The role of nonlinear pricing and resale price maintenance on nominal price stability

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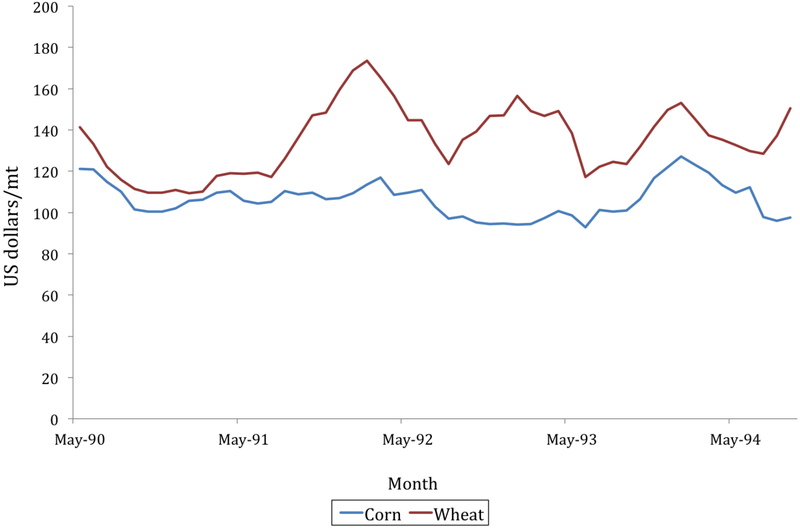
VI Congreso de Economía Colombiana
Universidad de los Andes
Bogotá ⋆ September 2018

Universidad del Rosario | Facultad de Economía

Price stickiness: central concern for Macroeconomics

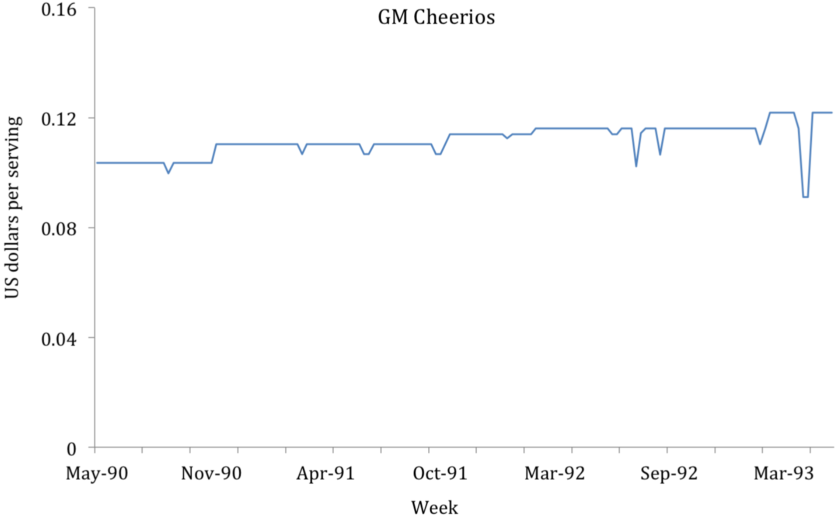
- Monetary policy is less effective in real terms the more responsive prices are to shocks.
- In standard New Keynesian models: the degree of stickiness in individual goods prices determines the degree of aggregate price inertia.
- Even small **menu costs** may be sufficient to generate substantial aggregate nominal rigidities.
  (Akerlof & Yellen, 1985; Mankiw, 1985; Parkin, 1986; Blanchard & Kiyotaki, 1987).
- There are **regular** prices and **temporary** prices (Kehoe and Midrigan, 2012).
- Variation in regular prices ultimately determines how responsive aggregate prices are to monetary policy.

Input prices are less stable than retail prices



Source: World Bank.

Input prices are less stable than retail prices



Sources: Dominick's data.

What can we learn from micro-analysis?

- There are three main sources of nominal price stability (Engel, 2002):
  - Local costs (international trade).
  - Markup adjustment.
  - Adjustment costs (e.g. menu costs).
- Vertical relations matter when it comes to explain incomplete transmission of costs shocks to retail prices.
- **Jullien and Rey (RAND, 2007):** Resale price maintenance (RPM) makes prices less responsive to local shocks on retail costs and demand.

Vertical relations: key concepts

- **Linear tariffs:** the manufacturer charges the retailer a constant price per unit of product.
  Gives rise to the double marginalization problem.
- **Two-part tariffs:** the manufacturer charges a franchise fee and a constant price per unit of product.
- **Resale price maintenance (RPM):** the manufacturer imposes the retail price in addition to wholesale tariffs.

This paper

Objective

- Empirically explore the role of two-part tariffs and RPM on nominal price stability in the presence of price adjustment costs.

Empirical strategy

- Develop a model of demand and supply, according to two vertical conducts: linear tariffs and two-part tariffs (with RPM).
- Account explicitly for price adjustment costs.
- Estimate a flexible demand model using sales data of RTE cereals.
- Back out bounds for retail price adjustment costs under each conduct.

Preliminary results

- Estimated bounds are slightly lower under RPM as compared to linear tariffs.
- Mean upper bound is 3% and mean lower bound is 1.6% of retailer's total yearly revenue, on average.

The IO literature

- **Structural models of vertical relationships:**
  - Accounting for price rigidity: **Goldberg and Hellerstein (REStud, 2013)**.
  - Other sources: Hellerstein (JIE, 2008), Hellerstein and Villas-Boas (JIE, 2010), **Bonnet et al. (REStats, 2013)**.
- **Other approaches:**
  - Accounting for price rigidity: Slade (RES, 1998), Leibtag et al. (2007), Nakamura and Zerom (RES, 2010).
  - Other sources: Bettendorf and Verboven (2000), Goldberg and Verboven (JIE, 2000), Chevalier et al. (AER, 2003), Campa and Goldberg (2006).

Outline of the talk

1. Data overview and preliminary evidence
2. The structural model
3. Empirical implementation
4. Results
5. Work in progress

Data overview

1. *Dominick's* database 1989–1997 (U. Chicago Kilts Center for Marketing).
    - Scanner data reported by the chain.
    - 489 UPCs of ready-to-eat breakfast cereals.
    - 93 stores in Chicago Metropolitan Area.
    - Contains (on a weekly basis): retail prices, average acquisition costs, volume sales, product description.
2. Additional data collected from several sources:
    - Brand characteristics: cereal boxes.
    - Instruments: US Department of Labor, World Bank, US Department of Agriculture.

Preliminary evidence

- The probability of observing a change in:
  - Retail prices is 21%.
  - Average Acquisition Cost (AAC) is 57%.
- Reduced-form regressions of the log of retail price on log of input prices yield very low pass-through rates.
- A 10% increase in
  - Labor compensation —> 1.3% increase in retail price.
  - Price of Corn —> 1.1% increase in retail price.
  - AAC —> 2% increase in retail price.

Supply models: price setting with adjustment costs

- Static model of single common agency.
- Competition upstream and a monopoly downstream.
- Manufacturers are indexed by $f = \{1, \ldots, N\}$.
- The retailer is indexed by r.
- Two alternative supply models: linear pricing and Two-part tariffs with RPM.
- The retailer faces a fixed cost of adjusting its prices.
- The retailer's optimization problem consists of two components:

1. **Static:** if a new price is set, it satisfies the static FOCs.
2. **Dynamic:** At each period, retailer weighs the benefits and costs of changing the price.
    - **Case 1:** If benefits are larger than costs, the price is adjusted.
    - **Case 2:** If costs are larger than benefits, the price remains constant. This implies a deviation from static FOCs.

Linear tariffs: model set-up

- There are $j = \{1, \ldots, J\}$ products in the market.
- Manufacturer f produces a subset G_f of products.
- It sets wholesale prices taking rivals' prices as given (Bertrand competition).
- The retailer carries all J products.
- It sets optimal retail prices taking wholesale prices as given.

Linear tariffs: static price setting

Manufacturer

Each f sets optimal wholesale prices according to the following program

$$\max_{\{w_{jt}\}} \sum_{j \in G_f} (w_{jt} - \mu_{jt}) s_{jt}(\mathbf{p}_t(\mathbf{w}_t)) M$$

Retailer

Sets optimal prices according to the following program

$$\max_{\{p_{jt}\}} \sum_{j} (p_{jt} - w_{jt} - c_{jt}) s_{jt}(\mathbf{p}_t) M - \mathbb{1}_{\{p_{jt} \neq p_{jt-1}\}} A_{jt}$$

where:
w_{jt}: wholesale price of product j at period t.
μ_{jt}: marginal cost of product j at t.
p_{jt}: retail price of product j at t.
c_{jt}: retail marginal cost of product j at t.
s_{jt}: market share of product j at t.
M: Size of the market.
A_{jt} : adjustment cost of the price of product j at t.

Two-part tariffs with RPM: model set-up

- Each manufacturer f proposes take-it-or-leave-it contracts to the retailer that specifies a wholesale price and a franchise fee for each product j.
- Contracts include also a retail price whenever RPM is used.
- The retailer announces which contracts it is willing to accept. These are public information.
- If the retailer accepts all contracts, they are implemented by manufacturers.
- If one offer is rejected, all firms earn zero profits and the game ends.

Two-part tariffs with RPM: static price setting

The retailer's profit function is given by

$$\Pi_t^r = \sum_{j=1}^{J} \left[(p_{jt} - w_{jt} - c_{jt}) s_{jt}(\mathbf{p}_t) M - F_{jt} - \mathbb{1}_{\{p_{jt} \neq p_{jt-1}\}} A_{jt}^r \right]$$

where:

F_{jt} : is product j's franchise fee at period t.

Two-part tariffs with RPM: static price setting

Each manufacturer offers a contract $\{p_{jt}, w_{jt}, F_{jt}\}$ to the retailer. Prices are set by maximizing

$$\Pi_t^f = \sum_{j \in G_f} \left[(w_{jt} - \mu_{jt}) s_{jt}(\mathbf{p}_t) M + F_{jt} \right]$$

subject to retailer's participation constraint

$$\Pi_t^r \geqslant \overline{\Pi}_t^r$$

Two-part tariffs with RPM: static price setting

Each manufacturer offers a contract $\{p_{jt}, w_{jt}, F_{jt}\}$ to the retailer. Prices are set by maximizing

$$\Pi_t^f = \sum_{j \in G_f} \left[(w_{jt} - \mu_{jt}) s_{jt}(\mathbf{p}_t) M + F_{jt} \right]$$

subject to retailer's participation constraint

$$\Pi_t^r \geqslant \overline{\Pi}_t^r$$

Solving for F_{jt} and plugging it in each manufacturer's profit function, yields

$$\Pi_t^f = \sum_{k \in G_f} (p_{kt} - \mu_{kt} - c_{kt}) s_{kt}(\mathbf{p}_t) M + \sum_{k \notin G_f} (p_{kt} - w_{kt} - c_{kt}) s_{kt}(\mathbf{p}_t) M - \sum_{j \notin G_f} F_{jt}$$
$$\underbrace{- \sum_{j \in G_f} \mathbb{1}_{\{p_{jt} \neq p_{jt-1}\}} A_{jt}^r - \sum_{j \notin G_f} \mathbb{1}_{\{p_{jt} \neq p_{jt-1}\}} A_{jt}^r}_{\text{Adjustment costs}}$$

Dynamic price setting

This part builds on **Goldberg and Hellerstein's (2013)** approach.

Let the retailer profit function be given by:

$$\Pi_t^r = \sum_{j=1}^{J} \left(\pi_{jt}^r(p_{jt}, \mathbf{p}_{-jt}) - \mathbb{1}_{\{p_{jt} \neq p_{jt-1}\}} A_{jt}^r \right), \tag{1}$$

where, the per-product variable profit is given by:

1. **Under linear tariffs:**

$$\pi_{jt}^r = (p_{jt} - w_{jt} - c_{jt}) s_{jt}(\mathbf{p}_t) M, \tag{2}$$

2. **Under two-part tariffs:**

$$\pi_{jt}^r = (p_{jt} - w_{jt} - c_{jt}) s_{jt}(\mathbf{p}_t) M - F_{jt}. \tag{3}$$

Case 1: the price changes from previous period

$\pi_{jt}(p_{jt}, \mathbf{p}_{-jt})$: retailer's actual profit at t,

$\pi_{jt}(p_{jt-1}, \mathbf{p}_{-jt})$: counterfactual profit retailer would obtain had he left the price unchanged at t.

A_{jt}: fixed costs of adjusting price of product j at t.

Case 1: the price changes from previous period

$\pi_{jt}(p_{jt}, \mathbf{p}_{-jt})$: retailer's actual profit at t,

$\pi_{jt}(p_{jt-1}, \mathbf{p}_{-jt})$: counterfactual profit retailer would obtain had he left the price unchanged at t.

A_{jt}: fixed costs of adjusting price of product j at t.

The retailer is willing to change the price at t if

$$\pi_{jt}(p_{jt}, \mathbf{p}_{-jt}) - A_{jt} \geq \pi_{jt}(p_{jt-1}, \mathbf{p}_{-jt})$$

The new price is set according to

$$\max_{\{p_{jt}\}} \pi_{jt}(p_{jt}, \mathbf{p}_{-jt})$$

An **upper bound** for adjustment costs can be computed as

$$A_{jt} \leq \overline{A_{jt}} = \pi_{jt}(p_{jt}, \mathbf{p}_{-jt}) - \pi_{jt}(p_{jt-1}, \mathbf{p}_{-jt})$$

Case 2: the price remains constant from previous period

$\pi_{jt}(p_{jt-1}, \mathbf{p}_{-jt})$: retailer's actual profit at t,

$\pi_{jt}(p_{jt}^{c}, \mathbf{p}_{-jt})$: counterfactual profit retailer would obtain had he ajusted the price at t.

A_{jt}: fixed costs of adjusting price of product j at t.

Case 2: the price remains constant from previous period

$\pi_{jt}(p_{jt-1}, \mathbf{p}_{-jt})$: retailer's actual profit at t,

$\pi_{jt}(p^c_{jt}, \mathbf{p}_{-jt})$: counterfactual profit retailer would obtain had he ajusted the price at t.

A_{jt}: fixed costs of adjusting price of product j at t.

The retailer is willing to leave the price unchanged if

$$\pi_{jt}(p_{jt-1}, \mathbf{p}_{-jt}) \geq \pi_{jt}(p^c_{jt}, \mathbf{p}_{-jt}) - A_{jt}$$

Since $p_{jt} = p_{jt-1}$, the counterfactual price is computed according to

$$\max_{\{p_{jt}\}} \pi_{jt}(p^c_{jt}, \mathbf{p}_{-jt})$$

A **lower bound** for adjustment costs can be computed as

$$A_{jt} \geq \underline{A_{jt}} = \pi_{jt}(p^c_{jt}, \mathbf{p}_{-jt}) - \pi_{jt}(p_{jt-1}, \mathbf{p}_{-jt})$$

Demand model

Let the indirect utility be given by

$$\begin{aligned} u_{ijt} &= V_{ijt} + \varepsilon_{ijt}, \\ &= \mathrm{x}_j \boldsymbol{\beta}_i - \alpha_i p_{jt} + \xi_j + \eta_t + \Delta\xi_{jt} + \varepsilon_{ijt}, \end{aligned}$$

with:

$$\begin{pmatrix} \alpha_i \\ \beta_i \end{pmatrix} = \begin{pmatrix} \alpha \\ \beta \end{pmatrix} + \boldsymbol{\pi}\mathrm{income}_i + \Sigma v_i, \qquad v_i \sim N(0, I_{K+1}).$$

Assuming $u_{iot} = 0$ and $\varepsilon_{ijt} \sim$ i.i.d. Type I Extreme Value, product j's market share at t is given by:

$$s_{jt} = \int \frac{\exp(V_{ijt})}{1 + \sum_{k=1}^{J} \exp(V_{ikt})} dF(\mu)$$

Empirical strategy

To identify adjustment costs bounds, I proceed as follows:

1. Estimate demand.
2. Compute elasticities and retrieve markups and marginal costs in two steps:
   i. I solve the system of equations derived from FOCs under each supply model (applies for prices that changed at t only).
   ii. Take retrieved costs and estimate a linear model on observables.
3. Compute counterfactual prices under each case.
4. Use estimated demand coefficients to predict counterfactual market shares given counterfactual price vectors.
5. Compute adjustment costs bounds per product-week.

Sample and market shares

The final sample

- Ready-to-eat breakfast cereals.
- Aggregate brand data across stores according to three price zones: high-, medium- and low-price.
- **224 weeks**: between May 1990 and September 1994.
- **22 products**: leading UPCs in the last quarter of the period.
- **672 markets**: week–'price zone' combination.

Observed market shares

- Potential market: one serving per day per capita (Nevo, 2001).
- Serving: the weigh suggested on each cereal box.
- S_{jt}: number of servings sold per week divided by the potential market.
- Outside option: consumption of other cereal brands, other products, no purchase.
- $S_{ot} = 1 - \sum_{j=1}^{J} S_{jt}$

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Results: Markups

Mean retail, wholesale and total retrieved markups by manufacturer (% of retail price)

	Linear tariffs			RPM
Producer	Retail	Wholesale	Total	Total
General Mills	30.74	10.70	38.14	29.69
Kellogg	38.98	6.93	45.81	38.74
Nabisco	10.99	14.80	29.11	9.05
Post	24.34	19.42	43.24	22.57
Quaker	10.55	9.27	22.02	8.06
All	29.22	10.68	38.51	28.16

As a reference: Nevo (2001) estimate lies between 38.5% and 42.2%.

Adjustment costs bounds

Averages across price zones, weeks and products
(US dollars)

	Linear tariffs		Two-part tariffs RPM	
Producer	Lower bound	Upper bound	Lower bound	Upper bound
General Mills	79.13	247.13	26.23	247.28
Kellogg	156.95	218.66	141.27	219.10
Nabisco	18.22	66.74	18.21	67.13
Post	36.71	115.71	16.43	116.27
Quaker	91.84	2,508.12	297.90	2,511.28
All	109.34	446.07	98.84	446.70
Share on revenue	7.27%	10.12%	6.52%	10.14%

Discussion

- **Rey and Vergé (2010):** When there is no downstream competition, simple two-part tariffs are sufficient to solve double marginalization and maintain monopoly profits.

- Two things are needed to fully capture the effects of RPM:
  1. A model of interlocking relationships with both upstream and downstream competition (Rey and Vergé, 2010, Bonnet and Dubois, 2010).
  2. A data set with info on multiple retailers.

In progress

Nilsen database: Retail Scanner Dataset

- Data on supermarket sales of ready-to-eat breakfast cereals.
- In Chicago between 2013 and 2015 (156 weeks).
- Weekly prices, sales, product-store characteristics at the upc-level.
- Household characteristics from the Nielsen Consumer Panel.

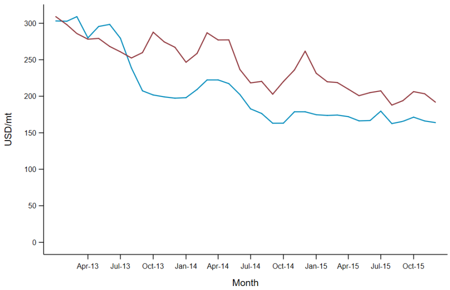
Final data

- **9 local markets:** defined by zip codes.
- **3 supermarket chains:** the leading in the Chicago area.
- **4 producers:** Kellog, General Mills, Quacker and Post.
- **40 products:** leading UPCs in the last quarter of the period.

In progress

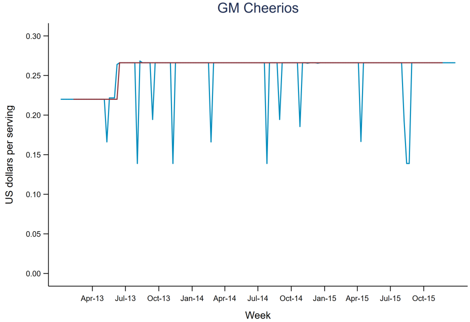
Wheat

Corn



Observed price

Regular price



Sources: World Bank (top), Nielsen (bottom).

In progress

Summary statistics for retail and regular price

Variable	Mean	Median	Std. Dev.	Min	Max
Observed retail price					
Cents/serving	27.18	26.26	6.823	0.07	58.07
Dummy for price change (=1 if yes)	0.56	1	0.50	0	1
Duration of given price (No. of weeks)	7.62	5	7.14	1	84
Regular price					
Cents/serving	28.81	27.28	6.52	9.41	49.06
Dummy for price change (=1 if yes)	**0.24**	0	0.42	0	1
Duration of given price (No. of weeks)	**40.17**	27	34.02	1	145

Source: Nielsen's database

In progress: reduced-form regressions

Explanatory variable (in logs)	*Dependent variable:* log of retail price (1)	(2)	(3)
Current hourly compensation	0.115***	0.497***	0.446***
	(0.008)	(0.011)	(0.022)
Oil		0.032***	0.056***
		(0.001)	(0.002)
Wheat			0.047***
			(0.004)
Corn			–0.003
			(0.002)
Sugar			–0.142***
			(0.004)
Constant	–1.785***	–3.296***	–3.614***
	(0.027)	(0.043)	(0.101)
R-squared	0.500	0.501	0.502

Summary

- So far, I have quantified repricing costs according to two models of vertical relations in a context of single common agency.
- Next steps:
  - Quantify adjustment costs bounds in a context with multiple common agency.
  - Include a model of linear tariffs with RPM.
  - Use nonnested tests to infer the appropriate supply model.
  - Determine how much of the incomplete pass-through is explained by markup adjustment and price adjustment costs according to alternative vertical contracts.
- **Future research:** What is the role of retailer buyer power on price rigidity?

Comments? Questions? Suggestions?

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Thank you!

Estimation

Estimation relies on the moment condition

$$E[h(z)'\rho(x, \theta_o)] = 0,$$

$(z_1, ..., z_M)$: set of instruments, $\theta = (\alpha, \beta, \pi, \sigma)'$

A GMM estimator is

$$\hat{\theta} = \arg\min_{\theta} \rho(\theta)' h(z) \hat{\Lambda}^{-1} h(z)' \rho(\theta),$$

with $\Lambda = Var(h(z)'\rho)$.

Given $\delta(\cdot)$, the error term writes as

$$\rho_{jst} = \delta_{jt}(x, p_t, S_t; \pi, \sigma) - (x_j \beta - \alpha p_{jt} + \xi_j + \eta_t + \Delta\xi_{jt})$$

Identification issues

1. Prices are correlated with consumer local valuation of unovserved product characteristics, $\Delta\xi_{jt}$.
2. There are multiple equilibria in the supply model of two-part tariffs with RPM (Rey and Vergé, JIE, 2010).
3. Margins and marginal costs are not identified from the structural model for periods in which prices do not adjust.

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   $\Longrightarrow$ I select the equilibrium with zero wholesale markups, yielding monopoly profits.

3. Margins and marginal costs are not identified from the structural model for periods in which prices do not adjust.

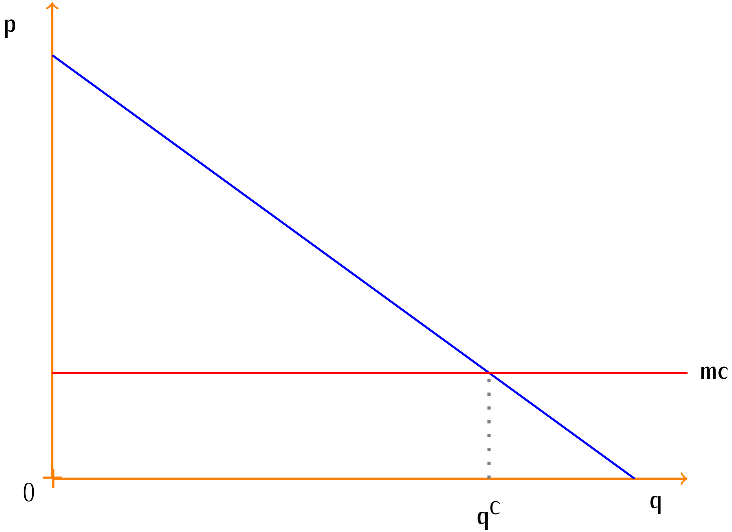
   $\Longrightarrow$ Following Goldberg and Hellerstein (2013):

   - Retrieve retail margins structurally for periods with price changes.
   - Compute total marginal costs as $C^s_{jt} = p_{jt} - \gamma^s_{jt}$.
   - Regress retrieved costs on observables:

   $$C^s_{jt} = \varsigma_j + \lambda d_z + \phi AAC_t + \tau_t + \eta_{jt}$$

   - Retrieve "fitted" margins for periods without price changes: $\hat{\gamma}_{jt} = p_{jt} - \widehat{C}_{jt}$.

Double marginalization problem



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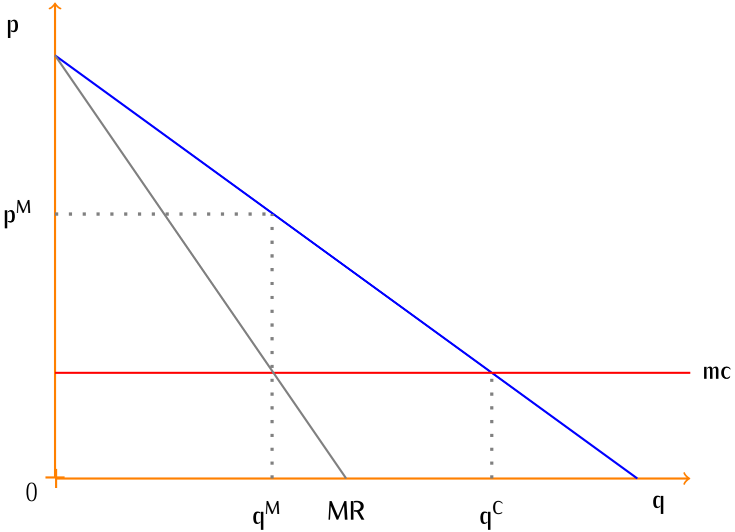
Double marginalization problem



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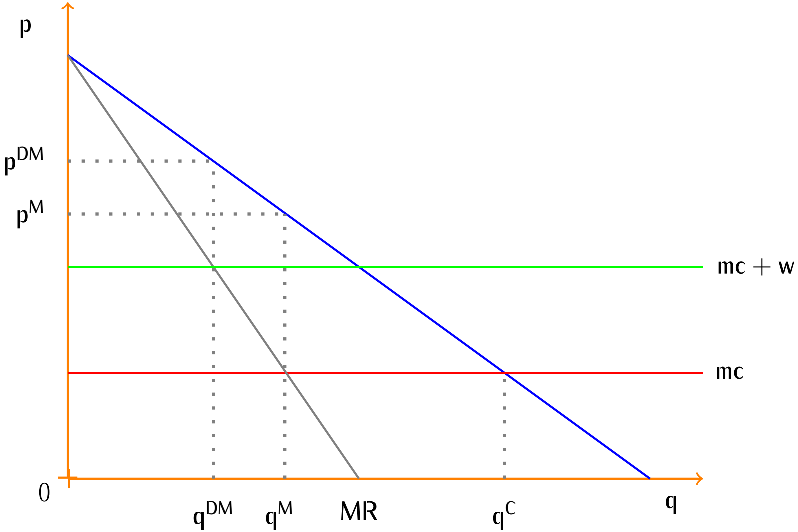
Double marginalization problem



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Low pass-through rates

Variable	(1)	(2)	(3)
Labor cost index	0.084**	0.132***	—
	(0.039)	(0.048)	
AAC	—	—	0.204***
			(0.044)
Wheat	—	0.009	—
		(0.033)	
Corn	—	0.114*	—
		(0.068)	
Oil	—	0.004	—
		(0.016)	
Constant	-2.630***	-3.374***	-2.352***
	(0.168)	(0.532)	(0.136)
R^2	0.9081	0.908	0.922

All variables are in logs. ***Significant at 1% level.

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Summary statistics of brands in the sample

Variable	Mean	Median	Std. Dev.	Min	Max
Serving weight (g)	32.73	29.5	8.84	27	58
Amounts per serving					
Calories	123.18	110	31.39	100	210
Caories from Fat	8.41	10	6.29	0	25
Sugar (g)	6.95	8	3.78	0	12
Fiber (g)	2.55	3	1.70	0	7
Protein (g)	3.05	2	2.70	1	10
Brands by segment (%)					
All family segment	31.82	—	—	—	—
Kids segment	31.82	—	—	—	—
Adult segment	36.36	—	—	—	—

Notes: Based on 14,784 observations. Source: Cereal boxes.

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Costs on observables

Variable	Linear tariffs	RPM
Average acquisition cost	0.604***	0.615***
	(0.043)	(0.043)
Product FE	Y	Y
Price zone FE	Y	Y
Week dummies	Y	Y
R^2	0.932	0.933
F-test	2,891	3,090
Observations	3,766	3,766

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Linear tariffs

Case 1: The price adjusts from previous period ($p_{jt} \neq p_{jt-1}$).

Retailer r will be willing to change the price of product j at time t if all $\mathbf{j} \neq \mathbf{k}$:

$$
\begin{aligned}
&(p_{jt} - w_{jt} - c_{jt}) s_{jt}(p_t) M + \sum_k (p_{kt} - w_{kt} - c_{kt}) s_{kt}(p_t) M - A^r_{jt} \\
&\geqslant (p_{jt-1} - w_{jt} - c_{jt}) s^c_{jt}(p_{jt-1}, p_{-jt}) M + \sum_k (p_{kt} - w_{kt} - c_{kt}) s^c_{kt}(p_{jt-1}, p_{-jt}) M,
\end{aligned}
$$

Rearranging terms, an upper bound for the adjustment costs of product j is given by:

$$
\begin{aligned}
A^r_{jt} \leqslant \overline{A^r_{jt}} = \Big[&(p_{jt} - w_{jt} - c_{jt}) s_{jt}(p_t) - (p_{jt-1} - w_{jt} - c_{jt}) s^c_{jt}(p_{jt-1}, p_{-jt}) \\
&+ \sum_k (p_{kt} - w_{kt} - c_{kt}) (s_{kt}(p_t) - s^c_{kt}(p_{jt-1}, p_{-jt})) \Big] M,
\end{aligned}
$$

Linear tariffs

Case 2: The price remains constant from previous period ($p_{jt} = p_{jt-1}$).

Retailer r may find it optimal to leave the price of product j unchanged from previous period if for all $j \neq k$

$$
\begin{aligned}
&(p_{jt-1} - w_{jt} - c_{jt})s_{jt}(p_{jt-1}, p_{-jt})M + \sum_k (p_{kt} - w_{kt} - c_{kt})s_{kt}(p_t)M \\
&\geqslant (p^c_{jt} - w_{jt} - c_{jt})s^c_{jt}(p^c_{jt}, p_{-jt})M + \sum_k (p_{kt} - w_{kt} - c_{kt})s^c_{kt}(p^c_{jt}, p_{-jt})M - A^r_{jt},
\end{aligned}
$$

Rearranging terms, a lower bound for the adjustment costs of product j is given by:

$$
\begin{aligned}
A^r_{jt} \geqslant \underline{A^r_{jt}} = \Big[&(p^c_{jt} - w_{jt} - c_{jt})\ s^c_{jt}(p^c_{jt}, p_{-jt}) - (p_{jt-1} - w_{jt} - c_{jt})s_{jt}(p_{jt-1}, p_{-jt}) \\
&+ \sum_k (p_{kt} - w_{kt} - c_{kt})(s^c_{jt}\ (p^c_{jt}, p_{-jt}) - s_{kt}(p_t))\Big]\, M,
\end{aligned}
$$

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Two-part tariffs + RPM

Case 1: The price adjusts from previous period ($p_{jt} = p_{jt-1}$).

Manufacturer f is willing to change the price of product j at time t if for all $\mathbf{j} \neq \mathbf{k}$:

$$
\begin{aligned}
&(p_{jt} - \mu_{jt} - c_{jt}) s_{jt}(p_t) M + \sum_{k \in G_f} (p_{kt} - \mu_{kt} - c_{kt}) s_{kt}(p_t) M \\
&\qquad + \sum_{k \notin G_f} (p^*_{kt} - w^*_{kt} - c_{kt}) s_{kt}(p_t) M - A^r_{jt} \\
\geqslant\ & (p_{jt-1} - \mu_{jt} - c_{jt}) s^c_{jt}(p_{jt-1}, p_{-jt}) M + \sum_{k \in G_f} (p_{kt} - \mu_{kt} - c_{kt}) s^c_{kt}(p_{jt-1}, p_{-jt}) M \\
&\qquad + \sum_{k \notin G_f} (p^*_{kt} - w^*_{kt} - c_{kt}) s^c_{kt}(p_{jt-1}, p_{-jt}) M
\end{aligned}
$$

Rearranging terms, an upper bound for the adjustment costs of product j is given by:

$$
\begin{aligned}
A^r_{jt} \leqslant \overline{A^r_{jt}} = \Big[& (p_{jt} - \mu_{jt} - c_{jt}) s_{jt}(p_t) - (p_{jt-1} - \mu_{jt} - c_{jt}) s^c_{jt}(p_{jt-1}, p_{-jt}) \\
& + \sum_{k \in G_f} (p_{kt} - \mu_{kt} - c_{kt}) (s_{kt}(p_t) - s^c_{kt}(p_{jt-1}, p_{-jt})) \\
& + \sum_{k \notin G_f} (p^*_{kt} - w^*_{kt} - c_{kt}) (s_{kt}(p_t) - s^c_{kt}(p_{jt-1}, p_{-jt})) \Big] M,
\end{aligned}
$$

Two-part tariffs + RPM

Case 2: The price remains constant from previous period ($p_{jt} = p_{jt-1}$).

Manufacturer f would rather leave the price constant if for all $\mathbf{k} \neq \mathbf{j}$

$$
\begin{aligned}
&(p_{jt-1} - \mu_{jt} - c_{jt}) s_{jt}(p_{jt-1}, p_{-jt}) M + \sum_{k \in G_f} (p_{kt} - \mu_{kt} - c_{kt}) s_{kt}(p_{jt-1}, p_{-jt}) M \\
&\quad + \sum_{k \notin G_f} (p^*_{kt} - w^*_{kt} - c_{kt}) s_{kt}(p_t) M \\
&\geqslant (p^c_{jt} - \mu_{jt} - c_{jt}) s^c_{jt}(p^c_{jt}, p_{-jt}) M + \sum_{k \in G_f} (p_{kt} - \mu_{kt} - c_{kt}) s^c_{kt}(p^c_{jt}, p_{-jt}) M \\
&\quad + \sum_{k \notin G_f} (p^*_{kt} - w^*_{kt} - c_{kt}) s^c_{kt}(p^c_{jt}, p_{-jt}) M - A^r_{jt}
\end{aligned}
$$

Rearranging terms, a lower bound for the adjustment costs of product j is given by:

$$
\begin{aligned}
A^r_{jt} \geqslant \underline{A^r_{jt}} = \Big[&(p^c_{jt} - \mu_{jt} - c_{jt}) s^c_{kt}(p^c_{jt}, p_{-jt}) - (p_{jt-1} - \mu_{jt} - c_{jt}) s_{jt}(p_{jt-1}, p_{-jt}) \\
&+ \sum_{k \in G_f} (p_{kt} - \mu_{kt} - c_{kt}) (s^c_{kt}(p^c_{jt}, p_{-jt}) - s_{kt}(p_{jt-1}, p_{-jt})) \\
&+ \sum_{k \notin G_f} (p^*_{kt} - w^*_{kt} - c_{kt}) (s^c_{kt}(p^c_{jt}, p_{-jt}) - s_{kt}(p_{jt-1}, p_{-jt})) \Big] M,
\end{aligned}
$$

back

Results: Demand

Variable	Means (β's)	Std. Deviations (σ's)	Interactions with Log of Income
Price	-45.251***	0.024	0.135
	(0.031)	(0.026)	(0.117)
Constant	2.052***	0.141**	-0.097***
	(0.038)	(0.050)	(0.014)
Cal from Fat	-1.615***	1.017***	—
	(0.004)	(0.005)	
Sugar	-0.175***	0.073***	—
	(0.021)	(0.017)	
Protein	-1.492***	0.761***	—
	(0.011)	(0.011)	
Kids	6.131***	2.739***	—
	(0.062)	(0.040)	
Adults	5.422***	0.081***	—
	(0.054)	(0.073)	

Significant at 5%, * significant at 1% level. Robust s.e. in parentheses.