Detecting Structural Breaks in Inflation Trends: A High-Frequency Approach

Alberto Cavallo
Harvard Business School

Gaston Garcia Zavaleta
Universidad de San Andres

Q-Group , Miami
May 2, 2023

Financial Disclosure: Alberto Cavallo is a shareholder in PriceStats LLC, a private company that provided inflation data for this research

Motivation

- Detecting changes in inflation trends is a fundamental problem for businesses, economists and central bankers
  - *The risk is that because of the multiplicity of shocks you start to transition into a higher inflation regime, and our job is to literally prevent that from happening.*

    Fed s Chair Jerome Powell, Sintra ECB conference, June 2022.

- In recent decades, there have been important methodological advances in the detection of structural breaks in macro time series
  - See Perron (2006) and Casini & Perron (2018)

- But their applicability for real-time inflation analysis has been severely limited by the low monthly frequency of CPIs
  - Longer time series are needed for the tests to have power (sensitivity)
  - Detecting a new trend requires several months of data (delays)

The price index is where we can best detect changes in the inflation trend

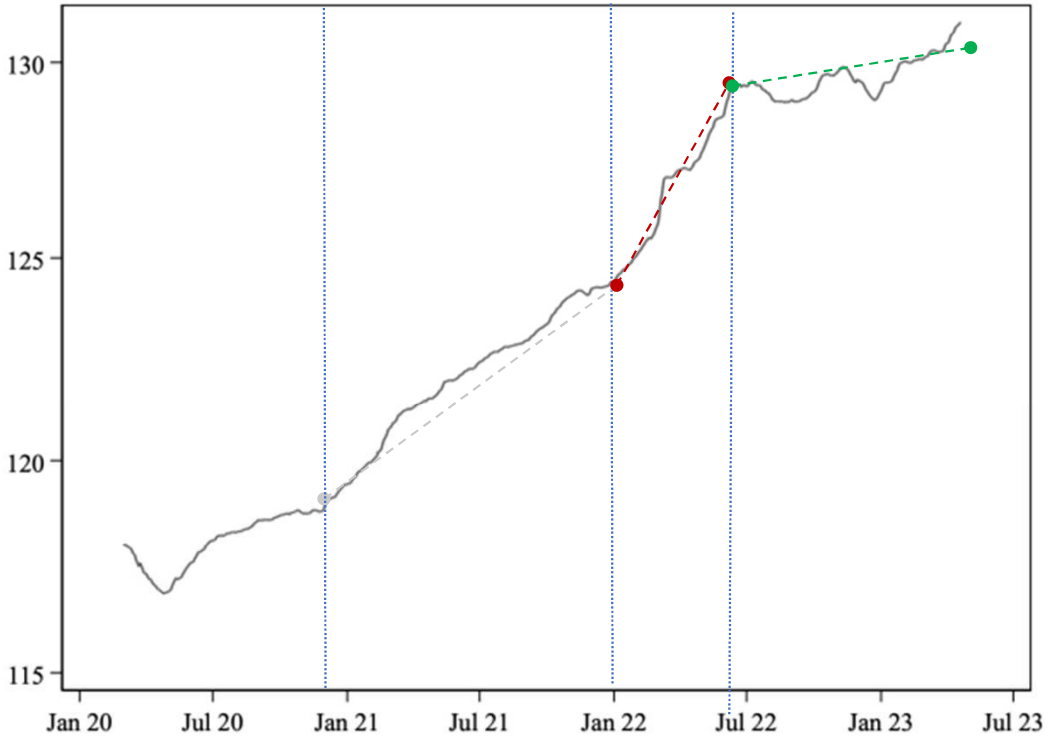


Figure 1: US Aggregate Daily Price Index

Source: PriceStats, State Street Global Markets

- Slope is the trend or trajectory of the price level → "inflation trend"
- Flexible time frame for analysis
  - Not pre-selected (like in annual, quarterly, or monthly rates)

What we do

We use daily inflation data from PriceStats (Billion Prices Project) in 25 countries from January 2021- April 2023 to:

1) Statistically identify “structural breaks” in the time series using the coefficients of simple linear regressions (see Perron (2006) and Casini & Perron (2018))

For our main results

- Test for a *single* trend break in *unknown* date within last 12 months
- Set trim percentage at 10%, statistical significance at 5%
- Ignore breaks where the slope change is less than 0.01

2) Use disaggregated series → compute the share of sector weights with trend breaks → measure how widespread the trend breaks are to identify an inflection point

Estimated Structural Break in US Aggregate Index ("all items")

$$Prices_t = \delta_1 + \beta_1 DT_t + \delta_2 I[t > T_b] + \beta_2 DT_t \times I[t > T_b] + \mu_t, \quad t = t_1, ..., T_b, ..., T$$

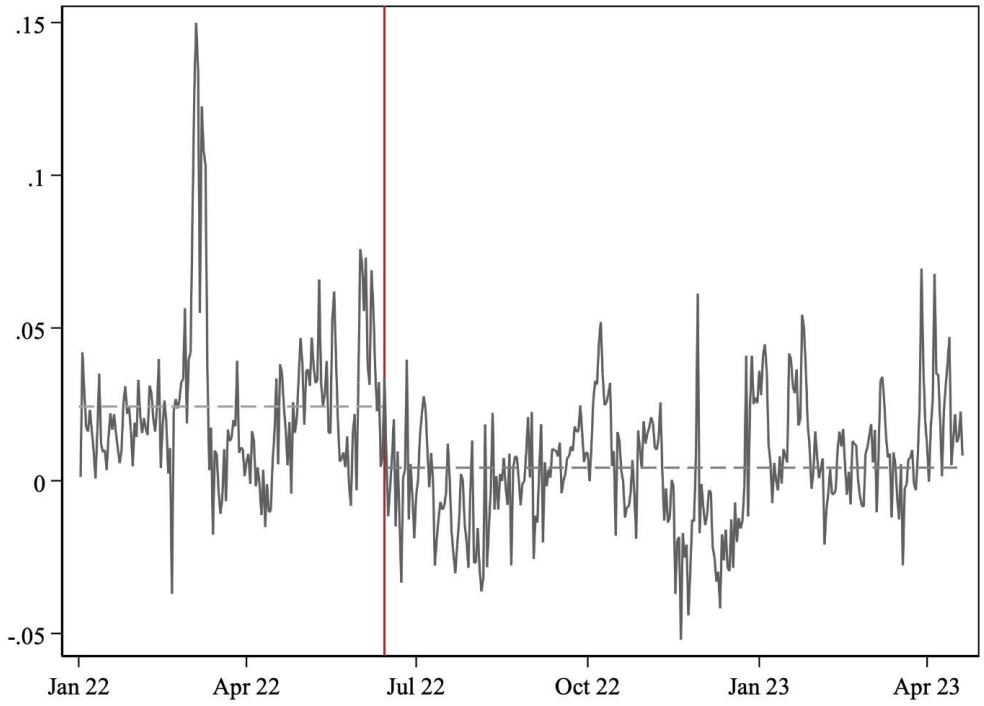


Figure 2: Structural Trend Break - US Aggregate Price Index

Source: Cavallo & Garcia Zavaleta (2023) "Detecting Structural Breaks in Inflation Trends: A High Frequency Approach"

- We follow Yang (2010) and estimate a simple first-differences model with unknown break date T_b

$$Prices_t - Prices_{t-1} = \alpha_1 + \alpha_2 I[t > T_b] + \mu_t$$

- T_b is the date that minimizes the sum of squared residuals
  - Grid search based on dynamic programming algorithm (Bai & Perron 2003a)
- Test significance vs null model with no break
  - Critical value at 10% trimming from (Bai & Perron 2003b)

Estimated Structural Break in US Aggregate Index ("all items")

$$Prices_t = \delta_1 + \beta_1 DT_t + \delta_2 I[t > T_b] + \beta_2 DT_t \times I[t > T_b] + \mu_t, \quad t = t_1, ..., T_b, ..., T$$

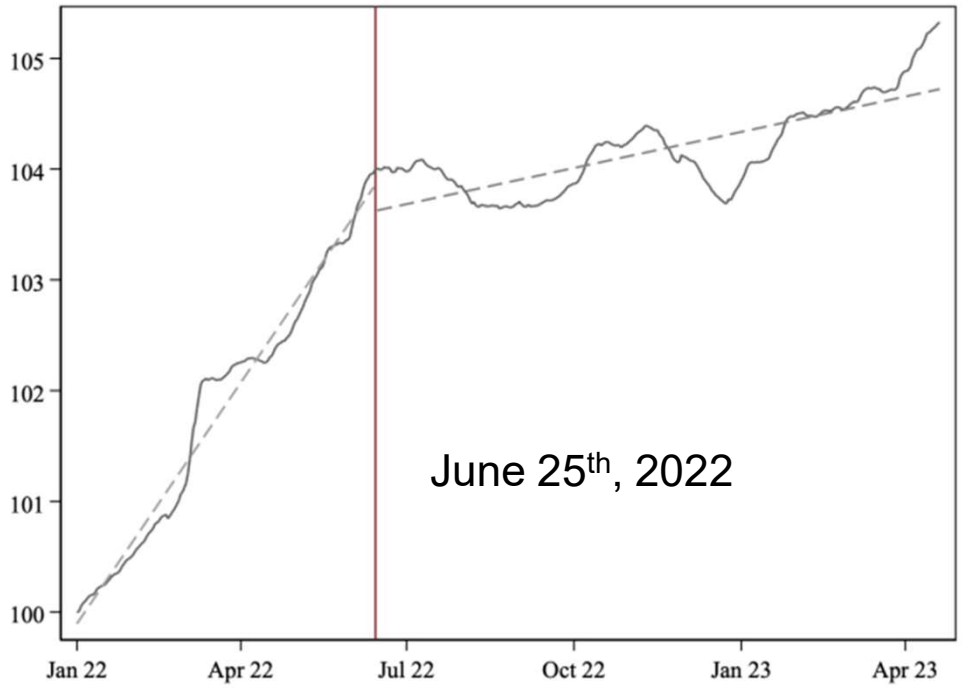


Figure 2: Structural Trend Break - US Aggregate Price Index

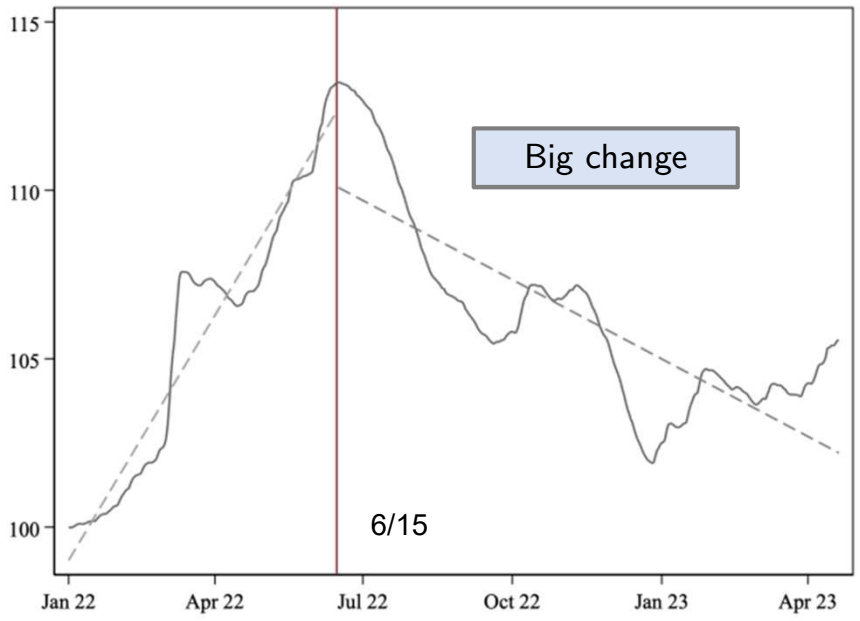
Source: Cavallo & Garcia Zavaleta (2023) "Detecting Structural Breaks in Inflation Trends: A High Frequency Approach"

- We follow Yang (2010) and estimate a simple first-differences model with unknown break date T_b

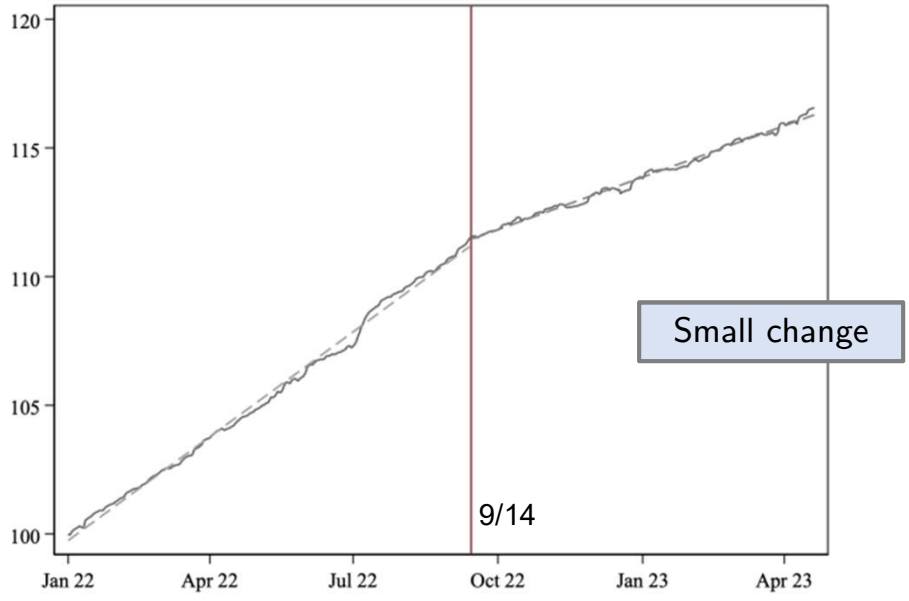
$$Prices_t - Prices_{t-1} = \alpha_1 + \alpha_2 I[t > T_b] + \mu_t$$

- T_b is the date that minimizes the sum of squared residuals
  - Grid search based on dynamic programming algorithm (Bai & Perron 2003a)
- Test significance vs null model with no break
  - Critical value at 10% trimming from (Bai & Perron 2003b)

US: Transportation break in June, Food break in September



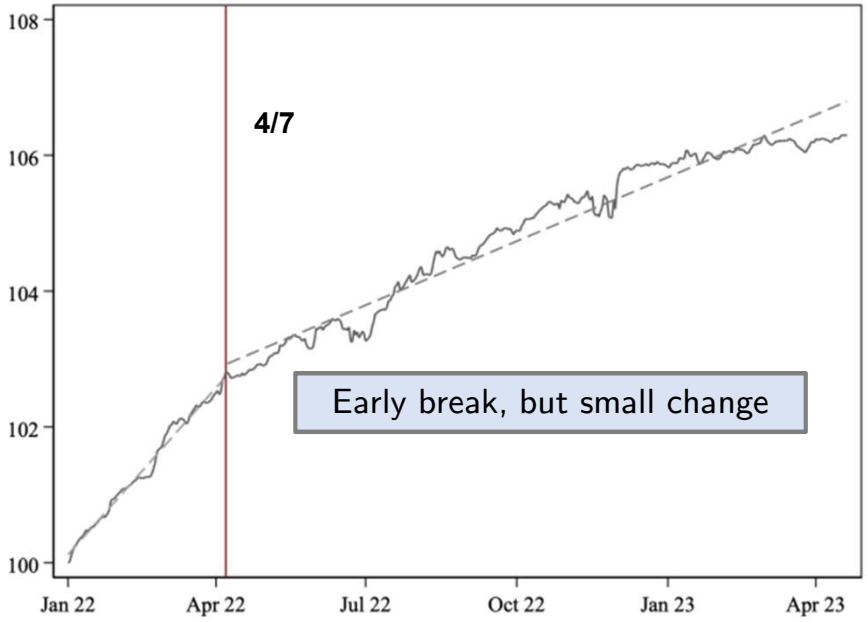
(a) Transportation



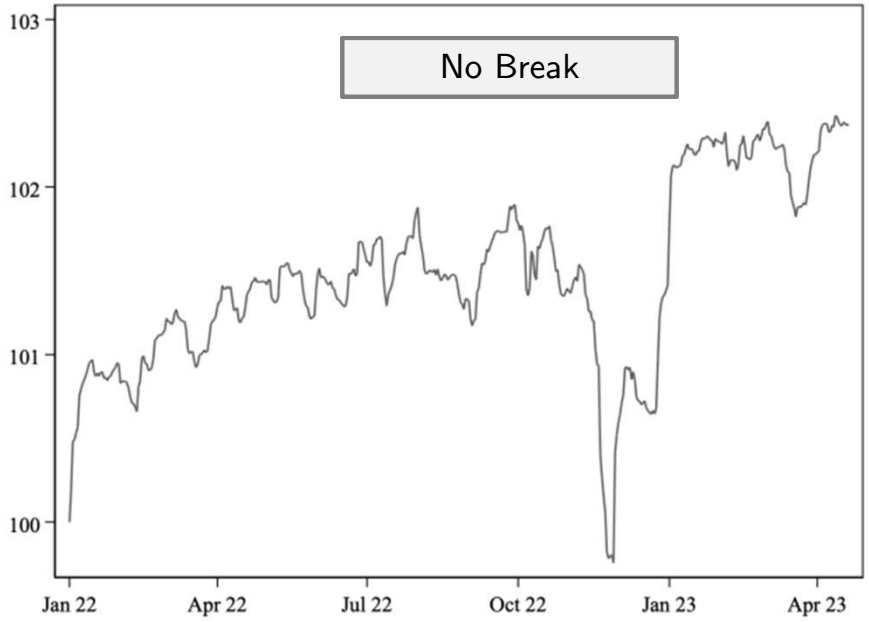
(b) Food and Beverages

Source: Cavallo & Garcia Zavaleta (2023) "Detecting Structural Breaks in Inflation Trends: A High Frequency Approach"

US: Core Goods with mixed breaks



(c) Household and Furnishings

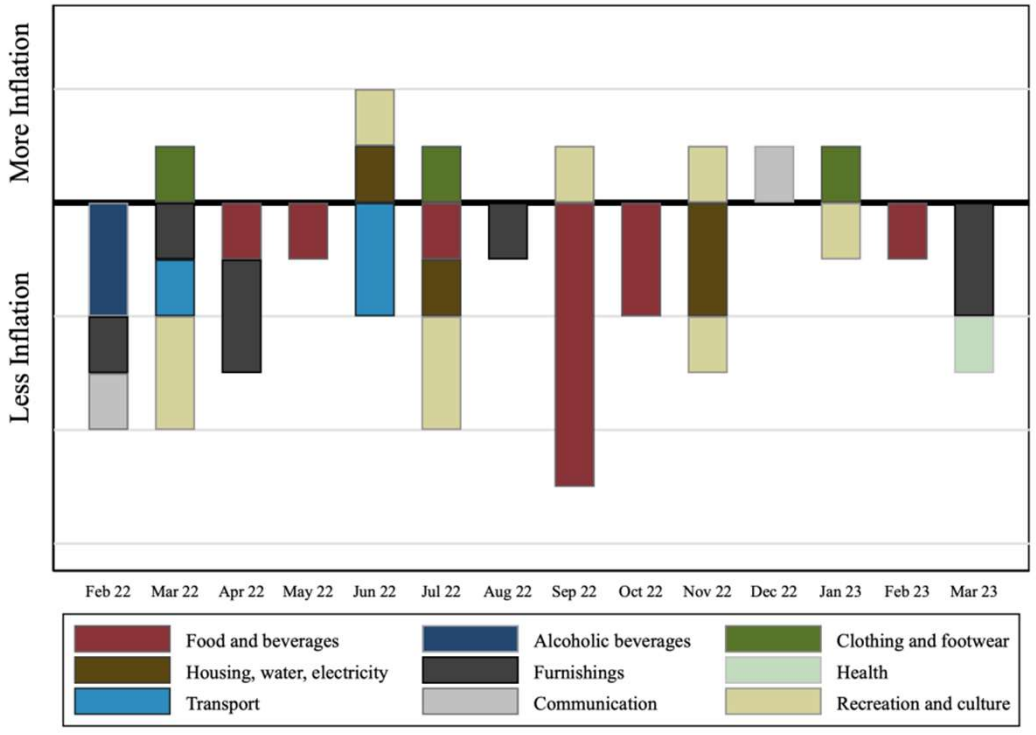


(d) Electronics

Figure 3: Estimated Structural Trend Breaks in US Sectors

Source: Cavallo & Garcia Zavaleta (2023) "Detecting Structural Breaks in Inflation Trends: A High Frequency Approach"

US: Timing of Breaks by Sector (3-digit COICOP, 55 sectors)

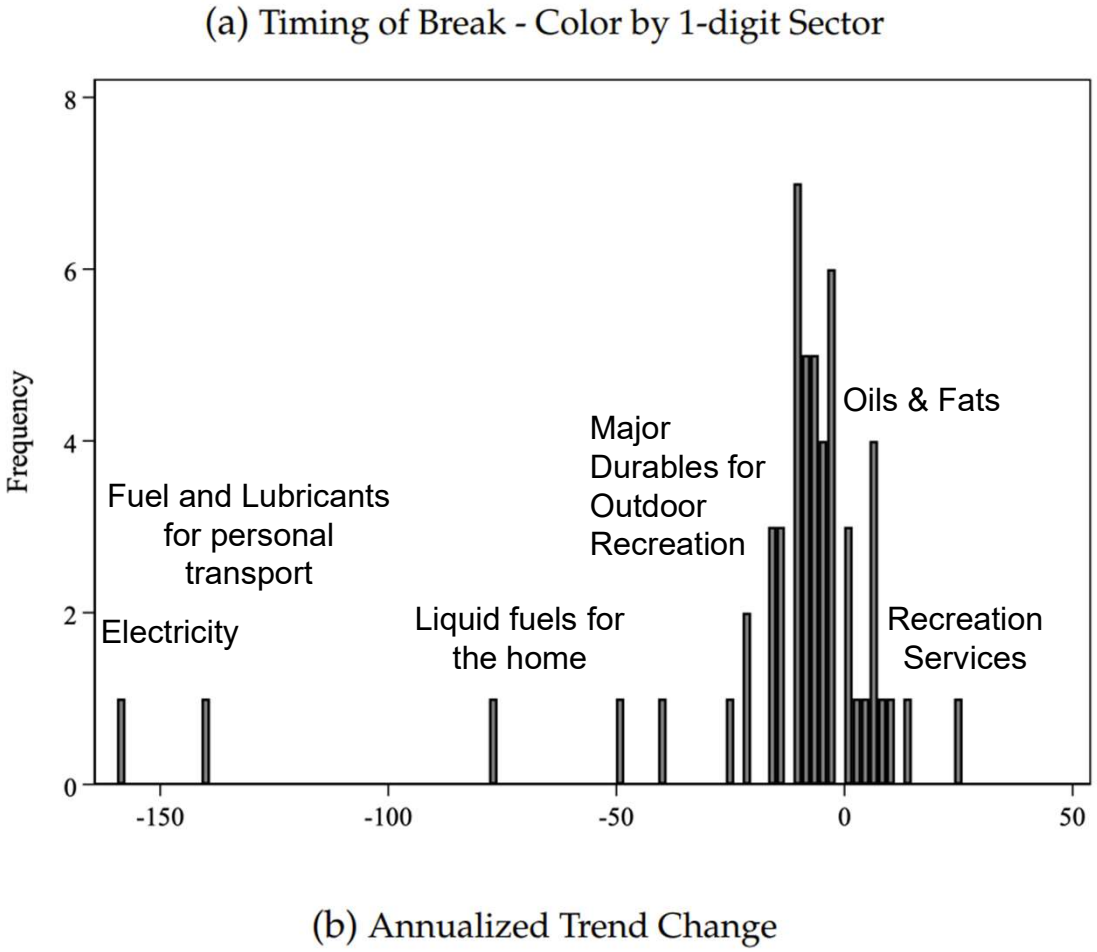


(a) Timing of Break - Color by 1-digit Sector

- Most sectors had negative breaks since Jan 22
- Transport (fuel) in March and June
- Food mostly in September

Source: Cavallo & Garcia Zavaleta (2023) "Detecting Structural Breaks in Inflation Trends: A High Frequency Approach"

US: Magnitude of Trend Change (3-digit COICOP, 55 Sectors)



Energy sectors are clear outliers

→ Timing + magnitude can explain the trend break in the aggregate index in June.

Is this a broad-based inflection point for the trend?

Source: Cavallo & Garcia Zavaleta (2023) "Detecting Structural Breaks in Inflation Trends: A High Frequency Approach"

Cumulative share of negative breaks rose to 67% of all CPI weights

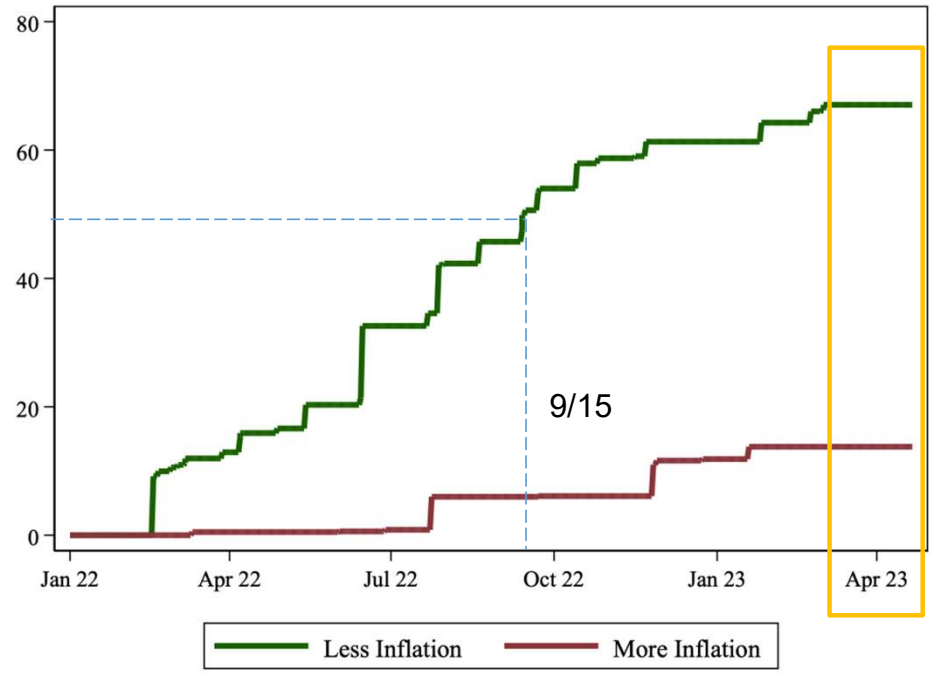


Figure 5: Share (%) of US CPI weights with structural breaks

We add weights for the sectors that have a negative, positive, or no break since January 2022.

On September 15th, 2022 → more than 50% of weights had experienced a negative break (less inflation)

As of 4/20/2023:
67% break with less inflation
15% break with more inflation
14% no trend break

Note: Percent of Expenditure Weights computed from the subset of official CPI weights covered by PriceStats data

Source: Cavallo & Garcia Zavaleta (2023) "Detecting Structural Breaks in Inflation Trends: A High Frequency Approach"

Positive breaks are concentrated in Recreation and Clothing

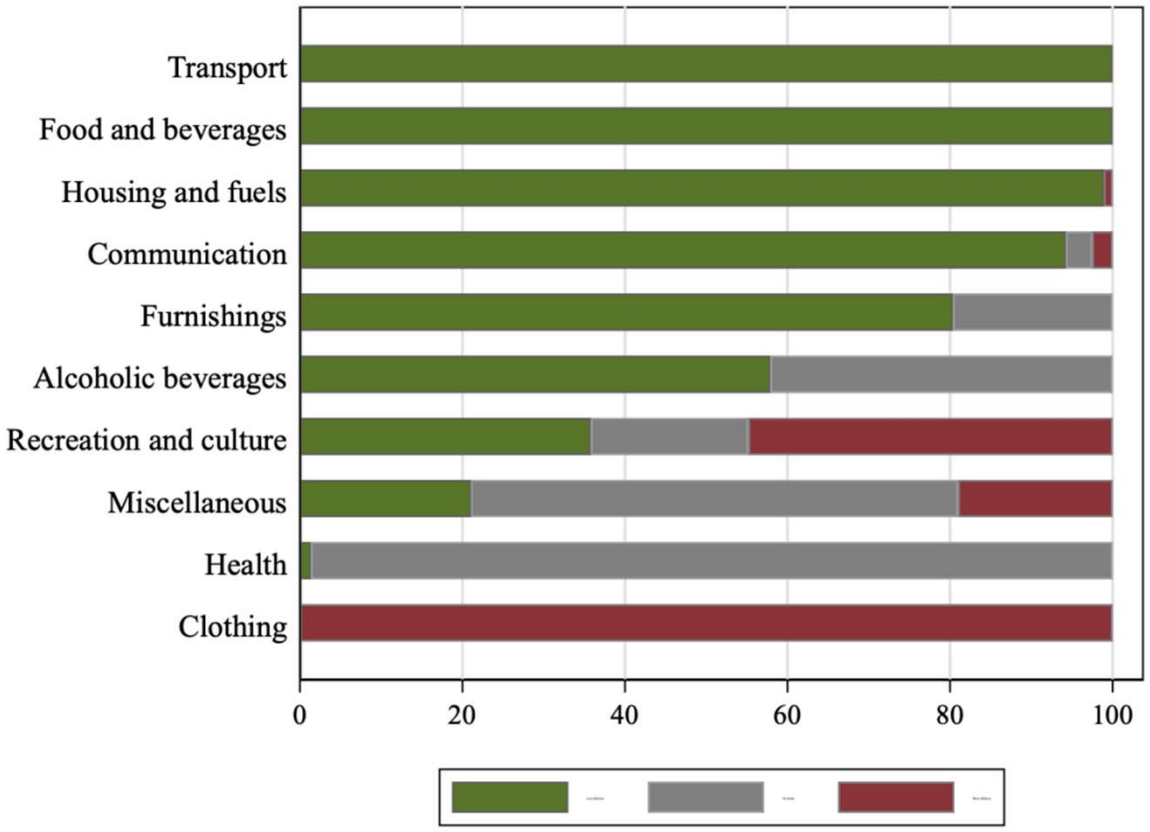
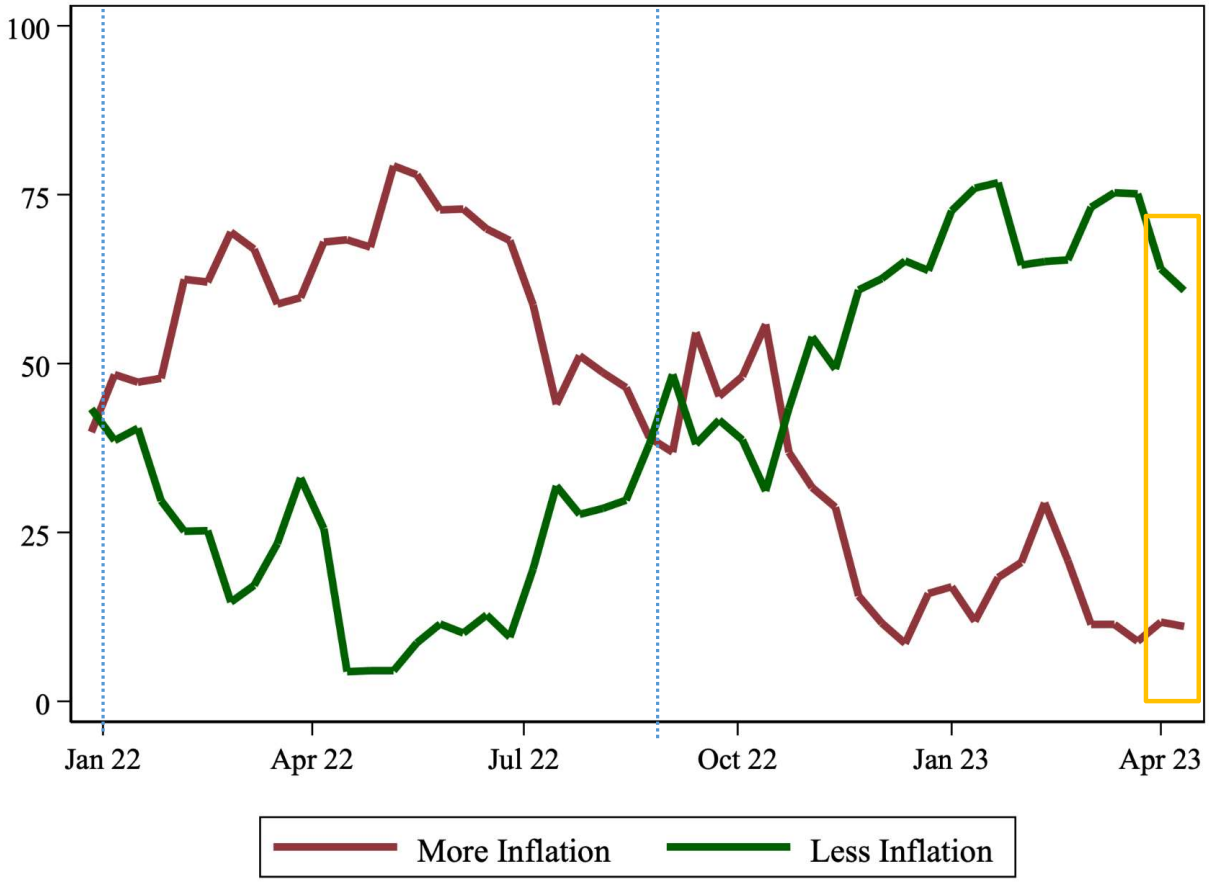


Figure 6: Share (%) of US CPI weights with Breaks by April 2023

Source: Cavallo & Garcia Zavaleta (2023) "Detecting Structural Breaks in Inflation Trends: A High Frequency Approach"

Share of Weights in 12-month Rolling Windows



This suggests 2 inflection points:

- January 2022 → more inflation
- September 2022 → less inflation

On 4/20/2023:

61 % break with less inflation

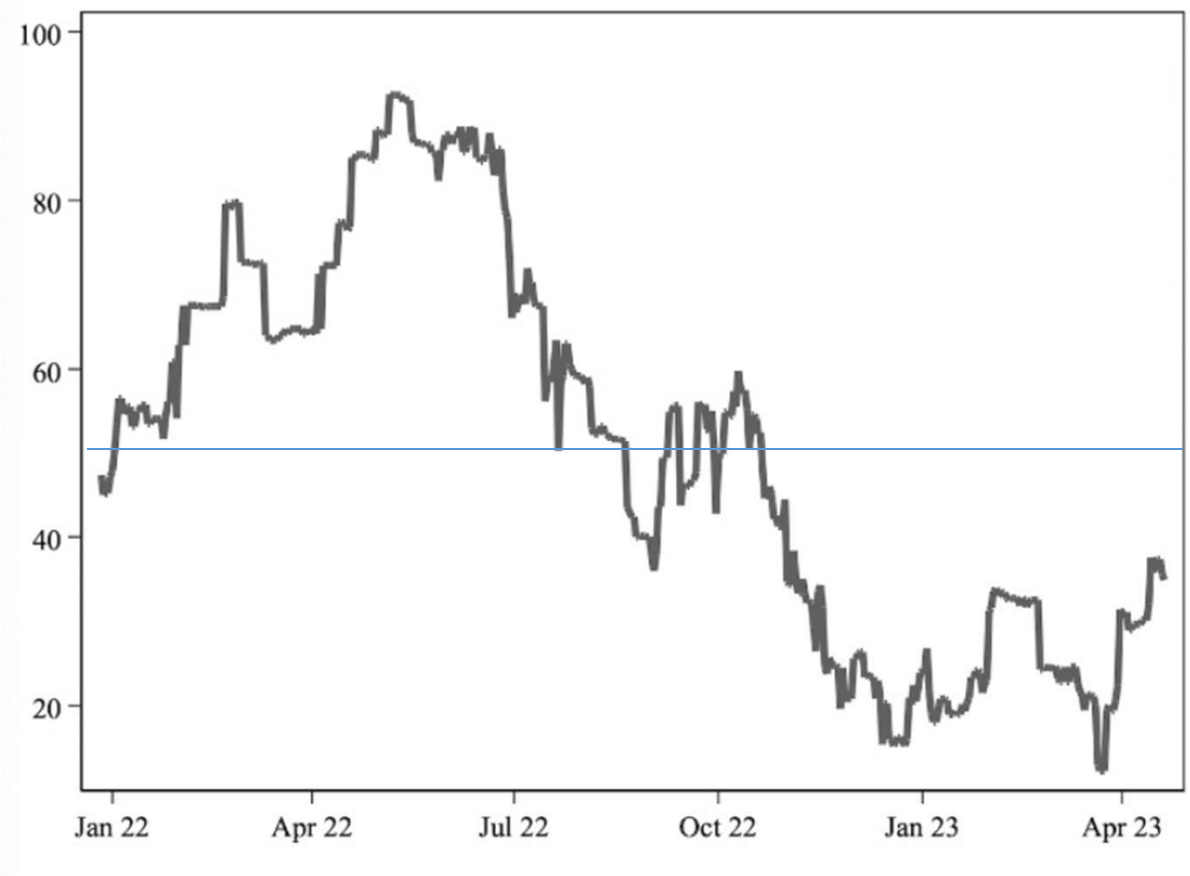
11% break with more inflation

26 % no trend break

Source: Cavallo & Garcia Zavaleta (2023) "Detecting Structural Breaks in Inflation Trends: A High Frequency Approach"

Diffusion Index

Negative Break = 0, No Break = 50, Positive Break = 100 → Take weighted mean.



-Incorporates the information from the "no break" sectors.

Same inflection points:

- January 2022 → more inflation
- September 2022 → less inflation

Source: Cavallo & Garcia Zavaleta (2023) "Detecting Structural Breaks in Inflation Trends: A High Frequency Approach"

We repeat the analysis using daily price indices in 25 countries

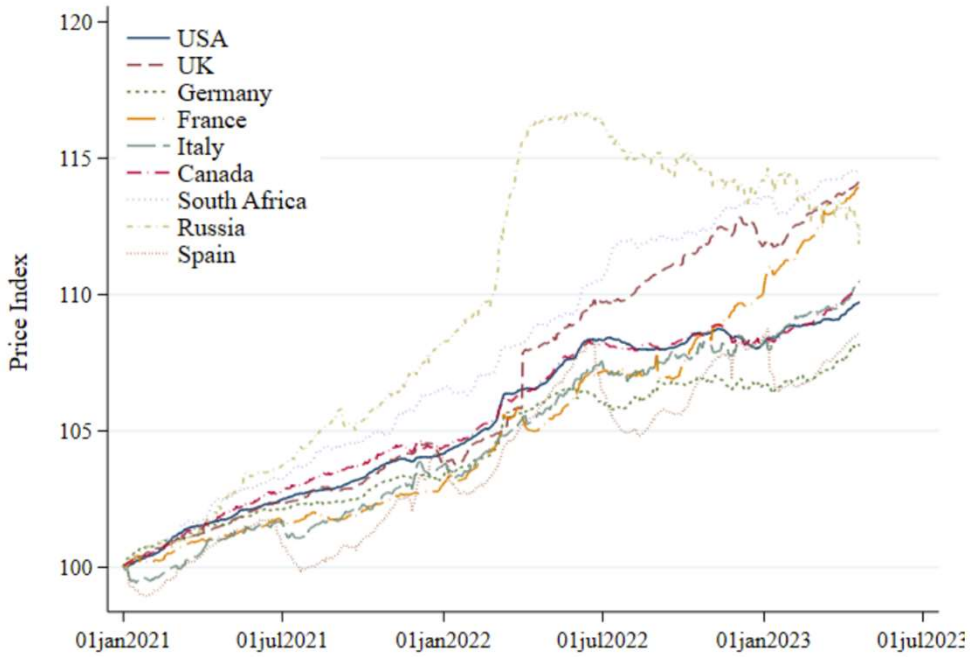


Figure 7: Aggregate Daily Price Indices - Selected Countries

- Russian prices rose in early 2022 with war, then started to fall
- European indices had a similar patterns in 2021, but diverge after mid-2022
- UK has a level breaks (energy price caps), but not clear if trend changes

Source: PriceStats, State Street Global Markets

Share of Weights with Trend Breaks in last 12 months, April 2023

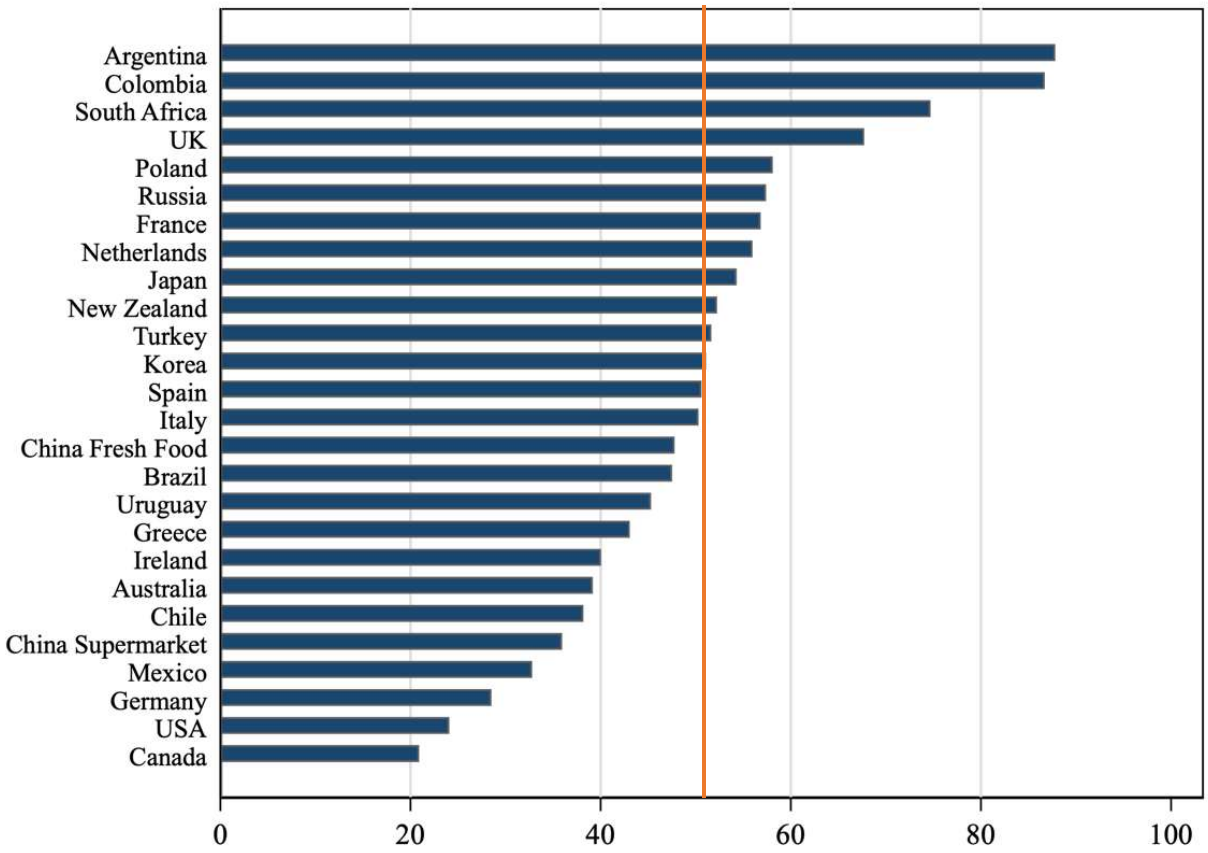
	Negative Break (Less inflation)	No break	Positive Break (More inflation)
Colombia	3	5	84
Argentina	9	0	88
South Africa	22	5	72
UK	20	16	60
China Fresh Food	23	0	48
France	29	14	50
Japan	17	33	38
Poland	31	17	50
Russia	43	0	57
Netherlands	39	8	52
Turkey	43	0	52
New Zealand	40	14	45
Spain	39	16	43
Korea	40	14	44
Italy	46	8	46
Greece	36	14	36
China Supermarket	36	0	36
Brazil	37	24	35
Australia	35	21	29
Uruguay	40	28	31
Ireland	50	5	37
Chile	44	23	27
Mexico	56	13	26
Germany	56	14	21
USA	61	26	11
Canada	65	15	13

Table 1: Share (%) of CPI Weights with Structural Breaks, April 2023

Note: Percent of Expenditure Weights computed from the subset of official CPI weights covered by PriceStats data

- We estimated the trend breaks for 1313 subsectors, added weights for those with negative, positive, or no breaks
- 14 countries have more positive than negative breaks→ more inflation
- Argentina and Colombia are at the top (over 80% of weights with positive breaks)
- US & Canada are at the bottom (over 60% of weights with negative breaks) → less inflation
- Divergence in Europe
  - UK, France, Poland→ more inflation
  - Germany, Ireland → less inflation

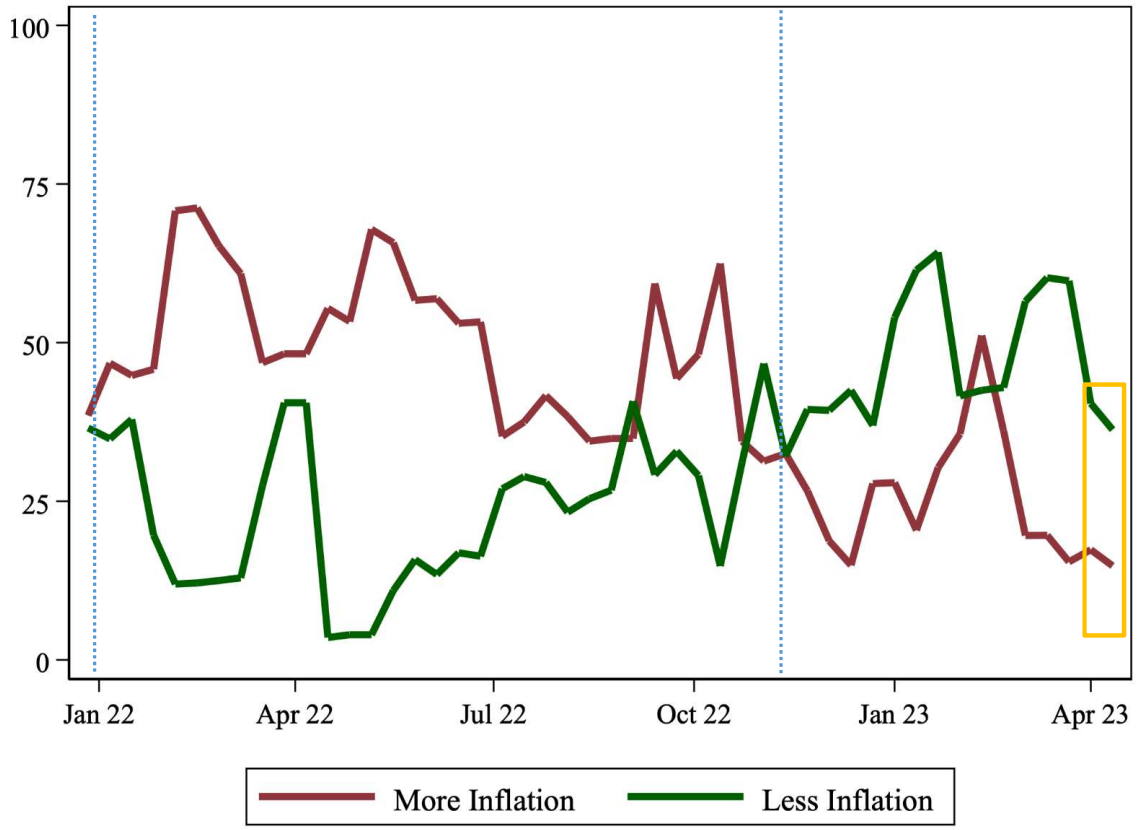
Break Diffusion Index, April 2023



- Similar results
- China improves → zero weights with no breaks (less uncertainty)

Source: Cavallo & Garcia Zavaleta (2023) "Detecting Structural Breaks in Inflation Trends: A High Frequency Approach"

Core Sectors (excluding Food and Energy)



2 inflection points:

- January 2022 → more inflation
- November 2022 → less inflation

On 4/20/2023:

36 % break with less inflation

15% break with more inflation

45 % no trend break

Source: Cavallo & Garcia Zavaleta (2023) "Detecting Structural Breaks in Inflation Trends: A High Frequency Approach"

Core Sectors - April 2023

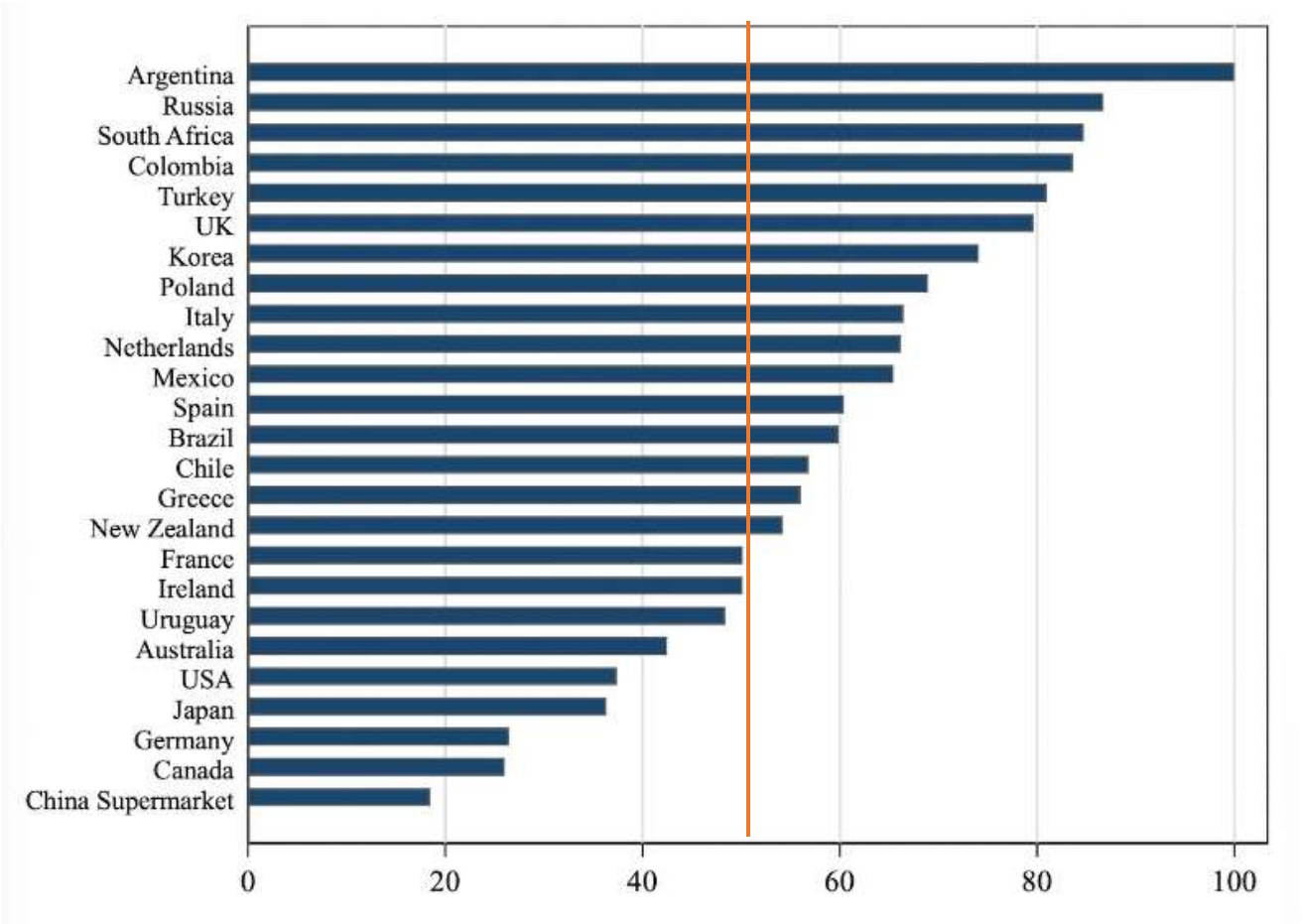
	Negative Break (Less inflation)	No break	Positive Break (More inflation)
Argentina	0	0	100
Colombia	3	5	81
Russia	13	0	87
South Africa	10	5	82
Turkey	17	0	81
UK	9	19	70
Korea	17	12	68
Mexico	19	3	64
Poland	21	19	59
Netherlands	27	11	61
Greece	12	21	46
Italy	30	8	63
Brazil	19	38	41
Spain	29	20	50
Chile	23	31	41
Ireland	33	9	46
France	32	11	45
New Zealand	41	10	49
China Supermarket	13	0	18
Australia	26	22	31
Uruguay	50	1	48
Japan	28	26	23
USA	36	45	15
Germany	52	15	19
Canada	63	8	22

Table 2: Share (%) of CORE CPI Weights with Structural Breaks, April 2023

Source: Cavallo & Garcia Zavaleta (2023) "Detecting Structural Breaks in Inflation Trends: A High Frequency Approach"

- Only 5 countries have more negative breaks than positives → inflation slowing down
- US, Canada, and Germany are still at the bottom
  →US more uncertainty, with 45% of core weights with no breaks
- Still a divergence in European countries
  - Not about fuel or food…

Core Break Diffusion Index - April 2023

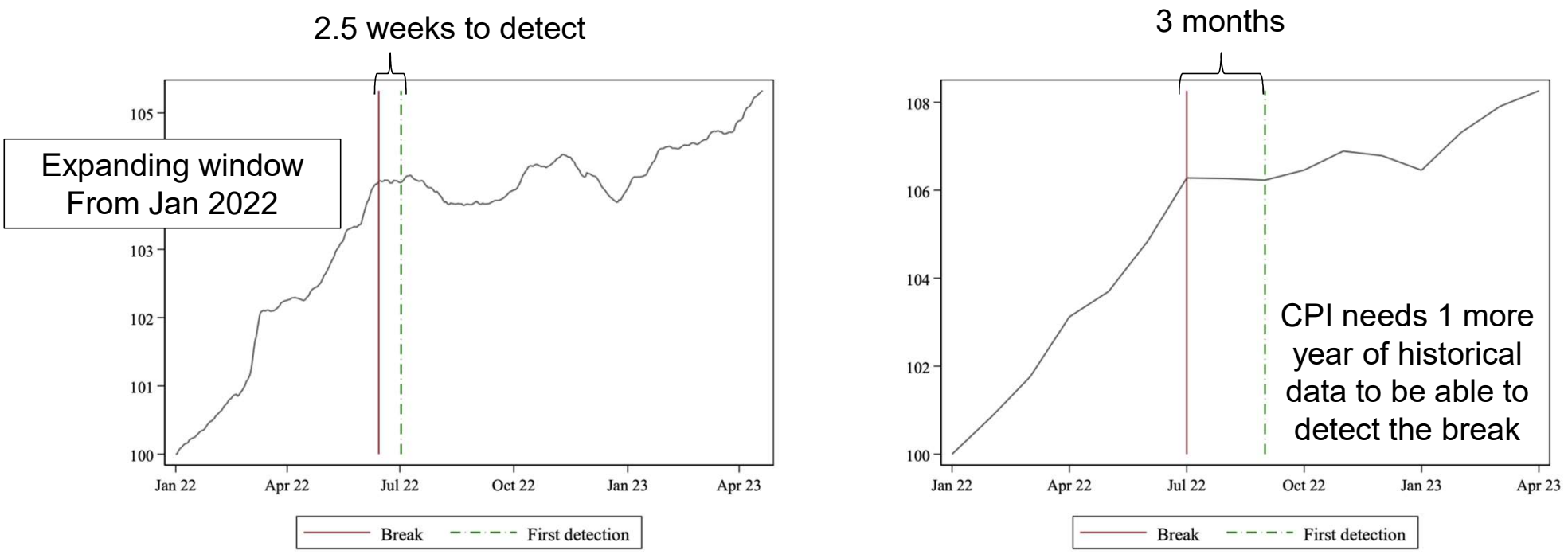


Compared to headline:

- Mexico, Turkey, Korea → worse
- France , China → better

Source: Cavallo & Garcia Zavaleta (2023) "Detecting Structural Breaks in Inflation Trends: A High Frequency Approach"

Why do we need high-frequency data? Speed and Sensitivity



(a) Daily data - PS Index

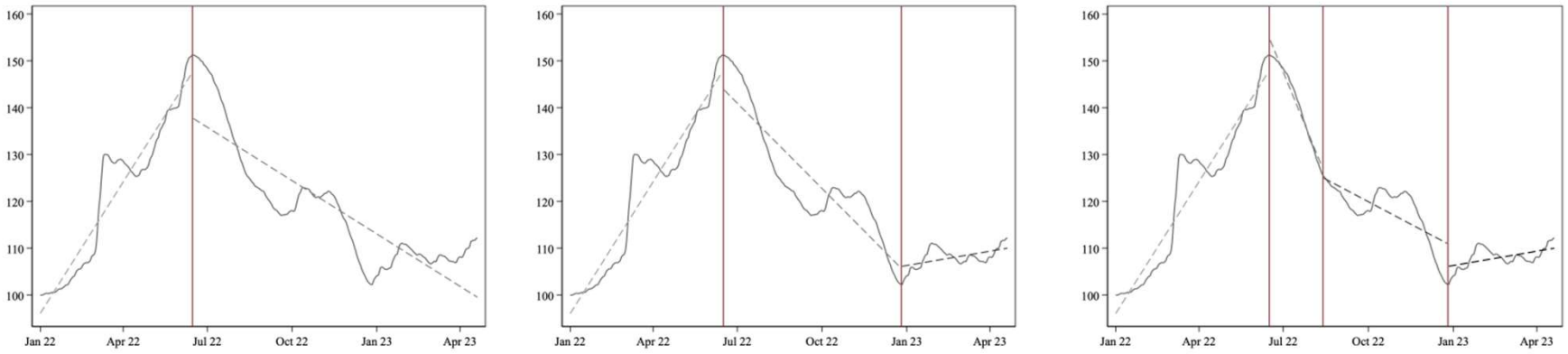
(b) Monthly data - CPI

Figure 8: Detection speed - Daily Data vs CPI

Source: Cavallo & Garcia Zavaleta (2023) "Detecting Structural Breaks in Inflation Trends: A High Frequency Approach"

Multiple-Breaks tests can be useful for some series (e.g. fuel)

- We extend the test sequentially to allow for up to 3 breaks :
    1. Test model for single break (largest reduction SSRs) vs model with no break.
    2. If significant, test model for 2 breaks (largest and second largest reduction in SSRs) vs 1 break.
    3. If significant, test model for 3 breaks vs 2 breaks.



(a) Up to 1 break (b) Up to 2 breaks (c) Up to 3 breaks

Figure A3: Multiple Break Tests - US Fuel Index

But only 13.2% of subsectors have more than 1 break

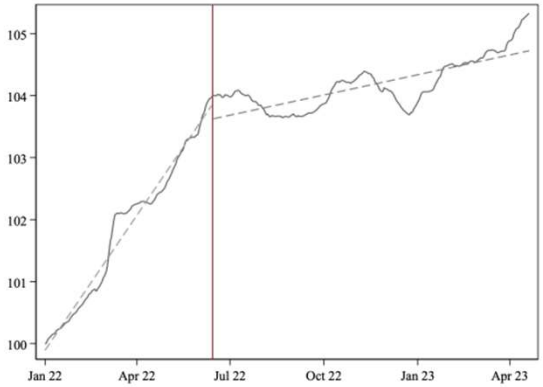
	No breaks	One break	Two breaks	Three breaks
Food and beverages	36 (12.6%)	207 (72.4%)	24 (8.4%)	19 (6.6%)
Alcoholic beverages	27 (30.7%)	46 (52.3%)	5 (5.7%)	10 (11.4%)
Clothing and footwear	11 (14.1%)	52 (66.7%)	6 (7.7%)	9 (11.5%)
Water, electricity, other fuels	19 (21.3%)	60 (67.4%)	3 (3.4%)	7 (7.9%)
Household and Furnishings	56 (25.5%)	148 (67.3%)	9 (4.1%)	7 (3.2%)
Health	20 (36.4%)	32 (58.2%)	2 (3.6%)	1 (1.8%)
Transport	15 (18.1%)	46 (55.4%)	11 (13.3%)	11 (13.3%)
Communication	9 (27.3%)	21 (63.6%)	0 (0%)	3 (9.1%)
Recreation and culture	88 (29.6%)	172 (57.9%)	20 (6.7%)	17 (5.7%)
Restaurants and hotels	3 (25%)	4 (33.3%)	0 (0%)	5 (41.7%)
Miscellaneous	25 (31.6%)	49 (62%)	4 (5.1%)	1 (1.3%)
All sectors	309 (23.4%)	837 (63.4%)	84 (6.4%)	90 (6.8%)

Table 3: Number of 3-Digit Sectors with Multiple-Breaks

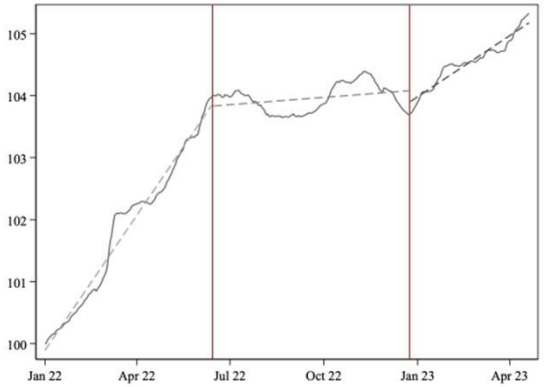
→ Additional breaks concentrated in food, transportation (fuel), and recreation (electronics)
→ Country shares and diffusion rankings do not change with multiple-breaks

Source: Cavallo & Garcia Zavaleta (2023) "Detecting Structural Breaks in Inflation Trends: A High Frequency Approach"

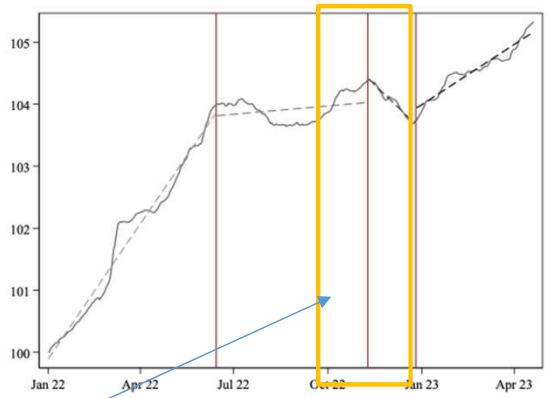
We can detect more breaks in the US aggregate series



(a) Up to 1 break



(b) Up to 2 breaks



(c) Up to 3 breaks

- But these additional breaks are
  - Less relevant and short-lived
  - Disappear when we expand the window of analysis

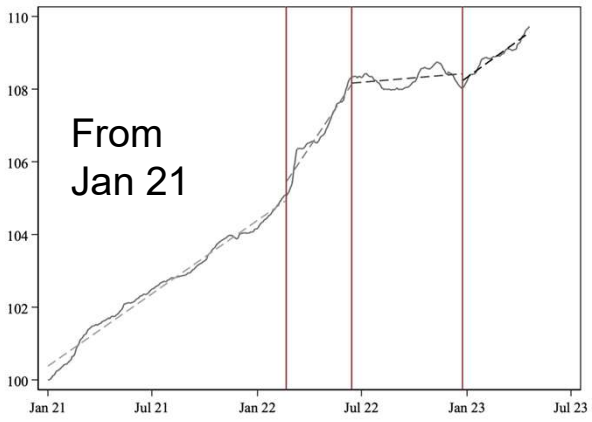


Figure A4: Multiple Break Tests - US Aggregate Index from January 2021

Source: Cavallo & Garcia Zavaleta (2023) "Detecting Structural Breaks in Inflation Trends: A High Frequency Approach"

Breaks vs Inflection Points (US results)

3 Structural Breaks in Aggregate Series

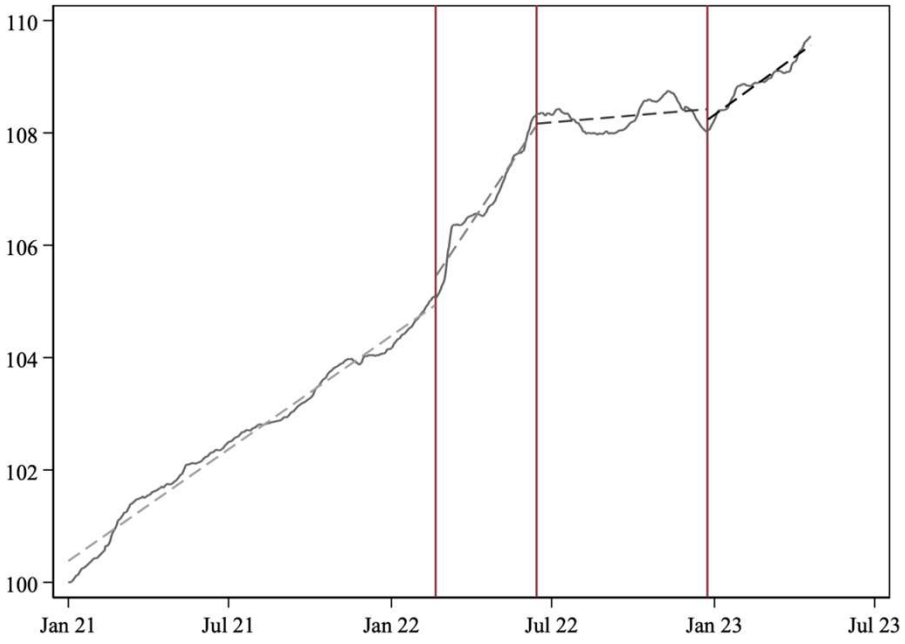
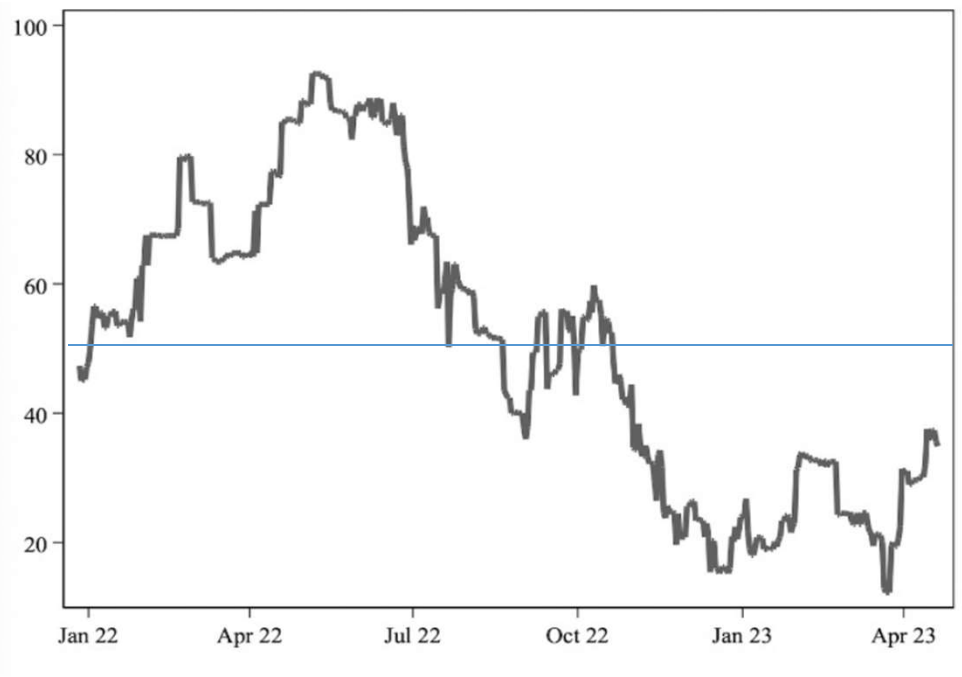


Figure A4: Multiple Break Tests - US Aggregate Index from January 2021

2 Inflection Points in Disaggregated Sectors



US Break Diffusion Index (weighted)

Source: Cavallo & Garcia Zavaleta (2023) "Detecting Structural Breaks in Inflation Trends: A High Frequency Approach"

Take-Aways

- High-frequency inflation data helps detect structural breaks in inflation trends within weeks
  - Single-break tests on 12-months rolling windows appear to be the most effective approach
  - Advantage over monthly CPI data is detection both sensitivity and speed
  - Disaggregated sectors are helpful to identify broad-based inflection points
- Latest data suggests:
  - US is past the peak of inflation in both headline and core
    - Inflection points: September ‘22 (headline) and November ‘22 (core)
  - Most countries are still experiencing higher inflation trends (particularly in core)
  - Divergence in Europe
    - Less inflation: Germany, Ireland
    - More Inflation: UK, France, Poland