Greater Than the Sum of Its Parts: Aggregate vs. Aggregated Inflation Expectations

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What Do We Do In This Paper?

1. Measurement – create novel dataset of "micro" and "macro" inflation expectations:
   - Micro inflation expectations $\mathbb{E}_t[\pi_{k,t+1}]$ of all major PCE categories
   - Macro inflation $\mathbb{E}_t[\pi_{t+1}]$ and spending expectations $\mathbb{E}_t[C_{t+1}]$: conventional aggregate measures
2. How do micro inflation expectations relate to macro inflation expectations? (and consumption spending plans)
3. Main findings:
   - Macro inflation expectations exceed micro inflation expectations, and are more volatile
   - Internal aggregation mechanism related to socio-demographics, task complexity, heuristics
   - Micro expectations $\mathbb{E}_t[\pi_{k,t+1}]$ contain additional information about consumption plans $\mathbb{E}_t[C_{t+1}]$ – not in macro expectations $\mathbb{E}_t[\pi_{t+1}]$

Why Do We Care?

1. Implications for measurement of expectations:
   - Results: Rather than measure abstract macro expectations, focus on micro expectations?
     - Macro expectations concern abstract, uncertain variables – humans use heuristics (Tversky and Kahneman (1974) + large literature), subject to biases
     - Micro expectations concern tangible, better understood variables – less prone to use of heuristics, subject to easier recall of relevant experiences (e.g. Bordalo et al. 2022)
   - Call for theory of optimal expectations measurement

2. Implications for policy:
   - Micro expectations data imply different estimate of the inter-temporal elasticity of substitution via estimation of Euler equation from macro expectations estimate
   - Key parameter for effectiveness of monetary and fiscal policy
     - Micro-based estimates imply e.g. monetary policy underpredicts inflation volatility by 25% in simple New-Keynesian textbook model, relative to macro-based estimate

Deeper Motivation: Why Do We Care?

3. Complementary, novel evidence that does not support the rationality of aggregate inflation expectations:
   - Coibion and Gorodnichenko (2012) reject full information and rational expectations (FIRE):
     - inflation expectations vs. inflation realizations
     - forecast errors are auto-correlated
   - Analysis in this paper rejects rational inflation expectations:
     - inconsistency of micro and macro expectations under plausibly rational aggregations
     - micro and macro expectations contain differential information

Data

Federal Reserve Bank of Cleveland's daily survey of consumers:

- Module on category inflation expectations
- Category inflation expectations data from July 9, 2020 through September 9, 2021, and on-going; aggregate inflation expectations since March 2020
- Representative of U.S. consumers with $N = 17,888$
  (age, gender, race, income, education and region)
- Survey weights to adjust for sampling inaccuracy

What Do We Measure?

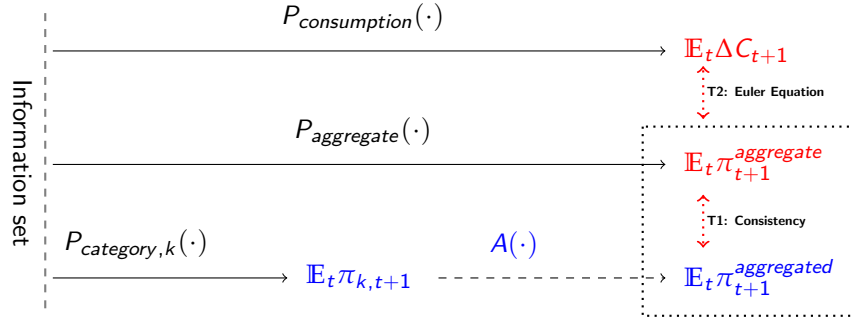
- $\mathbb{E}_t^i[\pi_{t+1}]$: Aggregate, "macro" inflation expectations over next 12 months – point and density forecasts following NY Fed SCE NY Fed SCE
- $\mathbb{E}_t^i[\pi_{k,t+1}]$: Category, "micro" inflation expectations over next 12 months – 11 PCE (NIPA-based) categories PCE categories
  - cover entire PCE basket
  - subsume minor categories to limit cognitive burden
- $\mathbb{E}_t^i[C_{t+1}]$: Spending plans over next 12 months, total, services and non-durables spending plans
- $\omega_{k,t}^i$: category weights by dollar spending or "importance" expenditure weights importance weights

Survey: Main, Category Inflation Expectations Question

Twelve months from now, what do you think will have happened to the price of the following items? I expect...

	Increase/Decrease	By ____ %
the price of **motor vehicles and parts** (such as cars and SUVs) to ___ [increase/decrease] by ___ percent		
the price of **recreational goods and vehicles** (such as sports equipment and laptops) to ___ [increase/decrease] by ___ percent		
the price of **other durable goods** (such as furniture, appliances, jewelry, luggage) to ___ [increase/decrease] by ___ percent		

Survey: Underlying Model of Inflation Expectations



Gauge consistency of inflation expectations and their formation:

- Internally: Test consistency between aggregate and *aggregated* expectations (T1)
  - What is the best-fitting internal aggregator $A(\cdot)$? rational aggregation?
  - What factors explain any inconsistency? cognitive boundedness
- Externally: Estimate Euler equation (T2)
  - Which measure best predicts spending plans? information + cross-domain consistency
  - Quantify implications for policy: why do we care?

Aggregate vs. Category Inflation Expectations

Aggregate vs. Category Inflation Expectations

Aggregate $\gg$ category inflation expecations:

- Higher aggregate mean than any category mean
- Higher aggregate dispersion than any category dispersion (cross section standard deviation)
- Higher aggregate time series volatility than any category

Important insight from individual-level data:

- **40%** of individual aggregate expectations outside range of individual category expectations (25% respondents above range by 6.93pp., 15% below by 12.4pp.)
- Linear aggregation of expectations impossible

Aggregate vs. Category Inflation Expectations

	Mean	Dispersion	Time Series Std. Dev.
Aggregate expectation	6.39	7.53	2.53
Category expectations			
Motor vehicles	5.49	5.95	1.78
Recreational goods	4.00	6.34	1.61
Other durable goods	4.12	6.14	1.69
Food and beverages	5.27	6.48	1.71
Gasoline	5.28	7.57	2.03
Other nondurable goods	4.15	6.02	1.41
Housing and utilities	4.93	6.46	1.50
Health care	3.96	6.52	1.58
Transportation services	4.82	6.19	1.53
Food services	4.78	6.46	1.54
Other services	4.32	5.64	1.29
Average	4.65	6.34	1.61

Time Series - Mean Time Series - Dispersion

Aggregate vs. Category Means - Demographics

	Gender		Grocery		Education		Income		
	Female	Male	Yes	No	High	Low	High	Middle	Low
Aggregate expectation	5.63	4.56	5.40	3.54	4.48	5.75	4.41	4.89	5.47
Category expectations									
Motor vehicles	4.48	4.53	4.71	3.61	4.65	4.41	4.61	4.57	4.48
Recreational goods	3.54	3.01	3.37	2.42	3.32	3.17	3.36	3.28	3.11
Other durable goods	3.29	3.18	3.33	2.52	3.24	3.20	3.33	3.33	3.09
Food and beverages	5.36	4.42	5.00	4.22	4.74	4.98	4.81	5.03	4.79
Gasoline	4.66	4.50	4.66	4.05	4.41	4.71	4.35	4.84	4.54
Other nondurable	3.77	3.40	3.66	3.01	3.55	3.62	3.73	3.61	3.42
Housing and utilities	5.19	4.52	4.92	4.36	5.04	4.68	4.91	5.27	4.44
Health care	3.16	3.22	3.30	2.46	3.23	3.16	3.47	3.25	2.95
Transportation	4.58	3.96	4.42	3.35	4.15	4.36	4.02	4.39	4.31
Food services	4.39	4.08	4.32	3.66	4.29	4.19	4.41	4.27	4.06
Other services	4.24	3.65	4.08	3.31	3.86	3.99	3.92	4.09	3.86
Average	4.24	3.86	4.16	3.36	4.04	4.04	4.08	4.18	3.91

- Much wider gaps by demographics at the aggregate level
- Trends differ by education and income $\rightarrow$ macro complexity
- Salience of shopping experiences has consistent relationship

Aggregate vs. Category Dispersion - Demographics

	Gender		Grocery		Education		Income		
	Female	Male	Yes	No	High	Low	High	Middle	Low
Aggregate expectation	7.31	6.01	6.70	5.87	6.11	7.46	7.65	6.36	6.97
Category expectations									
Motor vehicles	5.68	5.41	5.54	5.67	5.71	5.35	5.82	5.51	5.37
Recreational goods	4.45	3.72	4.01	4.04	4.23	3.82	4.27	4.18	3.85
Other durable goods	4.32	3.96	4.15	3.80	4.32	3.94	4.62	4.21	3.90
Food and beverages	5.79	4.88	5.28	5.60	5.39	5.27	5.60	5.52	5.25
Gasoline	5.78	4.96	5.28	5.74	5.40	5.35	5.39	5.72	5.27
Other nondurable	4.41	3.95	4.20	3.97	4.33	4.05	4.58	4.28	3.94
Housing and util.	5.28	4.66	4.99	4.94	5.22	4.77	5.30	5.34	4.69
Health care	4.15	3.90	4.03	3.95	4.21	3.81	4.53	4.13	3.70
Transportation	5.26	4.46	4.87	4.73	4.89	4.82	4.78	5.09	4.87
Food services	5.02	4.57	4.81	4.92	5.05	4.56	5.23	4.87	4.52
Other services	4.58	4.07	4.37	4.22	4.39	4.27	4.56	4.51	4.23
Average	4.98	4.41	4.68	4.69	4.83	4.55	4.97	4.85	4.51

- Consistent category and aggregate patterns according to dispersion
- Much wider dispersion gaps at the aggregate

Aggregate vs. Category Means and Dispersion - by Age

	Mean				Dispersion (SD)			
	18-34	35-44	45-54	above 55	18-34	35-44	45-54	above 55
Aggregate expectation	7.95	9.00	8.42	5.74	11.64	11.63	9.62	4.36
Category expectations								
Motor vehicles	4.62	5.89	5.98	6.35	6.38	6.26	6.04	4.97
Recreational goods	2.47	4.11	4.81	5.28	7.15	6.89	6.25	4.50
Other durable goods	2.82	4.25	4.77	5.23	6.76	6.87	6.13	4.64
Food and beverages	3.80	5.41	6.32	7.06	6.99	7.18	6.78	5.19
Gasoline	3.81	5.16	6.50	7.60	7.42	7.32	7.63	7.98
Other nondurable	2.85	4.26	5.11	5.25	7.00	6.57	6.00	4.34
Housing and util.	3.66	4.77	5.96	6.30	7.08	7.09	6.48	5.09
Health care	2.61	4.17	4.59	5.26	7.02	6.79	6.15	5.30
Transportation	3.51	4.80	5.59	6.27	6.86	6.74	6.41	4.95
Food services	3.06	4.65	5.55	6.62	6.94	6.77	6.32	5.32
Other services	3.37	4.24	5.06	5.20	6.35	6.26	5.56	4.08
Average	3.33	4.70	5.48	6.04	6.90	6.79	6.34	5.12

- Category and aggregate expectations differ by age
- No different patterns in dispersion

Aggregate vs. Aggregated Inflation Expectations

Aggregate vs. Aggregated Measures of Inflation Expectations

Three main findings:

- Aggregated "micro"-based inflation expectations are closer to zero than aggregate, "macro" expectations while also less dispersed
- Positive aggregation inconsistency for plausibly rational aggregations – internally inconsistent beliefs – equal-weighted provides best fit:

  Rational aggregate inflation expectations?
- Inconsistency varies with uncertainty and socio-demographic factors

Aggregated Measures of Inflation Expectations

Using variations in sets of weights, construct 8 measures of aggregated inflation expectations for each survey respondent i, based on their 11 category expectations $\mathbb{E}_t^i[\pi_{k,t+1}]$ and appropriately defined category weights $\omega_{k,t+1}^i$:

$$\mathbb{E}_t^i\left[\pi_{t+1}^{aggregated}\right] = \sum_{k=1}^{11} \omega_k^i \mathbb{E}_t^i[\pi_{k,t+1}] \text{ with } \sum_{k=1}^{11} \omega_k^i = 1 \text{ and } \omega_k^i \geq 0 \forall k.$$

Plausibly rational aggregations:

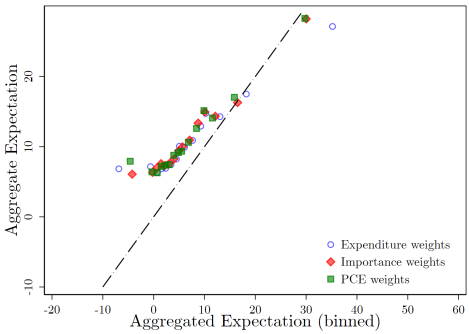
- Expenditure weights $\rightarrow$ rational benchmark
- Importance weights
- PCE weights

Behavioral aggregations:

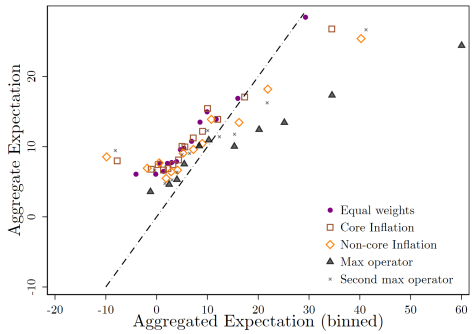
- Equal weights $\rightarrow$ neglects weights
- Highest, or second-highest category expectation $\rightarrow$ salient price changes
- Core, or non-core weights $\rightarrow$ salient gas, energy and grocery price changes

Aggregate vs. Aggregated Measures

Cross section



(plausibly rational)

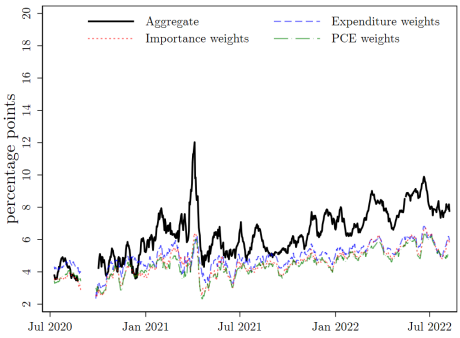


(behavioral)

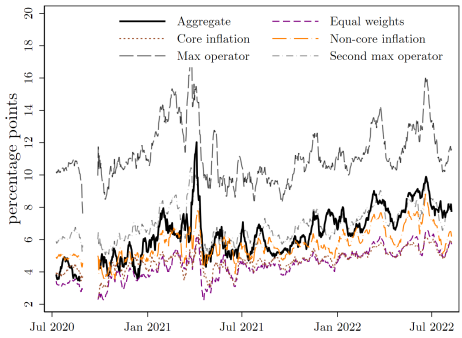
1. Positive aggregation inconsistency for plausibly rational aggregations
   - Aggregate exceed *aggregated* expectations but move 1-to-1; non-linear at extremes
2. Equal weights aggregator provides closest statistical match (AIC) in the cross section. In line with Dawes (1974).

Aggregate vs. Aggregated Measures: Means

Time Series



(plausibly rational)

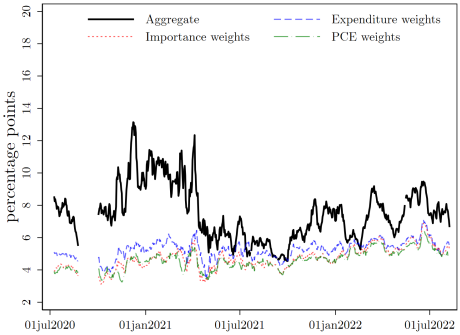


(behavioral)

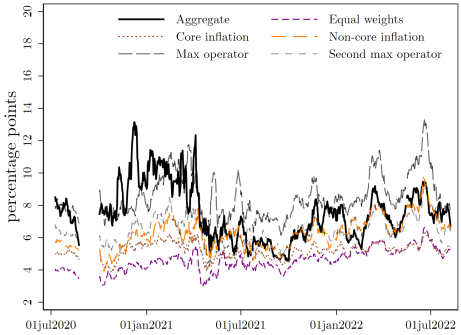
- Positive aggregation inconsistency:
  Aggregate expectations exceed plausibly rational aggregations and their volatility – very pronounced difference in recent high-inflation period
- Statistically, equal-weighted provides closest match (AIC) also in the time series

Aggregate vs. Aggregated Measures: Dispersion

Time Series



(plausibly rational)



(behavioral)

- Dispersion of aggregate inflation expectations exceeds dispersion of aggregated inflation expectations most markedly until April 2021 "inflation scare"

What Are Driving Processes of Aggregation Inconsistency?

Analyze inconsistency through individual-level data:

- Aggregate versus category-based forecasts:

$$\Lambda_t^i = \mathbb{E}_t^i \left[\pi_{t+1}\right] - \mathbb{E}_t^i \left[\pi_{t+1}^{aggregated}\right] \tag{1}$$

  $\mathbb{E}[\Lambda_t^i]$ – direction of discrepancy: $[0.68pp., 1.64pp.]$ (excl. (second) highest)

  $\mathbb{E}[|\Lambda_t^i|]$ – magnitude of discrepancy: $[5.33pp., 9.09pp.]$

- Next: Regress Λ_t^i on rich set of covariates, including socio-demographic factors and measures of complexity.

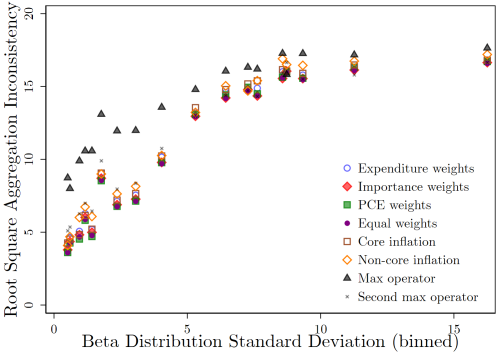
What Are Driving Processes of Aggregation Inconsistency?

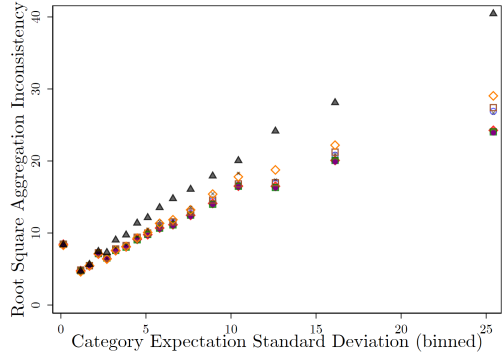
- Results generalize across aggregators – focus on case of expenditure weights

	(1)	(2)
Expenditure weights	Root Square Inconsistency $\sqrt{(\mathbb{E}_t\pi_{t+1} - \sum\omega_k\mathbb{E}_t\pi_{k,t+1})^2}$	
above 55 years	-2.001***	-0.854***
	(-30.31)	(-14.29)
High education (bachelor or above)	-0.591***	-0.398***
	(-8.54)	(-6.50)
Category expectations dispersion		0.470***
		(74.68)
Aggregate inflation expectations uncertainty		0.210***
		(28.34)
Constant	6.492***	2.011***
	(60.79)	(10.26)
N	54348	52117
R^2	0.0368	0.291

- Two main findings:
  - Education and age decrease inconsistency $\rightarrow$ mental abilities
  - Aggregate inflation expectations uncertainty and category dispersion increase inconsistency $\rightarrow$ complexity

What Are Driving Processes of Aggregation Inconsistency?





- Inconsistency across aggregators rises linearly with individual aggregate uncertainty and dispersion across categories, rather than having a flat relationship.

Why Do We Care?

Besides implications for measurement, and rationality of aggregate inflation expectations - important implications for modeling and policy:

- Estimation of Euler equation using category-based expectations yields
  - Better fit of spending forecasts
  - Different estimates of the inter-temporal elasticity of substitution
- Estimates may imply quantitative re-assessment of the stabilizing role of monetary and fiscal policy

Category-Based Expectations Contain Additional Aggregate Information

Which measure of inflation expectations predicts spending plans best: Conventional aggregate inflation expectations or aggregated inflation expectations?

- Use additional survey data on expected changes in spending
- Estimate Euler equation, varying measures of $\mathbb{E}_t^i[\pi_{t+1}]$:

$$\mathbb{E}_t^i[\Delta S_{i,t+1}] = \beta_0 + \beta_1 \mathbb{E}_t^i[\pi_{t+1}] + D_i + T_t + \epsilon_{i,t}$$

- Note $\mathbb{E}_t^i[\Delta C_{i,t+1}] = \mathbb{E}_t^i[\Delta S_{i,t+1}] - \mathbb{E}_t^i[\pi_{t+1}]$: $\hat{\sigma} = 1 - \hat{\beta}_1$ estimates intertemporal elasticity of substitution
- Control for household income expectations, socio-demographic factors and time fixed effects

How well does any inflation expectation measure $E_t^i \pi_{t+1}$ explain the spending data?

- Measure of fit: Akaike Information Criterion (AIC)

Category-Based Expectations Contain Additional Aggregate Information

	$\hat{\sigma} = 1 - \hat{\beta}_1$	t-stat	R^2	AIC	p-val (LR)	N
Aggregate	0.960***	7.69	0.057	168157	-	23682
Expenditure	0.821***	15.35	0.083	167499	0.000	23682
Importance	0.786***	16.79	0.087	167390	0.000	23682
PCE	0.788***	15.92	0.085	167439	0.000	23682
Equal	0.777***	16.57	0.088	167381	0.000	23682
Core inflation	0.842***	13.37	0.076	167674	0.000	23682
Non-core inflation	0.874***	14.52	0.076	167679	0.000	23682
Max	0.912***	14.58	0.074	167737	0.000	23682
Second max	0.870***	14.36	0.079	167598	0.000	23682

t statistics in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

- All category-based estimates lower and spending predicted better (likelihood ratio)
- Equal weight aggregation predict data best
- Similar results for services and non-durables spending

IV regression

Relative Performance of Category-Based Aggregated Expectations

		Likelihood Ratio								
	AIC	Equal	Imp.	PCE	Exp.	Second max	Core	Non-core	Max	Aggregate
Equal	167381	-								
Importance	167390	0.011	-							
PCE	167439	0.000	0.000	-						
Expenditure	167499	0.000	0.000	0.000	-					
Second max	167598	0.000	0.000	0.000	0.000	-				
Core infl.	167674	0.000	0.000	0.000	0.000	0.000	-			
Non-core infl.	167679	0.000	0.000	0.000	0.000	0.000	0.082	-		
Max	167737	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-	
Aggregate	168157	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-

Consider likelihood ratio of a row relative to a column specification:

- Equal weights outperform all others.
- Conventional aggregate expectations are outperformed by all others.

Re-assess stabilizing role of monetary and fiscal policy

Results on IES imply e.g. reassessment of monetary policy:

1. Potentially large welfare-relevant effects arise:

	IES	$var(\pi)$	$var(\tilde{y})$
Aggregate	0.863	2.0880	0.0506
Equal weights	0.684	2.3785	0.0536
Crump et al. (2022)	0.743	2.2687	0.0525

(based on Gali, 2015; $\sigma_{TFP} = 1/4$; IES from instrumental variables)

2. Other aspects of policy, such as forward guidance (McKay, Nakamura and Steinsson, 2016), also impacted.

Conclusion

Survey of "micro", category inflation expectations:

- Aggregate inflation expectations exceed aggregated category inflation expectations.
- Category expectations less volatile and dispersed
- Significant inconsistencies between aggregate and *aggregated* inflation expectations

Aggregation inconsistency:

- Increases with uncertainty and is more pronounced for individuals with lower socio-economic status

Estimate Euler equation:

- Category-based expectations contain additional aggregate information
- Potentially large policy effects

Extra Slides: Categories

Category	Example
Motor vehicles and parts	Cars and SUVs
Recreational goods and vehicles	Sports equipment and laptops
Other durable goods	Furniture, appliances, jewelry, luggage
Food and beverages	Food from grocery stores
Gasoline and other energy goods	
Other nondurable goods	Clothing, medicine and personal care products
Housing and utilities	Rent and utility bills
Health care	
Transportation services	Public transit tickets and airfare
Food services and accommodations	Restaurants and hotels
Other services	Internet/phone service, education, financial services

- Survey shows some examples for most product categories, e.g. "motor vehicles and parts (such as cars and SUVS)"

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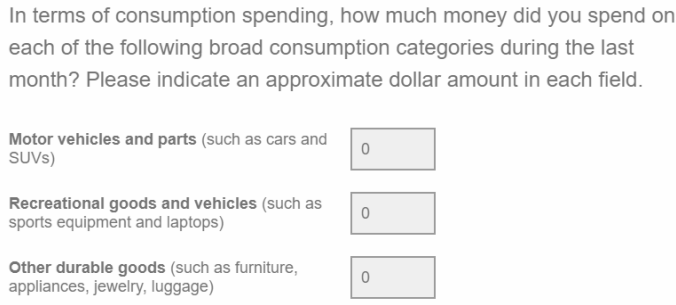
Extra Slides: Expenditure Weights - Survey Question



Calculate relative expenditure weights ω_k^{exp} from category spending S_k:

$$\omega_k^{exp} = \frac{S_k}{\sum_{i=1}^{11} S_i}$$

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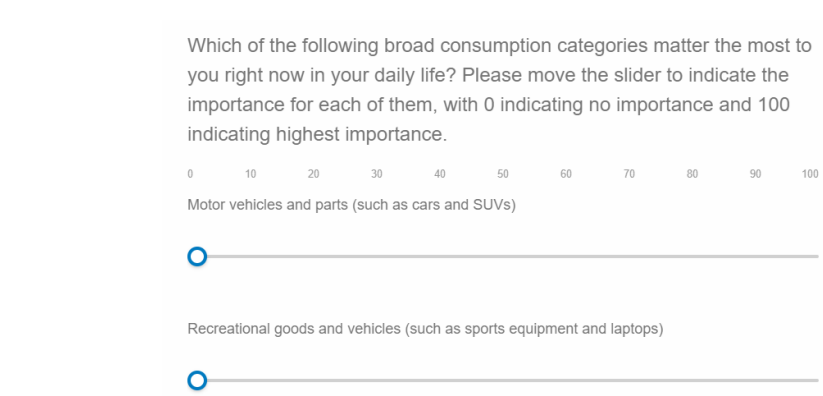
Extra Slides: Importance Weights - Survey Question



Calculate relative importance weights ω_k^{imp} from reported category specific importance S_k:

$$\omega_k^{imp} = \frac{I_k}{\sum_{i=1}^{11} I_i}$$

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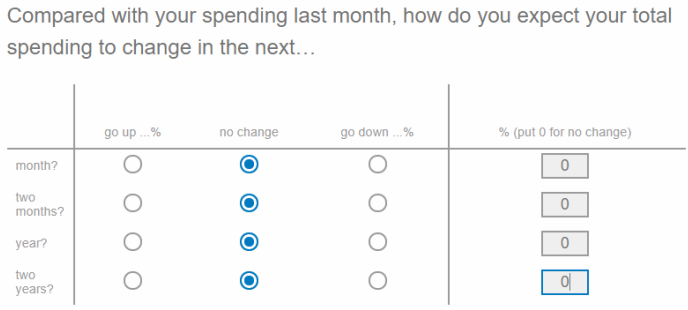
Extra Slides: Expected Change in Spending - Survey Question



- Similar questions for services and nondurable spending
  - "how do you expect your spending on services – such as medical and dental care, haircuts, and restaurant meals – to change in the next..."
  - "how do you expect your spending on nondurable goods – such as clothes, medicine, food at grocery stores, or personal care products – to change in the next..."

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Extra Slides: Categories

Over the next 12 months do you think there will be inflation or deflation?

- Inflation
- Deflation (opposite of inflation)

What do you expect the rate of inflation/deflation to be over the next 12 months? Please give your best guess.

I expect the rate of inflation/deflation to be _____ percent over the next 12 months.

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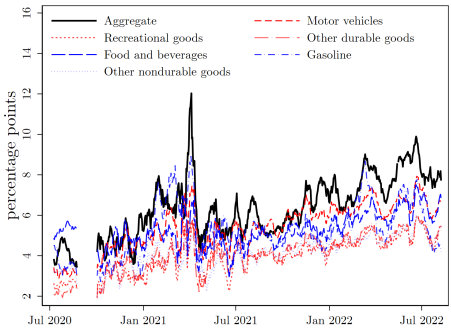
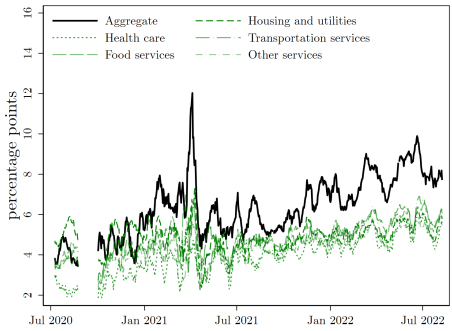
Inflation Expectations: Aggregate vs. Cetagory

Durable and non-durable goods



Services



Time series shows 11 day moving average of daily Huber-robust and survey-weighted mean

- Reported aggregate expectations are *higher* than individual product category expectations

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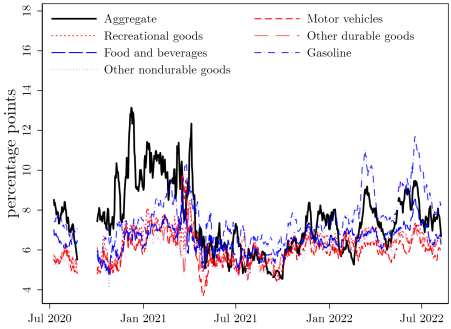
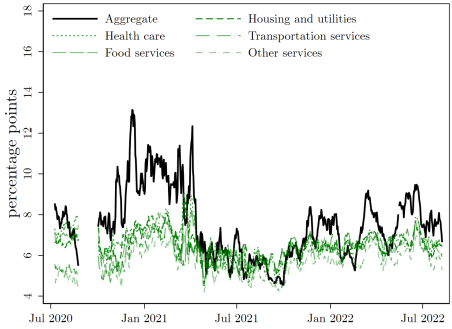
Disagreement on Inflation Expectations: Aggregate vs. Category

Durable and non-durable goods



Services



Time series shows 11-day moving average of daily cross section standard deviation

- Disagreement on reported aggregate expectations is higher than for most categories

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	$\hat{\sigma} = 1 - \hat{\beta}_{OLS}$ (OLS)	$\hat{\sigma} = 1 - \hat{\beta}_{IV}$ (IV)	t-stat	F-stat (first stage)	N
12-month-ahead aggregate spending					
Aggregate	0.960***	0.863***	7.34	478	23053
Expenditure	0.821***	0.700***	7.55	364	23053
Importance	0.786***	0.696***	7.63	445	23053
PCE	0.788***	0.673***	7.60	410	23053
Equal	0.777***	0.684***	7.63	463	23053
Core inflation	0.842***	0.667***	7.38	279	23053
Non-core inflation	0.874***	0.758***	7.45	364	23053
Max	0.912***	0.748***	7.29	198	23053
Second max	0.870***	0.717***	7.44	261	23053

Instrument: Mean of density forecast. Back