

Inflation Forecasting From Cross-Sectional Stocks

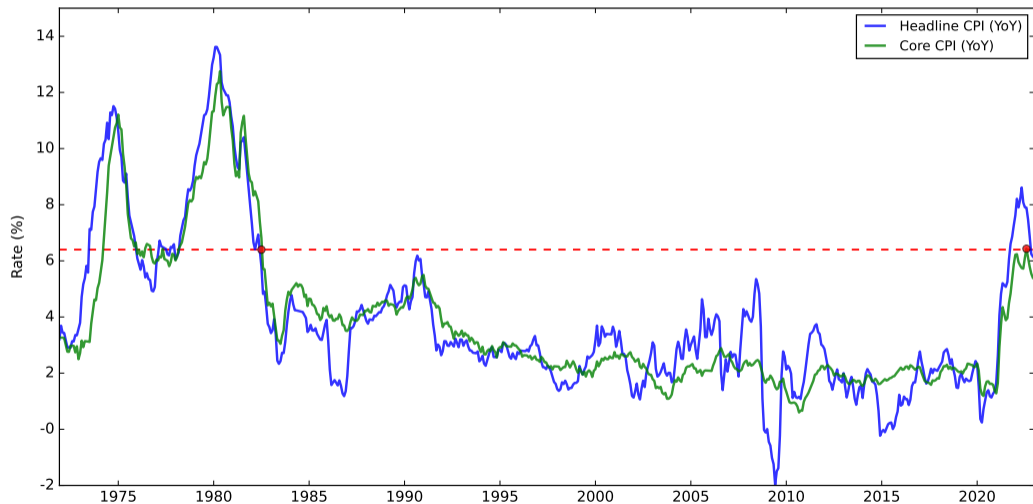
Jun Pan

**Shanghai Advanced Institute of Finance (SAIF)
Shanghai Jiao Tong University**

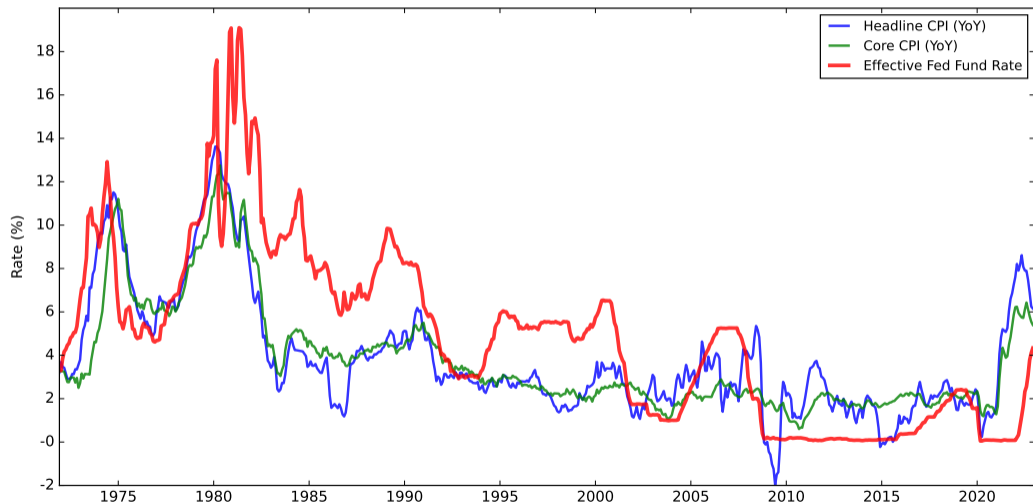
NBER Summer Institute, July 13, 2023

Joint work with Claire Yurong Hong and Shiwen Tian from SJTU

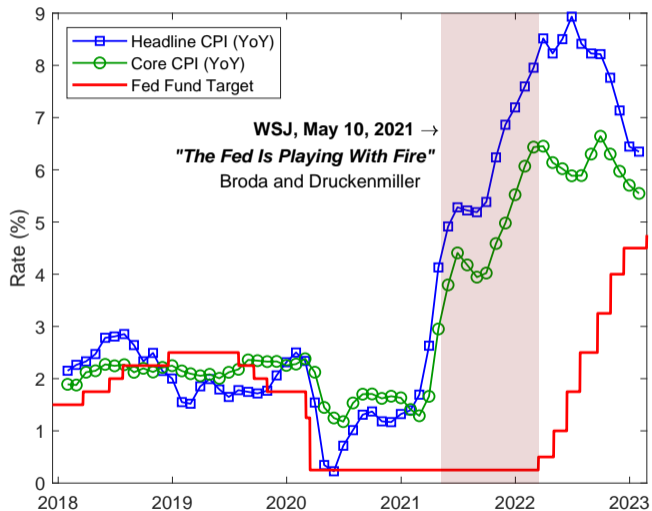
Motivation: The Post-Covid Inflation Surge



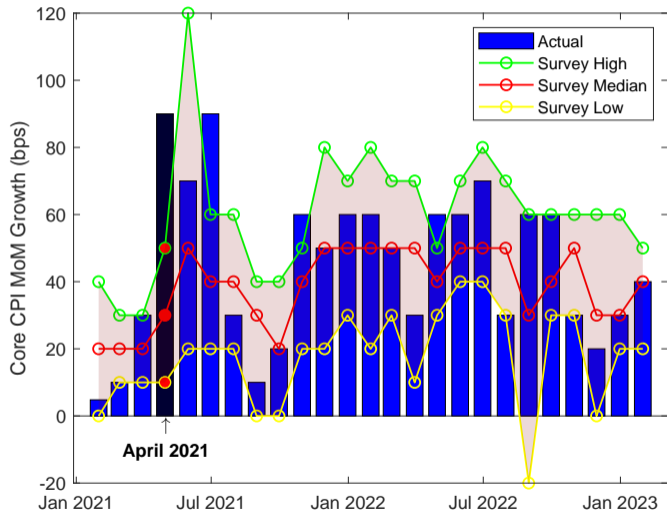
Policy Makers: Behind the Curve



Policy Makers: Behind the Curve



Economists' Forecasts: Missed the Initial Surge by a Wide Margin



Inflation Forecasting Using Information From Financial Markets

- **Treasury Bonds:**

- ▶ UST: Heavily influenced by expectations of monetary policy.
 - ★ Amid heightened inflation, Treasury yields might decrease, not due to reduced inflation risk, but fight-to-safety or Fed's pivot from tightening.
 - ★ Government interventions in the Treasury market (e.g., QE) distort bond pricing, masking the inflation expectations.
- ▶ TIPS: Illiquidity adds noise to the breakeven inflation forecasts.

- **Commodities:** Headline vs Core.

- **Aggregate Stock:**

- ▶ Also influenced by expectations of monetary policy.
- ▶ Not a good hedge for inflation (Fama and Schwert (1977)).

Inflation Forecasting From Cross-Sectional Stocks

- **The Cross-Sectional Approach:**

- ▶ Each inflation episode might be driven by different economic fundamentals.
- ▶ Use the market pricing to identify stocks the high- and low-inflation exposures.
- ▶ Focus on the relative pricing between stocks with high- and low-inflation beta.

- **Roll (1984):**

- ▶ The market price of frozen concentrated orange juice is affected by the weather.
- ▶ Financial markets (orange-juice futures) process this information and price it in.
- ▶ A statistically significant relation between OJ futures price changes and subsequent errors in temperature forecasts for Orlando, Florida.

- **The Informational Channel:**

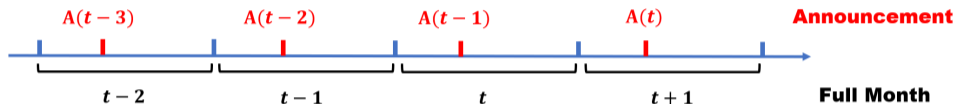
- ▶ Stock-level inflation exposures are persistent over time and vary across firms.
- ▶ Active price discovery for future inflation takes place in the equity market.
- ▶ Zero in on the inflation expectations embedded in the relative pricing.

Main Findings and Related Literature, Part 1

- Construct the headline- and core-focused inflation betas to differentiate stocks with *persistently* high- and low-inflation exposures to headline and core CPI innovations.
 - ▶ Components of the headline CPI (e.g., energy and food) observed and priced continuously and contemporaneously throughout the CPI month.
 - ▶ Information release of the core CPI (e.g., goods and services) concentrated at the CPI announcements.
 - ▶ Stock returns exhibit persistent sensitivity to headline-CPI shocks during the calendar month of CPI, and to core-CPI news on CPI announcement days.
- Related literature:
 - ▶ Cross-sectional pricing of inflation risk: [Chen, Roll, and Ross \(1986\)](#), [Boons et al. \(2020\)](#).
 - ▶ Asset-pricing impact of core vs. headline inflation: [Ajello, Benzoni, and Chyruk \(2020\)](#), [Fang, Liu, and Roussanov \(2021\)](#).

Headline- and Core-Focused Inflation Betas

- Price discovery with respect to inflation takes place
 - ▶ Through the inflation experiences: during the contemporaneous CPI month.
 - ▶ Via the informational shocks: at the CPI announcements.



- Two approaches to capture the sensitivity of stock returns to inflation innovations

$$R_t^i - r^f = \alpha + \beta_i \text{Innov}_t + \beta_i^M (R_t^M - r_f) + \varepsilon_t^i$$

- ▶ β^{Full} month- t returns on month- t CPI innovations.
- ▶ β^{Ann} announcement-day returns on announcement-day CPI innovations.
- ▶ Innov_t estimated using ARMA(1,1), following Fama and Gibbons (1984).
- Apply the full-month approach to headline CPI to get β^{FullHead} , and the announcement-day approach to core CPI to get β^{AnnCore} .

Inflation Beta Across Asset Classes

Full-Month Inflation Exposure							
	VWRETD	TMB	Δ UST10YR	TIPS	-UST	TIPS-UST	GSCI
Headline-CPI (FullHead)	-0.058 (-0.96)	0.129** (2.05)	0.198*** (4.03)	0.046 (0.50)	0.264*** (3.49)	0.339*** (3.08)	0.216*** (4.06)
Core-CPI (FullCore)	-0.103** (-2.38)	0.021 (0.40)	0.105* (1.69)	0.024 (0.35)	0.047 (0.82)	0.081 (1.09)	0.040 (0.86)
Announcement-Day Inflation Exposure							
Headline-CPI (AnnHead)	0.004 (0.05)	-0.034 (-0.32)	0.067 (1.15)	0.093 (0.80)	0.115 (1.33)	0.249** (2.43)	0.000 (-0.00)
Core-CPI (AnnCore)	-0.116*** (-2.79)	0.100** (2.46)	0.114** (2.14)	0.066 (1.33)	0.135** (2.44)	0.234*** (4.23)	0.072** (2.24)

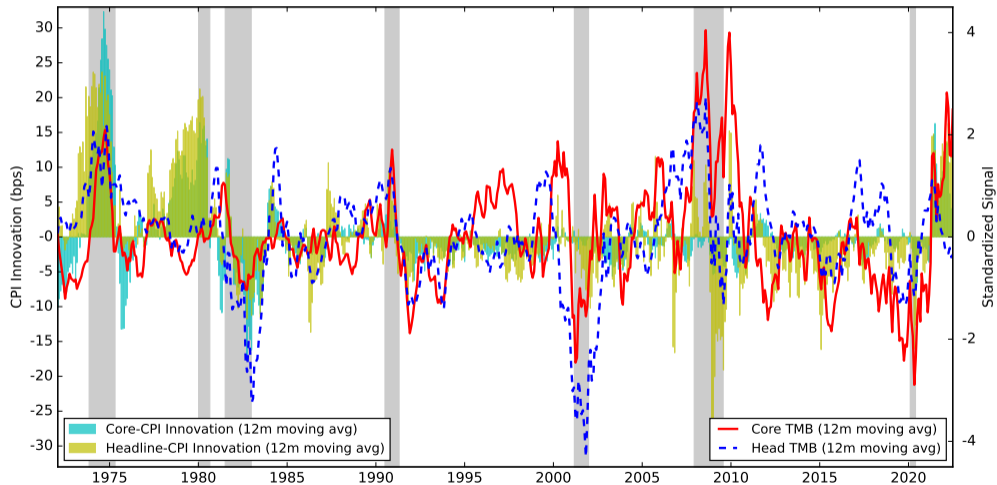
Post-Ranking Inflation Beta

		Sorted by Full-Month CPI Beta					
		Quintile1	Quintile2	Quintile3	Quintile4	Quintile5	Quintile 5-1
Headline-CPI	β	-3.51	-7.10	-3.97	1.46	39.07***	42.58***
(FullHead)	<i>t</i> -stat	(-0.30)	(-0.83)	(-0.50)	(0.16)	(2.64)	(3.09)
Core-CPI	β	-14.65	-11.01	-18.77**	-12.80	-7.58	7.06
(FullCore)	<i>t</i> -stat	(-1.10)	(-1.23)	(-2.39)	(-1.56)	(-0.66)	(0.63)
		Sorted by Announcement-Day CPI Beta					
		Quintile1	Quintile2	Quintile3	Quintile4	Quintile5	Quintile 5-1
Headline-CPI	β	0.16	2.64	2.00	3.26	2.54	2.38
(AnnHead)	<i>t</i> -stat	(0.08)	(1.35)	(0.94)	(1.37)	(0.89)	(0.98)
Core-CPI	β	-2.31	1.04	1.52	1.79	2.41	4.72***
(AnnCore)	<i>t</i> -stat	(-1.20)	(0.58)	(0.81)	(0.89)	(1.04)	(2.76)

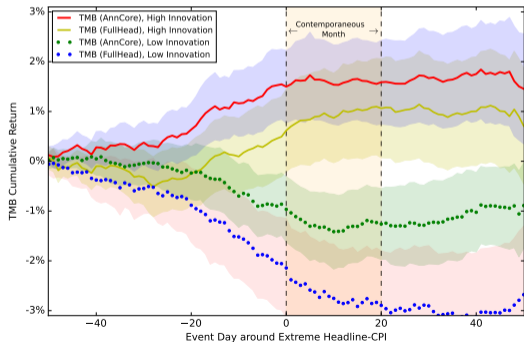
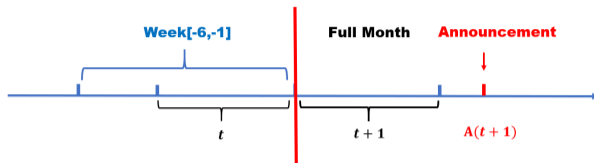
Main Findings and Related Literature, Part 2

- Inflation forecasting using the relative pricing between stocks with top and bottom inflation betas (TMB).
 - ▶ The core-focused TMB: a unique predictor for core CPI.
 - ▶ During the inflation surge of 2021 and 1973, its predictive R-squared for month-over-month core CPI innovations increases to 31.5% and 29%.
 - ▶ Stronger inflation predictability under Fed's QE and when the Fed is behind-the-curve in fighting inflation.
- The predictive information not incorporated by economists' forecasts. The core-focused TMB can forecast the economists' forecasting errors.
- Related literature:
 - ▶ Ang, Bekaert, and Wei (2007), Frost and Wright (2013).
 - ▶ Downing, Longstaff, and Rierson (2012).

The Core- and Headline-Focused TMB Portfolios



The Timeline of Inflation Forecasting



Predicting Month $t + 1$ Headline-CPI Innovation

	Week-8	Week-7	Week-6	Week-5	Week-4	Week-3	Week-2	Week-1
Core TMB	1.431 (0.97)	-1.268 (-0.72)	3.004** (2.06)	2.788 (1.55)	6.943*** (4.98)	2.188 (1.44)	3.091 (1.61)	0.598 (0.24)
Observations	606	606	606	606	606	606	606	606
R-squared	0.3%	0.2%	1.3%	1.2%	7.1%	0.7%	1.4%	0.1%
Head TMB	1.600 (1.35)	0.282 (0.18)	0.341 (0.27)	3.826* (1.69)	7.187*** (4.03)	0.528 (0.24)	3.346** (2.30)	3.945*** (3.13)
Observations	606	606	606	606	606	606	606	606
R-squared	0.4%	0.0%	0.0%	2.2%	7.6%	0.0%	1.7%	2.3%

Predicting the Headline-CPI Innovations

Predicting Month $t + 1$ Headline-CPI Innovation

Core TMB _{<i>t</i>}	8.286*** (6.62)		6.372*** (5.45)		3.737*** (3.07)		7.109*** (4.35)	4.592** (2.38)
Head TMB _{<i>t</i>}		7.618*** (5.54)	5.330*** (4.09)		2.978** (2.41)		5.358*** (3.40)	3.012* (1.87)
GSCI _{<i>t</i>}				13.111*** (8.32)	11.045*** (6.76)			12.730*** (5.35)
TIPS _{<i>t</i>} -UST _{<i>t</i>}						11.724*** (4.04)	8.417*** (3.12)	3.837 (1.41)
Observations	606	606	606	606	606	289	289	289
R-squared	10.2%	8.6%	13.8%	25.5%	29.4%	16.2%	27.8%	41.1%

- Core and Head TMB: the six-week TMB return observed by the end of month t .
- GSCI: the month- t return of Goldman Sachs Commodity Index.
- TIPS-UST: difference in month- t returns between TIPS and UST.

Predicting the Core-CPI Innovations

Predicting Month $t + 1$ Core-CPI Innovation								
Core TMB	2.459*** (3.31)		1.946** (2.47)		1.684** (2.14)		2.809** (2.59)	2.708** (2.42)
Head TMB		2.127*** (3.09)	1.428** (1.98)		1.193 (1.64)		0.206 (0.26)	0.112 (0.14)
GSCI				1.987*** (2.61)	1.10 (1.48)			0.512 (0.60)
TIPS-UST						1.869** (2.10)	1.096 (1.46)	0.912 (1.26)
Observations	606	606	606	606	606	289	289	289
R-squared	2.5%	1.8%	3.2%	1.6%	3.6%	2.9%	9.2%	9.4%

- Core and Head TMB: the six-week TMB return observed by the end of month t .
- GSCI: the month- t return of Goldman Sachs Commodity Index.
- TIPS-UST: difference in month- t returns between TIPS and UST.

Out-of-Sample Forecasting Power

- At each month t , we estimate the forecasting model, $CPIG_{k+1} = a + \sum b * X_k + \epsilon_k$
- Use the estimated coefficients to forecast month- $t + 1$ inflation growth
- Forecasting error = actual value - forecast value

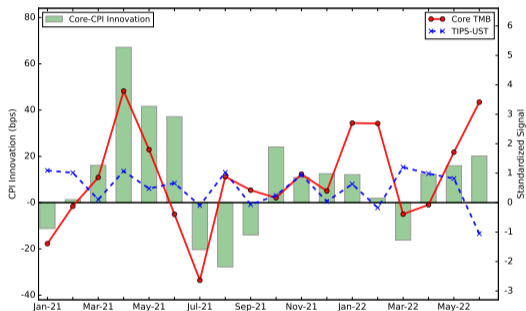
Model	Headline-CPI		Core-CPI	
	RMSE	Relative RMSE	RMSE	Relative RMSE
Benchmark: ARMA(1,1)	0.307%	100.0%	0.113%	100.0%
Core TMB	0.280%	91.4%	0.106%	93.8%
Head TMB	0.283%	92.3%	0.113%	100.0%
Core TMB + Head TMB	0.270%	88.0%	0.109%	95.7%
GSCI	0.254%	82.9%	0.111%	98.1%
TIP-UST	0.287%	93.6%	0.111%	98.1%
Survey	0.303%	98.9%	0.117%	103.2%
Real GDP Growth	0.325%	105.9%	0.139%	122.9%
VWRETD	0.293%	95.5%	0.116%	102.1%
Δ UST1YR	0.311%	101.4%	0.113%	99.7%
Δ UST10YR	0.309%	100.6%	0.112%	98.4%

Do Economists Update Inflation Expectations Using Equity Information?

- Change in Forecast: Bloomberg economists' forecast - ARMA(1,1) predicted value
- Forecasting Error: Actual month- $t + 1$ CPI growth - Bloomberg economists forecast

	Headline Inflation				Core Inflation			
	Change in Forecast		Forecasting Error		Change in Forecast		Forecasting Error	
Core TMB	7.935*** (4.34)	2.277 (1.14)	4.370*** (4.73)	2.814** (2.52)	1.066** (2.15)	0.450 (1.08)	2.754*** (3.65)	2.935*** (3.10)
Head TMB		2.854* (1.65)		1.331 (1.51)		0.641* (1.80)		-0.592 (-0.77)
GSCI		10.111*** (4.54)		3.134*** (3.49)		0.826* (1.77)		-0.180 (-0.23)
TIPS-UST		3.191 (1.42)		-0.500 (-0.52)		0.213 (0.58)		0.491 (0.72)
Constant	-1.881 (-1.33)	-1.881 (-1.52)	0.138 (0.19)	0.138 (0.20)	-0.252 (-0.84)	-0.254 (-0.86)	-0.280 (-0.45)	-0.278 (-0.45)
Observations	289	289	289	289	288	288	288	288
R-squared	9.8%	32.3%	11.2%	17.4%	4.2%	9.3%	6.5%	6.8%

The 2021 Inflation Surge

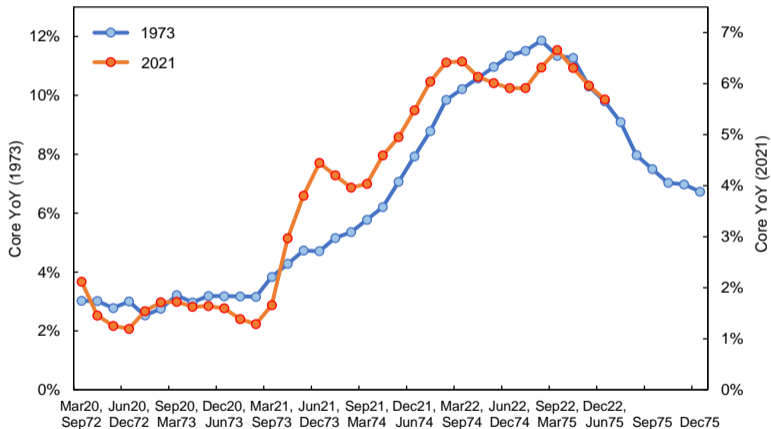


	Core Inflation Innovation				Forecast Error
Core TMB	10.466** (2.77)			10.863** (2.47)	8.307* (1.80)
Head TMB		7.348 (0.51)		2.452 (0.20)	-0.061 (-0.00)
GSCI			-2.609 (-0.39)	-3.149 (-0.55)	-5.807 (-1.07)
TIPS-UST				-0.208 (-0.02)	5.391 (0.66)
Constant	3.899 (0.84)	10.648* (1.94)	11.814 (1.37)	10.296* (1.93)	3.238 (0.53)
Observations	18	18	18	18	18
R-squared	31.5%	2.2%	0.8%	0.0%	34.3%

Out-of-Sample Relative RMSE

Core TMB	Head TMB	TIPS-UST	GSCI	Survey	VWRETD	Real GDP	Δ UST1YR	Δ UST1YR
85.7%	101.7%	102.4%	91.1%	102.5%	122.1%	101.6%	106.7%	98.5%

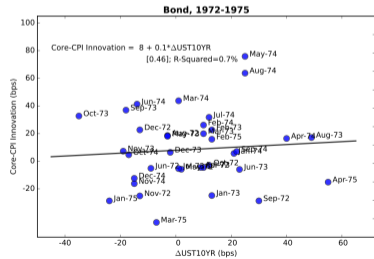
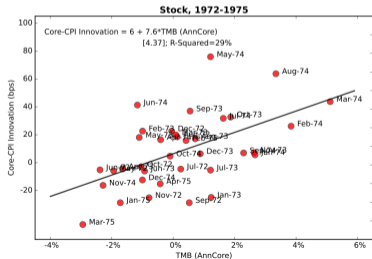
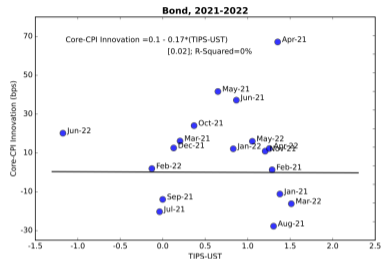
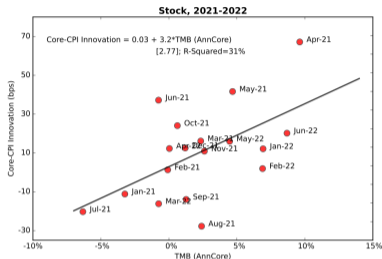
The Parallel of the 1973 Inflation Surge



Predicting the 1973 Inflation Surge

	Headline Innovation (1972 – 1975)					Core Innovation (1972 – 1975)				
Core TMB	15.576*** (3.51)		10.471** (2.50)			18.971*** (4.37)		20.109*** (5.13)		
Head TMB	6.837 (1.39)		-0.931 (-0.14)			1.024 (0.25)		-4.092 (-1.55)		
GSCI	11.459** (2.31)		8.788* (1.77)			2.650 (0.85)		1.468 (0.64)		
Δ UST10YR	21.684 (1.46)		11.367 (0.95)			3.491 (0.46)		-0.943 (-0.14)		
Observations	36	36	36	36	36	36	36	36	36	36
R-squared	11.3%	3.8%	25.4%	14.9%	34.4%	29.0%	0.1%	2.4%	0.7%	31.3%

Predicting the Inflation Surge of 2021 and 1973



Time-Varying Predictability – Uncertainty and Disagreement

	CPI Innovation			CPI Disagreement		
	High	Low	H-L	High	Low	H-L
Core TMB	4.166*** (3.58)	0.641 (1.03)	3.525*** (2.67)	2.763*** (2.62)	0.869 (1.44)	1.894 (1.56)
Observations	303	303		225	267	
R-squared	6.2%	0.2%		4.7%	0.8%	
Head TMB	3.203*** (3.26)	0.667 (0.77)	2.536* (1.94)	2.620*** (2.79)	0.591 (0.90)	2.029* (1.77)
Observations	303	303		225	267	
R-squared	4.1%	0.2%		3.9%	0.3%	

- |CPI Innovation|: the absolute value of CPI innovation in the last month
- CPI Disagreement: Difference between the 75th and 25th percentile of CPI forecasts
- Reported are for core-CPI innovations. Similar (and stronger) results for headline-CPI innovations.

Time-Varying Predictability – U.S. Treasury “Distortions”

	Distance from Taylor Rule			QE Periods		
	Behind	Normal	Diff	QE	Non-QE	Diff
Core TMB	5.980*** (3.17)	0.082 (0.10)	5.899*** (2.86)	5.973*** (2.69)	0.707 (0.86)	5.266** (2.25)
Head TMB	0.994 (0.52)	1.335* (1.97)	-0.341 (-0.17)	0.667 (0.26)	1.217* (1.91)	-0.550 (-0.21)
TIPS-UST	1.174 (0.95)	-0.146 (-0.18)	1.321 (0.89)	2.023 (1.38)	0.021 (0.03)	2.002 (1.27)
Observations	96	193		76	213	
R-squared	23.7%	3.0%		22.0%	4.4%	

- Behind: when the fed fund target rate is below that implied by the Taylor rule.
- QE Periods: when the Fed perform quantitative easing.

Components of CPI

Inflation Exposure: Post-Ranking Beta						
Quintile	Full Month			Announcement Day		
	Headline	Energy	Food	Core	Goods	Service
1	-3.51	-4.97	-15.92	-2.31	-2.89	-1.83
2	-7.10	-6.86	-16.69	1.04	-2.39	-0.08
3	-3.97	0.32	-18.50	1.52	-1.53	1.52
4	1.46	5.28	-21.01	1.79	-0.29	2.31
5	39.07	29.34	-19.41	2.41	0.11	1.24
5-1	42.58*** (3.09)	34.31** (2.12)	-3.49 (-0.45)	4.72*** (2.76)	3.00* (1.73)	3.06** (2.01)

Components of CPI

Predicting Headline CPI innovation

	β^{FullHead}	$\beta^{\text{FullEnergy}}$	β^{FullFood}	β^{AnnCore}	β^{AnnGoods}	$\beta^{\text{AnnService}}$
TMB	7.618*** (5.54)	7.756*** (5.04)	-1.305 (-0.98)	8.286*** (6.62)	6.340*** (5.45)	3.243*** (2.70)
Observations	606	606	606	606	606	580
R-squared	8.6%	8.9%	0.3%	10.2%	6.0%	1.6%

Predicting Core CPI innovation

	β^{FullHead}	$\beta^{\text{FullEnergy}}$	β^{FullFood}	β^{AnnCore}	β^{AnnGoods}	$\beta^{\text{AnnService}}$
TMB	2.127*** (3.09)	2.295*** (3.59)	-0.674 (-0.98)	2.459*** (3.31)	2.159*** (2.94)	-0.39 (-0.70)
Observations	606	606	606	606	606	580
R-squared	1.8%	2.1%	0.2%	2.5%	1.9%	0.1%

Industry vs. Stock-Level Inflation Exposure

- Top 10 and bottom 10 industries that are most and least sensitive to full-month headline CPI innovations and announcement-day core CPI innovations

Rank	β^{FullHead}		β^{AnnCore}	
	Top 10	Bottom 10	Top 10	Bottom 10
1	Petroleum and Natural Gas	Tobacco Products	Ship Building	Candy & Soda
2	Precious Metals	Restaurants & Hotels	Petroleum and Natural Gas	Beer & Liquor
3	Mining	Banking	Coal	Recreation
4	Coal	Candy & Soda	Precious Metals	Medical Equipment
5	Steel Works Etc	Insurance	Mining	Apparel
6	Agriculture	Beer & Liquor	Shipping Containers	Entertainment
7	Fabricated Products	Utilities	Defense	Agriculture
8	Ship Building	Rubber & Plastic Products	Rubber & Plastic Products	Tobacco Products
9	Machinery	Apparel	Business Supplies	Consumer Goods
10	Electrical Equipment	Shipping Containers	Wholesale	Computers

Industry vs. Stock-Level Inflation Exposure

- Top 10 and bottom 10 industries that are most and least sensitive to full-month headline CPI innovations and announcement-day core CPI innovations

Predictability of Industry vs. Stock Portfolios						
	Headline Innovation			Core Innovation		
	Core TMB ^{Ind}	4.586*** (3.69)		2.657** (2.13)	0.648 (1.04)	
Head TMB ^{Ind}	4.479*** (3.69)		0.486 (0.40)	1.397** (2.37)		0.271 (0.40)
Core TMB		6.372*** (5.45)	5.152*** (4.27)		1.946** (2.47)	1.962** (2.34)
Head TMB		5.330*** (4.09)	5.120*** (3.52)		1.428** (1.98)	1.277 (1.52)
Observations	606	606	606	606	606	606
R-squared	7.6%	13.8%	14.8%	1.2%	3.2%	3.2%

Conclusions

- Active price discovery on inflation in cross-sectional stocks:
 - ▶ Fresh and non-redundant information above and beyond other asset classes.
 - ▶ Not yet incorporated by the economists' forecasts.
 - ▶ Unique and unparalleled predictability for core inflation.
 - ▶ Stronger predictability
 - ★ During the 2021 and 1973 inflation surge.
 - ★ When the US Treasury is under QE.
 - ★ When the Fed is behind the curve.
- Methodological contribution:
 - ▶ The full-month approach to capture the headline-inflation exposure.
 - ▶ The announcement-day approach for core-inflation exposure.