.

3 Empirical Background and Data

We study three ready-to-consume categories: carbonated beverages, tea, and yogurt. The analysis combines NielsenIQ Retail Scanner data with the NielsenIQ Consumer Panel for 2007–2019.

Products, firms, and markets. A product is a brand standardized by package size and category-specific characteristics. We aggregate scanner data to the product–market–month level and measure price as a quantity-weighted monthly average. A firm is a corporate owner. For each firm, we define its set of potential products in a year as all products that it sells in any local market in the sample in that year. We define a market as a county–retail chain combination. In 70 percent of household-months, the entire purchase in a category comes from a single retailer, and the average household buys from only 1.38 retailers in a month.

Sample. Our carbonated beverages sample covers California, tea covers California, New York, and Texas, and yogurt covers California and New York. Table 1 reports summary statistics for all three categories in California. The standardized unit for carbonated beverage, tea, and yogurt is respectively 144oz, 64oz, and 16oz. The average annual sales are 113 million, 31 million, and 51 million units in quantity and \$598 million, \$82 million, and \$201 million in revenue. The average market has 363 carbonated-beverage products sold by 143 firms, 207 tea products sold by 120 firms, and 159 yogurt products sold by 70 firms. A small share of these firms are big firms, which we define as publicly traded firms with annual US revenue above one billion dollars. They have a total quantity share of 97%, 62%, and 90% in these three categories. The average price varies between \$3 and \$5 per unit, with products of big firms cheaper on average.

Table 1: Summary Statistics: Annual Average

Standard unit size	Carbonated 144 oz	Tea 64 oz	Yogurt 16 oz
Total quantity (standard units/yr)	113,337,533	30,574,672	50,849,823
Annual revenue (2019 $M/yr)	598.47	82.40	201.74
Products per market	363	207	159
Firms per market	143	120	70
Big firms	33	9	22
Big-firm quantity share (%)	97.0	62.0	90.4
Avg. price (2019 $/standard unit)	5.33	2.70	3.96
Big firms	5.16	2.35	3.78
Small firms	10.95	3.30	5.67
Markets	210	208	138

Notes: Statistics are annual averages over 2007–2019 for California markets. A market is a county–retail chain combination. Products are brand-by-characteristic combinations. Average price is quantity-weighted and measured in 2019 dollars per standard unit. Big firms are publicly traded firms with annual U.S. revenue above one billion dollars.

The fixed cost of offering a product. Part of the fixed cost is the cost of local marketing and distribution support. In addition, these costs also include logistics costs as firms in these categories often use direct-to-store delivery. These costs are likely to increase in market size. They may also exhibit (dis)economies of scope: on one hand, the incremental cost to market an additional product may be diminishing, implying economies of scope; on the other hand, the limited shelf-space makes adding another product harder, leading to dis-economies of scope.

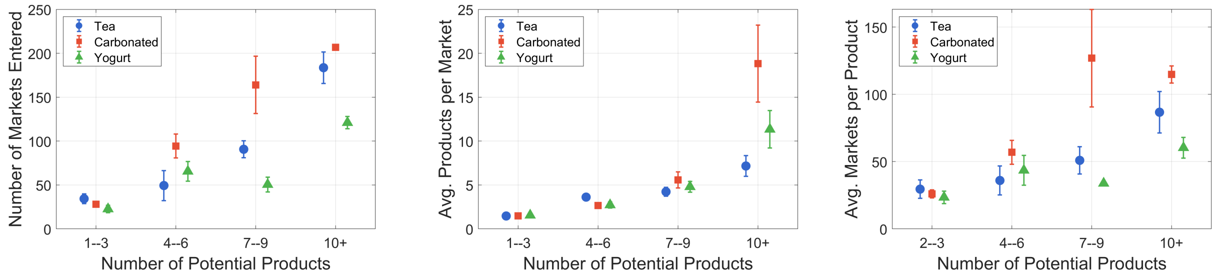
3.1 Suggestive Evidence on Economies of Scope

The product distribution patterns are consistent with economies of scope in local distribution. We group firms by their potential-product portfolio size and measure how widely their products are distributed. Figure 1 reports three measures of a firm's product distribution: the number of markets entered by a firm, the number of products offered conditional on entering a market, and the number of markets reached by each product.

All three measures rise with the number of potential products of a firm in all categories. Firms with larger potential portfolios enter more markets and offer more products per market. The average number of markets reached by a product also rises with the size of the firm's

Figure 1: Firm Potential Portfolio Size and Product Distribution

(a) # Markets Entered (b) Products per Market (c) Markets per Product



Notes: Firms are grouped by the number of potential products they hold. Markers report category means; bars report 95 percent confidence intervals.

potential product portfolio: a product is distributed more widely when it belongs to a firm with a larger portfolio of potential products. These patterns are consistent with economies of scope in fixed costs.

4 Model

We present the model for one product category and suppress the category index. The model has two stages.

4.1 Demand

Demand is described by a random-coefficient discrete-choice model. For each category, a product j's observable characteristics include a vector of indicator variables denoted by x_{kj}, where k indicates a dimension of the vector. The vector of characteristics differs across categories. We allow both household income and unobservable heterogeneity to affect preferences. The utility that household i gets from product j in market m in month t is:

$$\begin{aligned} u_{ijmt} = \sigma_0 \nu_{0i} &+ \gamma_0^{mid} \mathbb{1}(\text{mid income})_i + \gamma_0^{high} \mathbb{1}(\text{high income})_i \\ &+ \big(\alpha + \gamma_\alpha y_i\big) p_{jmt} + \sum_k \sigma_k \nu_{ki} x_{kj} + \mu_j^d + \mu_m^d + \mu_t^d + \xi_{jmt} + \varepsilon_{ijmt}, \end{aligned} \tag{1}$$

where y_i is the natural logarithm of household i's annual income, standardized by the mean and standard deviation, and $\nu_{\cdot i}$ is a household-specific unobserved taste shock, which follows

Table 2: Product Characteristics by Category

Category	# Characteristics	Characteristics
Carbonated beverages	7	Cola, Fruit Flavor, Herb/Spice, Diet, Sparkling, Coca-Cola owned, Pepsi owned
Tea	5	Lemon, Fruit Flavor, Green Tea, Black Tea, Organic
Yogurt	5	Fruit Flavor, Greek, Low Fat, Non Fat, Organic

Notes: Each characteristic is an indicator and receives a random coefficient in Equation (1).

a standard normal distribution and is independent across households. Therefore, the σ_0 and σ_k capture the dispersion in unobserved household tastes while the γ parameters measure the effect of household income on tastes. We allow the household income to affect price sensitivity through the term $\gamma_\alpha y_i p_{jmt}$ to capture the effect that higher-income household may be less price-sensitive. We also allow household income to affect the intercept of the utility. We define low-, middle-, and high-income groups according to income: low, (\$0, \$50K]; middle, (\$50K, \$100K]; and high, (\$100K, ∞). The low group is the omitted base so that γ_0^{mid} and γ_0^{high} are increments relative to it. This specification accommodates non-monotonic income effects on demand. For example, demand may rise with income at lower income levels but decline among high-income households. We thus allow for the possibility that products can become inferior goods at sufficiently high income levels. Product, market, and month fixed effects ($\mu_j^d, \mu_m^d, \mu_t^d$) capture unobserved factors at those levels. The term ξ_{jmt} captures transitory, product–market–month demand variation, and ε_{ijmt} is i.i.d. type-1 extreme value. Table 2 lists the observable characteristics x_{kj} in each category. The demand specification yields market shares $s_{jmt}(p_{jmt}, p_{-jmt})$ and, via the market size, demand $D_{jmt}(p_{jmt}, p_{-jmt})$, where p_{-jmt} denotes the vector of prices for all products other than j in market m in month t.

4.2 Supply

Supply is a two-stage static game. At the beginning of year τ, firms observe fixed costs and simultaneously choose product portfolios in each market. At the beginning of each month t, demand and marginal-cost shocks $(\xi_{jmt}, \omega_{jmt})$ are realized and firms choose prices. This timing follows, for example, Eizenberg (2014), Wollmann (2018), and Fan and Yang (2020, 2025). We address selection on unobserved demand and marginal-cost shocks by including product, market, and month fixed effects; the remaining unobservables are transitory product-market shocks that firms do not observe when choosing products.

Stage 2. Pricing. In month t, firm n chooses prices p_{jmt} for all products in its product portfolio $\mathcal{J}_{nm\tau}$ (i.e., all $j \in \mathcal{J}_{nm\tau}$) to maximize its variable profit,

$$\max_{p_{jmt},\, j \in \mathcal{J}_{nm\tau}} \sum_{j \in \mathcal{J}_{nm\tau}} \big(p_{jmt} - mc_{jmt}\big) D_{jmt}(p_{jmt}, p_{-jmt}). \tag{2}$$

The resulting first-order conditions characterize Nash-Bertrand pricing. We decompose marginal cost into product, market, and month fixed effects and a transitory shock,

$$\ln mc_{jmt} = \mu_j^{mc} + \mu_m^{mc} + \mu_t^{mc} + \omega_{jmt}. \tag{3}$$

We explore the scope effects in marginal cost in Section 8.

Stage 1. Product Choice. At the beginning of year τ, firm n is endowed with potential products $\mathcal{J}_{n\tau}$ and chooses $\mathcal{J}_{nm\tau} \subseteq \mathcal{J}_{n\tau}$ to offer in market m:

$$\max_{\mathcal{J}_{nm\tau} \subseteq \mathcal{J}_{n\tau}} \pi_{nm}\big(\mathcal{J}_{nm\tau}, \mathcal{J}_{-nm\tau}\big) - C_{nm}\big(\mathcal{J}_{nm\tau}\big), \tag{4}$$

where π_{nm} is expected variable profit and C_{nm} is the fixed cost.

We compute expected variable profit $\pi_{nm}\big(\mathcal{J}_{nm\tau}, \mathcal{J}_{-nm\tau}\big)$ given firm n's product portfolio $\mathcal{J}_{nm\tau}$ and firm n's competitors' product portfolios $\mathcal{J}_{-nm\tau}$ as follows. We substitute the second-stage equilibrium prices into the profit function, sum monthly profits over year τ, and take expectations over the transitory shocks. Let $p_{jmt}(\mathcal{J}_{nm\tau}, \mathcal{J}_{-nm\tau})$ and $Q_{jmt}(\mathcal{J}_{nm\tau}, \mathcal{J}_{-nm\tau})$ denote the second-stage equilibrium price and quantity, respectively, which depend on the observable covariates, fixed effects, as well as the shocks $(\xi_{jmt}, \omega_{jmt})$ for all products in market m. Let (ξ_{mt}, ω_{mt}) be the collections of demand and marginal cost shocks for all products in market m in month t. Then, firm n's expected variable profit, $\pi_{nm}\big(\mathcal{J}_{nm\tau}, \mathcal{J}_{-nm\tau}\big)$ in (4) is:

$$\begin{aligned} &\pi_{nm}\big(\mathcal{J}_{nm\tau}, \mathcal{J}_{-nm\tau}\big) \\ &= \sum_{t=1}^{12} E_{\xi_{mt},\omega_{mt}} \left(\sum_{j \in \mathcal{J}_{nm\tau}} \big(p_{jmt}(\mathcal{J}_{nm\tau}, \mathcal{J}_{-nm\tau}) - mc_{jmt}\big) \cdot Q_{jmt}(\mathcal{J}_{nm\tau}, \mathcal{J}_{-nm\tau}) \right). \end{aligned} \tag{5}$$

Next, we specify the fixed cost of selling a non-empty product portfolio $\mathcal{J}_{nm\tau}$. Let $J_{nm\tau}$ denote the size of the product portfolio $\mathcal{J}_{nm\tau}$: $J_{nm\tau} = |\mathcal{J}_{nm\tau}|$. The fixed cost is

$$\begin{aligned} &C_{nm}\big(\mathcal{J}_{nm\tau}\big) = \exp(\phi)\mathbb{1}(J_{nm\tau} > 0) + c_{nm} \cdot (J_{nm\tau})^{\lambda} + \sum_{j \in \mathcal{J}_{nm\tau}} \sigma_m \cdot \zeta_{jm\tau}, \\ &\text{where} \quad c_{nm} = \exp(w_{nm}^{(1)}\beta^{(1)}), \quad \sigma_m = \exp(w_m^{(2)}\beta^{(2)}). \end{aligned} \tag{6}$$

The first term in (6) is a market-entry cost that is independent of the product portfolio as long as it is non-empty. The second term is a baseline fixed cost c_{nm} scaled by the number of products J_{nm} via $(J_{nm})^{\lambda}$. When $\lambda < 1$, total fixed cost rises less than proportionally with the number of products, implying economies of scope; $\lambda = 1$ is the additive case; and $\lambda > 1$ corresponds to dis-economies of scope. The vector of covariates $w_{nm}^{(1)}$ in the baseline fixed cost c_{nm} includes a constant, indicators of whether firm n is a big firm and whether it is headquartered in the same state as market m. We also include ln(market size) and (ln(market size) − ln(median market size))$_+$, where $(x)_+ = \max(x, 0)$, to flexibly capture the effect of market size.

In the third term in (6), $\zeta_{jm\tau}$ is an unobserved product–market fixed-cost shock, which follows a standard normal distribution. We allow the standard deviation σ_m to be market-specific. The vector of covariates $w_m^{(2)}$ in the standard deviation σ_m includes a constant and the same two terms based on market size as above. In our baseline specification, we assume $\zeta_{jm\tau}$ to be i.i.d. In Section 8, we allow for correlated fixed-cost shocks.

Table 3: Excluded Instruments by Category

Category	Excluded instrument	Source of variation
Carbonated beverages	Local sugar tax indicator	Staggered county-level sugar tax adoption in California
Tea	Median manufacturing wage in the county of the nearest production plant	Wage variation at the county level and production location variation at the product level
Yogurt	(Raw milk price)$\times\mathbb{1}$(Greek)	Milk price variation at the time level and product type variation at the product level

Notes: The excluded instrument enters the macro moments alongside the exogenous product and market covariates.

5 Estimation of Demand and Marginal Cost

5.1 Estimation Procedure

We estimate demand and marginal costs separately by category, following Fan and Yang (2025). The estimation sample is from 2007 to 2019 in regions described in Section 3.

Demand is estimated by GMM, combining aggregate market-share moments with micro moments from the NielsenIQ Consumer Panel. The aggregate moments identify the mean price coefficient and fixed effects. The micro moments identify unobserved taste dispersion, the σ parameters, and income effects, the γ parameters. We provide details in Appendix A.

Macro moments and instruments. For any candidate parameter vector, we invert observed market shares to recover mean utilities and hence the structural demand shocks ξ_{jmt}, following Berry et al. (1995). The macro moments are $\mathbb{E}[\xi_{jmt}\, Z_{jmt}] = 0$, where Z_{jmt} collects exogenous covariates together with a category-specific excluded instrument for price. Table 3 summarizes the instrument for each category. For carbonated beverages, we exploit the staggered adoption of local sugar taxes across California counties. For tea, we use the median manufacturing wage in the county of the nearest production facility. For yogurt, we use the raw milk price interacted with an indicator for Greek yogurt, which uses substantially more milk per unit.

Micro moments. Following Fan and Yang (2025), we construct micro moments from the persistence of a household's purchases within a year. For a characteristic indicator k, we match the model-implied conditional mean $\mathbb{E}\left[q_{i\tau}^k \mid q_{i\tau}^k \geq 1\right]$ to its empirical counterpart where $q_{i\tau}^k$ represents the total type-k product quantity that a consumer purchases in year τ. A large σ_k makes a household's taste for characteristic f persistent across months, so the conditional mean is informative about σ_k. We add income-related moments to identify the income interactions.

Marginal cost. Given the demand estimates, we recover marginal costs from the Nash-Bertrand first-order conditions. We decompose the implied marginal cost into fixed effects and a transitory shock as in Equation (3).

5.2 Estimation Results

Table 4 reports the demand estimates for carbonated beverages. The estimated taste dispersions are large and precisely estimated. Herb and spice flavors have the largest dispersion. At an average income level of \$57,916, which corresponds with the standardized log income $y = 0$, the standard deviation estimate translates to \$6.14 per standard unit size (144oz). The Coca-Cola (\$3.38) and Pepsi (\$3.94) standard deviations are also large. The income estimates imply that middle-income households are more likely to buy an inside good. Higher-income households are less price-sensitive, which we find across all three categories. Table 5 and Table 6 report the demand estimates for tea and yogurt.

Table 7 compares data and model values for selected micro moments. The model closely matches total and fruit-flavor purchase intensity and the income-quantity gradient in all three categories.

Table 4: Demand Estimates: Carbonated and Low-Calorie Drinks

Unobserved	σ_0	1.46***	Income Effect	γ_α	0.007***
Heterogeneity		(< 0.01)			(< 0.01)
	σ^{Cola}	1.10***		γ_0	0.52
		(< 0.01)			(0.45)
	$\sigma^{\text{Fruit Flavor}}$	1.32***		γ_0^{mid}	0.57***
		(< 0.01)			(0.05)
	$\sigma^{\text{Herb/Spice}}$	3.93***		γ_0^{high}	0.12
		(< 0.01)			(0.08)
	σ^{Diet}	1.20***			
		(< 0.01)			
	$\sigma^{\text{Sparkling}}$	1.36***			
		(< 0.01)			
	σ^{Coke}	2.16***			
		(< 0.01)			
	σ^{Pepsi}	2.52***	Price Coefficient	α	−0.64**
		(< 0.01)			(0.31)
			Product FE		Yes
			Market FE		Yes
			Month FE		Yes
			# Observations		3,896,127

Notes: Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Instrument: sugar tax indicator. States: CA. Price per 144 oz. Quantity-weighted average own-price elasticity: −3.20.

Table 5: Demand Estimates: Tea

Unobserved	σ_0	0.63***	Income Effect	γ_α	0.25***
Heterogeneity		(< 0.01)			(0.04)
	σ^{Lemon}	2.28***		γ_0	0.36***
		(< 0.01)			(< 0.01)
	$\sigma^{\text{Fruit Flavor}}$	2.22***		γ_0^{mid}	0.53***
		(< 0.01)			(< 0.01)
	$\sigma^{\text{Green Tea}}$	2.34***		γ_0^{high}	−0.08***
		(< 0.01)			(< 0.01)
	$\sigma^{\text{Black Tea}}$	2.02***			
		(< 0.01)			
	σ^{Organic}	4.99***	Price Coefficient	α	−2.06***
		(< 0.01)			(0.65)
			Product FE		Yes
			Market FE		Yes
			Month FE		Yes
			# Observations		2,833,642

Notes: Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Instrument: nearest-plant county manufacturing median wage. States: CA, NY, TX. Price per 64 oz. Quantity-weighted-Mean own-price elasticity: -4.07.

Table 6: Demand Estimates: Yogurt

Unobserved	σ_0	1.27***	Income Effect	γ_α	0.51***
Heterogeneity		(< 0.01)			(< 0.01)
	$\sigma^{\text{Fruit Flavor}}$	1.38***		γ_0	0.32***
		(< 0.01)			(0.03)
	σ^{Greek}	1.80***		γ_0^{mid}	0.22***
		(< 0.01)			(< 0.01)
	$\sigma^{\text{Low Fat}}$	1.62***		γ_0^{high}	0.16***
		(< 0.01)			(0.01)
	$\sigma^{\text{Non Fat}}$	1.83***			
		(< 0.01)			
	σ^{Organic}	4.62***	Price Coefficient	α_p	−1.04***
		(< 0.01)			(0.04)
			Product FE		Yes
			Market FE		Yes
			Month FE		Yes
			# Observations		1,527,070

Notes: Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Instrument: raw milk price × Greek yogurt indicator. States: CA, NY. Price per 16 oz. Quantity-weighted-Mean own-price elasticity: −4.95.

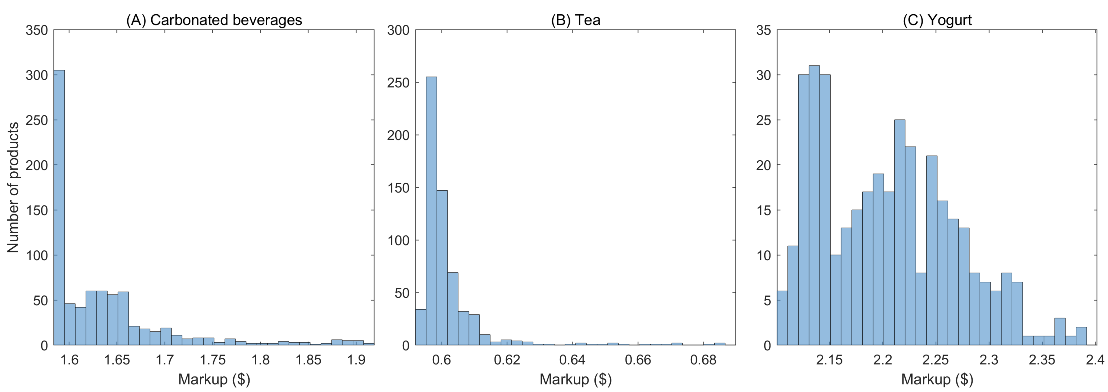
Table 7: Fit of Selected Micro Moments

	Carbonated		Tea		Yogurt	
Moment	Data	Model	Data	Model	Data	Model
$E[\sum_t q_{it} \mid \sum_t q_{it} \geq 1]$ (units/yr)	9.83	9.80	8.41	8.25	10.93	10.93
$E[\sum_t q_{it}^{\text{Fruit}} \mid \sum_t q_{it}^{\text{Fruit}} \geq 1]$ (units/yr)	5.77	5.83	6.37	6.42	8.90	9.01
Quantity diff: mid $-$ low income (units/yr)	3.47	3.45	2.68	2.90	1.08	1.14
Quantity diff: high $-$ low income (units/yr)	1.61	1.62	0.65	0.64	2.39	2.41
Expenditure/unit diff: mid $-$ low income (\$/unit)	0.03	0.02	0.06	0.04	0.05	0.07
Expenditure/unit diff: high $-$ low income (\$/unit)	0.14	0.06	0.19	0.15	0.20	0.15

Notes: Selected micro moments, data versus model. Purchase-intensity moments condition on at least one purchase of the relevant type during the year. Quantity is in standardized package-size units per household per year (see Table 1 for the package size used in each category). Expenditure/unit is in 2019 dollars per unit. The full estimation uses twelve micro moments for carbonated beverages and ten each for tea and yogurt.

The demand estimates imply the following quantity-weighted-average own-price elasticities: -3.20 for carbonated beverages, -4.95 for yogurt, and -4.07 for tea. Figure 2 plots the distribution of markups. The markup as a share of price is about 55% for yogurt, but lower for carbonated drinks (31%) and tea (22%).

Figure 2: Distribution of Markups



Notes: Markups in 2019 dollars, computed from the Nash-Bertrand first-order conditions at observed prices and estimated demand parameters.

6 Estimation of Fixed Cost

6.1 Inequalities for Estimation

In this section, we derive the inequalities used for estimating fixed cost parameters and describe the identification. Since we estimate the fixed cost parameters for each year separately, we suppress the year subscript τ in this section for expositional simplicity. We denote all fixed-cost parameters by θ.

Reformulation of the product choice problem. We first reformulate a firm's product choice decision from choosing a subset $\mathcal{J}_{nm} \subseteq \mathcal{J}_n$ from its potential products $\mathcal{J}_n$ to making a vector of binary product entry decisions regarding each potential product $j \in \mathcal{J}_n$. Let $Y_{jm} \in \{0, 1\}$ denote the product entry decision regarding potential product j. With this reformulation, we use $\pi_n(\boldsymbol{Y}_m)$ to denote firm n's variable profit in (5), where $\boldsymbol{Y}_m$ represents product-entry decisions of all firms regarding all potential products.

The following notations are useful: $\boldsymbol{Y}_{-jnm} = (Y_{j'm} : j' \in \mathcal{J}_n \setminus j)$ denotes firm n's entry decisions regarding all of its potential products other than j.; $\boldsymbol{Y}_{nm} = (Y_{jm} : j \in \mathcal{J}_n)$ denote firm n's entry decisions regarding all of its potential products; and $\boldsymbol{Y}_{-nm} = (Y_{n'm} : n' \neq n)$ denotes firm n's competitors' product entry decisions.

Inequalities for estimation. Given the entry decision regarding all other potential products in the market, the incremental change in firm n's variable profit when product j is added is:

$$\Delta_{jm}\left(\boldsymbol{Y}_{-jnm}, \boldsymbol{Y}_{-nm}\right) = \pi_{nm}\left(Y_{jm} = 1, \boldsymbol{Y}_{-jnm}, \boldsymbol{Y}_{-nm}\right) - \pi_{nm}\left(Y_{jm} = 0, \boldsymbol{Y}_{-jnm}, \boldsymbol{Y}_{-nm}\right), \quad (7)$$

which has following minimum and maximum:

$$\begin{aligned} \underline{\Delta}_{jm}(\boldsymbol{Y}_{-jnm}) &= \min_{\boldsymbol{Y}_{-nm}} \Delta_{jm}(\boldsymbol{Y}_{-jnm}, \boldsymbol{Y}_{-nm}), \quad (8) \\ \overline{\Delta}_{jm}(\boldsymbol{Y}_{-jnm}) &= \max_{\boldsymbol{Y}_{-nm}} \Delta_{jm}(\boldsymbol{Y}_{-jnm}, \boldsymbol{Y}_{-nm}). \end{aligned}$$

Similarly, the incremental change in the fixed cost when product j is added consists of two parts—a deterministic part (denoted by $\Delta FC_{jm}(\theta)$) and a product-specific shock (i.e., $\sigma_m \cdot \zeta_{jm}$)—as follows:

$$\underbrace{\exp(\phi)\mathbb{1}(J_{-jnm}=0) + c_{nm}\cdot\left[(J_{-jnm}+1)^{\lambda} - (J_{-jnm})^{\lambda}\right]}_{\overset{\text{def}}{=}\Delta FC_{jm}(\theta)} + \sigma_m \cdot \zeta_{jm}, \tag{9}$$

where $J_{-jnm} = \sum_{j' \in \mathcal{J}_{nm} \setminus j} Y_{j'm}$ is the number of non-zero elements in $\boldsymbol{Y}_{-jnm}$.

Since $Y_{jm} = 1$ if and only the incremental fixed cost being less than or equal to the incremental variable profit, i.e., $\Delta FC_{jm}(\theta) + \sigma_m \cdot \zeta_{jm} \leq \Delta_{jm}(\boldsymbol{Y}_{-jnm}, \boldsymbol{Y}_{-nm})$, we have

$$\begin{aligned} Y_{jm} = 1 &\implies \zeta_{jm} \;\leq\; \sigma_m^{-1}\big(\overline{\Delta}_{jm}(\boldsymbol{Y}_{-jnm}) - \Delta FC_{jm}(\theta)\big), \\ Y_{jm} = 0 &\implies \zeta_{jm} \;\geq\; \sigma_m^{-1}\big(\underline{\Delta}_{jm}(\boldsymbol{Y}_{-jnm}) - \Delta FC_{jm}(\theta)\big). \end{aligned} \tag{10}$$

These two inequalities define our econometric model, i.e., the model we take to the data for estimating fixed-cost parameters. Specifically, the econometric model consists of exogenous variables X_{jm}, endogenous outcome variable Y_{jm}, and parameters θ that satisfies the following restrictions:

$$\begin{aligned} Y_{jm} = 1 &\implies \zeta_{jm} \;\leq\; U_{jm}(\boldsymbol{Y}_{-jnm}, X_{jm}, \theta), \\ Y_{jm} = 0 &\implies \zeta_{jm} \;\geq\; L_{jm}(\boldsymbol{Y}_{-jnm}, X_{jm}, \theta), \end{aligned} \tag{11}$$

where $U_{jm}(Y_{-jnm}, X_{jm}, \theta)$ and $L_{jm}(Y_{-jnm}, X_{jm}, \theta)$ are the right-hand sides of (10). Here, we add the exogenous covariates X_{jm} as an argument in $U_{jm}(Y_{-jnm}, X_{jm}, \theta)$ and $L_{jm}(\boldsymbol{Y}_{-jnm}, X_{jm}, \theta)$ to this dependence explicit.[2] These bounds for an observation jm also depend on $\boldsymbol{Y}_{-jnm}$ because we allow for (dis-)economies of scope in fixed cost. Later, we sometimes drop these arguments, absorb them in the subscript jm, and shorten these bounds to $U_{jm}(\theta)$ and $L_{jm}(\theta)$ when it is unnecessary to make their dependence on these arguments explicit. We discuss how to compute the bounds in Appendix B.

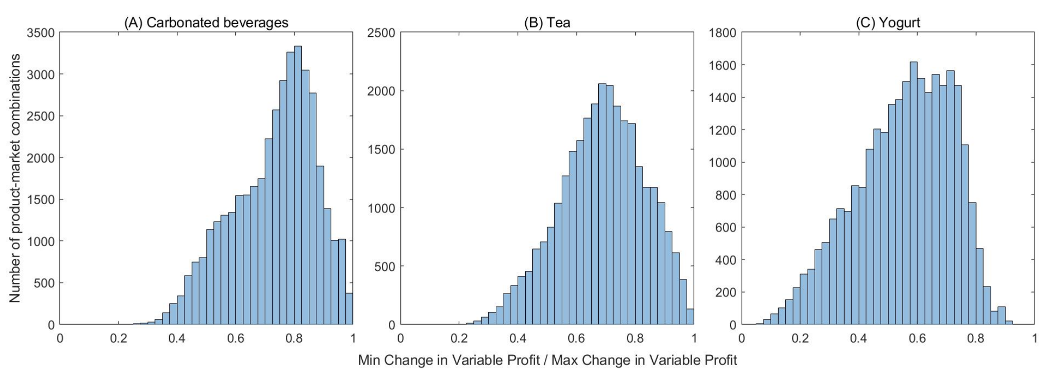
[2]Note that these covariates can include, for example, the characteristics of product j's competing products.

Identification of fixed-cost parameters. The identification intuition follows the idea of the special regressors in entry games: as shifters move the cutoff for the latent fixed-cost shock, the entry response identifies both the fixed-cost function and the shock distribution (Ciliberto and Tamer, 2009; Lewbel, 2019).

Specifically, exogenous variations in the covariates $w_{nm}^{(1)}$ identify $\beta^{(1)}$, the parameters in the baseline fixed cost c_{nm}. The scope parameter λ is identified from variations in a firm's product portfolio size induced by exogenous variations in demand and marginal cost shifters for the firm's potential products other than the focal product. As these exogenous variations lead to variation in J_{-jnm}, how the entry decision regarding j varies with J_{-jnm} identifies the scope parameter λ. Finally, $\beta^{(2)}$, the parameters in the standard deviation of the fixed-cost shock σ_m, are identified by how sharply product entry decisions respond to variations in variable profit bounds.

In our setting, we find that the upper and lower bounds of the incremental variable profit $\overline{\Delta}_{jm}$ and $\underline{\Delta}_{jm}$ are reasonably close (Figure 3), and both bounds are positively correlated with the entry probability.

Figure 3: Tightness of Incremental-Variable-Profit Bounds



Notes: Distribution of $\underline{\Delta}_{jm}/\overline{\Delta}_{jm}$, where a ratio near one means the bounds nearly coincide.

6.2 Inference

We construct the confidence set for fixed-cost parameters θ based on our econometric model (11) by inverting the optimal-transport-based test in Li and Henry (2025). The general idea is as follows. For each candidate parameter value, we ask whether the observed data can be matched to simulated unobservable shocks in a way that is consistent with the model under this parameter value. If yes, we keep the parameter value in the confidence set. If no, we reject it. Li and Henry (2025) formalize "match" as an optimal transport problem: match observed outcomes to simulated shocks at minimum "model violation cost." If the candidate parameter is plausible, there should be a low-cost matching between the observed data and the simulated shocks. Otherwise, even the best possible matching will leave large violations. So the test statistic basically measures the difficulty of rationalizing the data under a parameter value. In what follows, we show how to construct a tractable test statistic and critical value in our setting.

In our setting, an observation is a potential product-market combination indexed by jm. According to our model, each observed outcome Y_{jm} implies a support restriction for the unobservable shock according to (11). A fixed-cost parameter value is considered consistent with the data when the observed data can be matched with simulated shocks in a way that satisfies the model's support restrictions.

For expositional simplicity, let R denote the total number of potential product-market observations. Let r represent an observation indexed by jm. Therefore, Y_r represents the product entry outcome, X_r represents fixed-cost covariates, and ζ_r represents the fixed-cost shock for observation r.

6.2.1 Test Statistic

Simulated shock-covariate pairs. We draw R shocks from the distribution of the fixed-cost shock (i.e., the standard normal distribution) and denote them by $\{\tilde{\zeta}_r\}_{r=1}^{R}$. We pair each simulated draw with an observed covariate as $(\tilde{\zeta}_r, X_r)$.

Cost matrix. We define the cost of matching a simulated shock-covariate pair $(\tilde{\zeta}_r, X_r)$ to an observation $(Y_{r'}, X_{r'})$ as a Euclidean distance with two components, for r and r' from 1 to R. The first component measures how far $\tilde{\zeta}_r$ falls outside the model-implied support that the observed choice $Y_{r'}$ imposes on the support of ζ:

$$h_{r,r'}(\theta) = Y_{r'} \max\{0,\, \tilde{\zeta}_r - U_{r'}(\theta)\} + (1 - Y_{r'}) \max\{0,\, L_{r'}(\theta) - \tilde{\zeta}_r\}. \tag{12}$$

The second component measures the distance in covariates: $\|X_r - X_{r'}\|^2$. The cost of matching $(\tilde{\zeta}_r, X_r)$ to $(Y_{r'}, X_{r'})$:

$$d_{r,r'}(\theta) = \sqrt{h_{r,r'}(\theta)^2 + \|X_r - X_{r'}\|^2}. \tag{13}$$

Since this cost is defined for any pair of (r, r') where $r, r' = 1, ..., R$, this gives an $R \times R$ cost matrix. We denote this cost matrix by $d(Y^{\text{data}}, X^{\text{data}}, \theta)$ as it depends on the observables $(Y^{\text{data}}, X^{\text{data}}) = \{Y_r, X_r\}_{r=1}^R$.

Test statistic. The test statistic $T_R(\theta)$ is the solution to the optimal-transport problem given the cost matrix d:

$$\begin{aligned} T_R(\theta) \;&=\; \min_{\pi_{r,r'} \geq 0} \sum_{r=1}^{R} \sum_{r'=1}^{R} \pi_{r,r'}\, d_{r,r'}(\theta) \\ &\qquad \text{s.t.} \sum_{r=1}^{R} \pi_{r,r'} = \sum_{r'=1}^{R} \pi_{r,r'} = \tfrac{1}{R} \quad \text{for all } r, r'. \end{aligned} \tag{14}$$

The test statistic $T_R(\theta) = 0$ if and only if there exists a match such that every simulated shock rationalizes its matched observation.

Since this minimization problem is a linear programming problem over the cost matrix $d(y^{data}, \theta)$, we can denote it as $T_R(\theta) = D_R(d(Y^{\text{data}}, X^{\text{data}}, \theta))$, a notation that is useful to describe the critical value below.

6.2.2 Critical Value

Following Li and Henry (2025), the critical value is obtained by simulating the worst-case test statistic under the null hypothesis $H_0(\theta)$: θ is compatible with the observed data. For each Monte Carlo sample indexed by $b = 1, ..., B$, we draw $\{\tilde{\zeta}_r^b\}_{r=1}^R$. Since the model is incomplete, there may be many model-compatible outcomes $\{Y_r\}_{r=1}^R$ for a given $\{(\tilde{\zeta}_r^b, X_r)\}_{r=1}^R$, i.e., outcomes consistent with (11). Let $\mathcal{Y}(\{(\tilde{\zeta}_r^b, X_r)\}_{r=1}^R, \theta)$ be the collection of all such outcomes. We define the worse-case test statistic as the maximum over all such model-compatible outcomes: $T_R^b(\theta) = \max_{y \in \mathcal{Y}(\{(\tilde{\zeta}_r^b, X_r)\}_{r=1}^R, \theta)} D_R(d(y, X^{\text{data}}, \theta))$. The critical value is the $(1-\alpha)$ quantile of such a test statistic across draws.

In a setting with many firms and many decisions, computing this critical value can be prohibitive because it requires finding all model-compatible outcomes — enumerating all possible outcomes and checking whether each possible outcome is compatible with the model. This is computationally heavy because the number of possible outcomes increases exponentially with the number of firms and potential products.

Tractable critical value. We obtain a computable critical value through two relaxations of the test statistic above. The first relaxation enlarges the set $\mathcal{Y}(\{(\tilde{\zeta}_r^b, X_r)\}_{r=1}^R, \theta)$ while the second relaxation inflates the cost matrix. Therefore, both relaxations increase the critical value, making it more conservative. At the same time, both relaxations reduce the computational burden significantly.

Relaxation 1: "level-1 rationality".

We replace the model restrictions in (11) by weaker restrictions that resemble level-1 rationality. Specifically, we define the maximum of $U_{jm}(\theta)$ and the minimum of $L_{jm}(\theta)$ over $Y_{-j,nm}$, the product entry decisions regarding firm n's all potential products except j itself:

$$\overline{U}_{jm}(X_{jm}, \theta) = \max_{Y_{-j,nm}} U_{jm}(\boldsymbol{Y}_{-jnm}, X_{jm}, \theta), \quad \underline{L}_{jm}(X_{jm}, \theta) = \min_{\boldsymbol{Y}_{-jnm}} L_{jm}(\boldsymbol{Y}_{-jnm}, X_{jm}, \theta).$$

We consider an outcome vector in $\{0,1\}^R$ to be consistent with the simulated shocks if

$$Y_r = 1 \Rightarrow \tilde{\zeta}_r^b \leq \overline{U}_r(X_r, \theta) \quad \text{and} \quad Y_r = 0 \Rightarrow \tilde{\zeta}_r^b \geq \underline{L}_r(X_r, \theta) \quad \text{for all } r = 1, ..., R. \tag{15}$$

In other words, we enlarge the set $\mathcal{Y}(\{(\tilde{\zeta}_r^b, X_r)\}_{r=1}^R, \theta)$ to

$$\left\{\{Y_r\}_{r=1}^R \in \{0,1\}^R : \mathbb{1}(\tilde{\zeta}_r^b \leq \underline{L}_r(X_r, \theta)) \leq Y_r \leq \mathbb{1}(\tilde{\zeta}_r^b < \overline{U}_r(X_r, \theta))\right\}. \tag{16}$$

Since this set is directly defined, we do not need to enumerate and verify all possible outcomes. However, this set can be large, and computing the worse-case test statistic $T_R^b(\theta) = \max_{y \in \mathcal{Y}(\{(\tilde{\zeta}_r^b, X_r)\}_{r=1}^R, \theta)} D_R(d(y, X^{\text{data}}, \theta))$ still requires solving a number of optimal-transport problems that equals the cardinality of this set. The following second relaxation deals with this issue.

Relaxation 2: per-observation worst case.

Since the restrictions in (15) are independent across r, we can equivalently write the set in (16) as $\mathcal{Y}_1(W_1, \tilde{\zeta}_1^b, \theta) \times \ldots \times \mathcal{Y}_R((\tilde{\zeta}_r^b, X_r), \theta)$, where

$$\mathcal{Y}_r((\tilde{\zeta}_r^b, X_r), \theta) = \{Y_r \in \{0,1\} : \mathbb{1}(\tilde{\zeta}_r^b \leq \underline{L}_r(X_r, \theta)) \leq Y_r \leq \mathbb{1}(\tilde{\zeta}_r^b < \overline{U}_r(X_r, \theta))\}. \tag{17}$$

Define a new cost of matching for pair (r, r') as

$$\overline{d}_{r,r'}^{\,b}(\theta) = \max_{Y \in \mathcal{Y}_r((\tilde{\zeta}_r^b, X_r), \theta)} d_{r,r'}(Y; \theta). \tag{18}$$

Since $\mathcal{Y}_r((\tilde{\zeta}_r^b, X_r), \theta)$ has only two elements, this maximization problem is easy to compute: for each pair, we just choose $Y_r \in 0, 1$ that makes $\overline{d}_{r,r'}^{\,b}(\theta)$ larger.

Based on the new cost matrix $\overline{d}^{\,b}(\theta)$, we define the simulated worst-case test statistic as $\tilde{T}_R^b(\theta) = D_R(\overline{d}^{\,b}(\theta))$, which requires solving one optimal-transport. Our tractable critical value $\widehat{c}_{R,1-\alpha}(\theta)$ is the $(1-\alpha)$ quantile of $(\tilde{T}_R^b(\theta), b = 1, \ldots, B)$.

Since $\overline{d}_{r,r'}^{\,b}(\theta) \geq d_{r,r'}^b(y, X^{\text{data}}, \theta)$ in Relaxation 2 and the model-compatible set of outcomes is enlarged by Relaxation 1, this tractable critical value $\widehat{c}_{R,1-\alpha}(\theta)$ is a conservative one. The corresponding confidence region is

$$\widehat{\Theta} = \{\theta \in \Theta : T_R(\theta) \leq \widehat{c}_{R,1-\alpha}(\theta)\}. \tag{19}$$

6.3 Fixed-Cost Estimates

The fixed-cost parameters are estimated using Californian markets in 2019 following the procedure described above and report projected 95 percent confidence intervals. The potential products for a firm are defined as the set of unique products the firm sells in California. Therefore, a product the firm sells in market m but not in m' is a potential product that can enter in m'. We estimate the parameters $\beta^{(1)}$ in the baseline cost c_{nm}, the market entry cost $\exp(\phi)$, and the parameters $\beta^{(2)}$ in the shock scale σ_m in Equation (6). Table 8 reports the underlying structural parameters of the fixed-cost function in (6), and Table 9 reports the implied annual fixed costs at representative market sizes.

Table 8: Fixed-Cost Parameter Estimates: Projected 95% Confidence Intervals

	Carbonated	Tea	Yogurt
Scope and Market Entry Cost			
Scope parameter (λ)	$[0.24, 0.31]$	$[0.23, 0.32]$	$[0.24, 0.62]$
Market entry cost parameter (ϕ)	$[0.00, 0.68]$	$[-3.33, -2.85]$	$[1.11, 2.50]$
Baseline Fixed Cost ($\beta^{(1)}$)			
Constant	$[5.16, 5.49]$	$[5.03, 5.41]$	$[5.85, 6.61]$
$\mathbb{1}$(Big firm)	$[0.04, 0.38]$	$[-0.78, -0.41]$	$[-0.64, -0.09]$
$\mathbb{1}$(Local firm)	$[0.16, 0.61]$	$[-0.63, -0.29]$	$[-0.32, 0.75]$
Log market size	$[0.15, 0.24]$	$[0.09, 0.18]$	$[0.32, 0.59]$
(Log market size - Median)$_+$	$[-0.12, 0.05]$	$[0.21, 0.29]$	$[0.75, 1.09]$
Shock Dispersion ($\beta^{(2)}$)			
Constant	$[4.99, 5.28]$	$[4.96, 5.26]$	$[5.14, 5.88]$
Log market size	$[0.26, 0.33]$	$[0.41, 0.48]$	$[0.49, 0.75]$
(Log market size - log median)$_+$	$[0.35, 0.45]$	$[0.64, 0.15]$	$[0.53, 0.81]$
# product-market obs	40,320	29,120	27,048

Notes: The 95% confidence set projected to each parameter.

We find evidence for economies of scope, where λ is well below one in every category: the 95% projected interval is $[0.24, 0.31]$ for carbonated beverages, $[0.23, 0.32]$ for tea, and $[0.24, 0.62]$ for yogurt. This means that the incremental fixed cost for each additional product diminishes rapidly.

We allow fixed costs to vary by firm size and locality and find that both big firms and local firms enjoy a fixed-cost advantage in tea and yogurt but not in carbonated beverages.

We also find that both the level of the fixed cost and the dispersion of the shock rise with market size in every category. We allow fixed costs to depend on the logarithm of market size and also allow a kink at the median log market size. The estimated $\beta^{(1)}$ suggests that the slope is positive in all three categories and increases at the kink except for carbonated beverages. We also allow the dispersion of fixed costs to depend on market size ($\beta^{(2)}$) and find that the dispersion increases in market size across all three categories.

Table 9: Annualized Fixed Costs by Market Segment

	Carbonated	Tea	Yogurt
Small markets			
Big-owner AFC	[676, 1,041]	[338, 616]	[513, 1,737]
Small-owner AFC	[977, 1,316]	[904, 1,353]	[725, 2,396]
σ	[310, 445]	[259, 357]	[146, 406]
Medium markets			
Big-owner AFC	[771, 1,162]	[325, 593]	[1,201, 3,502]
Small-owner AFC	[1,273, 1,756]	[1,135, 1,605]	[2,702, 5,932]
σ	[507, 681]	[492, 661]	[795, 1,571]
Large markets			
Big-owner AFC	[1,201, 1,790]	[565, 1,067]	[3,462, 11,276]
Small-owner AFC	[1,594, 2,211]	[2,048, 3,025]	[11,446, 23,712]
σ	[1,654, 2,013]	[1,181, 1,644]	[2,469, 4,466]
Market size cutoffs	163K / 807K	43K / 235K	102K / 514K

Notes: Average annual fixed cost per entered product (AFC) and shock scale, evaluated at the median market size within each segment and the median portfolio size for each owner type. Ranges are $[\min, \max]$ across accepted parameter vectors. All values in 2019 U.S. dollars.

Table 9 translates the estimates into the average fixed cost of products that enter the markets in the data. Markets are organized into three groups, small, medium and large, with cutoffs at the terciles of each category's market sizes. Then, for big and small owners separately, we evaluate the fixed cost at the median market size within the group and the median number of entered products per firm within each group, across all parameter estimates in the 95% confidence set. We report the resulting average fixed cost per entered product (AFC) for each owner type, together with the scale of the corresponding fixed-cost shocks. Table 9 shows a clear ordering of distribution costs: yogurt is most expensive, followed by carbonated beverages and then tea. This ordering is consistent with differences in handling and replenishment requirements: yogurt requires refrigeration in transportation and storage and frequent restocking because it is more perishable, while carbonated beverages and tea are shelf-stable.

7 Counterfactual Simulations

We use the estimated model for two counterfactuals. The first studies how market growth, motivated by policies such as upzoning and densification, changes variety and welfare. The second asks whether mergers between small owners can raise welfare by pooling distribution under one portfolio. We report the minimum and maximum range across accepted parameter vectors in the 95 percent confidence set. The simulation procedure is described in Appendix C.

We draw product-level fixed-cost shocks that rationalize the observed product configuration as a complete-information Nash equilibrium. For each counterfactual scenario and each draw, we solve for a new equilibrium in product portfolios using best-response iteration, starting from the observed configuration, and solve the Nash-Bertrand pricing equilibrium within each candidate configuration.

7.1 Market Expansion

Urban densification raises the number of households served by a retailer, either uniformly or by reallocating population across locations. A larger market raises variable profit, encouraging firms to expand assortments. At the same time, as our estimates show, it also raises fixed distribution costs. Therefore, the net effect of increasing market size on product offerings is an empirical question. Suppose product variety increases with market size, then economies of scope amplify this effect: as the number of products increases with market size, the incremental cost of selling an additional product decreases under economies of scope,

Table 10: Uniform Population Increase (+10%): Changes from Baseline

	Baseline	(i) Full	(ii) FC fixed	(iii) Incumbents only
Panel A: Carbonated (210 markets)				
Markets affected	—	$[25, 54]$	$[32, 80]$	$[4, 24]$
Avg Δ products per affected mkt	—	$[+1.0, +1.3]$	$[+1.1, +1.9]$	$[+1.0, +1.2]$
Firm-market entry	—	$[14, 41]$	$[9, 31]$	0
Price ($/unit)	6.24	$[-0.008, +0.001]$	$[-0.027, -0.007]$	$[-0.005, +0.000]$
Quantity (units/yr)	62.2M	$[+6.23, +6.26]$M	$[+6.27, +6.37]$M	$[+6.22, +6.24]$M
Δ Consumer surplus ($/yr)	—	$[+10.9, +11.0]$M	$[+11.0, +11.2]$M	$[+10.9, +10.9]$M
per HH ($/HH/yr)	—	$[+0.003, +0.008]$	$[+0.010, +0.031]$	$[+0.000, +0.004]$
Δ Total surplus ($/yr)	—	$[+12.5, +12.8]$M	$[+13.3, +13.5]$M	$[+12.5, +12.8]$M
Panel B: Tea (208 markets)				
Markets affected	—	$[18, 43]$	$[19, 42]$	$[6, 30]$
Avg Δ products per affected mkt	—	$[+1.0, +1.3]$	$[+1.0, +1.4]$	$[+1.0, +1.2]$
Firm-market entry	—	$[6, 27]$	$[0, 7]$	0
Price ($/unit)	2.60	$[-0.022, +0.001]$	$[-0.035, -0.010]$	$[-0.021, -0.000]$
Quantity (units/yr)	18.8M	$[+1.89, +1.97]$M	$[+1.93, +2.05]$M	$[+1.89, +1.98]$M
Δ Consumer surplus ($/yr)	—	$[+1.3, +1.3]$M	$[+1.3, +1.4]$M	$[+1.3, +1.3]$M
per HH ($/HH/yr)	—	$[+0.004, +0.021]$	$[+0.012, +0.038]$	$[+0.003, +0.022]$
Δ Total surplus ($/yr)	—	$[+1.7, +1.8]$M	$[+1.8, +1.9]$M	$[+1.7, +1.8]$M
Panel C: Yogurt (138 markets)				
Markets affected	—	$[1, 74]$	$[8, 31]$	$[0, 72]$
Avg Δ products per affected mkt	—	$[-10.9, +1.0]$	$[+1.0, +1.2]$	$[-11.1, +1.0]$
Firm-market entry	—	$[0, 2]$	$[0, 1]$	0
Firm-market exits	—	$[0, 108]$	0	$[0, 108]$
Price ($/unit)	5.31	$[-0.013, +0.017]$	$[-0.006, -0.001]$	$[-0.013, +0.019]$
Quantity (units/yr)	4.06M	$[+0.21, +0.42]$M	$[+0.45, +0.58]$M	$[+0.21, +0.42]$M
Δ Consumer surplus ($/yr)	—	$[+0.46, +0.93]$M	$[+0.99, +1.29]$M	$[+0.46, +0.93]$M
per HH ($/HH/yr)	—	$[-0.078, +0.006]$	$[+0.017, +0.070]$	$[-0.078, +0.006]$
Δ Total surplus ($/yr)	—	$[+3$K$, +1{,}558$K$]$	$[+1{,}594$K$, +1{,}901$K$]$	$[+3$K$, +1{,}558$K$]$

Notes: Ranges are $[\min, \max]$ across accepted parameter vectors. (i) product choices of incumbents and entry of new firms respond, and fixed costs adjust to market size changes; (ii) product choices of incumbents and entry of new firms respond, but fixed costs do not adjust to market size changes; (iii) product choices of incumbents respond, no new entries are allowed, and fixed costs adjust to market size changes. Markets affected is the number of markets with product variety change. Average Δ products per affected mkt is the change in the average number of products in a market conditional on any variety change in the market. Firm-market entry is the total number of incidences where a new firm enters a market. All dollar values are annualized. M denotes million; K denotes thousand. "per HH" is the change in the per-household consumer surplus.

making it more likely that a firm sells more products.

7.1.1 Uniform Market-Size Changes

We scale the population of every California market by a common factor and let firms re-optimize. To separate the competing forces, we report three scenarios: (i) both variable profit and fixed costs adjust; (ii) variable profit adjusts but fixed costs are held at their baseline level, isolating the gain from higher variable profit alone; and (iii) only incumbents adjust, with no new firm entry.

Table 10 reports the aggregate and per-household changes when we increase the market size by 10%. Column (i) shows gains in the total consumer surplus. This gain arises mostly from the increase in the market size (new household consumers), not the average household. For carbonated beverages, 1 to 1.3 new products enter a new market. Comparing (i) with (iii) shows that most of the entry is due to incumbent variety expansion (average Δ products per affected market). There are between 14 and 41 incidences of new entrants across all markets. Both the incumbent variety expansion and the new firm entry bring niche, low-share products that add almost nothing to average consumer surplus (per HH row). The effects are similar for tea and yogurt.

Columns (i) and (ii) show that market-size-dependent fixed costs dampen the variety response. The gap is clearest in yogurt, where fixed costs rise most steeply with market size: under the full response, yogurt can lose variety on net.

The categories also differ sharply in the magnitude of the welfare gain, with carbonated beverages gaining an order of magnitude more consumer surplus than tea or yogurt. Welfare effects from the 30% increase and 10% decrease in market size scale roughly linearly with the shock, with the contraction larger than the expansion (Tables D.1 and D.2).

7.1.2 Population Movements

Densification also reallocates population across locations. We study transfers between California county pairs, holding the statewide total population fixed. Table 11 reports three transfer scenarios.

The transfers illustrate that reallocating population is not welfare-neutral. A transfer into a moderately sized county such as Merced raises combined surplus in carbonated beverages and tea, because the gaining county expands variety while the large losing county barely contracts. By contrast, the transfer into Fresno reduces combined surplus in carbonated beverages and yogurt, and the top-income transfer out of small San Benito reduces combined surplus in all three categories, because the small losing county suffers a significant variety reduction that outweighs the gains in the larger county.

Table 11: Population Transfers: Combined Welfare Effects

	(i) Carbonated	(ii) Tea	(iii) Yogurt
Fresno +10% *(from Santa Clara)*			
Δ Total surplus (K$/yr)	$[-91, -61]$	$[+14.1, +32.1]$	$[-24.7, -4.3]$
Δ Consumer surplus (K$/yr)	$[-88, -53]$	$[+4.8, +24.5]$	$[-47.9, -3.6]$
per HH ($/HH/yr)	$[-0.10, -0.06]$	$[+0.02, +0.08]$	$[-0.11, -0.01]$
Δ Producer surplus (K$/yr)	$[-9.3, -3.2]$	$[+7.1, +9.3]$	$[-4.9, +37.5]$
Merced +30% *(from Santa Clara)*			
Δ Total surplus (K$/yr)	$[+82, +91]$	$[+16.8, +20.4]$	$[-0.1, +7.6]$
Δ Consumer surplus (K$/yr)	$[+69, +77]$	$[+11.4, +14.8]$	$[-37.9, +2.6]$
per HH ($/HH/yr)	$[+0.10, +0.12]$	$[+0.05, +0.07]$	$[-0.11, +0.01]$
Δ Producer surplus (K$/yr)	$[+11.5, +15.4]$	$[+4.8, +6.1]$	$[+2.2, +37.7]$
Santa Clara +1% *(top-income movers from San Benito)*			
Δ Total surplus (K$/yr)	$[-58, -46]$	$[-10.1, -7.8]$	$[-34.8, -6.4]$
Δ Consumer surplus (K$/yr)	$[-47, -38]$	$[-6.6, -4.8]$	$[-37.8, +1.6]$
per HH ($/HH/yr)	$[-0.07, -0.06]$	$[-0.03, -0.02]$	$[-0.11, 0.00]$
Δ Producer surplus (K$/yr)	$[-13.4, -8.1]$	$[-4.4, -2.7]$	$[-16.4, +3.3]$

Notes: Combined welfare change across gaining and losing counties. Ranges are [min, max] across accepted parameter vectors. All dollar values are annualized; K$ denotes thousands of dollars. Scenario percentages refer to the gaining county's population change. "per HH" is the change in the per-household consumer surplus.

7.2 Mergers Between Small Owners

A merger between small owners alters welfare through three channels. First, the increased market power may lead to an increase in the variable profit associated with each product, incentivizing more product offerings. Second, the merged firm internalizes cannibalization among its products and may decide to drop products. Third, because $|\sum_n \mathcal{J}_{nm\tau}|^\lambda < \sum_n |\mathcal{J}_{nm\tau}|^\lambda$ with $\lambda < 1$ and the market entry cost is positive, the merged firm faces a lower fixed cost for the same product portfolio, leading to more product offerings.

We consider two counterfactual merger scenarios. For both, we rank the small firms in each category by the observed number of products that they sell in California. In the first merger scenario, the five largest small firms merge into a single firm. All other firms remain unchanged. Thus, this scenario studies a targeted consolidation among only the top five small firms. In the second merger scenario, all small firms are consolidated into groups of up to five firms. The five largest small firms merge into one firm, the next five largest small firms merge into another firm, and so on, with the remaining small firms merging into one

Table 12: Mergers Between Small Owners

	Carbonated		Tea		Yogurt	
	Due to internalization	Full	Due to internalization	Full	Due to internalization	Full
Merger Scenario 1: Top-Five Small-Firm Merger						
Markets with change	$[1, 5]$	$[39, 61]$	$[3, 12]$	$[40, 64]$	$[0, 3]$	$[49, 80]$
Avg Δ products per mkt	$[-1.4, -1]$	$[+1.2, +1.6]$	$[-1.4, -1]$	$[+1.2, +1.6]$	$[-1.3, -1]$	$[+1.5, +2.0]$
Δ Consumer surplus ($/yr)	$[-21, -8]$K	$[+15, +38]$K	$[-28, -13]$K	$[-10, -1]$K	$[-6, -0.4]$K	$[+10, +65]$K
Δ Producer surplus ($/yr)	$[+0.4, +2]$K	$[888, 1{,}219]$K	$[+0.6, +2]$K	$[645, 720]$K	$[-1.4, +0.0]$K	$[222, 315]$K
Δ Total surplus ($/yr)	$[-20, -7]$K	$[908, 1{,}248]$K	$[-27, -12]$K	$[640, 716]$K	$[-8, -0.4]$K	$[237, 360]$K
Merger Scenario 2: Grouped Small-Firm Consolidation						
Markets with change	$[1, 5]$	$[120, 141]$	$[4, 14]$	$[145, 159]$	$[0, 3]$	$[80, 101]$
Avg Δ products per mkt	$[-1.6, -1]$	$[+2.0, +2.5]$	$[-1.4, -1]$	$[+2.5, +3.0]$	$[-1.3, -1]$	$[+2.7, +3.4]$
Δ Consumer surplus ($/yr)	$[-23, -9]$K	$[+87, +195]$K	$[-30, -15]$K	$[+50, +84]$K	$[-6, -0.4]$K	$[+61, +166]$K
Δ Producer surplus ($/yr)	$[+0.5, +2]$K	$[1.53, 1.99]$M	$[+1, +2]$K	$[966, 1{,}052]$K	$[-1.4, +0.0]$K	$[334, 486]$K
Δ Total surplus ($/yr)	$[-22, -9]$K	$[1.69, 2.14]$M	$[-28, -14]$K	$[1.02, 1.14]$M	$[-8, -0.4]$K	$[395, 645]$K

Notes: In columns labeled "Due to internalization", the merged firm faces a fixed cost structure as if its merging firms were separate. In columns labeled "Full", we allow the merged firm to enjoy the full scope economies in fixed cost. Ranges are [min, max] across accepted parameter vectors in the 95% confidence set. All dollar flows annualized; K denotes thousand, M denotes million.

final firm.[3] Thus, this scenario studies broad consolidation among all small firms, grouped by size rank.

For each merger scenario, we conduct two counterfactual simulations in order to highlight the role of economies of scope in fixed cost. In the counterfactual simulations labeled "Due to internalization", we allow the merged firm to choose products out of potential products pooled across the merging firms and internalize all externalities among these products, except that its fixed cost is additive across the merging firms. In other words, the merged firm faces a fixed cost structure as if its merging firms were separate. Therefore, this counterfactual simulation rules out the third channel—the scope channel—explained above. In the counterfactual simulations labeled "Full", we additionally add the scope channel and allow the merged firm to enjoy the full economies of scope in fixed cost. The comparison of these two counterfactual simulations therefore isolates the scope channel.

We find that the scope channel dominates. Internalizing the business stealing incentives slightly reduces variety and consumer surplus in every category. Adding scope economies reverses this effect: the full merger expands variety in dozens of markets and raises total surplus substantially, by $[908, 1{,}248]$K per year for a single five-owner merger in carbonated

[3] For example, there are 29 small carbonated-beverage firms. The last merger therefore consists of four small firms.

beverages and by $[1.69, 2.14]$M per year when all small owners merge simultaneously. The gain is driven by scope savings that increase a firm's product portfolio. Consumer surplus also rises under the full merger in carbonated beverages and yogurt, although the consumer-surplus gains are an order of magnitude smaller than the producer-surplus gains.

8 Robustness Checks

This section reports three robustness exercises. Two keep the same model structure and vary the fixed-cost model: we consider correlated within-firm-market shocks and a flexible scope exponent. The third considers an alternative model where a retailer monopolist chooses both products and prices, and allows (dis)economies of scope in marginal costs. All exercises are based on the carbonated beverage category, and we show the robustness of our results from urban expansion. The estimates continue to imply sizeable scope economies in fixed costs. In the last, the monopolist retailer also expands product variety, similar to incumbent firms in the baseline model.

8.1 Correlation in the Fixed-Cost Shock

The baseline treats the product-level fixed-cost shocks ζ_{jm} as independent across a firm's products within a market. We relax this by allowing a common component,

$$\zeta_{jm} = \sqrt{\rho}\,\eta_{nm} + \sqrt{1-\rho}\,\epsilon_{jm}, \qquad \eta_{nm} \sim \mathcal{N}(0,1), \quad \epsilon_{jm} \sim \mathcal{N}(0,1), \tag{20}$$

where η_{nm} is common to all products of firm n in market m, ϵ_{jm} is idiosyncratic, and $\rho \in [0,1]$ governs the within-firm-market correlation, with $\rho = 0$ the baseline. The marginal distribution of each ζ_{jm} remains standard normal, so the inference framework of Section 6 is unchanged, and we estimate ρ jointly with the other fixed-cost parameters. Because the marginal is invariant to ρ, the single-product inequalities used in the baseline cannot identify it. We therefore use two sets of inequalities. The first is the same as the baseline; the second draws a pair of potential products, and builds inequalities based on the assumption that simultaneously reversing the entry decisions on both products reduces total profits. The parameter ρ shifts the probability of the joint outcomes and is identified from these paired inequalities. We use the Bonferroni correction to combine the test statistics from both sets of inequalities.

The estimated correlation is substantial, $\rho \in [0.62, 0.76]$, implying that about two thirds of the fixed-cost shock variance is common within an firm-market. The evidence for scope economies remains: the scope exponent stays at $\lambda \in [0.14, 0.27]$, well below one, and the other fixed-cost parameters are close to the baseline. Table 13 translates the estimates into annualized dollars by market segment.

Table 13: Annualized Fixed Costs under Correlated Shocks

	Small markets	Medium markets	Large markets
Big-firm AFC ($/yr)	[505, 1,940]	[423, 3,623]	[701, 4,421]
Small-firm AFC ($/yr)	[592, 2,313]	[837, 4,506]	[923, 5,498]
σ ($/yr)	[357, 591]	[358, 2,209]	[1,032, 2,209]
Scope and entry parameters (accepted range):			
Scope exponent (λ)		[0.14, 0.27]	
Entry cost ($/yr)		[0.5, 1.3]	
Shock correlation (ρ)		[0.62, 0.76]	

Notes: AFC is the annualized average fixed cost per entered product ($\times 12$); σ is annualized as $\sqrt{12}$ times the monthly scale. Scope, entry-cost, and correlation parameters are accepted ranges from the 95 percent confidence set. All values in 2019 U.S. dollars. Carbonated beverages.

Table 14 reports the uniform market-size counterfactual under the correlated-shock specification. A 10 percent increase raises the per-household consumer surplus by almost the same amount as in the baseline.

Table 14: Uniform Market-Size Changes under Correlated Shocks (Carbonated Beverage)

	Baseline	(i) Full	(ii) FC fixed	(iii) Incumb. only
Panel A: Population increase +10%				
Δ Products (net)	—	[−17, +79]	[+80, +209]	[−69, +0]
Firms entering	0	[7, 28]	—	0
Firms exiting	0	[0, 69]	—	[0, 69]
Avg price ($/unit)	6.24	[−0.040, −0.005]	[−0.042, −0.013]	[−0.030, +0.000]
Quantity (units/yr)	62.2M	[+6.23, +6.29]M	[+6.30, +6.41]M	[+6.22, +6.22]M
Δ CS ($/yr)	—	[+10.9, +11.0]M	[+11.0, +11.3]M	[+10.9, +10.9]M
per HH ($/HH/yr)	—	[+0.003, +0.014]	[+0.016, +0.039]	[−0.000, −0.000]
Δ PS ($/yr)	[9.5, 11.0]M	[+1.4, +1.7]M	[+2.3, +2.3]M	[+1.4, +1.7]M
Δ TS ($/yr)	—	[+12.3, +12.7]M	[+13.3, +13.6]M	[+12.3, +12.6]M
Panel B: Population increase +30%				
Δ Products (net)	—	[+30, +296]	[+313, +676]	[−136, +0]
Firms entering	0	[26, 70]	—	0
Firms exiting	0	[0, 136]	—	[0, 136]
Avg price ($/unit)	6.24	[−0.101, −0.022]	[−0.135, −0.062]	[−0.070, +0.000]
Quantity (units/yr)	62.2M	[+18.7, +18.9]M	[+18.9, +19.2]M	[+18.7, +18.7]M
Δ CS ($/yr)	—	[+32.7, +33.1]M	[+33.2, +33.8]M	[+32.6, +32.6]M
per HH ($/HH/yr)	—	[+0.009, +0.039]	[+0.047, +0.099]	[−0.001, +0.000]
Δ PS ($/yr)	[9.5, 11.0]M	[+4.3, +5.3]M	[+7.0, +7.0]M	[+4.3, +5.3]M
Δ TS ($/yr)	—	[+37.0, +38.2]M	[+40.2, +40.8]M	[+36.9, +37.9]M
Panel C: Population decrease −10%				
Δ Products (net)	—	[−972, −653]	[−1,527, −1,339]	[−976, −655]
Firms exiting	0	[76, 373]	—	[76, 373]
Avg price ($/unit)	6.24	[−0.011, +0.050]	[+0.099, +0.130]	[−0.011, +0.050]
Quantity (units/yr)	62.2M	[−6.6, −6.3]M	[−7.1, −6.9]M	[−6.6, −6.3]M
Δ CS ($/yr)	—	[−11.5, −11.1]M	[−12.5, −12.1]M	[−11.5, −11.1]M
per HH ($/HH/yr)	—	[−0.079, −0.027]	[−0.196, −0.148]	[−0.079, −0.027]
Δ PS ($/yr)	[9.5, 11.0]M	[−1.7, −1.4]M	[−2.3, −2.2]M	[−1.7, −1.4]M
Δ TS ($/yr)	—	[−13.2, −12.5]M	[−14.7, −14.3]M	[−13.2, −12.5]M

Notes: $\lambda \in [0.14, 0.27]$, $\rho \in [0.62, 0.76]$. Ranges are [min, max]; dollar values are annualized (×12). M denotes million. (i) product choices of incumbents and entry of new firms respond, and fixed costs adjust to market size changes; (ii) product choices of incumbents and entry of new firms respond, but fixed costs do not adjust to market size changes; (iii) product choices of incumbents respond, no new entries are allowed, and fixed costs adjust to market size changes. Under the −10% decrease there is no entry margin, so the full and incumbents-only columns coincide. Δ Products (net) is the total number of incidences a new product enters a market minus the number of incidences an existing product exits a market across all markets. "per HH" is the change in the per-household consumer surplus.

8.2 Flexible Scope Exponent

The baseline imposes a single scope exponent. To check that economies of scope are not an artifact of this constant-elasticity form, we let the exponent differ for small and large portfolios,

$$\lambda(n) = \begin{cases} \lambda_0 & \text{if } n \leq 6, \\ \lambda_0 + \lambda_1 & \text{if } n > 6, \end{cases} \tag{21}$$

where the cutoff $n = 6$ is near the median number of entered products per firm-market in carbonated beverages, and we re-estimate all parameters jointly. The estimates are $\lambda_0 \in [0.27, 0.41]$ for portfolios of six products or fewer and an increment $\lambda_1 \in [0.11, 0.31]$ above that, for a total exponent $\lambda_0 + \lambda_1 \in [0.45, 0.60]$ on larger portfolios. Both segments lie below one, so there are economies of scope throughout, and the positive λ_1 indicates that the scope economy weakens for large portfolios: the incremental fixed cost of an additional product falls less steeply once a firm already offers many products. This is consistent with diminishing returns to scope. Table 15 translates the estimates into annualized dollars by market segment and reports the scope and entry-cost parameters alongside.

Table 15: Annualized Fixed Costs under the Flexible Scope Exponent

	Small markets ($z \leq -0.55$)	Medium markets ($-0.55 < z \leq 0.48$)	Large markets ($z > 0.48$)
Big-firm AFC ($/yr)	$[276, 548]$	$[504, 921]$	[997, 1,826]
Small-firm AFC ($/yr)	$[405, 806]$	[921, 1,523]	[1,657, 2,962]
σ ($/yr)	$[117, 228]$	$[298, 466]$	[1,549, 2,322]
Scope and entry parameters (accepted range):			
Scope exponent, $n \leq 6$ (λ_0)		$[0.27, 0.41]$	
Scope increment, $n > 6$ (λ_1)		$[0.11, 0.31]$	
Total exponent, $n > 6$ ($\lambda_0 + \lambda_1$)		$[0.45, 0.60]$	
Entry cost ($/yr)		$[3.5, 8.7]$	

Notes: AFC is the annualized average fixed cost per entered product ($\times 12$), evaluated at the median market size within each tercile of standardized log market size z for a representative firm-market entity; σ is annualized as $\sqrt{12}$ times the monthly scale. Dollar cells are [min, max] across the 236 accepted draws. Scope and entry-cost parameters are accepted ranges. All values in 2019 U.S. dollars. Carbonated beverages.

Table 16 reports the market-expansion counterfactual under the flexible exponent, in the three-response format in which it was produced (full, fixed-cost held at baseline, and incumbents-only). The conclusions are qualitatively similar to those of our baseline results.

The per-household consumer surplus gain is slightly smaller. The steeper effective exponent for large portfolios sharpens one feature of the mechanism: when markets grow, incumbents with large portfolios trim marginal products even as they add others, but never drop their last product in a market, so firm-market exits remain zero under expansion. Under the 10 percent decrease, where there is no entry margin, the full and incumbents-only responses coincide.

Table 16: Uniform Market-Size Changes under the Flexible Scope Exponent (Carbonated Beverage)

	Baseline	(i) Full	(ii) FC fixed	(iii) Incumb. only
Panel A: Population increase +10%				
Δ Products (net)	—	$[+1, +46]$	$[+11, +121]$	$[-29, +11]$
Added by incumbents	—	$[5, 41]$	$[27, 117]$	$[5, 42]$
Added by new entrants	—	$[16, 41]$	0	—
Unique entrant firms	—	$[8, 14]$	0	0
Avg price (\$/unit)	6.24	$[-0.004, +0.003]$	$[+0.004, +0.013]$	$[-0.006, +0.001]$
Quantity (units/yr)	62.2M	$[+6.15, +6.25]$M	$[+6.26, +6.33]$M	$[+6.14, +6.23]$M
Π (\$/yr)	$[8.1, 9.3]$M	$[+1.62, +1.95]$M	$[+2.31, +2.32]$M	$[+1.63, +1.95]$M
Δ CS (\$/yr)	—	$[+10.73, +10.94]$M	$[+10.96, +11.09]$M	$[+10.71, +10.89]$M
per HH (\$/HH/yr)	—	$[-0.014, +0.007]$	$[+0.008, +0.022]$	$[-0.016, +0.002]$
Δ TS (\$/yr)	—	$[+12.43, +12.88]$M	$[+13.27, +13.41]$M	$[+12.42, +12.83]$M
Panel B: Population increase +30%				
Δ Products (net)	—	$[+79, +170]$	$[+197, +536]$	$[+17, +95]$
Added by incumbents	—	$[40, 125]$	$[181, 484]$	$[40, 128]$
Added by new entrants	—	$[55, 94]$	0	—
Unique entrant firms	—	$[13, 16]$	0	0
Avg price (\$/unit)	6.24	$[-0.008, +0.008]$	$[+0.021, +0.036]$	$[-0.011, +0.004]$
Quantity (units/yr)	62.2M	$[+18.49, +18.75]$M	$[+18.88, +19.03]$M	$[+18.47, +18.70]$M
Π (\$/yr)	$[8.1, 9.3]$M	$[+4.67, +5.58]$M	$[+6.98, +7.01]$M	$[+4.67, +5.57]$M
Δ CS (\$/yr)	—	$[+32.30, +32.79]$M	$[+33.05, +33.36]$M	$[+32.25, +32.69]$M
per HH (\$/HH/yr)	—	$[-0.027, +0.015]$	$[+0.037, +0.062]$	$[-0.027, +0.015]$
Δ TS (\$/yr)	—	$[+37.15, +38.34]$M	$[+40.04, +40.37]$M	$[+37.10, +38.23]$M
Panel C: Population decrease −10%				
Δ Products (net)	—	$[-2{,}071, -1{,}146]$	$[-1{,}972, -1{,}597]$	$[-2{,}071, -1{,}146]$
Dropped by incumbents	—	$[1{,}146, 2{,}071]$	$[1{,}597, 1{,}974]$	$[1{,}146, 2{,}071]$
Firm-market exits	—	$[396, 537]$	$[84, 106]$	$[396, 537]$
Unique exiting firms	—	$[31, 39]$	$[22, 30]$	$[31, 39]$
Avg price (\$/unit)	6.24	$[-0.064, -0.035]$	$[-0.122, -0.093]$	$[-0.064, -0.035]$
Quantity (units/yr)	62.2M	$[-6.60, -6.40]$M	$[-7.27, -6.99]$M	$[-6.60, -6.40]$M
Π (\$/yr)	$[8.1, 9.3]$M	$[-1.97, -1.63]$M	$[-2.23, -2.12]$M	$[-1.97, -1.63]$M
Δ CS (\$/yr)	—	$[-11.58, -11.21]$M	$[-12.85, -12.32]$M	$[-11.58, -11.21]$M
per HH (\$/HH/yr)	—	$[-0.086, -0.041]$	$[-0.240, -0.175]$	$[-0.086, -0.041]$
Δ TS (\$/yr)	—	$[-13.49, -12.87]$M	$[-14.97, -14.55]$M	$[-13.49, -12.87]$M

Notes: Piecewise scope $\lambda(n) = \lambda_0 + \lambda_1 \mathbf{1}(n > 6)$ with $\lambda_0 \in [0.27, 0.41]$, $\lambda_1 \in [0.11, 0.31]$. Ranges [min, max]; dollar values are annualized ($\times 12$); M denotes million. Prices use the baseline \$6.24/unit. (i) product choices of incumbents and entry of new firms respond, and fixed costs adjust to market size changes; (ii) product choices of incumbents and entry of new firms respond, but fixed costs do not adjust to market size changes; (iii) product choices of incumbents respond, no new entries are allowed, and fixed costs adjust to market size changes. Under the −10% decrease there is no entry margin, so columns (i) and (iii) coincide. Δ Products (net) is the total number of incidences a new product enters a market minus the number of incidences an existing product exits a market across all markets. "per HH" is the change in the per-household consumer surplus. Π is producer variable profit.

8.3 Retailer-Monopolist Pricing with (Dis)Economies of Scope in Marginal Costs

The baseline assumes firms of drink brands choose products and prices and ignores the strategic roles of the retailer. In this section, we assume the opposite: a retailer chooses products and prices. We re-estimate the model under the alternative assumption. The demand system is unchanged and only the supply side differs, in two places. First, the pricing first-order conditions are taken over the retailer's whole product set rather than each manufacturer's sub-portfolio, so the retailer chooses all shelf prices to maximize the joint variable profit $\Pi_m(S_m)$ of its assortment S_m. Second, the entry decision is made by the retailer, who adds or drops each product weighing its variable-profit contribution against its fixed cost. Economies of scope continue to enter the fixed cost through the per-product scaling $G(n) = n^\lambda$, indexed by the manufacturer-market portfolio as in the baseline.

We additionally allow (dis)economies of scope in marginal cost. Reinverting marginal costs under the retailer first-order conditions and regressing the recovered marginal cost on log portfolio size with product, market, and month fixed effects,

$$mc_{jmt} = \beta \log n_{f(j),m} + (\text{product, market, and month fixed effects}) + \omega_{jmt},$$

gives a slope of $\widehat{\beta} \approx -0.50$, suggesting economies of scope in marginal costs.

In contrast to the discrete game we analyze earlier, this setting features a retailer optimally choosing product offerings. Therefore, there are no multiple or mixed-strategy equilibria: the variable profit attached to each one-product deviation is a single number rather than an interval. As a result, we no longer need the relaxation of Section 6, because given a simulated draw of shocks from continuous distributions, there is a generically unique optimal choice. Our inference is thus based on the parameter-dependent critical value of Li and Henry (2025).

Table 17 reports the annualized fixed costs by market segment together with the scope and entry parameters. The scope economy survives: the scope exponent is $\lambda \in [0.14, 0.23]$ under retailer conduct. The level parameters shift as expected, since the higher equilibrium markups under monopolist conduct widen the variable-profit wedges that the fixed-cost inversion absorbs into the cost level.

Table 17: Annualized Fixed Costs under Retailer-Monopolist Pricing

	Small markets	Medium markets	Large markets
Big-firm AFC ($/yr)	$[286, 479]$	$[363, 507]$	$[1{,}779, 2{,}885]$
Small-firm AFC ($/yr)	$[473, 691]$	$[587, 727]$	$[1{,}774, 2{,}899]$
σ ($/yr)	$[650, 808]$	$[1{,}048, 1{,}271]$	$[5{,}102, 7{,}260]$
Scope and entry parameters (accepted range):			
Scope exponent (λ)		$[0.14, 0.23]$	
Entry cost ($/yr)		$[1.4, 2.5]$	

Notes: AFC is the annualized average fixed cost per entered product ($\times 12$), evaluated at the median market size within each tercile of standardized log market size z for a representative firm-market entity; σ is annualized as $\sqrt{12}$ times the monthly scale. All values in 2019 U.S. dollars. Carbonated beverages.

Table 18 reports the uniform market-size counterfactual under retailer conduct. The variety response is qualitatively the same as the baseline: a larger market supports more products and a smaller market fewer, with the full response dampened relative to the fixed-cost-held response. When market size decreases, the change in market outcomes is much larger than when the market size increases, because as products exit the survivors lose the scope discount, which raises their per-product fixed cost and compounds the contraction. The incumbents-only restriction binds only when there is new entry, so at the 10 percent decrease, where no entry occurs, the full and incumbents-only columns coincide. Welfare increases with market size, with per-household changes slightly smaller than in the baseline case.

Table 18: Uniform Market-Size Changes under Retailer-Monopolist Pricing (Carbonated Beverage)

	Baseline	(i) Full	(ii) FC fixed	(iii) Incumb. only
Panel A: Population increase +10%				
Active products	25,810	$[+249, +366]$	$[+291, +385]$	$[+233, +349]$
New firms entering	0	$[5, 18]$	$[5, 18]$	0
Firms exiting	0	$[13, 44]$	0	$[13, 44]$
Avg price ($/unit)	6.24	$[-0.008, -0.001]$	$[-0.008, -0.001]$	$[-0.007, -0.001]$
Quantity (units/yr)	62.2M	$[+4.2, +4.3]$M	$[+4.2, +4.3]$M	$[+4.2, +4.3]$M
Δ CS ($/yr)	—	$[+7.3, +7.4]$M	$[+7.3, +7.4]$M	$[+7.3, +7.4]$M
per HH ($/HH/yr)	—	$[+0.006, +0.011]$	$[+0.006, +0.011]$	$[+0.005, +0.010]$
Δ PS ($/yr)	$[1.2, 2.2]$M	$[+1.4, +1.5]$M	$[+1.5, +1.6]$M	$[+1.4, +1.5]$M
Δ TS ($/yr)	—	$[+8.8, +8.9]$M	$[+8.9, +9.0]$M	$[+8.8, +8.9]$M
Panel B: Population increase +30%				
Active products	25,810	$[+789, +1{,}001]$	$[+885, +1{,}056]$	$[+743, +945]$
New firms entering	0	$[31, 61]$	$[33, 64]$	0
Firms exiting	0	$[23, 78]$	0	$[23, 78]$
Avg price ($/unit)	6.24	$[-0.019, -0.009]$	$[-0.019, -0.009]$	$[-0.016, -0.007]$
Quantity (units/yr)	62.2M	$[+12.8, +12.8]$M	$[+12.8, +12.8]$M	$[+12.7, +12.8]$M
Δ CS ($/yr)	—	$[+22.1, +22.2]$M	$[+22.1, +22.2]$M	$[+22.0, +22.1]$M
per HH ($/HH/yr)	—	$[+0.020, +0.029]$	$[+0.020, +0.029]$	$[+0.017, +0.026]$
Δ PS ($/yr)	$[1.2, 2.2]$M	$[+4.4, +4.6]$M	$[+4.7, +4.8]$M	$[+4.3, +4.5]$M
Δ TS ($/yr)	—	$[+26.5, +26.7]$M	$[+26.8, +26.9]$M	$[+26.4, +26.6]$M
Panel C: Population decrease −10%				
Active products	25,810	$[-2{,}427, -2{,}239]$	$[-2{,}649, -2{,}401]$	$[-2{,}427, -2{,}239]$
Firms exiting	0	$[165, 223]$	$[210, 295]$	$[165, 223]$
Avg price ($/unit)	6.24	$[+0.065, +0.093]$	$[+0.065, +0.093]$	$[+0.065, +0.093]$
Quantity (units/yr)	62.2M	$[-4.7, -4.6]$M	$[-4.7, -4.6]$M	$[-4.7, -4.6]$M
Δ CS ($/yr)	—	$[-8.2, -8.0]$M	$[-8.2, -8.0]$M	$[-8.2, -8.0]$M
per HH ($/HH/yr)	—	$[-0.113, -0.085]$	$[-0.113, -0.085]$	$[-0.113, -0.085]$
Δ PS ($/yr)	$[1.2, 2.2]$M	$[-0.6, -0.4]$M	$[-0.7, -0.5]$M	$[-0.6, -0.4]$M
Δ TS ($/yr)	—	$[-8.7, -8.5]$M	$[-8.7, -8.6]$M	$[-8.7, -8.5]$M

Notes: $\lambda \in [0.14, 0.23]$. Ranges are [min, max]; flows annualized (×12); M denotes million. (i) retailer can change the incumbents' product choice and add products from firms not in the market, and fixed costs adjust to the change in market size; (ii) retailer can change the incumbents' product choice and add products from firms not in the market, and fixed costs do not adjust to the change in market size; (iii) retailer can change the incumbents' product choice but not add products from firms not in the market, and fixed costs adjust to the new market size. Active products is the number of product-market combinations in the baseline, and we report the changes in each simulation. "per HH" is the change in the per-household consumer surplus.

9 Conclusion

We develop a method for estimating fixed distribution costs and economies of scope when multiproduct firms choose among many potential products. The method uses bounds from observed product choices and evaluates them conditional on each firm's observed portfolio. This keeps the scope term well defined without enumerating market configurations. Combined with the finite-sample optimal-transport inference of Li and Henry (2025), the bounds deliver a confidence region for the fixed-cost parameters, including the scope exponent.

Applying the method to carbonated beverages, tea, and yogurt, we find economies of scope in distribution costs in every category: the incremental cost of adding a product falls as a firm's portfolio grows. These conclusions are robust to correlated fixed-cost shocks, alternative fixed-cost specifications, and an alternative model structure (Section 8).

Two counterfactual exercises illustrate the implications. Mergers between small firms can raise welfare by pooling distribution under a single portfolio, an effect most pronounced when the merging firms' products compete only weakly. Increases in local market size raise average consumer surplus in all three categories, and the gain runs largely through incumbents expanding their product offerings rather than through new firm entry.

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A Additional Details on Demand and Marginal Cost Estimation

This appendix provides additional details on the estimation of demand and marginal costs summarized in Section 5.

A.1 GMM criterion

Because our household sample is small relative to the size of each market and our specification absorbs a large number of fixed effects, we follow Fan and Yang (2025) and stack the macro and micro moments in a single GMM criterion rather than combining the two data sources into a joint likelihood. Grieco et al. (2021) show that the efficiency loss from stacking, as opposed to joint estimation, is modest in settings of this type.

A.2 Endogeneity and the excluded instruments

Within each category we use a cost shifter that moves price but is plausibly orthogonal to the local demand shock conditional on the product, market, and month fixed effects.

For carbonated beverages, we exploit the staggered adoption of local sugar taxes across California counties. The tax raises the price of sugar-containing products relative to others, generating price variation that is conditionally orthogonal to demand once product and market fixed effects are included. For tea, we use the median manufacturing wage in the county of the nearest production facility. Higher wages at the nearest plant raise production costs, and hence prices, but are plausibly uncorrelated with local demand shocks conditional on the fixed effects. For yogurt, we use the raw milk price interacted with an indicator for Greek yogurt. Greek yogurt uses substantially more milk per unit than regular yogurt, so movements in the raw milk price shift the relative cost, and hence the relative price, of Greek products.

A.3 Micro moment construction

Following Fan and Yang (2025), we construct micro moments from the persistence of a household's purchases within a year. For a product characteristic k, let $q^k_{i\tau} = \sum_t q^k_{it}$ denote household i's total purchases of products carrying characteristic k during year τ. We match the model-implied conditional mean $\mathbb{E}\left[q^k_{i\tau} \mid q^k_{i\tau} \geq 1\right]$ to its empirical counterpart. A large σ_k makes a household's taste for characteristic k persistent across months, so the conditional mean is informative about σ_k.

We add income-related micro moments to identify the income interactions. The difference in conditional annual purchase quantities between higher- and lower-income households identifies the income effects on the propensity to buy inside goods, κ_0^{mid} and κ_0^{high}, and the difference in expenditure per unit across income bins identifies the income effect on price sensitivity, κ_α.

In total we use twelve micro moments for carbonated beverages, namely an overall purchase-persistence moment, seven characteristic-specific persistence moments, and four income moments; and ten micro moments for tea and for yogurt, with the same structure and five characteristic-specific moments.

A.4 Marginal cost decomposition

We decompose the implied marginal cost into product, market, and month fixed effects and a transitory marginal cost shock ω_{jmt}:

$$\ln mc_{jmt} \; = \; \mu_j^{mc} + \mu_m^{mc} + \mu_t^{mc} + \omega_{jmt}, \tag{22}$$

where μ_j^{mc}, μ_m^{mc}, and μ_t^{mc} are product, market, and month fixed effects. We allow economies or diseconomies of scope in marginal cost only as a robustness check (Section 8); the baseline specification includes only the three sets of fixed effects.

B Variable Profit Computation and Bounding

With demand and marginal costs in hand, we compute each firm's expected variable profit at the Nash-Bertrand pricing equilibrium, summing the equilibrium variable profit over the months of the year and taking expectations over the transitory demand and marginal cost shocks, as in the model of Section 4. These expected variable profits are the inputs to the fixed-cost estimation.

For the fixed-cost step we work with the incremental variable profit of a single-product deviation, the change in a firm's expected variable profit from adding one product while holding the remainder of the firm's and rivals' portfolios at their observed configurations. Because the firm's beliefs over rival responses are not observed, we do not treat this incremental variable profit as a single known number but bound it.

Holding the observed environment fixed and varying only the configurations consistent with a one-product deviation, we compute a lower bound $\underline{\Delta}_j$ and an upper bound $\overline{\Delta}_j$ on the incremental variable profit, so that $\Delta_j \in [\underline{\Delta}_j, \overline{\Delta}_j]$. These two bounds are computed once from the demand and marginal-cost estimates and are treated as data in the fixed-cost step; they do not depend on the fixed-cost parameters.

Following Fan and Yang (2025), we approximate the extrema using the most and least competitive configurations:

$$\underline{\Delta}_j \approx \Delta_j(1, \ldots, 1), \qquad \overline{\Delta}_j \approx \Delta_j(0, \ldots, 0),$$

where $(1, \ldots, 1)$ denotes all other products present and $(0, \ldots, 0)$ denotes all absent. Under the maintained submodularity of variable profits, these extreme configurations yield the tightest and loosest competitive environments, respectively.

C Counterfactual Simulation Procedure

Two ingredients are common to all counterfactual exercises.

Recovering fixed-cost shocks. We draw product-level fixed-cost shocks that rationalize the observed product configuration as a complete-information Nash equilibrium. The shocks are drawn from truncated normal distributions that impose the per-product entry and non-entry conditions, a non-negativity restriction on realized incremental fixed costs, and portfolio-level feasibility. We verify that the implied best response reproduces the observed configuration: each firm's observed portfolio is a best response to its rivals' observed portfolios at the drawn shocks.

Solving for a new equilibrium. For each scenario we solve for a new equilibrium in product portfolios using best-response iteration: starting from the observed configuration, we cycle through owners and check whether any single-product addition or removal is profitable, declaring convergence when no owner has a profitable deviation. Within each candidate configuration we solve the Nash-Bertrand pricing equilibrium. We use multiple starting points and select the equilibrium with the highest total surplus. We report ranges $[\min, \max]$ across parameter vectors drawn from the 95 percent confidence set, which reflects the set identification of the fixed-cost parameters.

D Additional Market Expansion Counterfactual Results

Table D.1: Uniform Population Increase (+30%): Changes from Baseline

	Baseline	(i) Full	(ii) FC fixed	(iii) Incumbents only
Panel A: Carbonated (210 markets)				
Markets affected	—	$[82, 121]$	$[101, 150]$	$[36, 75]$
Avg Δ products per affected mkt	—	$[+1.3, +2.1]$	$[+2.0, +3.5]$	$[+1.2, +2.1]$
Firm-market entry	—	$[59, 101]$	$[28, 75]$	0
Price ($/unit)	6.24	$[-0.001, +0.001]$	$[-0.002, +0.001]$	$[-0.001, +0.001]$
Quantity (units/yr)	62.2M	$[+18.72, +18.81]$M	$[+18.87, +19.13]$M	$[+18.69, +18.74]$M
Δ Consumer surplus ($/yr)	—	$[+32.7, +32.9]$M	$[+33.0, +33.6]$M	$[+32.7, +32.8]$M
per HH ($/HH/yr)	—	$[+0.011, +0.025]$	$[+0.036, +0.078]$	$[+0.004, +0.013]$
Δ Total surplus ($/yr)	—	$[+37.4, +38.4]$M	$[+40.0, +40.6]$M	$[+37.3, +38.3]$M
Panel B: Tea (208 markets)				
Markets affected	—	$[58, 90]$	$[68, 110]$	$[27, 64]$
Avg Δ products per affected mkt	—	$[+1.2, +1.5]$	$[+1.4, +1.8]$	$[+1.1, +1.4]$
Firm-market entry	—	$[27, 59]$	$[5, 18]$	0
Price ($/unit)	2.60	$[-0.035, -0.011]$	$[-0.086, -0.045]$	$[-0.041, -0.018]$
Quantity (units/yr)	18.8M	$[+5.74, +5.91]$M	$[+5.89, +6.14]$M	$[+5.71, +5.90]$M
Δ Consumer surplus ($/yr)	—	$[+3.8, +4.0]$M	$[+4.0, +4.1]$M	$[+3.8, +4.0]$M
per HH ($/HH/yr)	—	$[+0.022, +0.053]$	$[+0.049, +0.091]$	$[+0.017, +0.049]$
Δ Total surplus ($/yr)	—	$[+5.1, +5.3]$M	$[+5.4, +5.6]$M	$[+5.1, +5.3]$M
Panel C: Yogurt (138 markets)				
Markets affected	—	$[7, 85]$	$[29, 64]$	$[4, 84]$
Avg Δ products per affected mkt	—	$[-10.2, +1.0]$	$[+1.1, +1.5]$	$[-10.3, +1.0]$
Firm-market entry	—	$[0, 3]$	$[0, 2]$	0
Firm-market exits	—	$[0, 123]$	0	$[0, 123]$
Price ($/unit)	5.31	$[-0.020, +0.017]$	$[-0.018, -0.006]$	$[-0.020, +0.018]$
Quantity (units/yr)	4.06M	$[+1.01, +1.32]$M	$[+1.42, +1.65]$M	$[+1.01, +1.32]$M
Δ Consumer surplus ($/yr)	—	$[+2.2, +2.9]$M	$[+3.1, +3.7]$M	$[+2.2, +2.9]$M
per HH ($/HH/yr)	—	$[-0.070, +0.035]$	$[+0.070, +0.150]$	$[-0.070, +0.035]$
Δ Total surplus ($/yr)	—	$[-0.1, +4.7]$M	$[+5.0, +5.6]$M	$[-0.1, +4.7]$M

Notes: Ranges are $[\min, \max]$ across accepted parameter vectors. (i) product choices of incumbents and entry of new firms respond, and fixed costs adjust to market size changes; (ii) product choices of incumbents and entry of new firms respond, but fixed costs do not adjust to market size changes; (iii) product choices of incumbents respond, no new entries are allowed, and fixed costs adjust to market size changes. Markets affected is the number of markets with product variety change. Average Δ products per affected mkt is the change in the average number of products in a market conditional on any variety change in the market. Firm-market entry is the total number of incidences where a new firm enters a market. All dollar values are annualized. M denotes million. "per HH" is the change in the per-household consumer surplus.

Table D.2: Uniform Population Decrease (−10%): Changes from Baseline

	Baseline	(i) Full	(ii) FC fixed	(iii) Incumbents only
Panel A: Carbonated (210 markets)				
Markets affected	—	$[195, 209]$	$[176, 202]$	$[195, 209]$
Avg Δ products per affected mkt	—	$[-7.4, -4.7]$	$[-8.7, -7.2]$	$[-7.4, -4.7]$
Firm-market exits	—	$[411, 585]$	$[77, 116]$	$[411, 585]$
Price ($/unit)	6.24	$[-0.013, -0.006]$	$[-0.003, +0.005]$	$[-0.013, -0.006]$
Quantity (units/yr)	62.2M	$[-6.57, -6.38]$M	$[-7.09, -6.91]$M	$[-6.57, -6.38]$M
Δ Consumer surplus ($/yr)	—	$[-11.5, -11.2]$M	$[-12.5, -12.2]$M	$[-11.5, -11.2]$M
per HH ($/HH/yr)	—	$[-0.080, -0.037]$	$[-0.198, -0.158]$	$[-0.080, -0.037]$
Δ Total surplus ($/yr)	—	$[-13.3, -12.8]$M	$[-14.7, -14.4]$M	$[-13.3, -12.8]$M
Panel B: Tea (208 markets)				
Markets affected	—	$[182, 200]$	$[143, 170]$	$[182, 200]$
Avg Δ products per affected mkt	—	$[-4.8, -3.8]$	$[-3.7, -2.8]$	$[-4.8, -3.8]$
Firm-market exits	—	$[471, 651]$	$[75, 124]$	$[475, 667]$
Price ($/unit)	2.60	$[-0.089, -0.045]$	$[-0.002, +0.044]$	$[-0.094, -0.043]$
Quantity (units/yr)	18.8M	$[-2.15, -2.05]$M	$[-2.26, -2.11]$M	$[-2.16, -2.05]$M
Δ Consumer surplus ($/yr)	—	$[-1.4, -1.4]$M	$[-1.5, -1.4]$M	$[-1.4, -1.4]$M
per HH ($/HH/yr)	—	$[-0.061, -0.039]$	$[-0.087, -0.053]$	$[-0.064, -0.040]$
Δ Total surplus ($/yr)	—	$[-1.9, -1.8]$M	$[-2.0, -1.8]$M	$[-2.0, -1.8]$M
Panel C: Yogurt (138 markets)				
Markets affected	—	$[47, 114]$	$[73, 95]$	$[45, 114]$
Avg Δ products per affected mkt	—	$[-7.9, -2.0]$	$[-8.8, -4.2]$	$[-7.9, -2.1]$
Firm-market entry	—	$[0, 2]$	0	$[0, 2]$
Firm-market exits	—	$[55, 153]$	$[15, 32]$	$[55, 153]$
Price ($/unit)	5.31	$[+0.013, +0.025]$	$[-0.008, +0.015]$	$[+0.013, +0.025]$
Quantity (units/yr)	4.06M	$[-0.63, -0.42]$M	$[-0.76, -0.62]$M	$[-0.63, -0.42]$M
Δ Consumer surplus ($/yr)	—	$[-1.4, -0.9]$M	$[-1.7, -1.4]$M	$[-1.4, -0.9]$M
per HH ($/HH/yr)	—	$[-0.109, -0.009]$	$[-0.172, -0.103]$	$[-0.109, -0.009]$
Δ Total surplus ($/yr)	—	$[-1.8, -0.8]$M	$[-2.2, -1.9]$M	$[-1.8, -0.8]$M

Notes: Ranges are [min, max] across accepted parameter vectors. (i) product choices of incumbents and entry of new firms respond, and fixed costs adjust to market size changes; (ii) product choices of incumbents and entry of new firms respond, but fixed costs do not adjust to market size changes; (iii) product choices of incumbents respond, no new entries are allowed, and fixed costs adjust to market size changes. Markets affected is the number of markets with product variety change. Average Δ products per affected mkt is the change in the average number of products in a market conditional on any variety change in the market. Firm-market entry is the total number of incidences where a new firm enters a market. All dollar values are annualized. M denotes million. "per HH" is the change in the per-household consumer surplus.