Endogenous frequencies and large shocks: price setting in Greece during the crisis

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Disclaimer: The views expressed are those of the authors and do not necessarily reflect the views of the Bank of Greece or the Eurosystem
Main findings

- We utilize a unique micro price data set for Greece that underpins the Greek CPI.
- We find that during this time there were significant changes in the pricing behaviour of Greek firms.
- Macro-economic developments such as annual inflation and output growth are important factors in determining the frequency and size of price increases and decreases.
- We set up a small simulation where by the inflation response reacts endogenously via an asymmetric impact on the frequency of price increases and the frequency of price decreases.
- The results of the simulations capture the Greek inflation developments well.
- They also capture developments in the frequency of price increases and decreases seen in other economies and over different time-periods.
The shock to Greece

Greek GDP 1995-2021 (Million 2010 EUR)
The Data

- Hellenic Statistical Authority (ELSTAT) CPI micro price data.
- 742 products (or items), across unique outlets at the NUTS 2 level.
- 46729 unique product identifiers (“prices”), an average of 37k per month.
- 8 million price observations, which cover more than 75% of the Greek HICP.
- EXCLUDES (most) energy prices, fresh fruit and vegetables, seasonal items, centrally collected prices, telecommunications and several service related components in particular for transport.
- We use “regular prices” excluding sales. Identified using PRISMA protocols (V shapes etc).
- We use unweighted data, weighting the data does not alter our main findings.
When we consider price setting there is often a focus on prices that do change, as they are the ones ‘producing’ inflation.

However, these prices tend to be a minority of the whole spectrum of prices used.

One informative way to look at price setting is to focus on the cross sectional aspect of price developments through the properties of price spells and the distribution of duration of price changes.

Price-spell: a sequence of observations with the same price.

Distribution of Durations DD: the pdf of all price-spells.

Cross-sectional distribution of durations CSD: reflects the behaviour of the price-setters. Price-spells are weighted by their duration.
There are a lot of short price-spells, with 30% of spells lasting for only one or two months.

Pre and post-crisis distributions are similar except for two key features:

- first, there are more one period spells post crisis, and
- second the 12 month spike has (almost) gone.

The second feature implies that the element of time dependence has been reduced somewhat post-crisis.
An alternative is to look at the price spell data to exploit its panel structure and take into account the fact that the spells are being generated by the behavior of the agents setting the prices (which we call firms).

We follow a row of the panel in terms of the price of a product/outlet pairing, observing a particular price over time. The behavior of the firms setting prices is better captured by the cross-sectional distribution of durations (CSD).

The average cross-sectional duration is 29 months, which is about three times longer than the average length of a spell. This indicates that the firms in Greece on average set prices for 29 months. (UK, for excluding energy and food the average is 14 months)
Plotting the CSD for pre- and post-crisis, we see an heterogeneous impact on firms’ price setting behaviour, with some firms responding with more frequent price changes, while others with less frequent price changes.

For example, food remains fairly similar, NEIG has a larger share of short spells, services have a lower share of short spells post crisis.
A time series analysis of price changes in Greece
Frequency developments, the share of prices that do change

- Total Frequency and Frequency of price increases and decreases
Share of price increases and decreases

- This change in the share of price increases and decreases in the total frequency is very unique to Greece.
- As we will see this change is a driving force of our results.
The size of price changes

Av. size of price increase
Av. size of price decrease
12mma price incr.
12 mma price decr.
Drivers of frequency and size

- Time series approach similar to Dixon et al. (2020), LDV and IV.
- Explanatory variables are HICP inflation, retail sales growth and consumer sentiment about future developments.
- We differentiate between increases and decreases and don’t look at total frequency or average/median price change.
- How would we expect the explanatory variables to affect frequency?
  - In a purely time dependent model, none of these variables would matter.
  - In a state-dependent framework, the decision to change the price this month is driven by the distance of the current price from the optimal flexible price $p^*$.

$$p_t^* = P_t + \gamma y_t$$

- This implies opposite signs for the frequency of increases and decreases.
## Regressions Frequency

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>Frequency of price increase</th>
<th>Frequency of price decrease</th>
</tr>
</thead>
<tbody>
<tr>
<td>LDV</td>
<td>0.216*** (0.0340)</td>
<td>0.314*** (0.0317)</td>
</tr>
<tr>
<td>Annual HICP inflation</td>
<td>0.397*** (0.0516)</td>
<td>0.341*** (0.0501)</td>
</tr>
<tr>
<td>Retail sales growth</td>
<td>0.0742*** (0.0144)</td>
<td>0.0602*** (0.0132)</td>
</tr>
<tr>
<td>Consumers Future Economic Situation</td>
<td>0.000212** (3.48e-05)</td>
<td>0.000105* (4.46e-05)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.0331*** (0.00301)</td>
<td>0.0366*** (0.00324)</td>
</tr>
<tr>
<td>Observations</td>
<td>209</td>
<td>209</td>
</tr>
<tr>
<td>R²-adj</td>
<td>0.848</td>
<td>0.829</td>
</tr>
</tbody>
</table>

**Note:**
- *** indicates significance at the 1% level.
- ** indicates significance at the 5% level.
- * indicates significance at the 10% level.
- Standard errors are in parentheses.
<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>Size of price increase</th>
<th>Size of price decrease</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LDV</td>
<td>0.691***</td>
<td>0.850***</td>
</tr>
<tr>
<td></td>
<td>(0.0473)</td>
<td>(0.0301)</td>
</tr>
<tr>
<td>Annual HICP inflation</td>
<td>-0.327***</td>
<td>-0.353***</td>
</tr>
<tr>
<td></td>
<td>(0.0768)</td>
<td>(0.0867)</td>
</tr>
<tr>
<td>Retail sales growth</td>
<td>-0.0154</td>
<td>0.0106</td>
</tr>
<tr>
<td></td>
<td>(0.0147)</td>
<td>(0.0160)</td>
</tr>
<tr>
<td>Consumers Future Economic Situation</td>
<td>-</td>
<td>0.000103*</td>
</tr>
<tr>
<td></td>
<td>(3.68e-05)</td>
<td>(5.06e-05)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.0475***</td>
<td>0.0248***</td>
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<tr>
<td></td>
<td>(0.00671)</td>
<td>(0.00431)</td>
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<tr>
<td>Observations</td>
<td>209</td>
<td>209</td>
</tr>
<tr>
<td>$R^2$-adj</td>
<td>0.825</td>
<td>0.813</td>
</tr>
</tbody>
</table>

Notes: *** p < 0.01, ** p < 0.05, * p < 0.1
So, What drives inflation?

- Counterfactual inflation rates 1) fix frequency developments and let price changes vary 2) fix price changes and let frequencies vary.

\[
\Pi_{f,t} = \sum_{j=1}^{n} w_{j,t} (f_{j,t}^{(+)} \cdot \pi_{j,t}^{(+)} - f_{j,t}^{(-)} \cdot \pi_{j,t}^{(-)})
\]  \hspace{1cm} (10)

\[
\Pi_{\pi,t} = \sum_{j=1}^{n} w_{j,t} (f_{j,t}^{+} \cdot \pi_{j,t}^{(+)} - f_{j,t}^{-} \cdot \pi_{j,t}^{(-)})
\]  \hspace{1cm} (11)

- Compare to inflation rate produced by our micro data set

\[
\Pi_{t} = \sum_{j=1}^{n} w_{j,t} (f_{j,t}^{+} \cdot \pi_{j,t}^{+} - f_{j,t}^{-} \cdot \pi_{j,t}^{-})
\]  \hspace{1cm} (4)
The inflation rate obtained by the micro data co-varies strongly with the inflation rate where prices are fixed and all the inflation dynamics come from changes in the frequency of increases and decreases.

Both in month-on-month and year-on-year terms the correlation of the inflation obtained from the data and the ‘fixed price’ counterfactual is around 0.80.

The correlation with the ‘fixed frequency’ counterfactual is about -0.20.

Holds for the two sub-periods of pre- and post-crisis separately.
What do our results imply for inflation dynamics

- Focus on the fact that annual inflation seems to be an important determinant of the current frequencies of increases and decreases.
- Thus, when we are looking at price changes this month, they are going to be affected by the previous behaviour of prices.
- For simplicity, we leave the size of price changes out.
- Partial look at this issue, we hold the other variables (output and sentiment of future developments) constant.
- Analogous to an impulse response function.
Set up of simulation

- From our estimations

\[ \Delta f^+ = 0.341 \Delta \Pi^A + 0.204 \Delta f_{-1}^+ \]

\[ \Delta f^- = -0.161 \Delta \Pi^A + 0.231 \Delta f_{-1}^- \]

- Identity

\[ \Delta \Pi = f_0^+ \Delta \pi^+ + f_o^- \Delta \pi^- + \pi_0^+ \Delta f^+ + \pi_0^- \Delta f^- \]

- The annual rate of inflation being given by:

\[ \Pi^A_t = \sum_{i=0}^{11} \Pi_{t-i} \]
Simulations results 1

- Scenario 1: A large permanent increase in the size of price increases
Simulations results 2

- Scenario 2: A large temporary increase in the size of price increases
Simulations results 3

- **Scenario 2:** A large permanent decrease in the size of price increases. Here we will try to see whether we can replicate developments in Greece, following the large negative shock it experienced in 2010.
Simulation results, summary

- The simple simulations are able to replicate not only the developments of the Greek economy well, but are also in line with stylized facts on the frequency of price changes of other economies and different periods of investigation. There are two key points to these results.
  - First, inflation dynamic across time are endogenous as monthly inflation (through changes in frequencies) feed into annual HCIP inflation which then affects pricing going on into the future.
  - Second, there is an asymmetric effect of macro-economic conditions on the frequency of increases and the frequency of decreases.
Conclusions

- We find that during the crisis there were significant changes in the pricing behaviour of firms.
- Both price increases and decreases became larger.
- The frequencies of price increases and price decreases also showed significant movements.
- Regressions of macro-economic variables on the frequency of price increases and decreases find that annual inflation is an important determinant for both.
- We set a small simulation where the inflation response reacts endogenously via an (asymmetric) impact on the frequency of price increases and decreases.
- The simulation based on the estimated equations captures the developments of the Greek inflation well.
- The results of the simulation also captures stylized facts of developments in the frequency of price increases and decreases seen in other economies and over different time-periods. In particular an increase in inflation increases the total frequency of price changes.
Thank you!

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Example DD vs CSD

- Two products: 12 months

<table>
<thead>
<tr>
<th></th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
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</thead>
<tbody>
<tr>
<td>Product 1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Product 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>12</td>
</tr>
</tbody>
</table>

Spells: 13 spells,

**Average spell duration** \(1.9\) \[\frac{12.1 + 1.12}{13} = \frac{24.22}{13} = 1.9\]

**Average duration across two products** \(6.5 = \frac{12 + 1}{2}\)

Average across products is more than three times the average spell
Sales in Greece

Figure A4: Share of prices on sale in Greece

Source: Calculation by authors
Alternative measures of inflation based on the micro data

Figure 2A: Actual and constructed annual inflation, including and excluding sales

Figure 2B: Actual and constructed annual inflation, weighted and unweighted

Source: Elstat and authors calculations
### Main categories pre and post crisis

<table>
<thead>
<tr>
<th>Food</th>
<th>NEIG</th>
<th>Services</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="chart1.png" alt="Food chart" /></td>
<td><img src="chart2.png" alt="NEIG chart" /></td>
<td><img src="chart3.png" alt="Services chart" /></td>
</tr>
</tbody>
</table>

**Source:** Elstat and authors calculations
VAT changes and frequency

Figure A5: Frequency of price changes and share of products with VAT changes

Source: ELSTAT, calculation by authors