Price rigidity with microeconomic data

Fernando Borraz\textsuperscript{1}  Giacomo Livan\textsuperscript{2}  Pablo Picardo\textsuperscript{1}  Anahí Rodríguez\textsuperscript{3}

\textsuperscript{1}Banco Central del Uruguay  \textsuperscript{2}University College London  \textsuperscript{3}CEMLA

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The opinions expressed here are those of the authors and do not reflect the views of CEMLA, University College London or the Central Bank of Uruguay.
Summary

- Understand price rigidity
- Characterize sales and explore its role in price flexibility
- Relate sales and retail price changes with unemployment and other macroeconomic variables
- Dataset: + 2.5 million observations
  1. +20,000 retail product prices
  2. Weekly basis
  3. Macroeconomic data
  4. From 2014 to now
Structure

1. Motivation
2. Literature review
3. Data
4. PCA
5. Forthcoming
Why retail data?

- Price forecasting, e.g.: fruits and vegetables
- Study price flexibility $\rightarrow$ PM models and analysis
- Possibility to manage and process big databases with a panel structure
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### Why sales?
- Mechanism of price rigidity
- Correlation with local business cycle
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Why sales?
- Mechanism of price rigidity
- Correlation with local business cycle

Why Uruguay?
- Small and open country
- Rich dataset to exploit
Literature review
Literature review

- **Nakamura and Steinsson (2006).** *Five facts about prices: a reevaluation of menu cost models.*

- **Nakamura and Steinsson (2013).** *Informational rigidities and the stickiness of temporary sales.*

- **Eichenbaum and Jaimovich (2011).** *Reference prices, costs and nominal rigidities.*

- **Coibion, Gorodichenko and Hee Hong (2013).** *The cyclicality of sales, regular and effective prices: business cycle and policy implications.*

- **Glandon (2018).** *Sales and the (mis)measurement of price level fluctuations.*
Data description
Data

- Retail prices: **weekly** from August 2014 to **now** (October 2019)
  - Classification by **sectors**:  
    1. Drinks  
    2. Alcoholic drinks  
    3. Food (sample)  
    4. Fruit and vegetables  
    5. Tobacco  
    6. Personal care  
    7. Other (stationery, pet food, toys, etc.)
  - Dummy variable for **sales** (1 on sale, 0 normal price)
  - Currency (Uruguayan pesos)

- Macrodata: **monthly** from May 2013 to September 2019
  - Cpi index
  - Employment rate
  - Unemployment rate
Data cleaning for the PCA

- Few constant prices were removed
- Missing values were filled by assuming the last previous observation
- Few multiple price cases, where a product reported multiple prices in the same week, we took the minimum price observed

Softwares: MATLAB + R
How many products changed its price?

Source: Banco Central del Uruguay from supermarket data
Price reductions and sales

Share of product on sales and price reductions by month

Source: Banco Central del Uruguay from supermarket data
Seasonality of price changes and sales

Share of products that change its price and sales by month

Source: Banco Central del Uruguay from supermarket data
Product sectors

Source: Banco Central del Uruguay from supermarket data
Price variation: all sectors

Source: Banco Central del Uruguay from supermarket data
Price variation: retail data vs. official CPI

Source: Banco Central del Uruguay from supermarket data and National Institute of Statistics
Price variation: food and drinks

Source: Banco Central del Uruguay from supermarket data and National Institute of Statistics
Price change probability

Source: Banco Central del Uruguay from supermarket data
Price change probability: **upward**

Source: Banco Central del Uruguay from supermarket data
Price change probability: **downward**

Source: Banco Central del Uruguay from supermarket data
Duration

Duration in weeks = \(-\frac{1}{1 - \log(\text{prob}(\text{price change}))}\)

Source: Banco Central del Uruguay from supermarket data
Duration by quantiles

Source: Banco Central del Uruguay from supermarket data
Unemployment variation, price reduction and sales

Source: Banco Central del Uruguay from supermarket data and National Institute of Statistics
Principal Component Analysis
Data and PCs

- January - October 2019 (41 weeks)
- Sectors:

  - Drinks
    - $N = 132; \frac{\lambda_1}{N} = 34.8\%; \frac{\lambda_2}{N} = 14.0\%$
  - Alc. drinks
    - $N = 608; \frac{\lambda_1}{N} = 53.6\%; \frac{\lambda_2}{N} = 12.5\%$
  - Food
    - $N = 896; \frac{\lambda_1}{N} = 49.4\%; \frac{\lambda_2}{N} = 10.7\%$
  - Fruit
    - $N = 140; \frac{\lambda_1}{N} = 38.1\%; \frac{\lambda_2}{N} = 16.9\%$
  - Other
    - $N = 317; \frac{\lambda_1}{N} = 61.0\%; \frac{\lambda_2}{N} = 12.8\%$
  - Personal
    - $N = 1601; \frac{\lambda_1}{N} = 45.9\%; \frac{\lambda_2}{N} = 14.3\%$
1st and 2nd PCs

![Graph showing the first and second principal components over time from January 2019 to October 2019 for various categories such as Drinks, Alc. Drinks, Food, Fruit & veg., Other, and Personal care.](image-url)
PCs and employment
Correlations

• Highest correlation and significance is achieved between employment and PCs in 2nd week of the following month (especially with 2nd PC)

<table>
<thead>
<tr>
<th></th>
<th>1st PC</th>
<th>2nd PC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drinks</td>
<td>0.74*</td>
<td>0.17</td>
</tr>
<tr>
<td>Alc. drinks</td>
<td>0.69*</td>
<td>0.60*</td>
</tr>
<tr>
<td>Food</td>
<td>0.64*</td>
<td>0.92***</td>
</tr>
<tr>
<td>Fruit &amp; veg.</td>
<td>0.67*</td>
<td>0.82**</td>
</tr>
<tr>
<td>Other</td>
<td>0.60*</td>
<td>0.79*</td>
</tr>
<tr>
<td>Personal care</td>
<td>0.75*</td>
<td>0.75**</td>
</tr>
</tbody>
</table>

• Much lower correlation and significance in the case of unemployment
Granger causality

- Granger causality (at 5% significance level, 1 time lag) of PCs by employment

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</tr>
</thead>
<tbody>
<tr>
<td>Drinks</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td>Alc. drinks</td>
<td>✓</td>
<td>×</td>
</tr>
<tr>
<td>Food</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Fruit &amp; veg.</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td>Other</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td>Personal care</td>
<td>×</td>
<td>×</td>
</tr>
</tbody>
</table>
In 4 out of 5 cases, there is a clear interpretation of 1st PC as a source of positive correlation between products, driven by employment ("sector mode" / "employment mode").
2nd eigenvectors

Roughly 50-50 splits in 4 out of 5 sectors: possible interpretation as a source of negative correlation between groups of products w.r.t. 1st PC (different responses w.r.t. changes in employment)
(Very preliminary) Conclusions

- All sectors share a **common correlation structure** as revealed by PCA.
- 1st PC: “**employment mode**”
- 2nd PC: correlations with respect to employment mode, describing different product sensitivity
- Some **causality** (especially in the case of **food**).
Forthcoming
Forthcoming

- PCA with all the data
- More MACRO variables
- More MICRO variables
- Seasonality
- Price forecasting
  - Nowcasting
  - Martingale prediction market methodology
¡Gracias! / Thanks!
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