

Inflation and Price Dynamics Analysis using High-Frequency Data from Supermarkets

Evidence from Peru

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The opinions expressed in this study belong to the author and should not be attributed to the Banco Central de Reserva del Perú.

Contents

- 1 [Introduction](#)
- 2 [Data](#)
- 3 [Discount filter](#)
- 4 [Results](#)
- 5 [Conclusions](#)
- 6 [Appendix](#)

Inflation after 2020

- The inflationary process in Peru since the onset of the millennium has been characterized by a stable and low rate, akin to that of developed countries.
- Supply shocks were a major factor in the inflation surge in Peru observed since mid-2021, peaking in January 2023 (8.66 percent year-on-year).

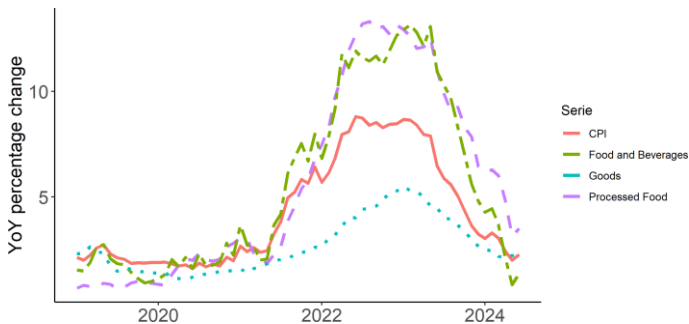


Figure: Year-on-year variations of price indices

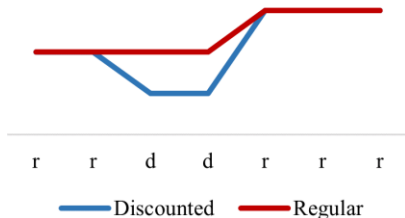
Data was collected from supermarket webs using web-scraping:

- Items were divided between food, beverages and goods.
- They were classified according to the COICOP using machine learning techniques.
- The names of items had to be processed and simplified to optimize the machine learning algorithm.
- Around 134k products were considered in the sample of this investigation.
- A 30 day moving average was calculated to smooth price series.

Discount filter

- Extracted data includes regular and online (or sale) prices. The minimum between both is the effective price a consumer pays.
- The effective price still shows discount periods.
- To process the data, I developed a filter that removes sales and discounts. It is based on Nakamura & Steinsson (2008).
- If a price reduction lasts less than 30 days, then it is considered a discount and not a permanent change.

Regular price and discount



Contenidos

1 [Introduction](#)

2 [Data](#)

3 [Discount filter](#)

4 [Results](#)

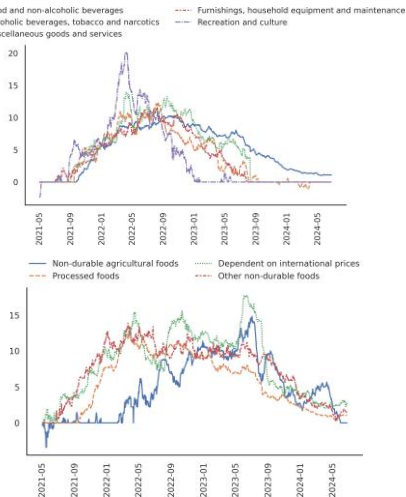
5 [Conclusions](#)

6 [Appendix](#)

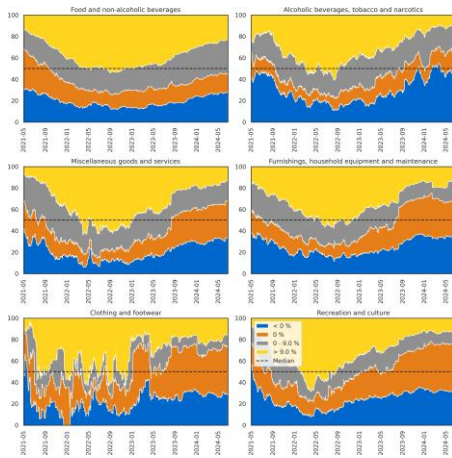
Prices increased similarly but decelerated asymmetrically

Year-on-year variation distribution

Median of year-on-year variations



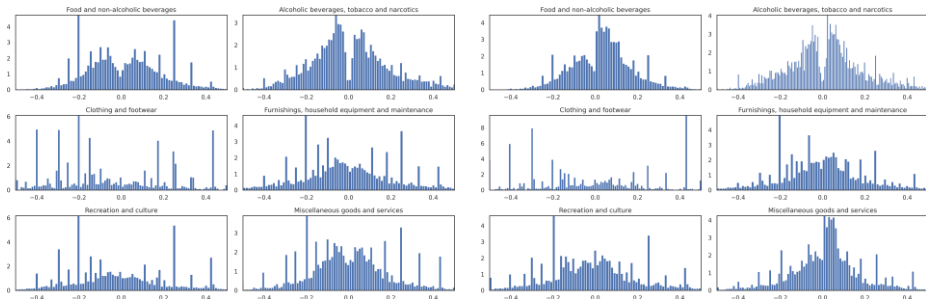
Year-on-year variation distribution



Persistent changes tend to be positive

Year-on-year percentage change magnitude

- Divisions seem to follow a bimodal distribution of changes. Small changes are less frequent.
- When removing discounts, as expected, positive changes have a higher presence.



Frequency of change

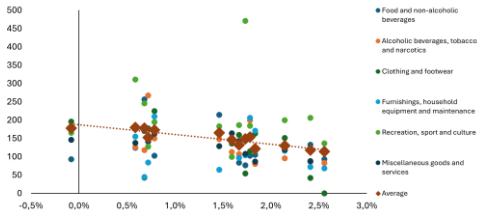
- Raw prices (without filtering) exhibit a rapid update.
- As the discount removal parameter increases, the implicit duration increases accordingly, therefore, prices seem to last for 7 to 13 months before moving upwards.

Divisions	Frequency of change (change probability)							
	Median				Mean			
	Regular	7	30	100	Regular	7	30	100
Food and non-alcoholic beverages	4.1%	2.3%	1.0%	0.7%	3.6%	1.9%	0.9%	0.6%
Alcoholic beverages, tobacco and narcotics	3.1%	1.9%	0.8%	0.4%	2.9%	1.9%	0.8%	0.4%
Clothing and footwear	2.3%	1.6%	0.6%	0.3%	2.5%	1.8%	0.6%	0.3%
Furnishings, household equipment and maintenance	2.3%	1.6%	0.7%	0.4%	2.4%	1.5%	0.7%	0.4%
Recreation, sport and culture	1.6%	1.2%	0.6%	0.4%	3.3%	2.1%	0.9%	0.5%
Miscellaneous goods and services	2.5%	1.7%	0.7%	0.4%	2.5%	1.7%	0.7%	0.4%

División	Implicit duration (in days)							
	Median				Mean			
	Regular	7	30	100	Regular	7	30	100
Food and non-alcoholic beverages	24	43	101	149	27	52	111	165
Alcoholic beverages, tobacco and narcotics	32	54	121	229	34	53	121	233
Clothing and footwear	43	62	155	392	39	54	157	399
Furnishings, household equipment and maintenance	43	62	139	263	40	65	142	235
Recreation, sport and culture	61	82	161	254	30	47	108	195
Miscellaneous goods and services	39	58	140	223	40	60	143	234

Duration changed with inflation

- There is a negative correlation between quarterly inflation and price duration.
- When shocks lead to persistent inflation, prices increase more and also adjust more quickly and frequently.



Division	Frequency of change (median)															
	Regular				7 days				30 days				100 days			
	20-IV	21-IV	22-IV	23-IV	20-IV	21-IV	22-IV	23-IV	20-IV	21-IV	22-IV	23-IV	20-IV	21-IV	22-IV	23-IV
Food and non-alcoholic beverages	1.7%	4.0%	3.5%	4.0%	1.3%	2.9%	2.3%	2.3%	0.8%	1.3%	1.2%	1.0%	0.3%	0.9%	0.9%	0.5%
Alcoholic beverages, tobacco and narcotics	1.5%	2.1%	3.0%	2.8%	1.4%	1.7%	2.4%	1.4%	0.8%	0.6%	0.9%	0.6%	0.3%	0.3%	0.6%	0.2%
Clothing and footwear	0.0%	4.9%	1.8%	1.6%	0.0%	3.3%	1.2%	1.2%	0.0%	1.8%	0.7%	0.3%	0.0%	0.2%	0.3%	0.2%
Furnishings, household equipment and maintenance	1.7%	3.5%	3.1%	2.4%	1.2%	2.6%	2.1%	1.9%	0.6%	1.0%	1.0%	0.7%	0.3%	0.7%	0.6%	0.2%
Recreation, sport and culture	0.9%	1.2%	1.4%	1.7%	0.7%	1.0%	1.0%	1.3%	0.3%	0.2%	0.5%	0.6%	0.1%	0.1%	0.2%	0.2%
Miscellaneous goods and services	2.4%	2.3%	2.7%	2.9%	1.9%	1.9%	1.6%	2.0%	0.7%	0.9%	0.7%	0.7%	0.4%	0.7%	0.4%	0.4%

Division	Implicit duration in days (median)															
	Regular				7 days				30 days				100 days			
	20-IV	21-IV	22-IV	23-IV	20-IV	21-IV	22-IV	23-IV	20-IV	21-IV	22-IV	23-IV	20-IV	21-IV	22-IV	23-IV
Food and non-alcoholic beverages	58	25	28	24	74	34	43	42	124	77	85	96	311	107	108	185
Alcoholic beverages, tobacco and narcotics	64	46	33	36	70	60	42	71	128	153	106	176	359	324	167	438
Clothing and footwear		20	54	61		29	80	80		54	138	388		636	384	582
Furnishings, household equipment and maintenance	58	28	32	41	84	39	48	53	155	104	104	147	298	136	154	494
Recreation, sport and culture	110	80	72	60	134	96	97	75	311	488	196	174	919	713	402	538
Miscellaneous goods and services	40	43	37	33	53	52	62	50	139	110	147	144	266	148	254	272

Conclusions

- **Price Formation Insights:** Online price data helps understanding price formation processes. It also enriches the analysis of how economic shocks propagate.
- **Price Changes:** The proportion of products with price changes increased, moving the distribution of year-on-year price variations toward higher values until 2023, after which it moderated. Changes were balanced or biased towards increases, contributing to inflation.
- **Behavioral Shifts:** As quarterly inflation grew, price changes became more frequent. This resulted in a negative correlation between inflation and price stability.
- **Data Quality and Index Generation:** Ongoing efforts include improving the classification of supermarket data and generating a high-frequency Consumer Price Index (CPI).

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Appendix

Discount filter

Detection of v-shapes (30 days max.
for discounts)

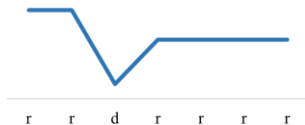
Symmetrical V



Asymmetrical V



Discount and reduction



Price increase outlier (7 days)

Regular price and hike



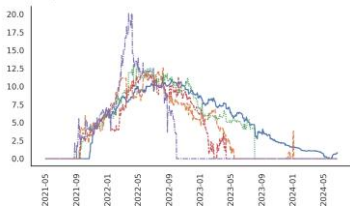
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— Hike — Regular

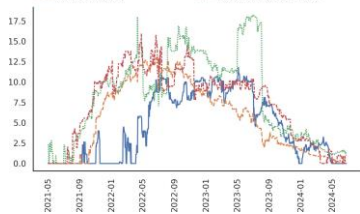
Variation distribution with filtered data

Median of year-on-year variations

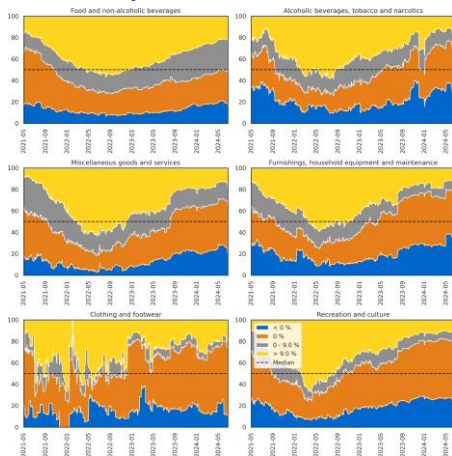
— Food and non-alcoholic beverages - - - Furnishings, household equipment and maintenance
- - - Alcoholic beverages, tobacco and narcotics - - - Recreation and culture
- - - Miscellaneous goods and services



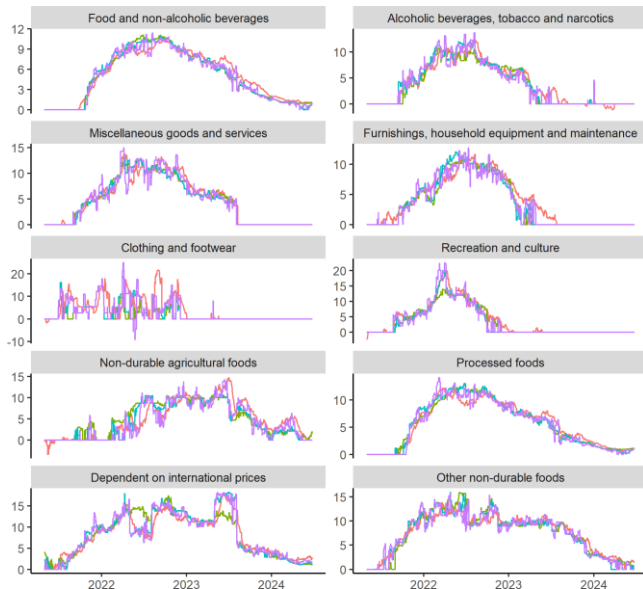
— Non-durable agricultural foods - - - Dependent on international prices
- - - Processed foods - - - Other non-durable foods



Year-on-year variation distribution



Discount filter parameter comparison



Frequency of change over different years

