The Role of Variety in Explaining Law of One Price Deviations

Fernando Borraz\textsuperscript{1} \hspace{1cm} Leandro Zipitría\textsuperscript{2}

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\textsuperscript{1}Banco Central del Uruguay, dECON - FCS - UdelaR and UM
\textsuperscript{2}dECON - FCS - UdelaR
Motivation

- Literature has established **price arbitrage** between stores—gravity—as the main force for prices to **converge** to the LOP (Figure)
- We propose a new source of arbitrage: **variety arbitrage**
- **Variety arbitrage**: is the effect caused by the availability of similar products—varieties—to consumers within a store
- See the price evolution with **same varieties** and with **different varieties**
Median Price Differences (Stores up to 200 Meters)

Price Difference (in %): Sparkling Water Brand Salus (1.5L)

Date
- 2007/12
- 2009/06
- 2010/12
- 2012/06
- 2013/12

Price Difference (in %)
Prices at Two Stores up to 200 Meters (Same Varieties)

Mayonnaise Brand Hellmann's (0.5 L)

Uruguayan Pesos

Store A

Store B

2007/12 2009/06 2010/12 2012/06 2013/12
Prices at Two Stores up to 200 Meters (Different Varieties)

Mayonnaise Brand Hellmann's (0.5 L)

- Store A
- Store B (another brand available (Uruguay))
Motivation

- Literature has established **price arbitrage** between stores—gravity—as the main force for prices to converge to the LOP (Figure).
- We propose a new source of arbitrage: **variety arbitrage**
- **Variety arbitrage**: is the effect caused by the availability of similar products—varieties—to consumers within a store.
- See the price evolution with **same varieties** and with **different varieties**.
This paper

- An extension of Borraz and Zipitría (2018)
- Document the effect of differences in varieties on relative price convergence

Findings

The fall in price dispersion over time is mainly explained by changes in varieties within stores, not by price arbitrage

- Adds to the literature on the aggregate effect of microeconomic decisions
Plan of the Talk

Literature

Data

Empirical Analysis

Concluding Remarks
Literature
Previous Literature

- Long run price convergence has been studied within and between countries
- Within countries long run price convergence has been found for the US, China, Canada, and Mexico
- Between countries evidence is mixed
  - Found for the US and Canada
  - Contested for the European car market
- Within countries, convergence is expected in the literature
- Main reason for explaining non-convergence between countries: **consumer price discrimination** (Dvir and Strasser, 2018)
Data
Database

- Daily prices collected by the Ministry of Economy and Finance (April 2007, August 2014)
- We calculate the mode price for each product/store/month
- Goods:
  - 125 products, 51 markets/categories (3 most selling brands, after excluding supermarkets own brands)
  - most goods defined at the UPC code, with some exceptions (cheese, meat)
- Supermarkets: #387 (54% in Montevideo), geographical location, chain, number of cashiers
Methodology

- We separate varieties in two categories: competitors and brands.
- Two products could be competitors if they have different producers; or brands if they are owned by the same producer.
- Identify the producer for each good in the database.
- Count the number of competitors and brands for each product/month/store (Identification: if price is posted at the store/month).
- Three examples:
  - Cola market: all competitors
  - Beer market: all varieties
  - Sparkling water: competitors and varieties
## Varieties Cross Tabulation (Competitors and Brands, in %)

<table>
<thead>
<tr>
<th>Number of Brands by Same Prod.</th>
<th>Number of Competitors</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>10.5</td>
<td>26.2</td>
<td>20.3</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>16.2</td>
<td>12.6</td>
<td>0.9</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>11.0</td>
<td>0.2</td>
<td>1.0</td>
<td>0.2</td>
</tr>
</tbody>
</table>
Prices and Varieties

Are prices affected by varieties?

We estimate

$$p_{its}^m = \alpha_i + \alpha_{st} + \alpha_{mt} + \sum_{j=0}^{3} \beta_{1j} \ Comp_{its}^j + \sum_{k=0}^{2} \beta_{2k} \ Brd_{its}^k + \epsilon_{its},$$

where $p_{its}$ is the—log—mode price; $i$ is for good; $t$ for time; $s$ for store; and $m$ for market.

$Comp_{its}^j$: competitor dummy with $j \in \{0, 1, 2, 3\}$

$Brd_{its}^k$: brand dummy with $k \in \{0, 1, 2\}$

Control for unobservable confounding shocks:

- time specific shocks to supermarkets—i.e., location, cost shocks, opening of new competitors, management, etc.
- time specific shocks to markets—i.e., cost increases, regulatory changes, etc.
### Prices and Varieties: Results

**Dependent variable: log of real price (times 100)**

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>95% CI</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>#Brand=1</td>
<td>-4.342***</td>
<td>(0.239)</td>
<td>-5.14, -3.54</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>#Brand=2</td>
<td>-5.762***</td>
<td>(0.521)</td>
<td>-7.18, -4.34</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>#Competitor=1</td>
<td>-3.407***</td>
<td>(0.178)</td>
<td>-4.11, -2.70</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>#Competitor=2</td>
<td>-7.838***</td>
<td>(0.311)</td>
<td>-9.23, -6.43</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>#Competitor=3</td>
<td>-14.064***</td>
<td>(1.010)</td>
<td>-17.82, -10.30</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

**# Observations** 2,077,443  
Product Dummies: Yes  
Market-Time Dummies: Yes  
Supermarket-Time Dummies: Yes  
R square: 0.92

*** p < 0.01. Clustered standard errors (by supermarket and time) in parentheses.
Empirical Analysis
Main Regression

- Following equation is estimated to calculate the dispersion of prices (Dvir and Strasser, 2018)

\[
SD(p_{it}) \times 100 = \alpha_i + \beta_1 T_t + \beta_2 T_t^2 + \gamma \bar{p}_{it} + u_{it},
\]

where: \(SD\) is the standard deviation, \(\alpha_i\) is a product dummy, \(\beta_1\) and \(\beta_2\) measure the speed of convergence across time, and \(\bar{p}_{it}\) is the average price for good \(i\) in time \(t\)

- The equation estimates both the effect of price arbitrage and variety arbitrage on price convergence

- Problem: cannot disentangle the effect of varieties—as they vary with \(s\)—directly in Equation 1

- The variety effect on \(p_{its}\) in \(SD\) need to be previously filtered off
To account for the effect of variety composition within stores we filtered the price series by our varieties dummies:

\[ p_{its} = \sum_{j=0}^{3} \beta_1^j \text{Comp}_{its}^j + \sum_{k=0}^{2} \beta_2^k \text{Brd}_{its}^k + \varepsilon_{its}, \]

We keep the residuals \( \varepsilon_{its} \)—i.e., what is not explained by the effect of varieties on prices—and analyze its dispersion across time

\[ SD(\varepsilon_{it}) \times 100 = \alpha_i + \beta_1 T_t + \beta_2 T_t^2 + \gamma \bar{\varepsilon}_{it} + \nu_{it}, \quad (2) \]
Disentangling Effects

- The estimation of $\beta_1$ and $\beta_2$ Equation 2 measure the effect of price arbitrage on price convergence
- The variety arbitrage was hidden in the previous literature
- Our preferred estimation restricts the number of stores and products to those at the beginning of the sample (year 2007)
- We also show the results including the full sample of stores and products
### Regression Results

**Dependent variable:** standard deviation of prices (in %)

<table>
<thead>
<tr>
<th></th>
<th>Stores &amp; Products in year 2007</th>
<th>Full Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Trend</strong></td>
<td>-5.019***</td>
<td>-1.198</td>
</tr>
<tr>
<td></td>
<td>(1.259)</td>
<td>(1.967)</td>
</tr>
<tr>
<td><strong>Trend Square</strong></td>
<td>0.044***</td>
<td>0.022</td>
</tr>
<tr>
<td></td>
<td>(0.011)</td>
<td>(0.020)</td>
</tr>
<tr>
<td><strong>Average Price</strong></td>
<td>0.623</td>
<td>1.704</td>
</tr>
<tr>
<td></td>
<td>(0.049)</td>
<td>(1.430)</td>
</tr>
<tr>
<td><strong># Observations</strong></td>
<td>6,140</td>
<td>6,140</td>
</tr>
<tr>
<td><strong>Product dummies</strong></td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Price filtered by competition and variety</strong></td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>R square</strong></td>
<td>0.54</td>
<td>0.68</td>
</tr>
</tbody>
</table>

*** $p < 0.01$, ** $p < 0.05$. Clustered standard errors (by product) in parentheses.
Results

- We estimate a 98% (28%) decrease in price dispersion over the 89 month for the restricted (full) sample
- \[ 98\% = -5.05 \times 89 + 0.044 \times 89^2 \]
- Nevertheless, in both cases, when variety is taken into account no change in price dispersion is found
- \[ \Rightarrow \] price convergence seems to be explained by **variety arbitrage**
Regression Results: Montevideo City

<table>
<thead>
<tr>
<th></th>
<th>Dependent variable: standard deviation of prices (in %)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stores &amp; Products in year 2007</td>
</tr>
<tr>
<td>Trend</td>
<td>-5.395*** (1.391)</td>
</tr>
<tr>
<td>Trend Square</td>
<td>0.054*** (0.011)</td>
</tr>
<tr>
<td>Average Price</td>
<td>-0.195 (1.073)</td>
</tr>
<tr>
<td># Observations</td>
<td>6,140</td>
</tr>
<tr>
<td>Product dummies</td>
<td>Yes</td>
</tr>
<tr>
<td>Price filtered by competition and variety</td>
<td>No</td>
</tr>
<tr>
<td>R square</td>
<td>0.49</td>
</tr>
</tbody>
</table>

*** $p < 0.01$, ** $p < 0.05$. Clustered standard errors (by product) in parentheses.
Results for Montevideo City

- Montevideo is the capital—and largest city—in the country
- We estimate a 58% (9%) decrease (increase) in price dispersion over the 89 month for the restricted (full) sample
  \[58\% = -5.395 \times 89 + 0.054 \times 89^2\]
- Again, in both cases, when variety is taken into account no change in price dispersion is found

⇒ price convergence seems to be explained by \textit{variety arbitrage}
Concluding Remarks
Takeaways

Our results show that differences in varieties at each product category offered by stores are relevant to explain long-run price convergence.

As a result

We find that price convergence attributed to price arbitrage maybe mainly due to variety arbitrage.

The paper adds to the literature on the aggregate effect of microeconomic decisions.
Thank you for your attention!

fborraz@bcu.gub.uy