JÖNKÖPING UNIVERSITY
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Left-Digit Bias in Household Inflation Expectations

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Motivation: how the media reports on inflation

menu TAGESSPIEGEL Register ABO

Highest rate in 70 years Inflation rises to 10 percent in September

Tagesspiegel, September 29, 2022 Link

Research question

- **Inflation expectations**: crucial role in households' economic decisions and are highly relevant for monetary policy
- Ongoing question: How do households form inflation expectations? Determinants?
- One determinant: current and past inflation rate (Carillo and Shahe Emran, 2012; Coibion et al., 2023)

→ Are households subject to **left-digit bias** when processing information about the inflation rate? How does this bias affect inflation expectations?

- Example: Difference if inflation increases from 4.8 to 4.9 versus 4.9 to 5.0 percent?

What we do

- Theory: left-digit-biased inflation expectations
- Empirical approach
  - Cross-country data and regression discontinuity design
  - Mechanism? Sensational news coverage of inflation rate
    - *Eurostat: Inflation on the rise* versus *Eurostat: Soaring inflation breaks all records*
    - Cross-country data and RCT
- Data: inflation rate, household inflation expectations, and inflation headlines (machine learning to determine sensational inflation headlines) for 30 European economies, monthly, 2017–2023
- Macroeconomic and monetary policy implications? NK model with left-digit-biased inflation expectations

Results: preview

- **Inflation threshold event** (e.g., inflation increases from 4.99 to 5.00%)
  - Multiples of five
  - More households expect rising inflation, mean and median inflation expectations increase by 0.6 and 1.1 pp
  - Asymmetry
- **Sensational news coverage**
  - IV estimates: mean probability of sensational headlines more than doubles when inflation surpasses a threshold, inducing more household to expect increasing inflation
  - Supported by RCT (individual level, control headline exposure)
- **NK model**: Positive demand shock with left-digit-bias results in
  - Weaker initial response of inflation
  - More persistent inflation, once inflation crosses threshold

  $\rightarrow$ Initially less aggressive, but more persistent monetary policy response necessary

Related literature 1: inflation expectations

- Single good prices
  Coibion & Gorodnichenko '15, Cavallo et al. '20, Weber et al. '22, ...
- Central bank announcements — Dräger et al. '16, Coibion et al. '22, ...
- Past experiences — Malmendier & Nagel '15, Goldfayn-Frank & Wohlfart '20
- Cognitive ability — Cavallo et al. '17, D'Acunto et al. '19,'22
  → Left-digit bias
- Current inflation — Bracha '22, Coibion et al. '23, ...
  → Left-digit bias and discontinuities
- Rational (in)attention, thresholds
  Sims '03, Cavallo et al. '17, Bracha '22, Pfäuti '23, Weber et al. '23, ...
  → Left-digit bias: thresholds are round-numbers
- Media — Caroll '03, Pfajfar & Santoro '13, Kmetz et al. '22 ...
  → Sensationalism ('good' or 'bad')

Related literature 2: left-digit bias

- Psychology: people often process numerical values as round numbers, especially when cognitive efforts are supposed to remain low — Rosch '75
- Economics
  - 99-cent pricing — Thomas & Morwitz '05, Sokolova et al. '20, Strulov-Shlain '22, List et al. '23,...
  - Clustering of stock and currency prices — Sonnemans '06, Bhattacharya et al. '12, Urquhart '17
  - Unemployment and voting — Garz '18, Garz & Martin '21
  - Mortgage demand, used cars and mileage, ... — Agarwal et al. '22, Lacetera et al. '12, ...

$\rightarrow$ Study left-digit bias in context of inflation and inflation expectations

Related literature 3: media transmission of macroeconomic information

- Effects of media on economic outcomes
  DellaVigna & Gentzkow '10, DellaVigna & La Ferrara '15, Prat & Strömberg '13, ...
- Inflation: see penultimate slide
- Unemployment Garz '13, Soric et al. '19,...
- Consumer sentiment
  Nguyen & Claus '13, Garmaise et al. '20, Eggers et al. '21, ...
- Forecasting of macro-variables
  Rambaccussing & Kwiatkowski '20, Aprigliano et al. '23, ...

→ Mostly volume or tone of coverage (positive/negative), we: sensational vs. non-sensational

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Definitions

Inflation expectations formation

$$\mathbb{E}_t^b(\pi_{t+1}) = f(\pi_t, \pi_{t-1}, \mathbf{X}_t)$$

Inflation threshold event

- *inflation threshold* τ: inflation expectation function f has a jump discontinuity at $\pi_t = \tau$
- *increasing-inflation threshold event*: $\pi_{t-1} < \tau$ and $\pi_t \geq \tau$ for some τ
- *decreasing-inflation threshold event*: $\pi_{t-1} > \tau$ and $\pi_t \leq \tau$ for some τ

Left-digit bias in inflation expectations

Household inflation expectations exhibit *left-digit bias* when inflation thresholds occur at round numbers.

▸ jump-discontinuity

A theory of left-digit biased inflation expectations

A representative household perceives inflation as

$$\overbrace{\pi_t^p}^{\text{Perception}} = \overbrace{\pi_{t-1}^p}^{\text{Perception } t-1} + \overbrace{d(\pi_t, \pi_{t-1})}^{\text{Discontinuous updating}} + \overbrace{(1-\theta)\left[\Delta\pi_t - d(\pi_t, \pi_{t-1})\right]}^{\text{Attention to inflation changes}} + \underbrace{(1-\lambda)\left[\pi_{t-1} - \pi_{t-1}^p\right]}_{\text{Attention to inflation level}}, \tag{1}$$

with discontinuous updating

$$d(\pi_t, \pi_{t-1}) = \left(\left\lfloor \frac{\pi_t}{\tau} \right\rfloor - \left\lfloor \frac{\pi_{t-1}}{\tau} \right\rfloor\right) \times \begin{cases} \tau & \text{if } \left\lfloor \frac{\pi_t}{\tau} \right\rfloor \geq \left\lfloor \frac{\pi_{t-1}}{\tau} \right\rfloor \\ \tau^- & \text{if } \left\lfloor \frac{\pi_t}{\tau} \right\rfloor < \left\lfloor \frac{\pi_{t-1}}{\tau} \right\rfloor. \end{cases} \tag{2}$$

$\rightarrow$ Left-digit bias captured by inattention $\theta \in [0, 1]$

$\rightarrow$ Full attention with $\theta = \lambda = 0$: $\pi_t^p = \pi_t$

Symmetric left-digit bias

If $\tau = \tau^- = 1$ and $\lambda = 1$, identical to formulation in literature on left-digit bias and 99-cent pricing (List et al., 2023; Strulov-Shlain, 2023)

$$\pi_t^p = \lfloor \pi_t \rfloor + (1 - \theta)\left(\pi_t - \lfloor \pi_t \rfloor\right).$$

For example, if $\pi_t = 2.9$

- $\pi_t^p = 2$ if $\theta = 1$ — full left-digit bias
- $\pi_t^p = 2.5$ if $\theta = 0.5$ — intermediate bias
- $\pi_t^p = 2.9$ if $\theta = 0$ — unbiased

$\rightarrow$ More general formulation (1)–(2) allows for asymmetry, is dynamic, and stationarity for $\lambda < 1$

Inflation expectations

Household assumes that inflation π_t evolves according to AR(1) process

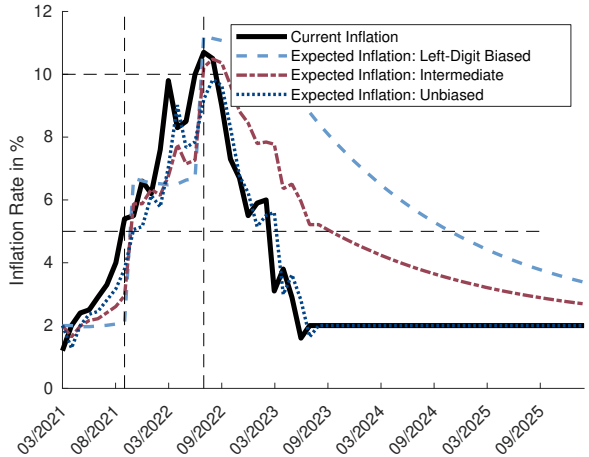
$$\pi_{t+1} = \rho\pi_t + (1-\rho)\pi^* + \epsilon_{t+1}$$

Inflation expectations:

$$\mathbb{E}_t^b(\pi_{t+1}) = \rho\pi_t^p + (1-\rho)\pi^*. \tag{3}$$

$\rightarrow$ Jump discontinuities in perceived inflation translate into jump discontinuities in inflation expectations

Example using Spanish data with $\tau = 5$ and $\tau^{-} = 0$



▸ symmetric ▸ inflation below 10% in Spain

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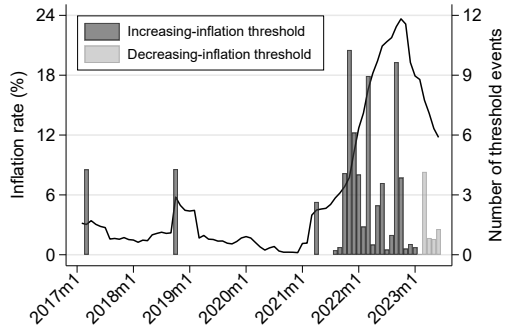
I. Inflation

- HICP from Eurostat, monthly year-on-year changes, originally published values, since 2016
- Inflation thresholds: 5, 10, 15, 20, 25 percent
- 85 inflation threshold events, 26 different month-year points, in 29 out of 30 countries



▸ Spain and Lithuania ▸ HICP vs CPI

II. Inflation expectations

European Commission: European Business and Consumer Surveys

Qualitative measure

By comparison with the past 12 months, how do you expect that consumer prices will develop in the next 12 months? They will

1. increase more rapidly — *PP*%
2. increase at the same rate — *P*%
3. increase at a slower rate — *E*%
4. stay about the same — *M*%
5. fall — *MM*%
6. don't know — *N*%

Balance $= (PP + 1/2P) - (1/2M + MM)$

Quantitative measure

By how many percent do you expect consumer prices will go up/down in the next 12 months?

III. Inflation-related stories

- Articles published by online news sites
- Source: Global Database of Events, Language, and Tone (GDELT)
  - over 150,000 news sites worldwide, extracting entities, actors, and themes from reports every 15 minutes
  - Computationally analyzes the content by applying natural language processing techniques
- We use
  - Headlines of reports covering the theme "econ_inflation"
  - Focus on major outlets according to BBC's media country profiles

  → 179 outlets, 6 outlets on average per country

  → Downloaded: 281,206 inflation-related stories

▸ List of outlets

III. Sensationalism in inflation-related headlines

- Sensationalism involves news coverage that accentuates thrilling, shocking, or other emotionally captivating aspects of a story
- News on economy: round numbers and historical rarities (Renton, 2020)

→ Sensational headlines are those stating that inflation or prices have reached a milestone, broken some historical record, or surpassed some round-number threshold

III. How to measure sensationalism

1. Translate to English: "M2M100_1.2B" multilingual encoder-decoder model developed by Facebook Research
2. Instruct human coders to annotate random sample of 9,500 translated headlines as sensational or not
3. Use this to train deep learning classifier based on Bidirectional Encoder Representations from Transformers (BERT $\rightarrow$ RoBERTa) to predict sensationalism of remaining 281,206 headlines
4. Aggregation: calculate mean probability of sensational inflation-related headlines by country and month

III. Example headlines

This has not been the case for a long time: Inflation has exceeded 10%, the highest since 2000! What costs the most?

cas.sk, Apr 19, 2022, Slovakia
→ sensational

Highest rate in 70 years: Inflation rises to 10% in September

tagesspiegel.de, Sep 29, 2022, Germany
→ sensational

Inflation rises but remains within target

danas.rs, Aug 18, 2021, Serbia
→ non-sensational

Data linking

- π_t: published between end of month t and beginning of $t+1$
- $\mathbb{E}_t^b(\pi_{t+1})$: surveyed during first 2–3 weeks of month t

↯ Survey responds cannot know π_t when answering the survey

→ We consider $\pi_{t-2}, \pi_{t-1} \Rightarrow \mathbb{E}_t^b(\pi_{t+1})$

✓ Benefit: $\mathbb{E}_t^b(\pi_{t+1}) \not\gg \pi_{t-1}$

- News stories: published immediately when π_t is released → assign all reports published within first 7 days of month t to $t-1$

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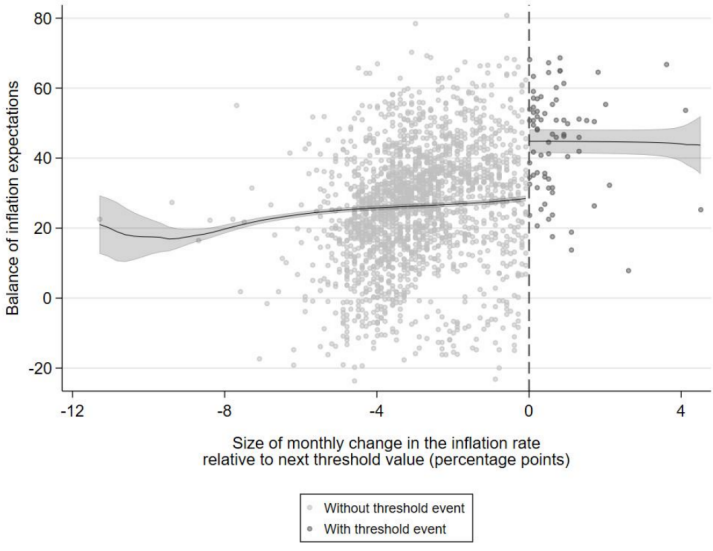
I. How to test for left-digit bias in household inflation expectations

- Problem: Cannot isolate effect of increase in inflation from inflation threshold event (e.g., inflation increases from 4.1% to 5.1%)
- Solution: exploit discontinuity around inflation threshold event by controlling for π_{t-2} and $\Delta\pi_{t-1}$
- Assumption: conditional on π_{t-2} and $\Delta\pi_{t-1}$, inflation threshold event is random (e.g., $\pi_{t-2} = 4.4\%$ and $\Delta\pi_{t-1} = 59$bp vs. $\Delta\pi_{t-1} = 60$bp) ▸ balance checks
- Difference to conventional RDD: assignment is a function of two variables, π_{t-2} and $\Delta\pi_{t-1}$
- We estimate

$$y_{i,t} = \alpha_1 t_{i,t-1}^{increasing} + \alpha_2 t_{i,t-1}^{decreasing} + \alpha_3 X_{i,t-1} + \theta_i + \rho_t + \epsilon_{i,t}$$

where $X_{i,t-1}$: bin dummies for π_{t-2} (10bp) and polynomial of order 3 for $\Delta\pi_{t-1}$

I. Increasing-inflation threshold events and inflation expectations



II. Transmission via sensationalism

- How are inflation threshold events transmitted to households?

↯ Self-calculated CPI or direct information from statistical agencies

↯ Social networks: friends, family, colleagues

→ Media: sensational headlines on news sites D'Acunto et al. (2024, fig. 6)

- We estimate

$$s_{i,t-1} = \beta_1 t_{i,t-1}^{increasing} + \beta_2 t_{i,t-1}^{decreasing} + \beta_3 X_{i,t-1} + \theta_i + \rho_t + \epsilon_{i,t}$$

$$y_{i,t} = \gamma_1 \hat{s}_{i,t-1} + \gamma_2 t_{i,t-1}^{decreasing} + \gamma_3 X_{i,t-1} + \theta_i + \rho_t + \nu_{i,t}$$

- Exclusion restriction:
  - Volume effects?
  - Broadcast or social media?

→ Complementary controlled survey experiment

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Main results

	(1) Expectations (OLS reduced form)	(2) Sensational headlines (IV first stage)	(3) Expectations (IV second stage)
P(sensational headlines)			3.682***
			(1.145)
			[0.005]
Increasing-infl. threshold	5.764***	1.566***	
	(1.431)	(0.318)	
	[0.002]	[0.000]	
Decreasing-infl. threshold	4.909	-0.117	5.341
	(3.960)	(0.935)	(5.243)
	[0.278]	[0.935]	[0.423]
Mean of dependent variable	24.693	1.425	24.693
SD of dependent variable	17.071	2.912	17.071

Robustness

- Inflation thresholds
  - Separate dummies for multiples of 5 and 2% — ▸ figure
  - All integers — ▸ table
  - Placebo thresholds — ▸ figure
- 6- and 18-month protection periods — ▸ table
- Alternative bandwidths for π_{t-2} — ▸ table
- Alternative polynomial orders for $\Delta\pi_{t-1}$ — ▸ table
- Bin dummies for $\Delta\pi_{t-1}$ — ▸ table
- Interaction π_{t-2} and $\Delta\pi_{t-1}$ — ▸ table
- Omit population weights — ▸ table
- CPI instead of HICP — ▸ table
- Headlines including keyword "inflation" or "consumer price*" — ▸ table
- Conventional RDD with $\Delta\pi_{t-1} - (\tau_{t-2} - \pi_{t-2})$ — ▸ table

Quantitative inflation expectations

	Mean estimate			Median estimate		
	(1) Expectations (OLS reduced form)	(2) Sensational headlines (IV first stage)	(3) Expectations (IV second stage)	(4) Expectations (OLS reduced form)	(5) Sensational headlines (IV first stage)	(6) Expectations (IV second stage)
P(sensational headlines)			0.364**			0.647**
			(0.150)			(0.314)
Increasing-infl. threshold	0.605**	1.663***		1.076**	1.663***	
	(0.228)	(0.381)		(0.523)	(0.381)	
Decreasing-infl. threshold	1.314	0.640	1.081	3.299	0.640	2.885
	(0.876)	(1.238)	(1.047)	(1.995)	(1.238)	(2.326)
Mean of dependent variable	6.396	1.451	6.396	5.337	1.451	5.337
SD of dependent variable	3.740	2.983	3.740	6.406	2.983	6.406

Extensive versus intensive margin

$$\overbrace{\Delta \bar{\mathbb{E}}_t^b(\pi_{t+1})}^{\text{total change}} = \overbrace{\sum_{i=1}^{I} \Delta\omega_i \times \bar{\mathbb{E}}_{t,i}^b(\pi_{t+1})}^{\text{extensive margin}} + \overbrace{\sum_{i=1}^{I} \omega_i \times \Delta\bar{\mathbb{E}}_{t,i}^b(\pi_{t+1})}^{\text{intensive margin}} + \overbrace{\sum_{i=1}^{I} \Delta\omega_i \times \Delta\bar{\mathbb{E}}_{t,i}^b(\pi_{t+1})}^{\text{interaction term}}$$

$$61 = 48 + 13 \quad \text{[basis points]}$$

- We can estimate extensive margin, but not intensive margin directly (no panel)

$\rightarrow$ Calculate intensive margin + interaction term residually

- Change in average inflation expectation driven by extensive margin

(Andrade et al., 2023)

▸ table

Other mechanisms for round-number milestones

- Volume effect: more headlines on inflation? table
  - → No effect of inflation threshold events on # of inflation headlines
  - → No effect of # inflation headlines on expectations

- Do households actively search for relevant information when threshold events occur? table
  - Volume of Google searches for the search topics “inflation” and “consumer price index” as proxies of interest in the topic
  - → We do not find an effect on inflation expectations
  - ↯ Rational (in)attention

Inflation threshold events and durable consumption

- Real effects?
- EC Survey question on *readiness to spend on durables* Bachmann et al., 2015
- Inflation threshold event leads to
  - 6.6 pp more households stating that now is a good moment to purchase durables relative to households stating the opposite
  - Sensational headlines seem to again play an important role

table

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RCT to test effect of sensationalism on inflation expectations at individual level in experimental setting

→ Structure of survey experiment:

1) Present survey respondents 5 headlines randomly, 4 of which are non-inflation related (and ask how interested they would be to read the story) ...

Category	Headline
Culture	Joaquin Phoenix wins best actor Oscar for role in "Joker"
Politics	Narendra Modi elected as Prime Minister of India
Society	Elon Musk announces that Twitter will be rebranded to X
Sports	Co-host New Zealand exits Women's World Cup after goalless draw

2) ... and one out of 8 groups of inflation headlines

#	Non-sensational phrasing	Sensational phrasing
1	Consumer price index increases in 2022	Consumer price index reaches historic double-digit threshold in 2022
2	Consumer prices have climbed to higher level	Consumer prices skyrocket to unprecedented levels
3	New inflation estimate: Higher rate of price change	Never seen before: Inflation exceeds 10% threshold
4	Eurostat: Inflation on the rise	Eurostat: Soaring inflation breaks all records
5	Food price growth accelerates	Food price growth reaches 5% milestone!
6	Price developments: Inflation rate accelerates	RECORD HIGH: Inflation reaches double digits
7	Inflation rate on rise, according to Statistical Office	Inflation rate hits 20% barrier for the first time ever
8	Economy: Higher oil prices in 2023	Oil prices highest since 1973

3) After all headlines: quiz part I: attention check

#	Question	Answer options
1	Who won the Oscar for his role in “Joker”?	a) Joaquin Phoenix (correct)
		b) Anthony Hopkins
		c) Christian Bale
2	What will Twitter be rebranded as?	a) X (correct)
		b) Twitter-X
		c) xTwitter

3) After all headlines: quiz part II: inflation expectations

#	Question	Answer options
3	How will consumer prices develop in the next 12 months? Prices will ...	a) ... increase more rapidly b) ... increase at the same rate c) ... increase at a slower rate d) ... stay about the same e) ... fall
	If a), b), or c) → 4a, if d) → end, if e) → 4b.	
4a	By how many percent do you expect consumer prices to go up in the next 12 months?	Consumer prices will increase by [—.-]%.
4b	By how many percent do you expect consumer prices to go down in the next 12 months?	Consumer prices will decrease by [—.-]%.

Implementation

- Coded with Qualtrics and done by Prolific → survey takers from almost all EU member states and candidate countries
- Online survey, in English, during Oct 5–12, 2023
- 0.70 Euro per participant, 150 seconds on average, mean hourly wage of 16.82 EUR (17.58 USD)
- Sample size
  - 2 000 respondents
  - 7.3% attrition rate, exclusion of top and bottom 1% of respondents in terms of survey duration, 3 participants failed both attention test questions in quiz

  → 1,816 participants
- Distribution of participants across EU states correlates positively with EU states population shares
- Demographic variables: sex, age, employment status, and country of residence

→ No significant differences between treatment and control group

▸ table

Estimation equation and descriptive stats

- High share of respondents (69%) expects rising inflation
- We estimate

$$y_{i,h} = \alpha_1 + \alpha_2 T_{i,h} + \alpha_3 X_i + \mu_h + \epsilon_{i,h}$$

- $y_{i,h}$: reading interest, expected inflation (quantitative and qualitative)
- μ_h: headline-pair fixed effect capturing potential effects due to variation in content between the 8 pairs of inflation headlines
- X_i: sex, age, employment status, and country of residence

Results

	Reading interest	Expecting increasing inflation	Quantitative estimate	Winsorized quantitative estimate
Sensational headline treatment	-0.03	0.03	4.00***	1.38***
	(0.05)	(0.02)	(1.29)	(0.41)
Mean of dependent variable	3.68	0.69	15.85	11.55
SD of dependent variable	1.13	0.46	27.36	8.72
Observations	1816	1816	1797	1797

▸ numerical vs. non-numerical headlines

Plan

Model

Three-equation NK-model (Galí, 2015) + left-digit-biased inflation expectations:

$$\pi_t = \beta \mathbb{E}_t^b \pi_{t+1} + \kappa \widetilde{y}_t$$
$$\widetilde{y}_t = \mathbb{E}_t \widetilde{y}_{t+1} - \frac{1}{\sigma}\left(\hat{i}_t - \mathbb{E}_t^b \pi_{t+1}\right) + \frac{1}{\sigma}(1-\rho_z) z_t$$
$$\hat{i}_t = \phi_\pi \pi_t + \phi_y \widetilde{y}_t,$$

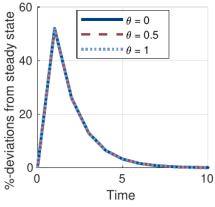
with $\mathbb{E}_t \widetilde{y}_{t+1} = \rho_y \widetilde{y}_t$, demand shock z_t following AR(1) with persistence ρ_z, and left-digit-biased inflation expectations given by equations (1), (2), and (3)

Differences to standard NK-model? Households and firms

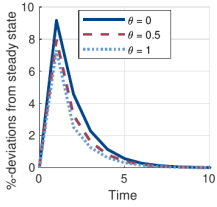
1. Believe C and π follow AR(1)
2. Do not observe π perfectly, but have left-digit-biased inflation perceptions

calibration and solution

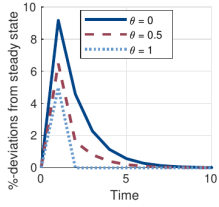
Inflation increases less with left-digit bias (less amplification)



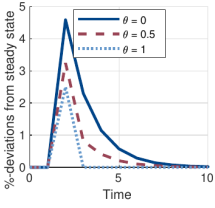
(a) Demand shock



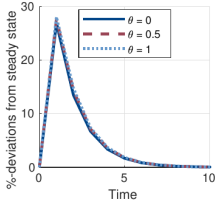
(b) Inflation



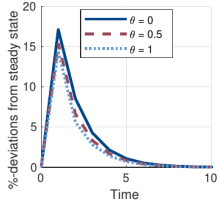
(c) Perceived inflation



(d) Expected inflation

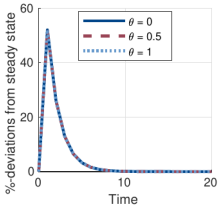


(e) Output gap

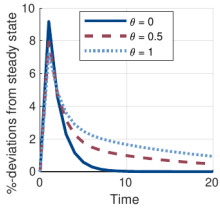


(f) Nominal interest rate

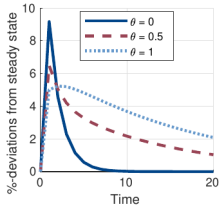
Inflation stays elevated longer with left-digit bias (more persistence)



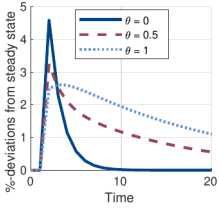
(a) Demand shock



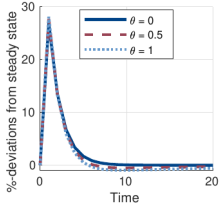
(b) Inflation



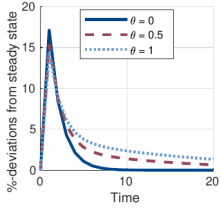
(c) Perceived inflation



(d) Expected inflation



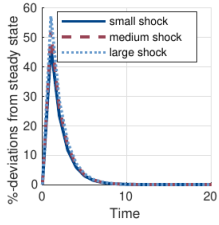
(e) Output gap



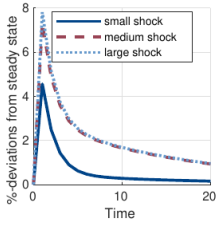
(f) Nominal interest rate

$\tau^- = 0, \lambda = 0.9$

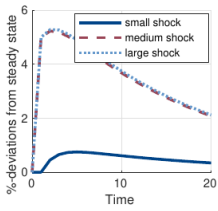
Non-linearity of inflation in shock-size



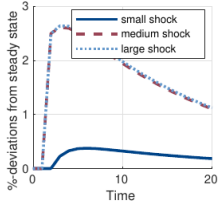
(a) Demand shock



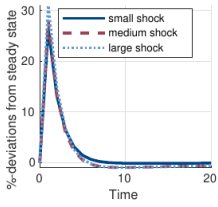
(b) Inflation



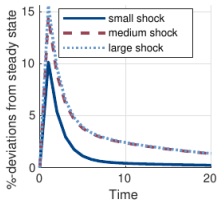
(c) Perceived inflation



(d) Expected inflation



(e) Output gap



(f) Nominal interest rate

10% differences in initial shock sizes

Plan

Conclusion

- Theory: Left-digit bias in inflation expectations
- Empirical evidence using data from 30 European countries, 2017–2023, regression-discontinuity design:
  - Inflation thresholds at multiples of 5%
  - Mean and median inflation expectations jump by 0.6 and 1.1 percentage points, respectively, in response to positive inflation threshold event
  - Asymmetry: negative inflation threshold events insignificant
  - Driven by households expecting zero or negative inflation $\rightarrow$ now expect rising inflation
- IV approach and RCT: Sensationalist media coverage transmits effects
- Embed left-digit-biased inflation expectations in NK model
  - Demand shocks have weaker initial, but more persistent effect on inflation
  - Monetary policy should react less aggressively but more persistently

Appendix

Jump discontinuity

A jump discontinuity is defined as follows. For

$$\bar{l}^{+} \equiv \lim_{\pi_t \searrow \tau} f(\pi_t, \pi_{t-1} < \tau, \mathbf{X}_t) \qquad \bar{l}^{-} \equiv \lim_{\pi_t \searrow \tau} f(\pi_t, \pi_{t-1} > \tau, \mathbf{X}_t)$$

$$\underline{l}^{+} \equiv \lim_{\pi_t \nearrow \tau} f(\pi_t, \pi_{t-1} < \tau, \mathbf{X}_t) \qquad \underline{l}^{-} \equiv \lim_{\pi_t \nearrow \tau} f(\pi_t, \pi_{t-1} > \tau, \mathbf{X}_t),$$

a jump discontinuity at an increasing-inflation threshold τ exists if $\bar{l}^{+} \neq \underline{l}^{+}$ and similarly, a jump discontinuity at a decreasing-inflation threshold τ exists if $\bar{l}^{-} \neq \underline{l}^{-}$.

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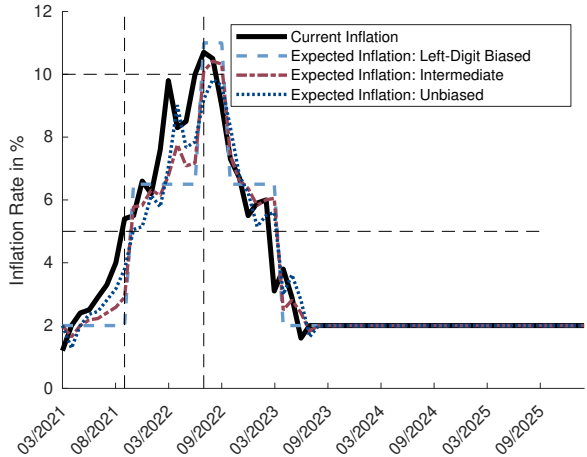
Example using Spanish data with $\tau = \tau^{-} = 5$



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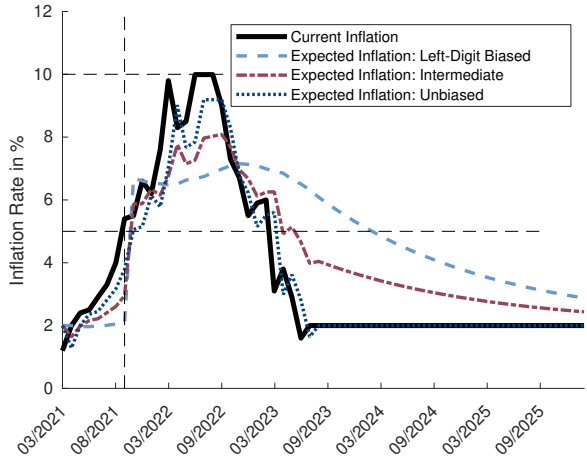
Counterfactual example, Spanish data, $\tau = 5$ and $\tau^{-} = 0$



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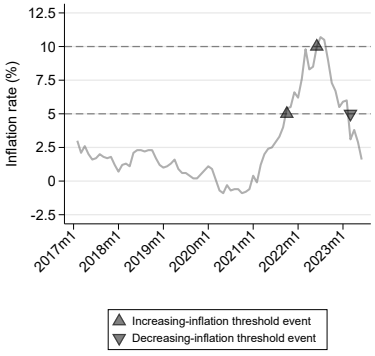
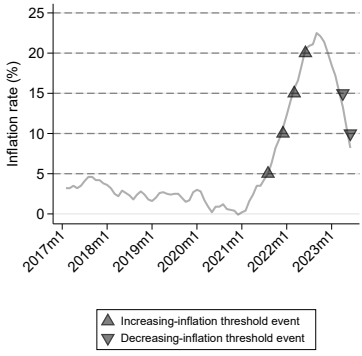
Example of milestone events: Spain and Lithuania



Spain



Lithuania

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HICP vs CPI

- We evaluate 50 press releases from statistical offices in France, Germany, Italy, Spain, and the Netherlands
  - 46% of headlines refer to HICP
  - 54% of headlines refer to CPI

$\rightarrow$ Supports the relevance of HICP in inflation reporting

$\lightning$ Non-revised CPI data not consistently available

$\rightarrow$ We use CPI only for robustness checks

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HICP vs CPI: example headlines

Country	Month	HICP	CPI	Example headline
France	Nov 2019	1.2%	**1.0%**	France: inflation rose again in November to 1% per year (*lefigaro.fr, Dec 12, 2019*)
Germany	Mar 2022	7.6%	**7.3%**	Federal Office Confirms Pricing Rate of 7.3 Percent (*tagesspiegel.de, Apr 12, 2022*)
Italy	Jun 2021	**1.3%**	**1.3%**	Italy, inflation June +0.1% month, +1,3% year (*ilmessaggero.it, Jun 30, 2021*)
Netherlands	Jul 2022	**11.6%**	10.3%	Inflation rises to 11.6% in July after previous decline (*telegraaf.nl, Jul 29, 2022*)
Spain	Jan 2023	**5.9%**	7.5%	Inflation rises by two-tenths, up to 5.9%, due to the withdrawal of fuel aid (*lavanguardia.com, Feb 15, 2023*)

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News sites

Country	News sites	# of stories
Austria	diepresse.com, krone.at, kleinezeitung.at, wienerzeitung.at, derstandard.at, kurier.at, news.at	8,964
Belgium	nieuwsblad.be, hln.be, lesoir.be, standaard.be, tijd.be, demorgen.be, lalibre.be, grenzecho.net	5,919
Bulgaria	dnevnik.bg, 24chasa.bg, telegraph.bg, trud.bg, standartnews.com, segabg.com, capital.bg	7,409
Croatia	vecernji.hr, jutarnji.hr, 24sata.hr, slobodnadalmacija.hr, novilist.hr, gla-sistre.hr, poslovni.hr	9,612
Cyprus	cyprus-mail.com, cyprusweekly.com.cy, philenews.com, politis.com.cy, sime-rini.sigmalive.com	606
Czechia	lidovky.cz, idnes.cz, pravo.cz, blesk.cz, hn.cz, respekt.cz	2,298

News sites

Country	News sites	# of stories
Denmark	jyllands-posten.dk, berlingske.dk, politiken.dk, ekstrabladet.dk, infor-mation.dk, bt.dk	1,120
Estonia	postimees.ee, ohtuleht.ee, epl.delfi.ee, aripaev.ee, maaleht.delfi.ee, ek-spress.delfi.ee	2,391
Finland	hs.fi, is.fi, iltalehti.fi, hbl.fi, kauppalehti.fi, helsinkitimes.fi	5,357
France	lemonde.fr, liberation.fr, lefigaro.fr, ouest-france.fr, lexpress.fr, lepoint.fr	22,168
Germany	faz.net, sueddeutsche.de, welt.de, handelsblatt.com, focus.de, spiegel.de, zeit.de, bild.de	30,597
Greece	tanea.gr, ethnos.gr, tovima.gr, kathimerini.gr, naftemporiki.gr	14,436

Country	News sites	# of stories
Hungary	magyarhirlap.hu, nepszava.hu, magyarnemzet.hu, blikk.hu, metropol.hu, hvg.hu	6,223
Ireland	irishtimes.com, independent.ie, irishexaminer.com, sundayworld.com, busi-nesspost.ie, thesun.ie, irishmirror.ie	10,099
Italy	corriere.it, repubblica.it, ilmessaggero.it, lastampa.it, ilsole24ore.com	16,271
Latvia	diena.lv, nra.lv, db.lv, la.lv, ves.lv, mklat.lv	1,934
Lithuania	lrytas.lt, kauno.diena.lt, vz.lt, veidas.lt	9,076
Luxembourg	journal.lu, wort.lu, tageblatt.lu	1,786
Malta	timesofmalta.com, independent.com.mt, maltatoday.com.mt	4,405
Netherlands	ad.nl, nrc.nl, telegraaf.nl, volkskrant.nl, trouw.nl, fd.nl, vn.nl, parool.nl	3,770

Country	News sites	# of stories
Macedonia	novamakedonija.com.mk, vecer.mk, koha.mk, slobodenpecat.mk	1,943
Poland	wyborcza.pl, rp.pl, fakt.pl, se.pl, dziennik.pl, polityka.pl, wprost.pl, newsweek.pl	10,521
Portugal	dn.pt, publico.pt, cmjornal.pt, jn.pt, expresso.pt	1,333
Romania	adevarul.ro, click.ro, libertatea.ro, evz.ro, jurnalul.ro, romanialibera.ro, capi-tal.ro	14,102
Serbia	politika.rs, blic.rs, danas.rs, glas-javnosti.rs, nin.co.rs, vreme.com, novosti.rs	9,341
Slovakia	dennikn.sk, pravda.sk, sme.sk, cas.sk, pluska.sk	4,130
Slovenia	dnevnik.si, delo.si, vecer.com, slovenskenovice.si, finance.si, dnevnik.si, mladina.si, primorske.svet24.si	4,998

News sites

Country	News sites	# of stories
Spain	elmundo.es, elpais.com, abc.es, larazon.es, lavanguardia.com, elperiodi-co.com/es	19,115
Sweden	aftonbladet.se, dn.se, expressen.se, svd.se, gp.se, sydsvenskan.se	8,019
Turkey	hurriyet.com.tr, sozcu.com.tr, milliyet.com.tr, cumhuriyet.com.tr	43,263
	Total	281,206

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Balance checks

	(1) Population size	(2) GDP	(3) Government debt	(4) Interest rate	(5) Unemploy-ment rate	(6) Balance of payments
Increasing-infl. threshold	-2.37	-1.14	-23.24	0.14	0.10	-6.59
	(3.05)	(0.70)	(18.55)	(0.10)	(0.14)	(345.98)
Decreasing-infl. threshold	3.66	3.63	-93.61	0.10	-0.78	-394.49
	(7.77)	(3.36)	(56.04)	(0.16)	(0.53)	(435.26)
Country fixed effects	no	yes	yes	yes	yes	yes
Time fixed effects	yes	yes	yes	yes	yes	yes
Observations	2146	2077	1942	1977	2031	1745

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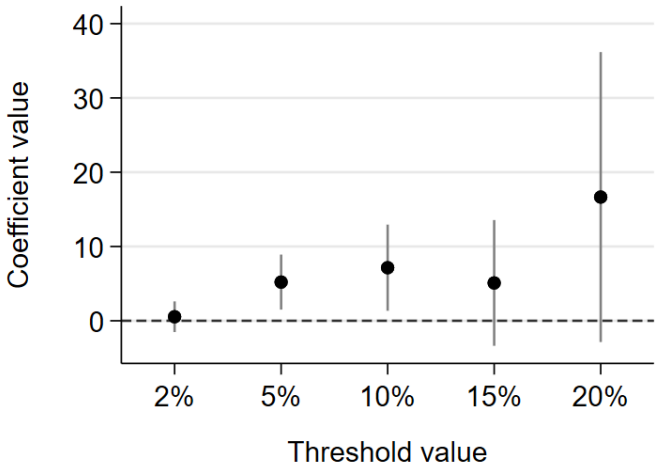
Individual inflation thresholds and inflation expectations



Inflation threshold events, sensational news, and inflation expectations (integers as thresholds)

	(1) Expectations (OLS reduced form)	(2) Sensational headlines (IV first stage)	(3) Expectations (IV second stage)
P(sensational headlines)			-6.029
			(18.000)
Increasing-inflation threshold	1.047	-0.174	
	(0.944)	(0.527)	
Decreasing-inflation threshold	-0.017	0.279	1.666
	(1.169)	(0.266)	(5.136)
Mean of dependent variable	24.693	1.425	24.693
SD of dependent variable	17.071	2.912	17.071
Kleibergen-Paap F statistic		0.109	

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Inflation threshold events and qualitative inflation expectations (decomposed by answer options)

	Share of households expecting prices to...				
	(1) ...increase more rapidly	(2) ...increase at same rate	(3) ...increase at slower rate	(4) ...stay about same	(5) ...fall
Increasing-infl. threshold	3.956**	1.022	-1.441	-2.749**	-0.788**
	(1.442)	(1.006)	(1.039)	(1.040)	(0.372)
Decreasing-infl. threshold	6.639	-2.816	-7.615*	2.603	1.189*
	(4.688)	(2.740)	(3.877)	(3.775)	(0.616)
Mean of dependent variable	20.191	38.955	14.759	24.194	1.901
SD of dependent variable	10.595	11.775	7.178	14.612	2.070

Inflation threshold events and quantitative inflation expectations (decomposed by answer options)

	Mean inflation estimate of households expecting prices to...			
	(1) ...increase more rapidly	(2) ...increase at the same rate	(3) ...increase at a slower rate	(4) ...fall
Increasing-infl. threshold	0.112	-0.203	0.005	0.226
	(0.292)	(0.274)	(0.155)	(0.256)
Decreasing-infl. threshold	-0.764	0.813	-0.158	-1.119***
	(1.050)	(0.755)	(0.752)	(0.401)
Mean of dependent variable	11.724	9.358	6.916	-3.183
SD of dependent variable	4.871	4.221	3.061	1.064
Observations	1854	1854	1854	1683

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Inflation threshold events, sensational news, and inflation expectations (narrow definition of inflation headlines)

	(1) Expectations (OLS reduced form)	(2) Sensational headlines (IV first stage)	(3) Expectations (IV second stage)
P(sensational headlines narrow)			5.558***
			(1.872)
Increasing-infl. threshold	5.764***	1.037***	
	(1.431)	(0.211)	
Decreasing-infl. threshold	4.909	-0.192	5.974
	(3.960)	(0.608)	(5.894)
Mean of dependent variable	24.693	0.764	24.693
SD of dependent variable	17.071	2.150	17.071
Kleibergen-Paap F statistic		24.261	

back

Alternative threshold protection periods

	(1) Expectations (OLS reduced form)	(2) Sensational headlines (IV first stage)	(3) Expectations (IV second stage)	(4) Expectations (OLS reduced form)	(5) Sensational headlines (IV first stage)	(6) Expectations (IV second stage)
P(sensational headlines)			3.821***			4.419***
			(1.211)			(1.502)
6-month protection period						
- Increasing-infl. threshold	5.870***	1.536***				
	(1.442)	(0.332)				
- Decreasing-infl. threshold	1.346	0.554	-0.770			
	(3.965)	(0.618)	(5.473)			
18-month protection period						
- Increasing-infl. threshold				6.701***	1.516***	
				(1.728)	(0.389)	
- Decreasing-infl. threshold				NA	NA	NA
Mean of dependent variable	24.693	1.425	24.693	25.683	1.465	25.683
SD of dependent variable	17.071	2.912	17.071	17.331	3.040	17.331
Kleibergen-Paap F statistic		21.462			15.180	
Observations	2098	2098	2098	1903	1903	1903

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Alternative bandwidths for inflation rate bin dummies

	(1) Expectations (OLS reduced form)	(2) Sensational headlines (IV first stage)	(3) Expectations (IV second stage)	(4) Expectations (OLS reduced form)	(5) Sensational headlines (IV first stage)	(6) Expectations (IV second stage)
P(sensational headlines)			3.685**			2.206**
			(1.342)			(0.828)
Increasing-infl. threshold	4.684***	1.271***		2.794**	1.267***	
	(1.332)	(0.358)		(1.223)	(0.325)	
Decreasing-infl. threshold	4.150	0.271	3.152	2.503	-0.142	2.818
	(5.093)	(0.749)	(5.655)	(4.604)	(0.935)	(4.663)
Bandwidth of inflation rate bin dummies	0.2	0.2	0.2	0.5	0.5	0.5
Mean of dependent variable	24.740	1.419	24.740	24.858	1.427	24.858
SD of dependent variable	16.999	2.896	16.999	16.990	2.886	16.990
Kleibergen-Paap F statistic		12.642			15.242	

back

Alternative polynomial orders for inflation rate change

	(1) Expectations (OLS reduced form)	(2) Sensational headlines (IV first stage)	(3) Expectations (IV second stage)	(4) Expectations (OLS reduced form)	(5) Sensational headlines (IV first stage)	(6) Expectations (IV second stage)
P(sensational headlines)			3.722***			3.802***
			(1.187)			(1.204)
Increasing-infl. threshold	5.824***	1.565***		5.964***	1.569***	
	(1.463)	(0.325)		(1.490)	(0.336)	
Decreasing-infl. threshold	4.319	-0.112	4.735	5.641	-0.106	6.046
	(3.707)	(0.918)	(5.050)	(3.877)	(0.987)	(5.414)
Change of inflation rate, order of polynomial	2	2	2	4	4	4
Mean of dependent variable	24.693	1.425	24.693	24.693	1.425	24.693
SD of dependent variable	17.071	2.912	17.071	17.071	2.912	17.071
Kleibergen-Paap F statistic		23.183			21.840	

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Bin dummies for inflation rate change

	(1) Expectations (OLS reduced form)	(2) Sensational headlines (IV first stage)	(3) Expectations (IV second stage)
P(sensational headlines)			3.314***
			(1.117)
Increasing-infl. threshold	5.336***	1.610***	
	(1.360)	(0.315)	
Decreasing-infl. threshold	5.021	-1.122	8.739
	(6.519)	(1.039)	(9.191)
Mean of dependent variable	24.646	1.426	24.646
SD of dependent variable	17.088	2.921	17.088
Kleibergen-Paap F statistic		26.040	

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Interactive specification

	(1) Expectations (OLS reduced form)	(2) Sensational headlines (IV first stage)	(3) Expectations (IV second stage)
P(sensational headlines)			5.359**
			(2.395)
Increasing-infl. threshold	7.131***	1.331***	
	(2.322)	(0.406)	
Decreasing-infl. threshold	-4.134	-0.169	-3.228
	(4.479)	(0.599)	(5.681)
Inflation rate bin dummies (bandwidth = 0.1) × absolute change in the inflation rate	yes	yes	yes
Mean of dependent variable	24.693	1.425	24.693
SD of dependent variable	17.071	2.912	17.071
Kleibergen-Paap F statistic		10.729	

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Without regression weights

	(1) Expectations (OLS reduced form)	(2) Sensational headlines (IV first stage)	(3) Expectations (IV second stage)
P(sensational headlines)			3.100*
			(1.673)
Increasing-infl. threshold	3.631**	1.171***	
	(1.327)	(0.403)	
Decreasing-infl. threshold	2.374	-0.089	2.648
	(4.010)	(0.861)	(4.951)
Mean of dependent variable	26.563	1.663	26.563
SD of dependent variable	17.017	4.058	17.017
Kleibergen-Paap F statistic		8.456	

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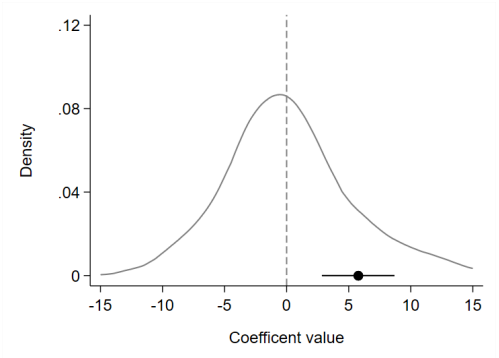
Regression discontinuity estimates

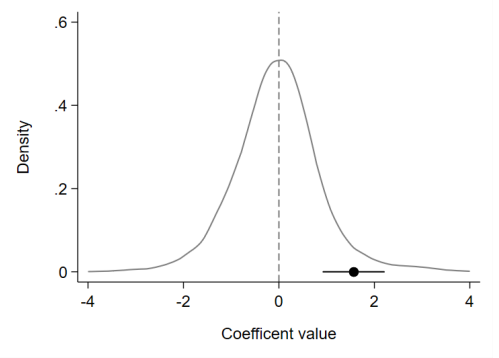
	(1) Expectations	(2) Expectations	(3) Expectations
Increasing-infl. threshold	3.993***	12.254***	6.913***
	(0.812)	(2.033)	(0.581)
Value of assignment variable for threshold events occurring within 12 months after crossing the same threshold:	original	set to -0.1	set to missing
Original number of obs. left of the cutoff	2017	2072	2017
Original number of obs. right of the cutoff	129	74	74
Local number of obs. left of the cutoff	96	132	77
Local number of obs. right of the cutoff	75	32	28
Regression function: order of polynomial	1	1	1
Regression function: bandwidth	0.565	0.445	0.409
Bias function: order of polynomial	2	2	2
Bias function: bandwidth	1.741	0.722	0.625

back

Placebo thresholds



Reduced form



First stage

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CPI instead of HICP

	(1) Expectations (OLS reduced form)	(2) Sensational headlines (IV first stage)	(3) Expectations (IV second stage)
P(sensational headlines)			3.957*
			(2.283)
Increasing-infl. threshold	3.679**	0.930**	
	(1.619)	(0.390)	
Decreasing-infl. threshold	6.126	-0.123	6.614
	(3.828)	(0.982)	(4.187)
Mean of dependent variable	24.618	1.419	24.618
SD of dependent variable	16.927	2.906	16.927
Kleibergen-Paap F statistic		5.693	

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Volume effects?

	(1) Number of inflation reports (IV first stage)	(2) Expectations (IV second stage)	(3) Number of inflation reports (IV first stage)	(4) Expectations (IV second stage)
Number of inflation reports		-22.154		-26.672
		(16.718)		(26.300)
Increasing-infl. threshold	-0.260		-0.206	
	(0.216)		(0.219)	
Decreasing-infl. threshold	0.811	22.887	0.809	26.508
	(0.669)	(22.062)	(0.674)	(30.972)
Total number of reports			-0.000*	-0.000
			(0.000)	(0.001)
Mean of dependent variable	2.191	24.693	2.191	24.693
SD of dependent variable	2.062	17.071	2.062	17.071
Kleibergen-Paap F statistic	1.457		0.882	

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Inflation threshold events, Google searches, and inflation expectations

	(1) Google searches for inflation (IV first stage)	(2) Expectations (IV second stage)	(3) Google searches for CPI (IV first stage)	(4) Expectations (IV second stage)
Google searches for inflation		1.494		
		(1.918)		
Google searches for CPI				1.506
				(2.086)
Increasing-infl. threshold	3.858		3.639	
	(4.988)		(5.240)	
Decreasing-infl. threshold	-8.969	18.309	-11.272	21.900
	(7.743)	(15.558)	(7.231)	(24.046)
Mean of dependent variable	24.626	24.693	29.586	24.693
SD of dependent variable	24.290	17.071	23.807	17.071
Kleibergen-Paap F statistic	0.598		0.482	

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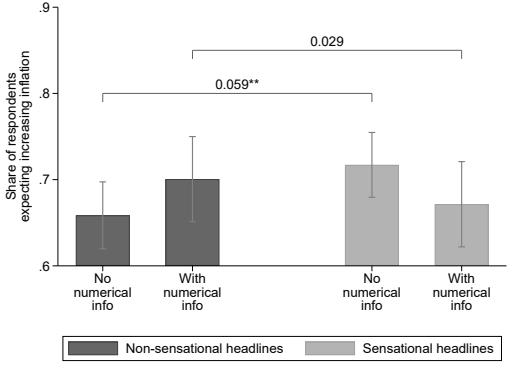
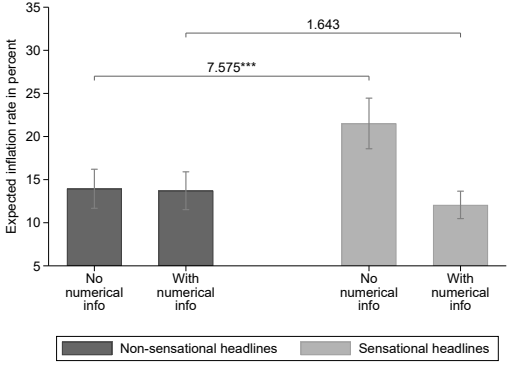
Balance table of demographic variables

	Mean treated	Mean untreated	Difference (p-value)
Male (binary)	0.51	0.51	0.961
Age category:			
- missing	0.01	0.01	0.606
- 18 to 25	0.27	0.27	0.974
- 26 to 30	0.25	0.26	0.725
- 31 to 38	0.24	0.23	0.358
- 39 to 74	0.23	0.24	0.681
Employment status:			
- other	0.24	0.25	0.463
- full-time	0.55	0.53	0.431
- part-time	0.12	0.13	0.326
- unemployed	0.09	0.08	0.385
Number of participants	911	905	

Effects of sensational headline treatment on inflation expectations





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Inflation threshold events, sensational news, and readiness to spend on durables

	Sociotropic question			Egocentric question		
	(1) Attitudes (OLS reduced form)	(2) Sensational headlines (IV first stage)	(3) Attitudes (IV second stage)	(4) Attitudes (OLS reduced form)	(5) Sensational headlines (IV first stage)	(6) Attitudes (IV second stage)
P(sensational headlines)			4.186***			1.346**
			(1.489)			(0.593)
Increasing-infl. threshold	6.553***	1.566***		2.108**	1.566***	
	(1.976)	(0.318)		(0.812)	(0.318)	
Decreasing-infl. threshold	4.071	-0.117	4.562	2.185	-0.117	2.343
	(4.657)	(0.935)	(6.663)	(5.123)	(0.935)	(6.060)
Mean of dependent variable	-17.851	1.425	-17.851	-13.689	1.425	-13.689
SD of dependent variable	22.037	2.912	22.037	12.290	2.912	12.290
Kleibergen-Paap F statistic		24.211			24.211	

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Model solution

- Solution: forward iteration, solving system of non-linear (left-digit bias) equations at each time step
- Calibration:
  - Standard parameters (Galí, 2015): $\beta = 0.99$, $\kappa = 0.172$, $\sigma = 1$, $\phi_\pi = 1.5$, and $\phi_y = 0.125$
  - Inflation thresholds at multiples of 5, $\tau = 5$
  - Subjective persistence of inflation and consumption: $\rho_\pi = 0.5$ and $\rho_y = 0.5$
  - Demand shock: inflation surpassing the threshold of 5% on impact, $u_1 = 0.52$, persistence $\rho_z = 0.5$.

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