Indirect Consumer Inflation Expectations: Theory and Evidence

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The views expressed herein are those of the authors and do not necessarily reflect the views of the Federal Reserve Bank of Cleveland or the Federal Reserve System.

What Do We Do In This Paper?

1. Measurement – create a novel measure of household inflation expectations:
   - Conventional measures are abstract and complex for households (inflation, deflation, aggregate) – humans predict using heuristics (Tversky and Kahneman (1974) + large literature), subject to biases
   - We – indirectly – elicit *individually* relevant inflation expectations.
     - Consumers are relatively attentive to tangible prices of their *own* consumption basket ultimately because most decisions are about one's own prices and own real income.
2. Implementation as big data survey yielding a large and high-frequency sample:
   - 2+ million responses in US / 20k weekly
   - 350k+ responses internationally in 14 countries / 14k monthly
3. Use survey data to understand the role of personal experiences for inflation expectations:
   - New facts about age, gender, and racial gaps in inflation expectations across countries, within the US and over time.
   - Explore effect of local inflation experiences.
   - Re-examine reaction of individual inflation expectations to gas price changes.

What We Do In This Talk

1. Show the foundations from indirect utility theory.
2. Explain survey implementation and validation.
3. Exploit large sample in cross section and time-series to characterize heterogenous expectation formation process.

Indirect Consumer Inflation Expectations (ICIE): Question

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Q: *Next we are asking you to think about changes in prices during the next 12 months in relation to your income. Given your expectations about developments in prices of goods and services during the next 12 months, how would your income have to change to make you equally well-off relative to your current situation, such that you can buy the same amount of goods and services as today? (For example, if you consider prices will fall by 2% over the next 12 months, you may still be able to buy the same goods and services if your income also decreases by 2%.) To make me equally well off, my income would have to ...*

- Increase by __%;
- Stay about the same;
- Decrease by __%.

Randomize order of answers, experiment with zero option.

Foundations from Indirect Utility Theory

Measuring Individual Inflation Expectations

1. Challenge: Ask consumers about expected price changes and aggregate them to obtain inflation expectations.

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2. Indirect utility approach: Variations in *individual* prices must be reflected in variations in *individual* income holding individual consumption basket fixed – we construct an individual Laspeyres index:

   - $u(c_{i,t})$ - utility function; increasing and concave in $c_{i,t}$ of individual i.

   $$\text{period budget constraint: } P_{i,t}c_{i,t} = Y_{i,t}$$
   $$\text{expected budget constraint: } \mathbb{E}_{i,t}\left(P_{i,t+1}c_{i,t+1}\right) = \mathbb{E}_{i,t}Y_{i,t+1}$$

   - Defining inflation and using $c_{i,t} = c_{i,t+1}$:

   $$\mathbb{E}_{i,t}\pi_{i,t+1} = \mathbb{E}_{i,t+1}\left(\frac{P_{i,t+1}}{P_{i,t}}\frac{c_{i,t}}{c_{i,t}}\right) = \mathbb{E}_{i,t+1}\left(\frac{P_{i,t+1}c_{i,t+1}}{P_{i,t}c_{i,t}}\right) = \mathbb{E}_{i,t}\left(\frac{Y_{i,t+1}}{Y_{i,t}}\right) = \frac{gY_{i,t}}{Y_{i,t}} = g$$

   $\rightarrow$ The survey question elicits g and thereby, indirectly, $\mathbb{E}_{i,t}\pi_{i,t+1}$. With savings

Indirect Consumer Inflation Expectations vs. Conventional Measures

- How does aggregating individual prices expectations compare with aggregate individual aggregate expectations?

Indirect Consumer Inflation Expectations vs. Conventional Measures

- How does aggregating individual prices expectations compare with aggregate individual aggregate expectations?
- Assume following structure with common knowledge but π_t unobserved by individuals:
  - DGP: $\pi_t = \rho\pi_{t-1} + \varepsilon_t$
  - Individual i observes a private signal about aggregate inflation – "inflation experiences:" $s_{it} = \pi_t + u_{it}, \qquad u_{it} \sim iid \;\; \mathcal{N}(0, \tau^{-1/2})$.
  - Asking individuals about *own* expected inflation experience:

$$\mathbb{E}_{it} s_{i,t+1} = \rho(s_{it} - u_{it})$$

  - Asking individuals about *aggregate* inflation expectations leads them to solve a Kalman filtering problem with

$$\mathbb{E}_{it}\pi_{t+1} = \frac{\rho\kappa}{1-\rho(1-\kappa)\mathbb{L}} s_{it}$$

  with Kalman gain parameter κ and lag structure $\mathbb{L}$.

Indirect Consumer Inflation Expectations vs. Conventional Measures

Aggregating up Individual Inflation Expectations

- Compare aggregated ICIE with average of conventional expectations:

$$\pi^e_{t,personal} - \pi^e_{t,aggregate} = \int_i \mathbb{E}_{it} s_{i,t+1} - \int_i \mathbb{E}_{it} \pi_{t+1} di = \frac{\rho(1-\kappa)}{1-\rho(1-\kappa)\mathbb{L}} \varepsilon_t$$

- Prediction 1: On average, they will deliver the same point estimate, in inflationary environments with $\varepsilon_t > 0$, $\pi^e_{t,personal} > \pi^e_{t,aggregate}$.

- Prediction 2: The variance of the ex-post inflation forecast errors relative to the conventional expectations is smaller for the aggregated ICIE measure of inflation expectations: Comparison of forecast errors

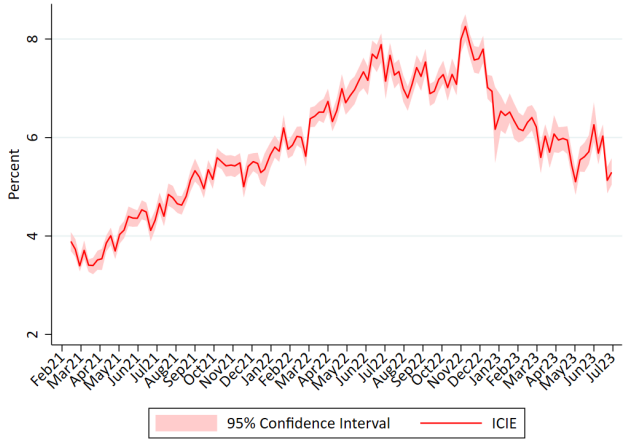
$$Var(\pi_{t+1} - \pi^e_{t,personal}) \leq Var(\pi_{t+1} - \pi^e_{t,aggregate})$$

Why? (Aggregation of) ICIE avoids uncertainty about current realizations of individual experiences; conventional measures face uncertainty of both current and future inflation

Survey: Indirect Consumer Inflation Expectations (ICIE)

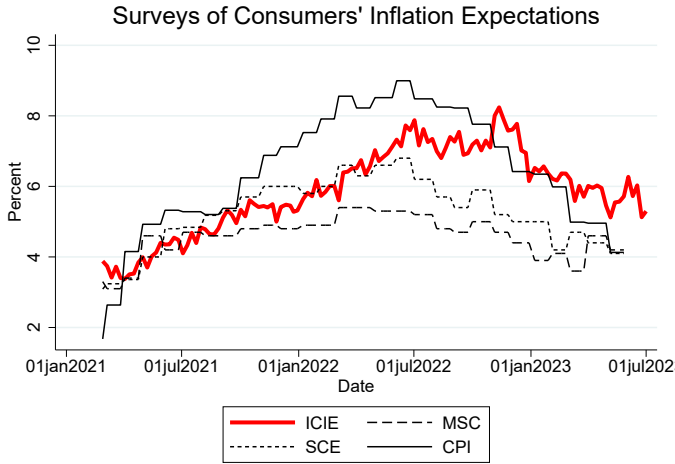
- Joint project between Morning Consult and the Federal Reserve Bank of Cleveland.
- Start date: February 2021.
- Nationally representative sample: 20,000 weekly observations on average Comparison US population
- The main question is asked on a monthly basis in 14 other countries, 1,000 respondents each: Australia, Brazil, Canada, China, France, Germany, India, Italy, Japan, Mexico, Russia, Korea, Spain, and the UK. (new data for Argentina and Turkey)
- Available online and updated weekly via CEBRA at https://cebra.org/indirect-consumer-inflation-expectations/

Survey: Indirect Consumer Inflation Expectations (ICIE)



Trimmed-weighted average: remove top and bottom 10% of observations, bootstrap 1000 times to get confidence interval.

Times-Series Validation of ICIE



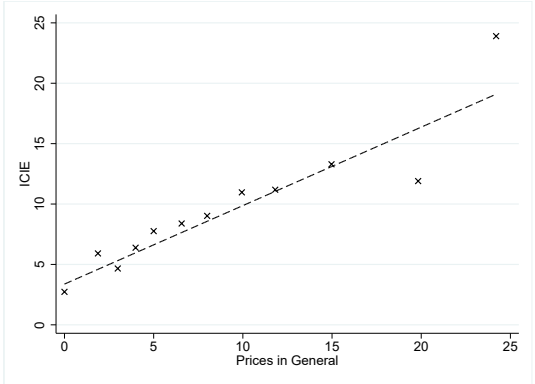
ICIE inflation expectations share level and trend with the inflation expectations from the Michigan Survey of Consumers (MSC) and NY Fed SCE.

Individual-Level Validation of ICIE

- Compare to MSC-type question from supplement in Hajdini et al. (2022): "In the next year, do you think prices in general will increase, decrease or stay about the same?"

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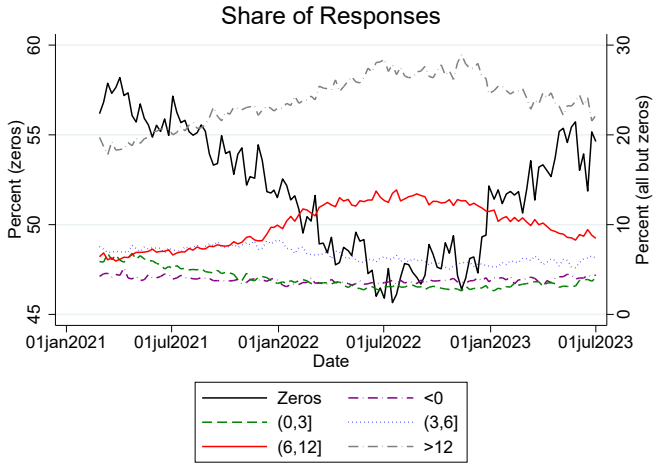


- Similar distribution, slope of 0.690(0.04) with time FE

Important Characteristics of the Response Distribution

- Heterogeneity in the survey responses.
- Cross-sectional distribution of responses in a given week: typically contains a mass at 0; very few responses below 0.
  - Consistent with the zero-lower-bound in inflation expectations documented by Gorodnichenko and Sergeyev (2021).
  - High incidence when 0 is a possible outcome: not an option in NY SCE.
  - Andrade et al. (2021) also find high incidence and relevant economic behavior of them.

Share of 0s and Other Brackets Over Time



- Similar U-shape shown in Armantier et al. (2022) for values ≤ 0. Rounding as in Binder (2017).

Origin of Zeros: Demographics and Numeracy

$$\mathbf{1}(\pi_{it}^{ICIE} = 0) = \alpha_t + \beta X_{it} + \gamma Numeracy_{it} + \varepsilon_{it}$$

	Numeracy Q1		Numeracy Q2		Numeracy Q3	
	(1)	(2)	(3)	(4)	(5)	(6)
Numeracy (Questions)	-0.114***	-0.095***	-0.337***	-0.305***	-0.162***	-0.140***
	(0.014)	(0.014)	(0.013)	(0.014)	(0.012)	(0.012)
Income (50k-100k)		-0.012		-0.000		-0.019
		(0.014)		(0.015)		(0.013)
Income (Over 100k)		0.022		0.012		-0.001
		(0.018)		(0.019)		(0.018)
Age (35-44)		-0.077***		0.004		-0.027
		(0.019)		(0.021)		(0.019)
Age (45-64)		-0.146***		-0.045**		-0.167***
		(0.015)		(0.018)		(0.015)
Age (65 and more)		-0.185***		-0.078***		-0.189***
		(0.017)		(0.020)		(0.017)
Education (Bachelors)		-0.101***		-0.045***		-0.078***
		(0.015)		(0.016)		(0.015)
Education (Post-grad)		-0.114***		-0.072***		-0.101***
		(0.018)		(0.018)		(0.018)
Gender (Female)		0.036***		0.020		-0.012
		(0.012)		(0.013)		(0.012)
Week FE	✓	✓	✓	✓	✓	✓
Observations	6,733	6,733	5,585	5,585	6,822	6,822

Meaningful Correlation of ICIE with Socioeconomic Demographics

$$\pi_{it}^{ICIE} = \alpha_t + \beta X_{it} + \gamma Numeracy_{it} + \varepsilon_{it}$$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Income (50k-100k)	0.128***		-0.406*		-0.788***		-0.502**
	(0.0.16)		(0.243)		(0.269)		(0.243)
Income (Over 100k)	-0.821***		-1.067***		-1.404***		-1.264***
	(0.019)		(0.299)		(0.320)		(0.294)
Age (35-44)	1.098***		1.365***		0.338		0.629*
	(0.021)		(0.333)		(0.388)		(0.336)
Age (45-64)	2.581***		2.030***		0.662**		2.151***
	(0.017)		(0.266)		(0.326)		(0.269)
Age (65 and more)	2.444***		1.572***		0.116		1.510***
	(0.018)		(0.289)		(0.356)		(0.289)
Education (Bachelors)	0.738***		0.779***		-0.118		0.588**
	(0.017)		(0.265)		(0.277)		(0.263)
Education (Post-grad)	0.640***		0.283		0.130		0.514*
	(0.019)		(0.289)		(0.322)		(0.303)
Gender (Female)	0.694***		0.209		0.109		0.757***
	(0.013)		(0.210)		(0.231)		(0.209)
Numeracy		0.655***	0.749***	3.063***	3.072***	1.107***	1.171***
		(0.240)	(0.245)	(0.238)	(0.258)	(0.206)	(0.211)
Week FE	✓	✓	✓	✓	✓	✓	
Observations	1,997,972	6,764	6,764	5,571	5,571	6,841	6,841

The Power of the ICIE Data: Three Applications

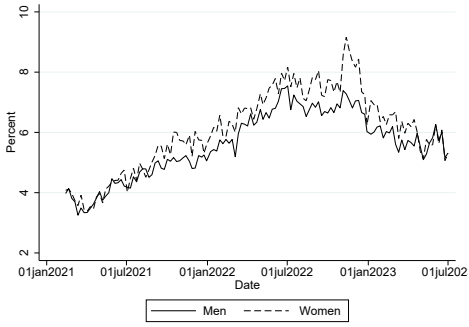
- Very dense data set:
  - High-frequency time variation:
    - Allows to track change in behavior in real time.
  - Large US and international cross-sectional variation:
    - Allows us to characterize demographic and regional groups well to explore role of experiences
    - Allows us to merge our data with external sources of data.

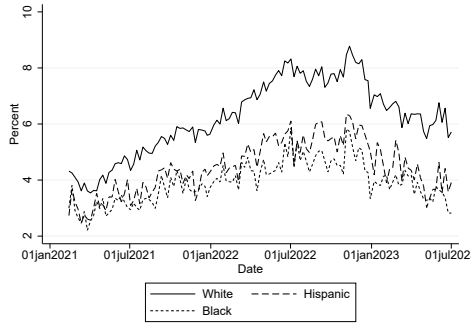
- Three applications:
  1. A high-frequency + global view of gender and racial gaps.
  2. Revisiting the role of individual experiences for inflation expectations.
  3. ICIE inflation expectations reaction to gas prices.

Application 1: Inflation Expectations and Demographics Gaps

- The Gender Gap:
  - Positive gender gap on average.
  - Time variation: gap was higher in periods of high inflation.
  - Internationally, we see different pattern, US is the exception.
- Racial Gap:
  - Significant differences.
  - Whites have higher inflation expectation than other demographic groups.

Meaningful Correlation with Socioeconomic Demographics

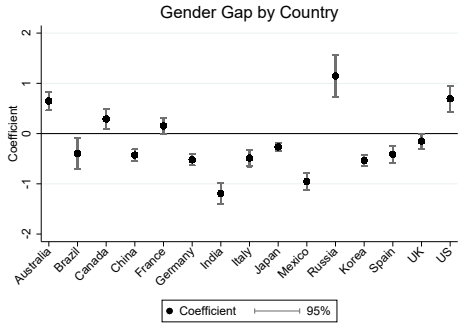




- Unstable gender gap, could be associated with different consumption basket or attention to certain goods (D'Acunto et al., 2021)

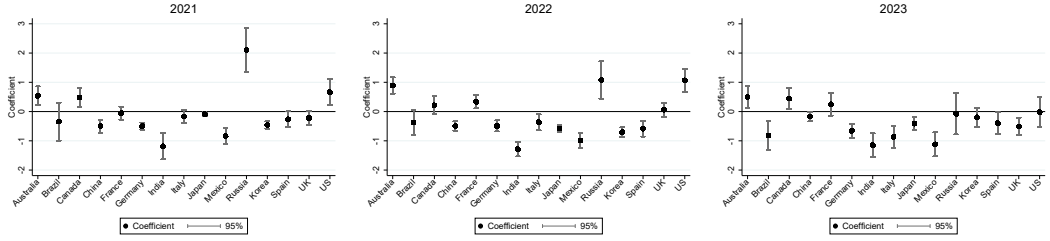
Gender Gaps in ICIE by Country

$$\pi_{i,c,t}^{ICIE} = \alpha_t + \gamma_c + \theta X_i + \beta \left(\gamma_c \times X_i\right) + \varepsilon_{i,c,t}$$



- Only Australia, Russia and US share positive gender gap. Neutral or flipped elsewhere.

Gender Gaps in ICIE by Country: Time Series



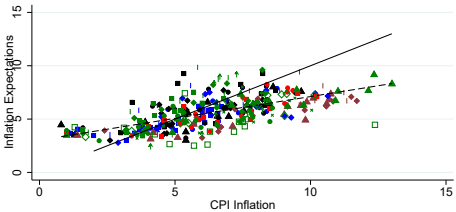
- Positive gender gap has closed in some countries: not a constant!
- Similar prices trajectories across countries, other personal experiences could be influencing the gaps.

- Complex topic – call for further work with thick and/or international data.

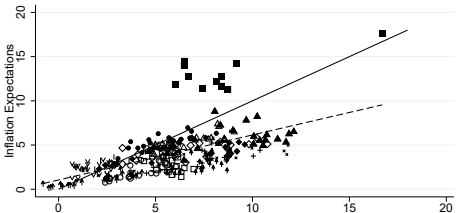
Application 2: The Role of Individual Experience for Inflation Expectations

- Personal (inflation) experiences are highly related to (inflation) expectations, e.g. Malmendier and Nagel (2016), Bordalo et al. (2021), Pedemonte, Toma and Verdugo (2023)
- Rich data allow to extract nuanced picture of the role of personal experiences for inflation expectations based on US and international cross-section:
  - Individual, local inflation experiences affect inflation expectations.
  - Heterogeneity in sign of age effects across US states and countries.

Local Experiences and Inflation Expectations: US Cities and 14 Countries



Blue is Northeast, black Midwest, maroon South and green West

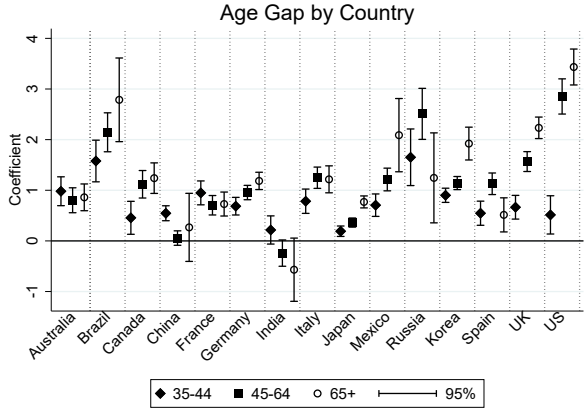


Monthly data between May 2021 and April 2023, for Russia CPI data available until March 2022

Local past inflation affect currents own price inflation expectations (D'Acunto et al. (2021), Kuchler and Zafar (2019)). Regression results with region and time FE

Inflation Expectations and Age: International Evidence

$$\pi_{i,c,t}^{ICIE} = \alpha_t + \gamma_c + \theta X_i + \beta\,(\gamma_c \times X_i) + \varepsilon_{i,c,t}$$



- X_i - age indicator for respondent i

Inflationary Experiences and ICIE

$$\pi^{ICIE}_{i,c,t} = \alpha_t + \gamma_c + Cohort_i + \beta\bar{\pi}_{i,c,t} + \varepsilon_{i,c,t}$$

	(1)	(1)	(2)	(3)
Mean Inflation Experienced	0.009***	0.009***	0.005***	0.005***
	(0.002)	(0.002)	(0.001)	(0.001)
Country FE	✓	✓	✓	✓
Time FE	×	✓	✓	✓
Cohort FE	×	×	✓	✓
Cohort-Time FE	×	×	×	✓
Observations	300,226	300,226	300,226	300,226
R-squared	0.105	0.109	0.113	0.114

- $\bar{\pi}_{i,c,t}$ - average inflation that individual i experienced in country c in period t
- Aggregate inflation past experiences matters for own price inflation expectations, even after controlling for tight cohort-specific fixed effects

Application 3: Gasoline Price Shocks and Inflation Expectations

- Gasoline prices are salient and widely discussed in the press.
- Coibion and Gorodnichenko (2015), among others, find that oil prices highly correlate with inflation expectations.
- Is it gas or other time-varying shocks? How much do consumers weigh gas prices, relative to the importance in their consumption basket?
- Use shift-share mechanism to exploit cross sectional variation in gas use and control for common time shocks to find.

Gasoline Price Shocks and ICIE in the US

- High correlation between gasoline or oil price and consumers' inflation expectations.

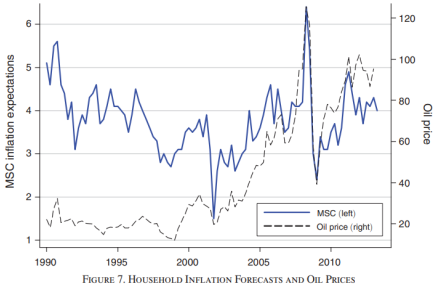
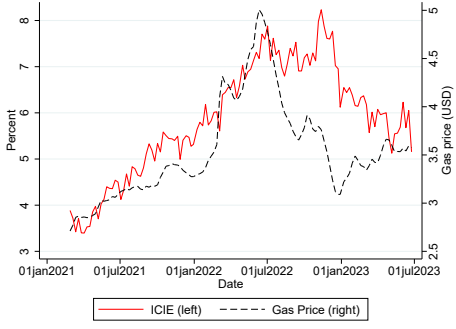


FIGURE 7. HOUSEHOLD INFLATION FORECASTS AND OIL PRICES

(a) Coibion and Gorodnichenko (2015)



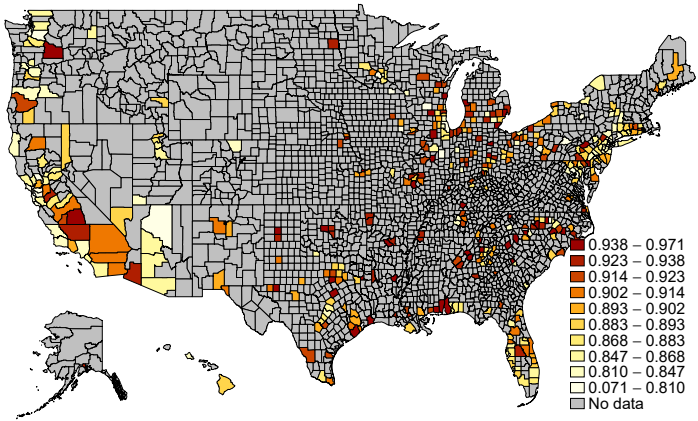
(b) ICIE and gas prices

ICIE and oil prices

Gasoline Price Shocks and ICIE in the US

$$\pi_{i,t}^{ICIE} = \alpha_{c(i)} + \gamma_t + \beta \left(\log P_{gas,t} \times Comm_{c(i)} \right) + \varepsilon_{i,t}$$

Figure: Share of households that use own vehicle to commute (*Comm*)

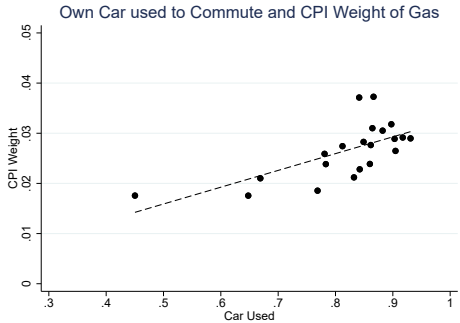


Gasoline Price Shocks and ICIE in the US

$$\pi_{i,t}^{ICIE} = \alpha_{c(i)} + \gamma_t + \beta \left(\log P_{gas,t} \times Comm_{c(i)} \right) + \varepsilon_{i,t}$$

	(1)	(2)	(3)	(4)
$\log P_{gas,t}$	7.381***	2.919***		
	(0.483)	(0.431)		
$\log P_{gas,t} \times Comm_{c(i)}$		5.237***	5.769***	4.508***
		(0.646)	(0.708)	(1.058)
County FE	✓	✓	✓	✓
Time FE	×	×	✓	✓
State-Time FE	×	×	×	✓
Observations	1,902,831	1,221,284	1,221,284	1,221,273
R-squared	0.038	0.024	0.030	0.036

Implications for Over/Under-weighing Gas Prices



- Average $Comm_{c(i)}$ is 82% for BLS sub-sample: $\beta \times 0.82 \times 0.01 = 0.037$
- 1% increase in the price of gasoline increases the ICIE by 3.7 ppt.
- Larger effect than CPI share (2.7%) implying ICIE slight over-reaction to current gasoline price changes.
- There is a perception of *overly* persistent gasoline prices. Sketch

Ongoing Work

- What else can be done exploiting dense, international aspects of the ICIE data?
  1. What is the causal relationship between inflation expectations and income growth expectations? Why do people dislike inflation? Do people expect a wage-price spiral?

     Hajdini et al (2022) "Low Passthrough from Inflation Expectations to Income Growth Expectations: Why People Dislike Inflation"
  2. What is the role of social networks for the (inflation) expectations formation process? Garcia-Lembergman et al (2023) "The Expectations of Others"

Conclusion

1. Novel measure of household inflation expectations, exploiting indirect utility theory.
2. Validation in large sample (2.5 million responses, 15 countries).
   - Consistent in comparison with time series and cross section of existing measures.
   - Meaningful, consistent socioeconomic and demographic correlations.
3. Nuanced picture of the role of personal experiences for inflation expectations, based on rich US and international cross-section:
   - Heterogeneity in sign of age and gender effects across countries and US states.
   - Individual, local inflation experiences affect inflation expectations, but differentially by age – points to refined models of expectations formation.
   - Gasoline prices affect inflation expectations, with inflation expectations exhibiting slight overreaction to changes in gasoline prices.

Numeracy Questions

Q1 Imagine there are white and black balls in a ballot box. You draw a ball 70 times. 56 times, you have drawn a white ball, 14 times a black ball. Given this record, what would you say is the probability of drawing a black ball the next time? The probability is ___ percent.

Q2 Imagine that the interest rate on your savings account was 1% per year and inflation was 2% per year. After 1 year, how much would you be able to buy with the money in this account?

Q3 Imagine that we roll a fair, six-sided dice 1,000 times. Out of 1,000 rolls, how many times do you think the dice would come up even (2, 4, or 6)? Back to Origin of Zeros

Sketch

- Let inflation be driven by changes in prices of gasoline and others:

$$\pi_t = \gamma \Delta\% P_{gas,t} + (1-\gamma)\Delta\% P_{other,t}$$

- Normalize $P_{gas,t-1} = 1$.
- Inflation expectations are driven by expected changes in gasoline prices and others:

$$\mathbb{E}_t \pi_{t+1} = \gamma \mathbb{E}_t \Delta\% P_{gas,t+1} + (1-\gamma)\mathbb{E}_t \Delta\% P_{other,t+1} \Rightarrow \frac{\partial \mathbb{E}_t \pi_{t+1}}{\mathbb{E}_t \Delta\% P_{gas,t+1}} = \gamma = 0.027$$

- From our empirical analysis,

$$\frac{\partial \mathbb{E}_t \pi_{t+1}}{\partial \Delta\% P_{gas,t}} \approx \frac{\partial \mathbb{E}_t \pi_{t+1}}{\partial log P_{gas,t}} = \beta \times 0.82 \times 0.01 = 0.037 > \gamma$$

- $\frac{\mathbb{E}_t \Delta\% P_{gas,t+1}}{\Delta\% P_{gas,t}} > 1$: higher gasoline prices imply over-reaction of inflation expectations and persistence.

Back to Gasoline Price Shocks and ICIE in the US

Longer-run ICIE Survey Question

Now we would like to ask you to think about changes in prices over a longer time in relation to your income. Given your expectations about developments in prices of goods and services during the next 3 years, how would your income have to change each year, on average, to make you equally well-off relative to your current situation, such that you can buy the same amount of goods and services as today?(For example, if you consider prices will fall by 2% on average each year during the next 3 years, you may still be able to buy the same goods and services if your income also decreases by 2% on average per year.)To make me equally well off, on average my income would have to...

- Increase by %;
- Stay about the same;
- Decrease by %.

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Foundations from Indirect Utility Theory with Savings

$$\text{period budget constraint: } P_{i,t}c_{i,t} + S_{i,t} = Y_{i,t} + R_{t-1}S_{i,t-1}$$
$$\text{expected budget constraint: } \mathbb{E}_{i,t}\left(P_{i,t+1}c_{i,t+1}\right) = \mathbb{E}_{i,t}\left(Y_{i,t+1} - (S_{t+1} - R_t S_t)\right)$$

- $S_{i,t}$ nominal savings in period t with gross rate of return R_t
- Constant net savings rate:

$$Y_{i,t} - \underbrace{(S_{i,t} - R_{t-1}S_{i,t-1})}_{\text{net savings}} = (1 - s_i)Y_{i,t}$$

$$\mathbb{E}_{i,t}\left[Y_{i,t+1} - (S_{i,t+1} - R_t S_{i,t})\right] = (1 - s_i)\mathbb{E}_{i,t}Y_{i,t+1}$$

- Divide the 2^{nd} by the 1^{st} using $c_{i,t} = c_{i,t+1}$:

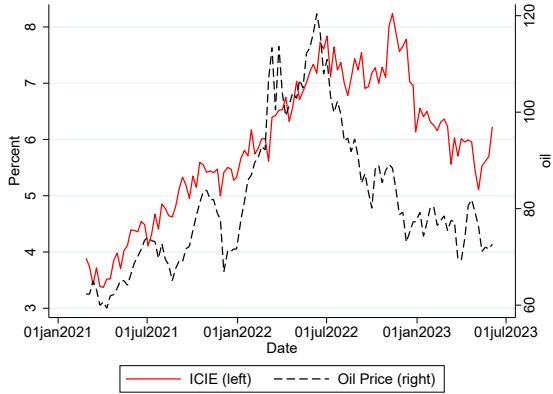
$$\mathbb{E}_{i,t}\pi_{i,t+1} = \mathbb{E}_{i,t}\left(\frac{P_{i,t+1}}{P_{i,t}}\right) = \mathbb{E}_{i,t}\left(\frac{(1-s_i)Y_{i,t+1}}{(1-s_i)Y_{i,t}}\right) = \mathbb{E}_{i,t}\left(\frac{Y_{i,t+1}}{Y_{i,t}}\right) = g$$

- Estimates that approx 40% of US consumers are hand-to-mouth (Kaplan et al (2014), Aguiar et al (2023)).
- More generally, savings not at issue for aggregate ICIE in a closed economy.

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ICIE and oil prices

Figure: ICIE and oil prices (WTI)



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Local CPI and ICIE

$$\pi^{ICIE}_{i,c,t} = \alpha_t + \gamma_c + \delta\pi_{c,t} + \beta X_i + \varepsilon_{i,c,t} \quad (1)$$

- $\pi_{c,t}$ - CPI inflation in country c.
- X_i - demographic characteristics of respondent i.

Table: Regression of ICIE on Local Inflation

	US			International		
	(1)	(2)	(3)	(4)	(5)	(6)
CPI	0.511***	0.135**	0.139**	0.390***	0.426***	0.420***
	(0.043)	(0.054)	(0.061)	(0.045)	(0.093)	(0.108)
Region FE	✓	✓	✓	✓	✓	✓
Time FE	×	✓	✓	×	✓	✓
Dem FE	×	×	✓	×	×	✓
Observations	392,793	392,793	387,390	267,429	267,429	189,866
R-squared	0.017	0.024	0.042	0.110	0.111	0.100

Survey: Indirect Consumer Inflation Expectations (ICIE)

	Survey	US Population		Survey	US Population
Age			**Education**		
18-34	27.55 %	28.99%	<College	50.27%	58.3%
35-44	16.99%	16.56%	Bachelors degree	23.27%	23.50%
45-64	33.70%	32.21%	Post-grad	16.45%	14.4%
65+	21.76%	22.24%			
			Income		
Gender			**Under 50k**	48.72%	37.8 %
Male	46.14%	48.70%	50k-100k	32.94%	28.6%
Female	53.86%	51.29%	100k+	18.34%	33.6%

- Representative sample
- Survey weights to correct for remaining sampling inaccuracy

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Origin of Zeros: Not the Imprecise Wording

$$\mathbf{1}(\pi_{it}^{ICIE} = 0) = \delta + \beta X_{it} + \gamma Wording_{it} + \varepsilon_t$$

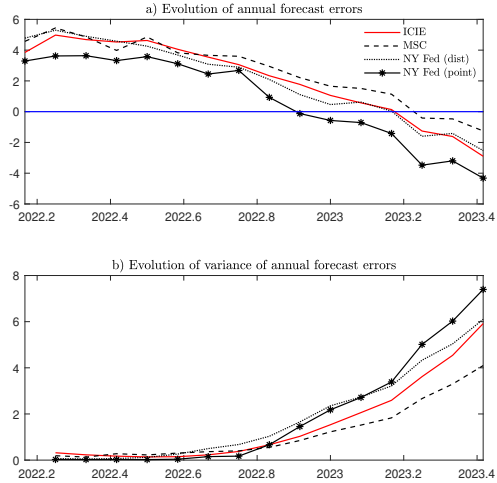
- $Wording_{it} = \begin{cases} 1 & \text{if "Remain } \textit{about} \text{ the same"} \\ 0 & \text{if "Remain the same"} \end{cases}$

	$\mathbf{1}(\pi_{it}^{ICIE} = 0)$	
	(1)	(2)
"Remain *about* the same"	-0.001	0.004
	(0.021)	(0.021)
Constant	0.477***	0.475***
	(0.015)	(0.015)
Demographic Controls	×	✓
Observations	2,209	2,209
R-squared	0.000	0.021

- Choice of wording "Remain *about* the same" is not responsible – indistinguishable impact on probability of responding with 0 compared to "Remain the same" choice.

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ICIE vs Conventional Measures: Forecast Errors



Panel b) plots recursive variance of year-ahead forecast errors.

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