Inflation Forecasting From Cross-Sectional Stocks

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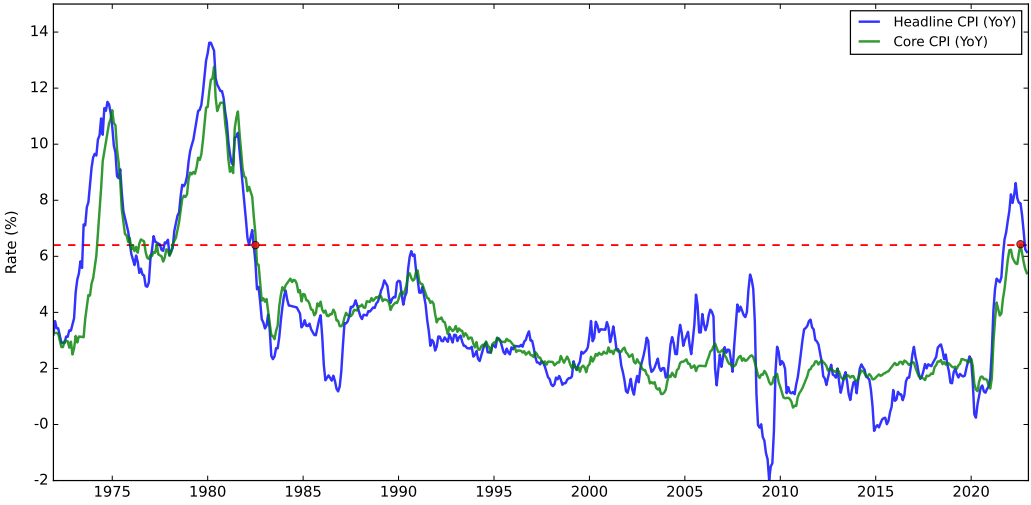
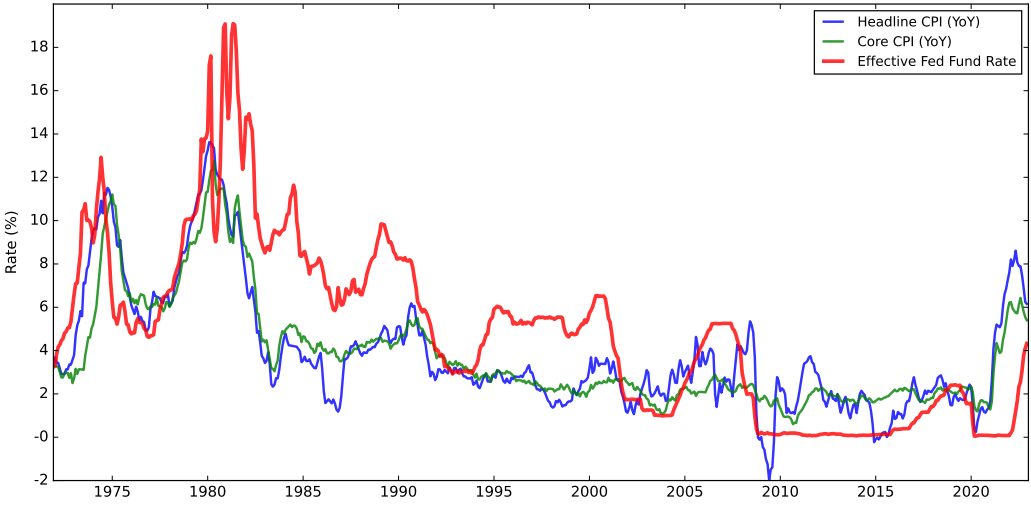
Joint work with Claire Yurong Hong and Shiwen Tian from SJTU

Motivation: The Post-Covid Inflation Surge



Policy Makers: Behind the Curve



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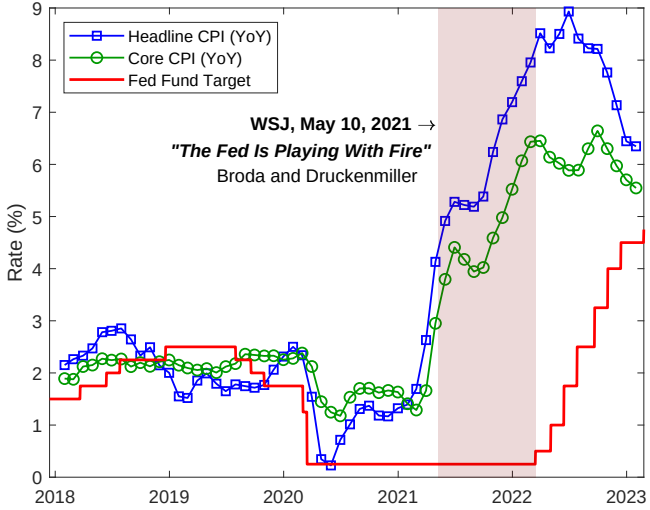
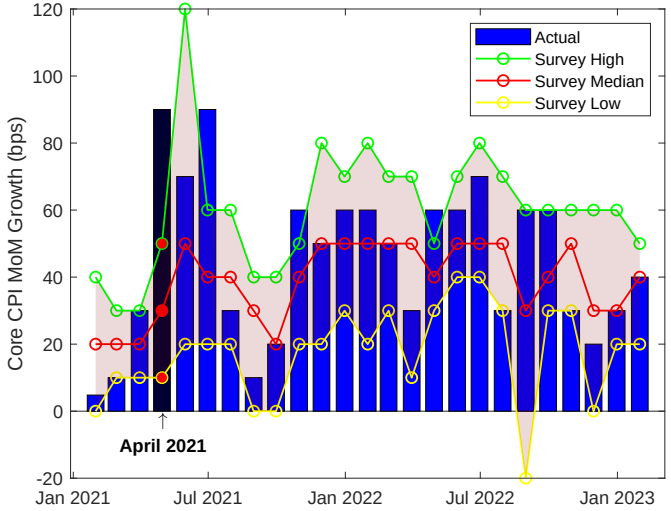


Economists' Forecasts: Missed the Initial Surge by a Wide Margin



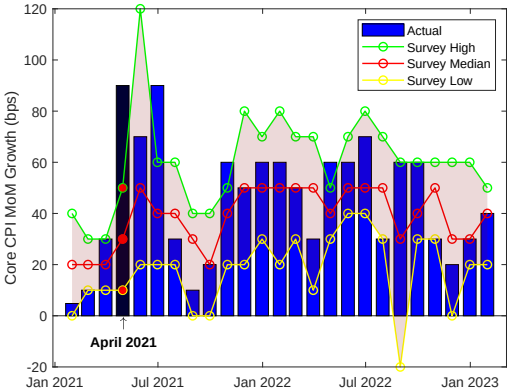
Inflation Forecasting Using Information From Financial Markets

- **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)).

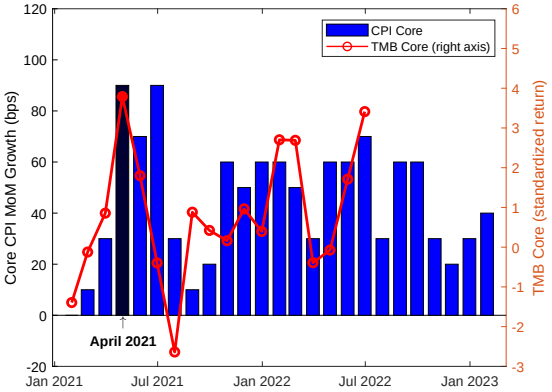
Inflation Forecasting From Cross-Sectional Stocks

- **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.

Inflation Forecasting From Cross-Sectional Stocks



Economists' Forecast



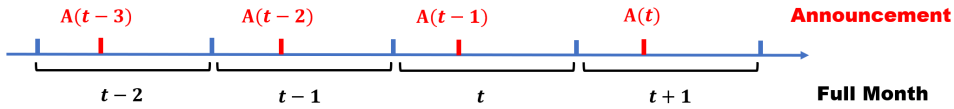
Cross-Sectional Forecast

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

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

  - 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

	VWRETD	TMB	ΔUST10YR	TIPS	−UST	TIPS−UST	GSCI
Full-Month Inflation Exposure							
Headline-CPI	-0.058	0.129**	0.198***	0.046	0.264***	0.339***	0.216***
(FullHead)	(-0.96)	(2.05)	(4.03)	(0.50)	(3.49)	(3.08)	(4.06)
Core-CPI	-0.103**	0.021	0.105*	0.024	0.047	0.081	0.040
(FullCore)	(-2.38)	(0.40)	(1.69)	(0.35)	(0.82)	(1.09)	(0.86)
Announcement-Day Inflation Exposure							
Headline-CPI	0.004	-0.034	0.067	0.093	0.115	0.249**	0.000
(AnnHead)	(0.05)	(-0.32)	(1.15)	(0.80)	(1.33)	(2.43)	(-0.00)
Core-CPI	-0.116***	0.100**	0.114**	0.066	0.135**	0.234***	0.072**
(AnnCore)	(-2.79)	(2.46)	(2.14)	(1.33)	(2.44)	(4.23)	(2.24)

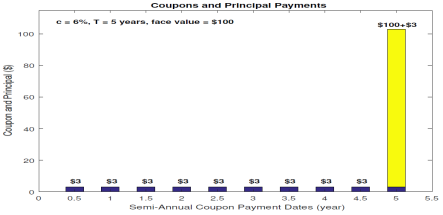
Post-Ranking Inflation Beta

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

Determinants of Inflation Beta

Dependent Variable = Quintile Rank of Core Beta					
Log(Size)	0.041*	0.038*	0.035	0.039*	0.018
	(1.92)	(1.75)	(1.60)	(1.76)	(0.41)
Asset Growth	-0.002	-0.002	0.003	0.008	0.006
	(-0.48)	(-0.35)	(0.67)	(1.55)	(1.38)
Momentum	0.017	0.016	0.014	0.009	-0.002
	(1.28)	(1.22)	(1.05)	(0.68)	(-0.16)
ME/BE	-0.041**	-0.048***	-0.037**	-0.019	0.006
	(-2.51)	(-2.93)	(-2.21)	(-1.09)	(0.30)
Operating Profitability		0.030**	0.043***	0.056***	0.011
		(2.07)	(2.66)	(3.35)	(0.84)
Dividend Payout			0.030***	0.030***	0.017**
			(2.88)	(2.84)	(1.97)
Duration				-0.042**	-0.065***
				(-2.25)	(-2.88)
Time FE	Y	Y	Y	Y	Y
Firm FE	N	N	N	N	Y
R-squared	0.3%	0.3%	0.4%	0.5%	27.0%

Higher inflation beta firms offer more immediate cash flow.



Q5 relative to Q1:

lower mkt-to-book (value)

higher profitability

higher dividend payout

lower duration.

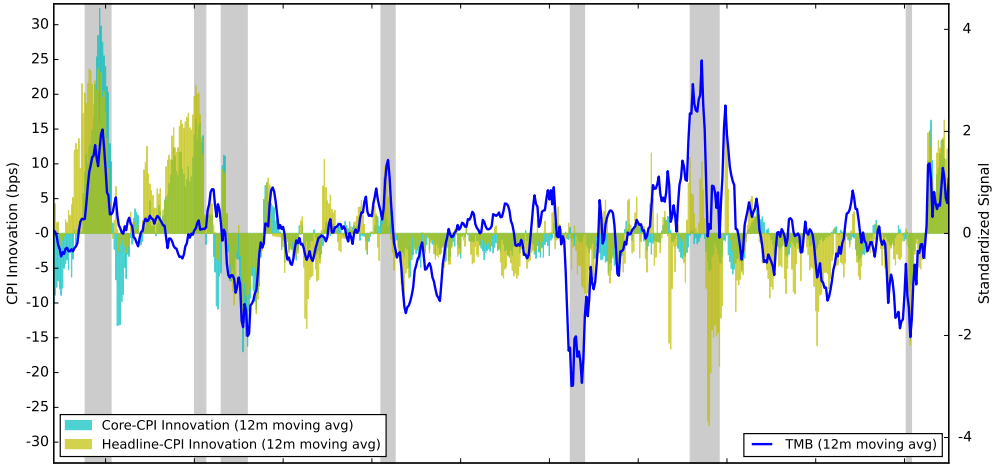
Core- and Headline-Focused Inflation Beta of the Fama-French Factors

	TMB	HML	SMB	RMW	CMA
	Full-Month Inflation Exposure				
Headline-CPI (FullHead)	0.176*** (3.09)	0.047 (0.86)	0.01 (0.28)	-0.129*** (-3.47)	0.006 (0.16)
Core-CPI (FullCore)	0.035 (0.63)	0.034 (0.74)	-0.067* (-1.84)	-0.01 (-0.20)	-0.005 (-0.14)
	Announcement-Day Inflation Exposure				
Headline-CPI (AnnHead)	0.067 (0.98)	0.068 (0.78)	0.019 (0.42)	-0.011 (-0.25)	0.063 (1.42)
Core-CPI (AnnCore)	0.122*** (2.76)	0.096** (2.33)	0.006 (0.13)	-0.029 (-0.71)	0.043 (1.05)

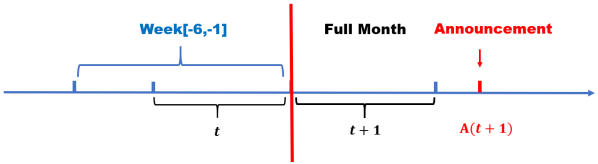
Main Findings and Related Literature, Part 2

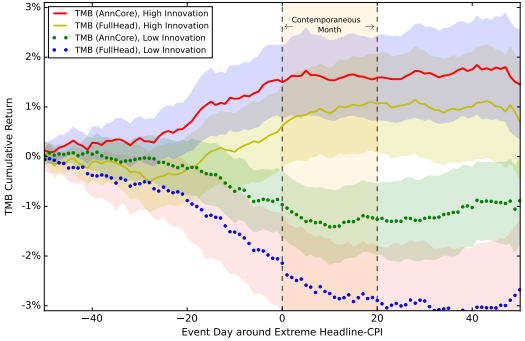
- Inflation forecasting using the relative pricing between stocks with top and bottom inflation betas (TMB).
  - The core-focused TMB: a unique predictor for core CPI.
  - During the inflation surge of 2021 and 1973, its predictive R-squared for month-over-month core CPI innovations increases to 31.5% 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	-1.268	3.004**	2.788	6.943***	2.188	3.091	0.598
	(0.97)	(-0.72)	(2.06)	(1.55)	(4.98)	(1.44)	(1.61)	(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	0.282	0.341	3.826*	7.187***	0.528	3.346**	3.945***
	(1.35)	(0.18)	(0.27)	(1.69)	(4.03)	(0.24)	(2.30)	(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$_t$	8.286***		6.372***		3.737***		7.109***	4.592**
	(6.62)		(5.45)		(3.07)		(4.35)	(2.38)
Head TMB$_t$		7.618***	5.330***		2.978**		5.358***	3.012*
		(5.54)	(4.09)		(2.41)		(3.40)	(1.87)
GSCI$_t$				13.111***	11.045***			12.730***
				(8.32)	(6.76)			(5.35)
TIPS$_t$-UST$_t$						11.724***	8.417***	3.837
						(4.04)	(3.12)	(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***		1.946**		1.684**		2.809**	2.708**
	(3.31)		(2.47)		(2.14)		(2.59)	(2.42)
Head TMB		2.127***	1.428**		1.193		0.206	0.112
		(3.09)	(1.98)		(1.64)		(0.26)	(0.14)
GSCI				1.987***	1.10			0.512
				(2.61)	(1.48)			(0.60)
TIPS-UST						1.869**	1.096	0.912
						(2.10)	(1.46)	(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

	Headline-CPI		**Core-CPI**	
Model	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%
ΔUST1YR	0.311%	101.4%	0.113%	99.7%
ΔUST10YR	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

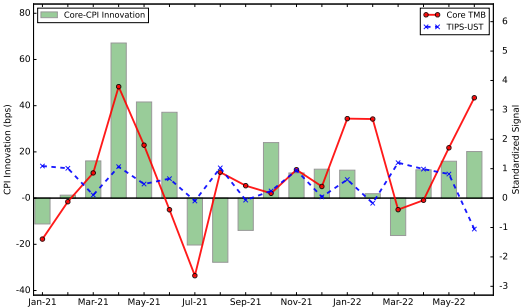
	Headline Inflation				**Core Inflation**			
	Change in Forecast		Forecasting Error		Change in Forecast		Forecasting Error	
Core TMB	7.935***	2.277	4.370***	2.814**	1.066**	0.450	2.754***	2.935***
	(4.34)	(1.14)	(4.73)	(2.52)	(2.15)	(1.08)	(3.65)	(3.10)
Head TMB		2.854*		1.331		0.641*		-0.592
		(1.65)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

Predictability for Inflation Swaps and Treasury Yields

	Dependent Variable = Change in Inflation Swap Rate (%)						
	1 Year	2 Year	3 Year	5 Year	10 Year	20 Year	30 Year
Core TMB	0.157***	0.107***	0.078***	0.056**	0.032**	0.029**	0.022*
	(3.14)	(2.75)	(2.61)	(2.39)	(2.29)	(2.28)	(1.84)
Observations	214	213	213	213	214	213	213
R-squared	8.8%	7.4%	6.7%	6.0%	4.4%	4.1%	2.5%
	Dependent Variable = Change in Nominal Yield (%)						
	1 Year	2 Year	3 Year	5 Year	10 Year	20 Year	30 Year
Core TMB	0.112***	0.100***	0.096***	0.082***	0.063***	0.058***	0.054***
	(4.06)	(4.09)	(4.35)	(4.10)	(3.69)	(3.73)	(3.44)
Observations	606	551	606	606	606	606	543
R-squared	2.3%	2.3%	2.5%	2.1%	1.7%	1.7%	1.6%

- Change in rate: from end-month t to CPI announcement day for month $t+1$.

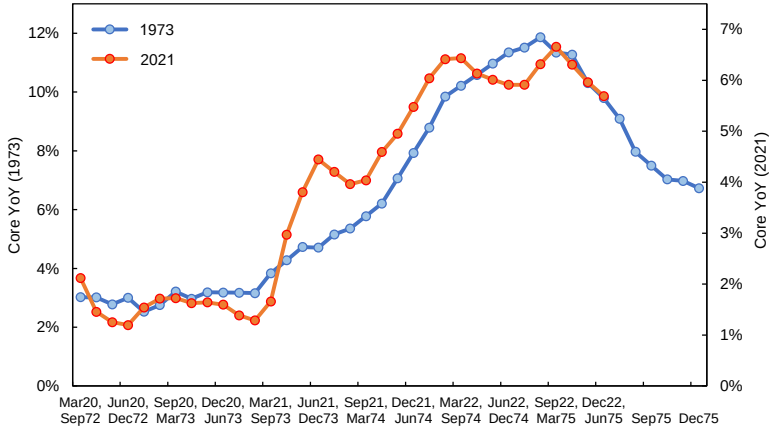
The 2021 Inflation Surge



	Core Inflation Innovation					Forecast Error
Core TMB	10.466**				10.863**	8.307*
	(2.77)				(2.47)	(1.80)
Head TMB		7.348			2.452	-0.061
		(0.51)			(0.20)	(-0.00)
GSCI			-2.609		-3.149	-5.807
			(-0.39)		(-0.55)	(-1.07)
TIPS-UST				-0.208	5.391	0.519
				(-0.02)	(0.66)	(0.07)
Constant	3.899	10.648*	11.814	10.296*	3.238	6.683
	(0.84)	(1.94)	(1.37)	(1.93)	(0.53)	(1.08)
Observations	18	18	18	18	18	18
R-squared	31.5%	2.2%	0.8%	0.0%	34.3%	26.7%

Out-of-Sample Relative RMSE								
Core TMB	Head TMB	TIPS-UST	GSCI	Survey	VWRETD	Real GDP	ΔUST1YR	ΔUST1YR
85.7%	101.7%	102.4%	91.1%	102.5%	122.1%	101.6%	106.7%	98.5%

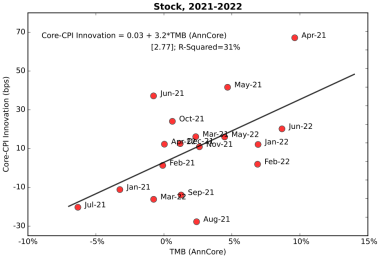
The Parallel of the 1973 Inflation Surge

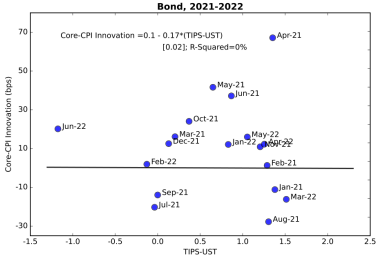


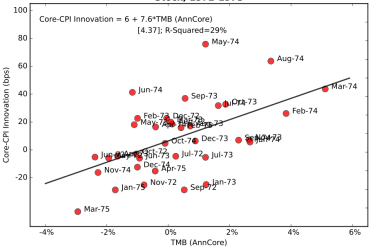
Predicting the 1973 Inflation Surge

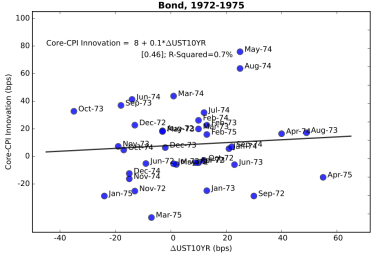
	Headline Innovation (1972 – 1975)					Core Innovation (1972 – 1975)				
Core TMB	15.576***				10.471**	18.971***				20.109***
	(3.51)				(2.50)	(4.37)				(5.13)
Head TMB		6.837			-0.931		1.024			-4.092
		(1.39)			(-0.14)		(0.25)			(-1.55)
GSCI			11.459**		8.788*			2.650		1.468
			(2.31)		(1.77)			(0.85)		(0.64)
ΔUST10YR				21.684	11.367				3.491	-0.943
				(1.46)	(0.95)				(0.46)	(-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***	0.641	3.525***	2.763***	0.869	1.894
	(3.58)	(1.03)	(2.67)	(2.62)	(1.44)	(1.56)
Observations	303	303		225	267	
R-squared	6.2%	0.2%		4.7%	0.8%	
Head TMB	3.203***	0.667	2.536*	2.620***	0.591	2.029*
	(3.26)	(0.77)	(1.94)	(2.79)	(0.90)	(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***	0.082	5.899***	5.973***	0.707	5.266**
	(3.17)	(0.10)	(2.86)	(2.69)	(0.86)	(2.25)
Head TMB	0.994	1.335*	-0.341	0.667	1.217*	-0.550
	(0.52)	(1.97)	(-0.17)	(0.26)	(1.91)	(-0.21)
TIPS-UST	1.174	-0.146	1.321	2.023	0.021	2.002
	(0.95)	(-0.18)	(0.89)	(1.38)	(0.03)	(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						
	Full Month			Announcement Day		
Quintile	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***	34.31**	-3.49	4.72***	3.00*	3.06**
	(3.09)	(2.12)	(-0.45)	(2.76)	(1.73)	(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***	7.756***	-1.305	8.286***	6.340***	3.243***
	(5.54)	(5.04)	(-0.98)	(6.62)	(5.45)	(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***	2.295***	-0.674	2.459***	2.159***	-0.39
	(3.09)	(3.59)	(-0.98)	(3.31)	(2.94)	(-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

	β^{FullHead}		β^{AnnCore}	
Rank	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***		2.657**	0.648		-0.093
	(3.69)		(2.13)	(1.04)		(-0.15)
Head TMB^{Ind}	4.479***		0.486	1.397**		0.271
	(3.69)		(0.40)	(2.37)		(0.40)
Core TMB		6.372***	5.152***		1.946**	1.962**
		(5.45)	(4.27)		(2.47)	(2.34)
Head TMB		5.330***	5.120***		1.428**	1.277
		(4.09)	(3.52)		(1.98)	(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.