Heterogeneity in Prices and Inflation over the Life Cycle

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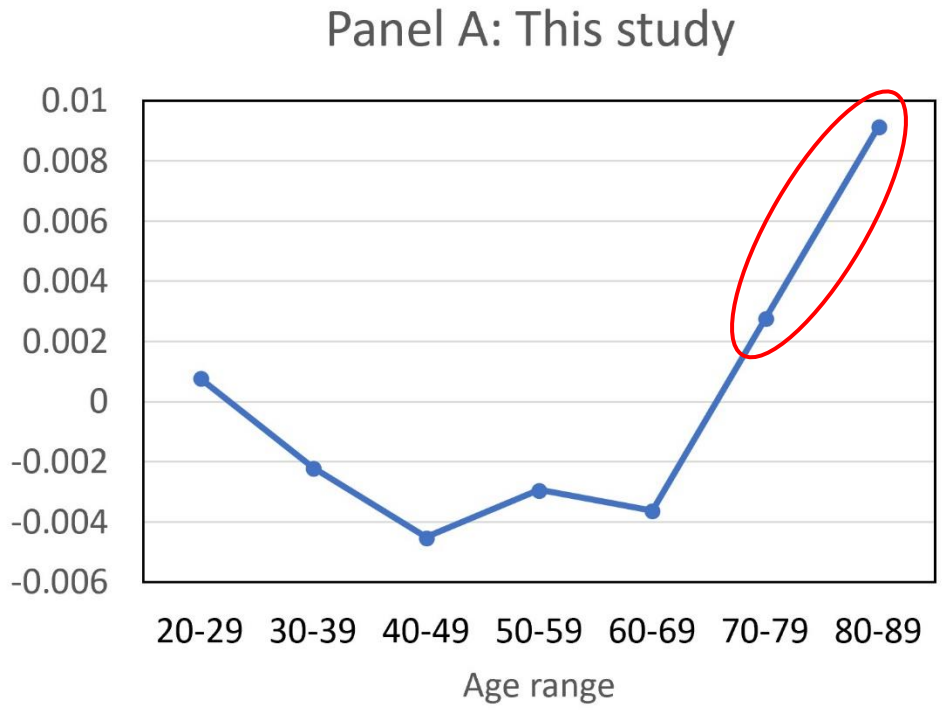
This study

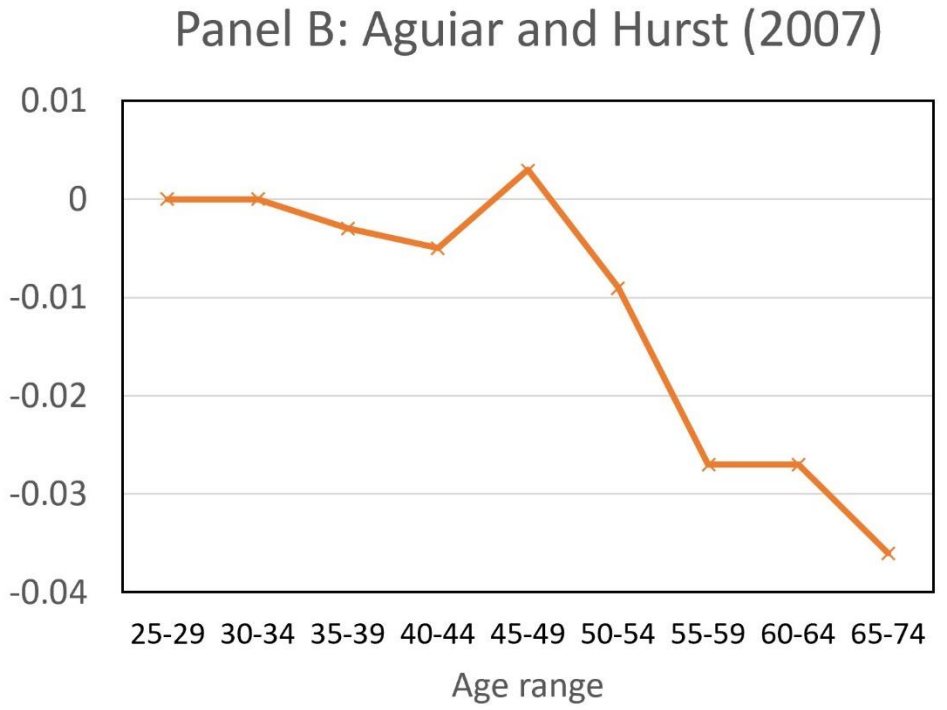
- Uses Japanese scanner data and examines prices paid by consumers across age groups.

- Main findings:
- **Heterogeneity**
  - Price level: older consumers pay higher prices for a given product than younger consumers.
  - Inflation: older consumers (around the retirement age) face lower inflation rate than working-age consumers.

- **Shopping behavior**
  - Inflation rates and the frequency of shopping trips have a negative correlation.

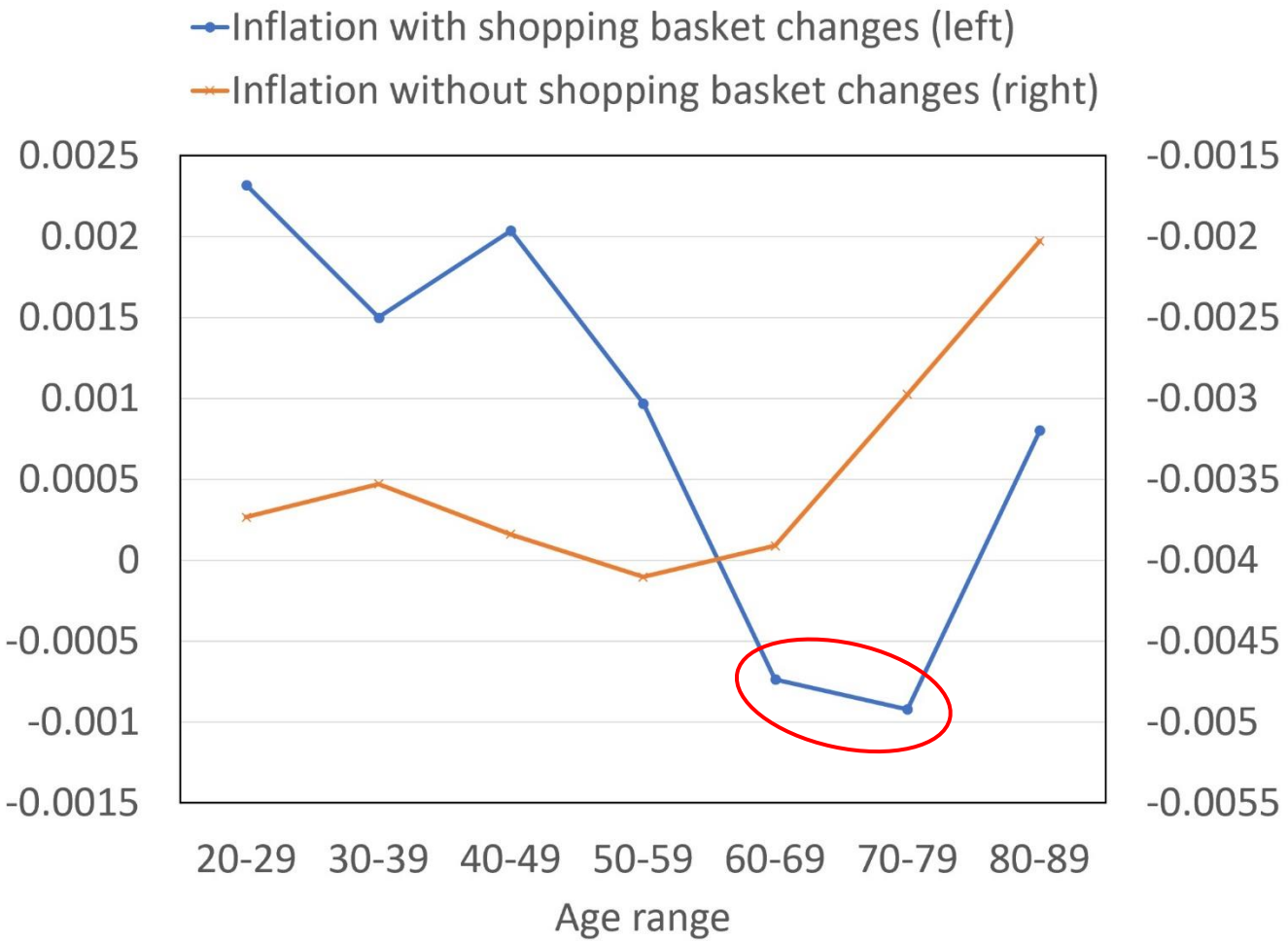
Finding I: Price level comparison





In Japan, older consumers pay higher prices for a given product than younger consumers. (opposite to the US)

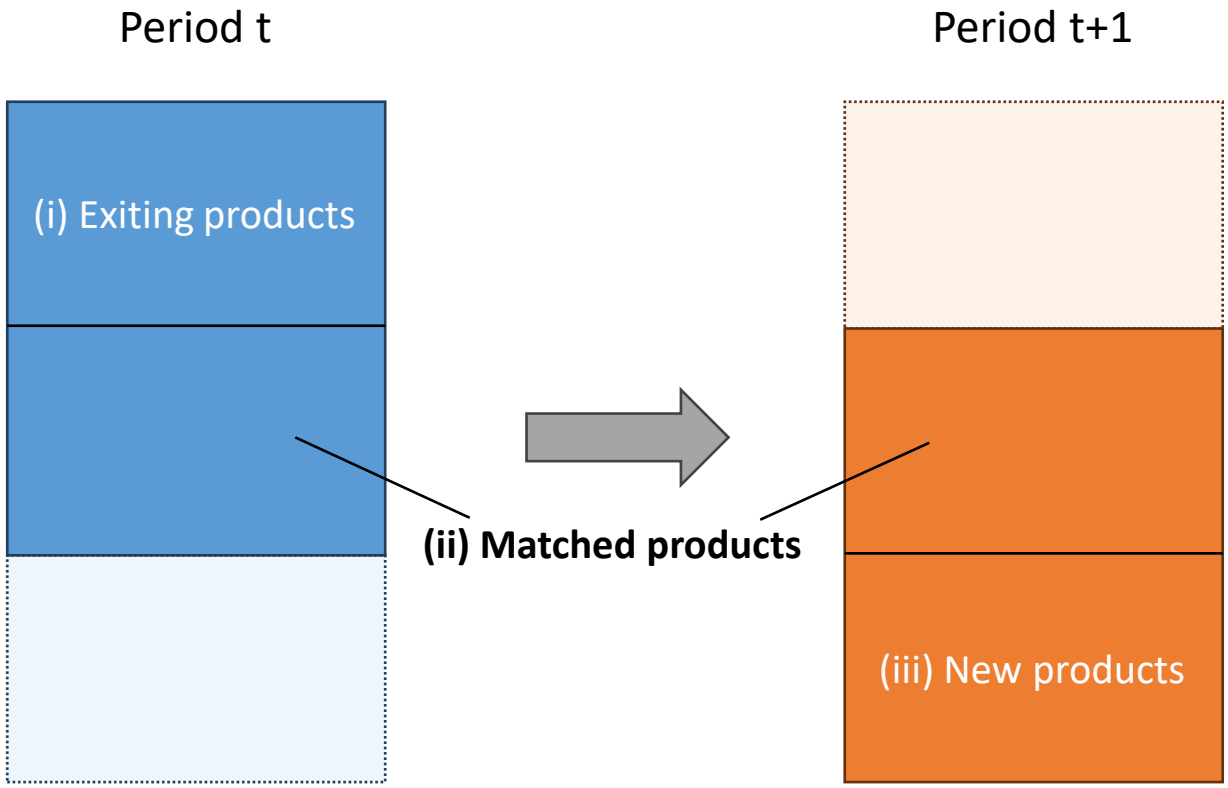
Finding II: Inflation inequality



Consumers around the retirement age face lower inflation rate than working-age consumers.

Contribution: Methodology

A consumer's shopping basket



Previous studies, such as Kaplan and Schulhofer-Wohl (2017), focus on matched products only. This study considers new and exiting products based on Feenstra's (1994) approach (assuming CES functional form).

Related Literature

- **Shopping behavior and prices paid** (through the allocation of time)
  - Becker (1965), Aguiar and Hurst (2005, 2007), Aguiar et al. (2013), Nevo and Wong (2019), Baker et al. (2021), Coibion et al. (2021)

- **Heterogeneity in price level and inflation**
  - Hobijn and Lagakos (2005), Hobijn et al. (2009), Aguiar and Hurst (2007), Kaplan and Menzio (2015), Kaplan and Schulhofer-Wohl (2017)

- **Japanese empirical studies using scanner data**
  - Abe and Shiotani (2014), Diamond et al. (2020)

Data (provided by Magee Co., Ltd.)

- Scanner data consist of daily purchasing records (prices and quantities) for each consumer & each product.
  - Sample **period**: Jan. 2012 to Dec. 2013
  - Sample **stores**: around 450 (supermarkets)
  - Sample **consumers**: 1,777,714 (No. of IDs)

  } Total no. of obs. 11,817,061

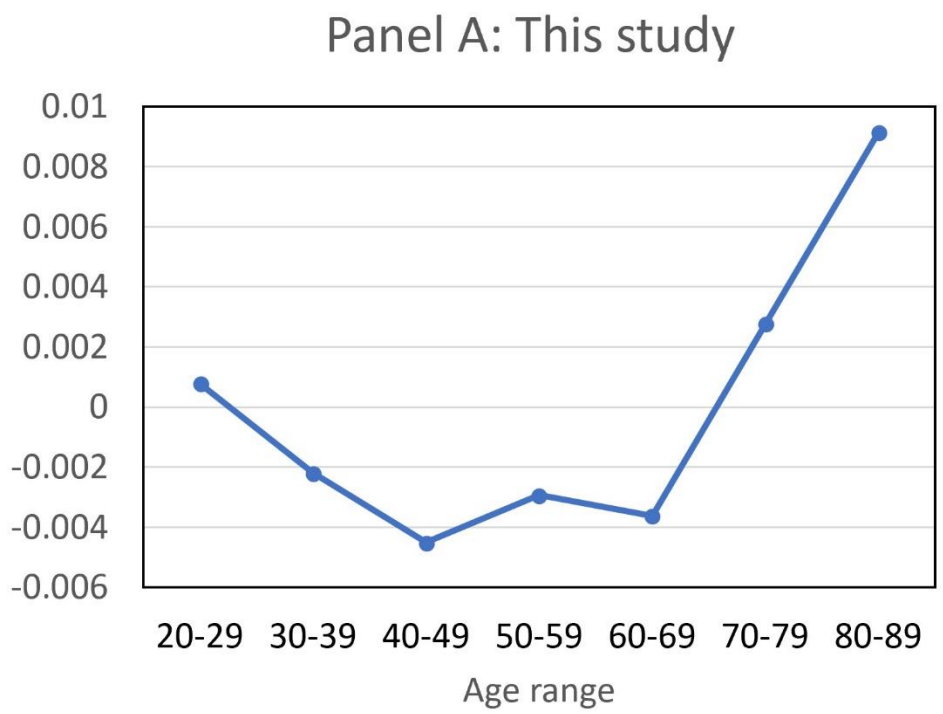
- Observation unit: consumer × store × month

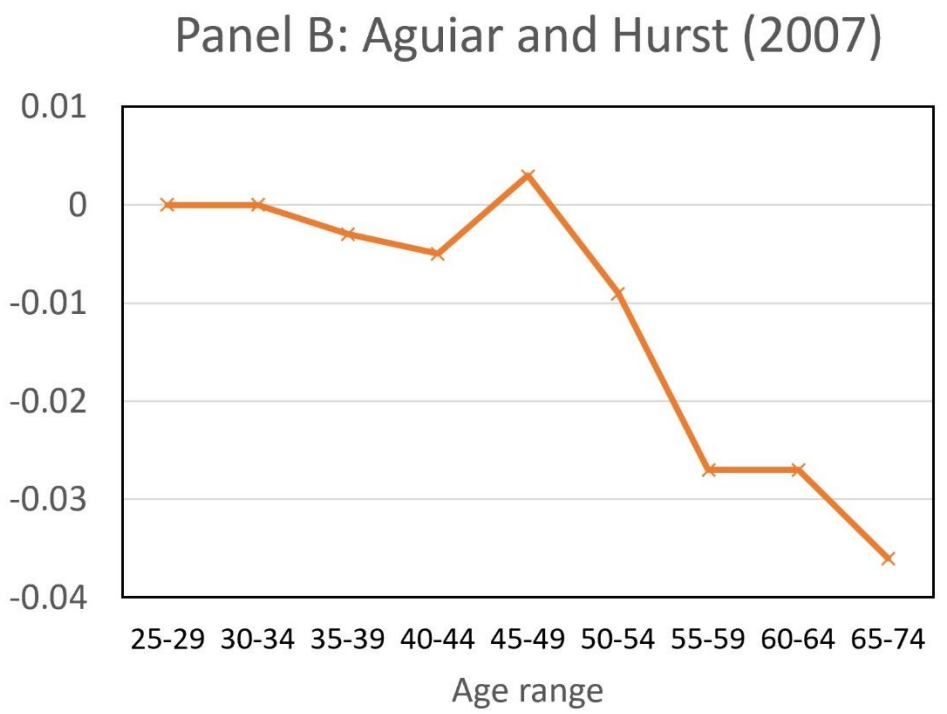
Year			2012		
Percentile	1	25	50	75	99
Expenditure (in yen)	509	3,961	7,911	14,463	46,151
Number of products	3	17	31	53	140
Shopping frequency	1	3	6	10	27
Age	25	44	56	67	85

Dispersion of consumer-level inflation rates
(for matched products only)

	Magee data	DWW (2020)	KS (2017)
Interquartile range			
Laspeyres	4.43	4.83	7.33
Fischer	4.38	4.87	7.13
Paasche	4.44	5.19	7.37
Törnqvist	4.40	4.78	
90th percentile minus 10th percentile			
Laspeyres	12.82	11.65	15.87
Fischer	12.58	11.91	15.32
Paasche	12.86	13.00	15.83
Törnqvist	12.62	11.41	
Sample period	2012–2013	2012–2014	2004–2013
Type of scanner data	Store	Household	Household

Cross-sectional price level comparison





Aguiar and Hurst's (2007) price index: $\boxed{\sum_i p_{i,s}^h q_{i,s}^h \,/\, \sum_i \bar{p}_{i,s} q_{i,s}^h}$

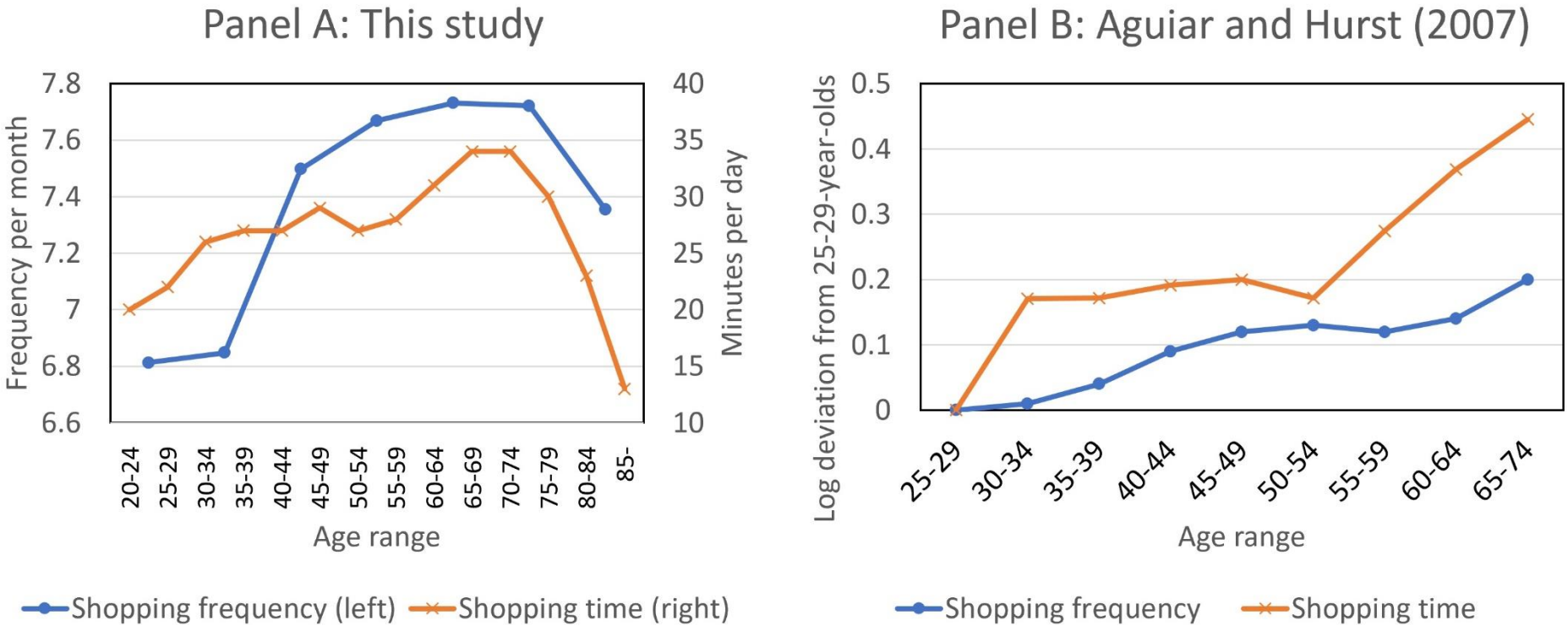
$p_{i,s}^h$: the price that consumer h pays for purchases of product i at store s

$q_{i,s}^h$: the quantity of product i purchased by consumer h at store s

$\bar{p}_{i,s}$: the average price of product i sold at store s

- This price index compares **the actual expenditure** of consumer h with **a hypothetical expenditure** to purchase the same basket of goods at the average price.

Shopping behavior across age groups



In Japan, shopping time is increasing over the life cycle (except consumers over 80).
Basically, the same pattern is observed for the US.
Puzzle: **High shopping intensity** but **high price levels** for older consumers in Japan

Calculation of individual inflation rates

- The cost-of-living index (COLI) denotes **the minimum cost needed to achieve a certain level of utility**. By assuming a CES functional form, the COLI is defined as:

$$C(p(t), I_t) = \left(\sum_{i \in I_t} c_i(t) \right)^{1/(1-\sigma)},$$

I_t: the set of goods purchased by the consumer in month t,
$c_i(t)$: the inverse of the cost incurred for good i in month t

$$c_i(t) = b_i p_i(t)^{1-\sigma},$$

$p_i(t)$: the price paid for good i in month t, σ: the elasticity of substitution,
b_i : the quality of good i (or preference for good i)

Under the CES functional form, we can use the following relationship, as shown by Feenstra (1994).

$$\frac{C(p(t), I_t)}{C(p(t-12), I_{t-12})} = \frac{\left[\sum_{i \in I_t} c_i(t)\right]^{1/(1-\sigma)}}{\left[\sum_{i \in I_{t-12}} c_i(t-12)\right]^{1/(1-\sigma)}}$$

$$= \left[\frac{\sum_{i \in I_t} c_i(t)}{\sum_{i \in I_{t-12} \cap I_t} c_i(t)} \times \frac{\sum_{i \in I_{t-12} \cap I_t} c_i(t)}{\sum_{i \in I_{t-12} \cap I_t} c_i(t-12)} \times \frac{\sum_{i \in I_{t-12} \cap I_t} c_i(t-12)}{\sum_{i \in I_{t-12}} c_i(t-12)}\right]^{1/(1-\sigma)}$$

$$= \left[\frac{\sum_{i \in I_t} p_i(t) q_i(t)}{\sum_{i \in I_{t-12} \cap I_t} p_i(t) q_i(t)} \times \frac{\sum_{i \in I_{t-12} \cap I_t} c_i(t)}{\sum_{i \in I_{t-12} \cap I_t} c_i(t-12)} \times \frac{\sum_{i \in I_{t-12} \cap I_t} p_i(t-12) q_i(t-12)}{\sum_{i \in I_{t-12}} p_i(t-12) q_i(t-12)}\right]^{1/(1-\sigma)}$$

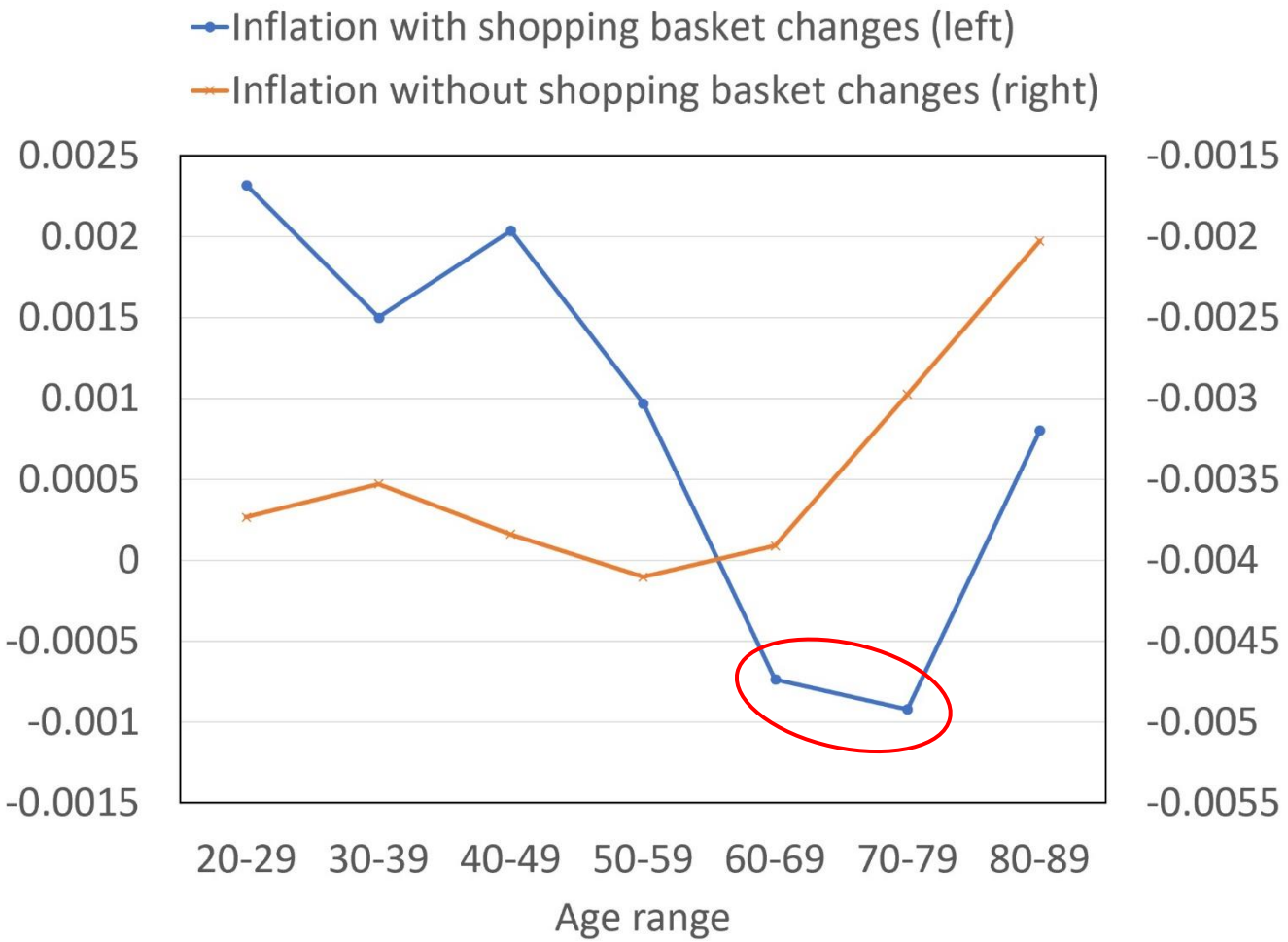
The contribution of new products

Matched products

The contribution of exiting products

For the second term, I use the Tornqvist weight to calculate the inflation rate, which is a good approximation of COLI (shown by Diewert, 1976).

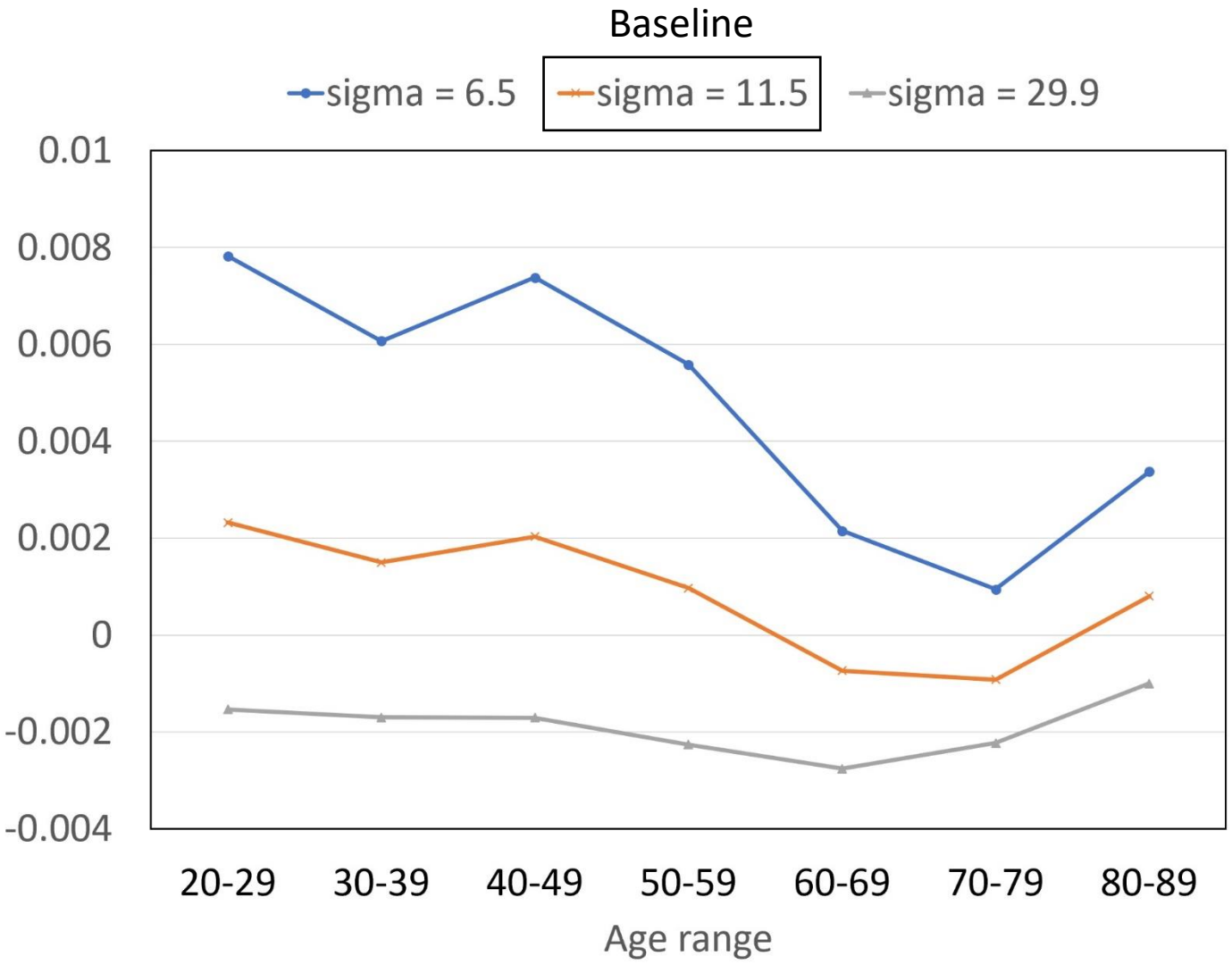
Results



Consumers around the retirement age face lower inflation rate than working-age consumers.

➢ The contribution of **shopping basket changes** is large.

Using different values for σ



Statistical test of inflation differences

Regressors	ln(Inflation rate)			
	With basket changes		Without basket changes	
	(1)	(2)	(3)	(4)
Age 30–39	−0.0010	−0.0006	0.0001	0.0000
	(0.0003)	(0.0003)	(0.0002)	(0.0002)
Age 40–49	−0.0004	0.0002	−0.0003	−0.0002
	(0.0003)	(0.0003)	(0.0002)	(0.0002)
Age 50–59	−0.0015	−0.0012	−0.0005	−0.0006
	(0.0003)	(0.0003)	(0.0002)	(0.0002)
Age 60–69	−0.0032	−0.0033	−0.0003	−0.0006
	(0.0003)	(0.0003)	(0.0002)	(0.0002)
Age 70–79	−0.0034	−0.0038	0.0005	0.0002
	(0.0003)	(0.0003)	(0.0002)	(0.0002)
Age 80–89	−0.0018	−0.0024	0.0013	0.0011
	(0.0004)	(0.0004)	(0.0003)	(0.0003)
Include controls for shopping needs	No	Yes	No	Yes

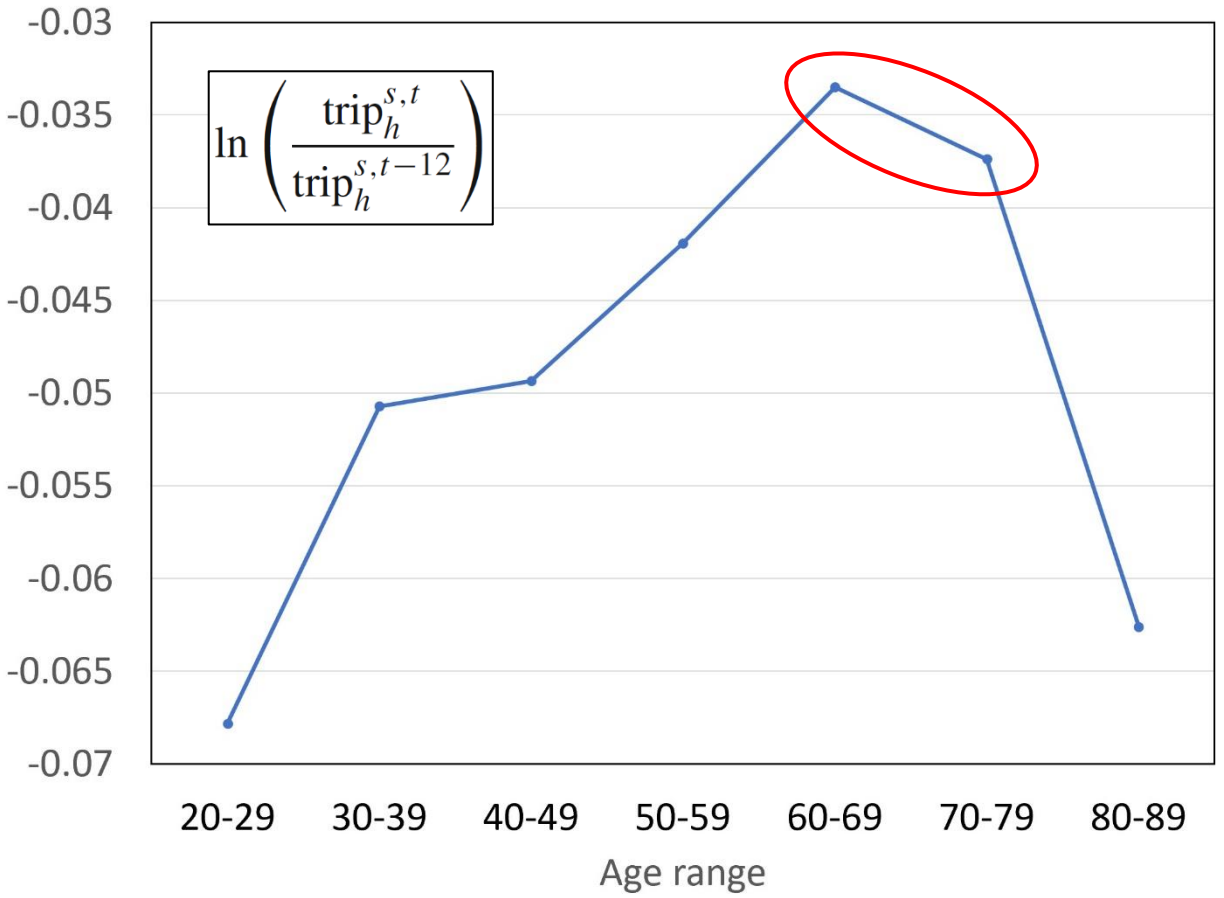
Quantifying the impact of shopping behavior

$$\underbrace{\pi_h^{s,t}}_{\text{Log inflation rate}} = \beta_0 + \beta_{\text{trip}} \underbrace{\ln\left(\frac{\text{trip}_h^{s,t}}{\text{trip}_h^{s,t-12}}\right)}_{\text{Change in the shopping frequency}} + \sum_{k=1}^{K} \beta_k \underbrace{X_{k,h}^{s,t}}_{\text{Control variables}} + \epsilon_h^{s,t},$$

- Aguiar and Hurst (2007) tried a similar estimation (for **the price level**).
- We use the age-category dummies as the instrument set. (Assumption: the opportunity cost of time varies across age groups, which in turn affects their shopping behavior)
- Control variables: the number of items and the number of product categories

	(1)	(2)	(3)	(4)
Estimated elasticity: β_{trip}	−0.069	−0.120	−0.001	−0.027
	(0.000)	(0.005)	(0.000)	(0.004)
Include basket changes	Yes	Yes	No	No
Regression type	OLS	IV	OLS	IV

- Frequency of shopping trips has a negative impact on the individual inflation rates.
- Changes in the frequency of shopping trips are higher for consumers aged 60-79.
- (Interpretation: retired consumers tend to increase shopping frequency)



Conclusion

- This study used 1.7 million consumers' purchasing records and examined heterogeneity in price levels and inflation rates across age groups.

➢ Finding I: older consumers pay higher prices for a given product than younger consumers.

➢ Finding II: consumers around the retirement age face the lower inflation rate than working-age consumers.

➢ Finding III: the frequency of shopping trips has a negative impact on the individual inflation rate.

Some updates based on post-pandemic data

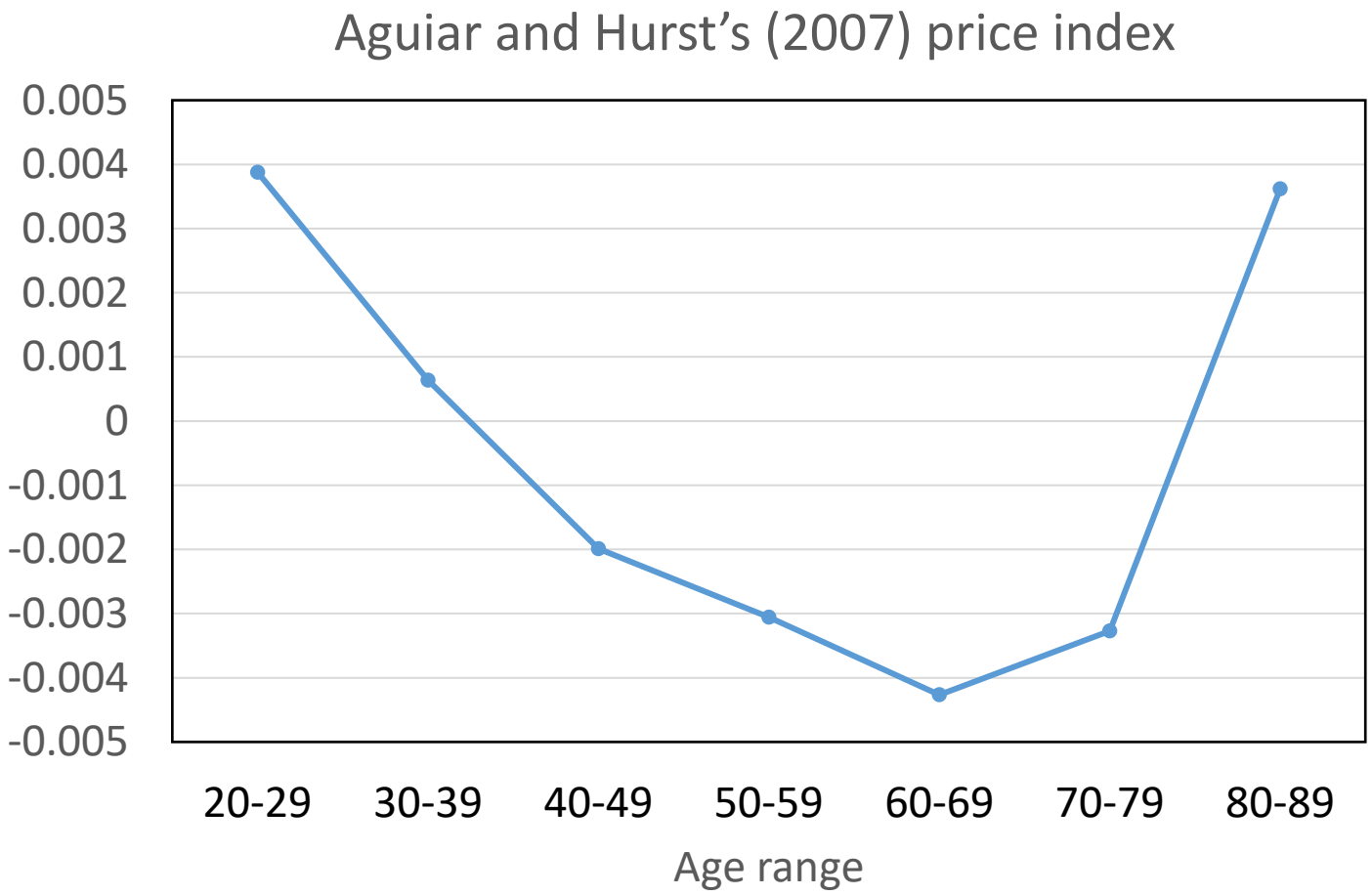
Note that the results are very preliminary.

Updated data

- Sample **period**: April 2021 to March 2023
- Sample **stores**: 303
- Sample **consumers**: 815,174

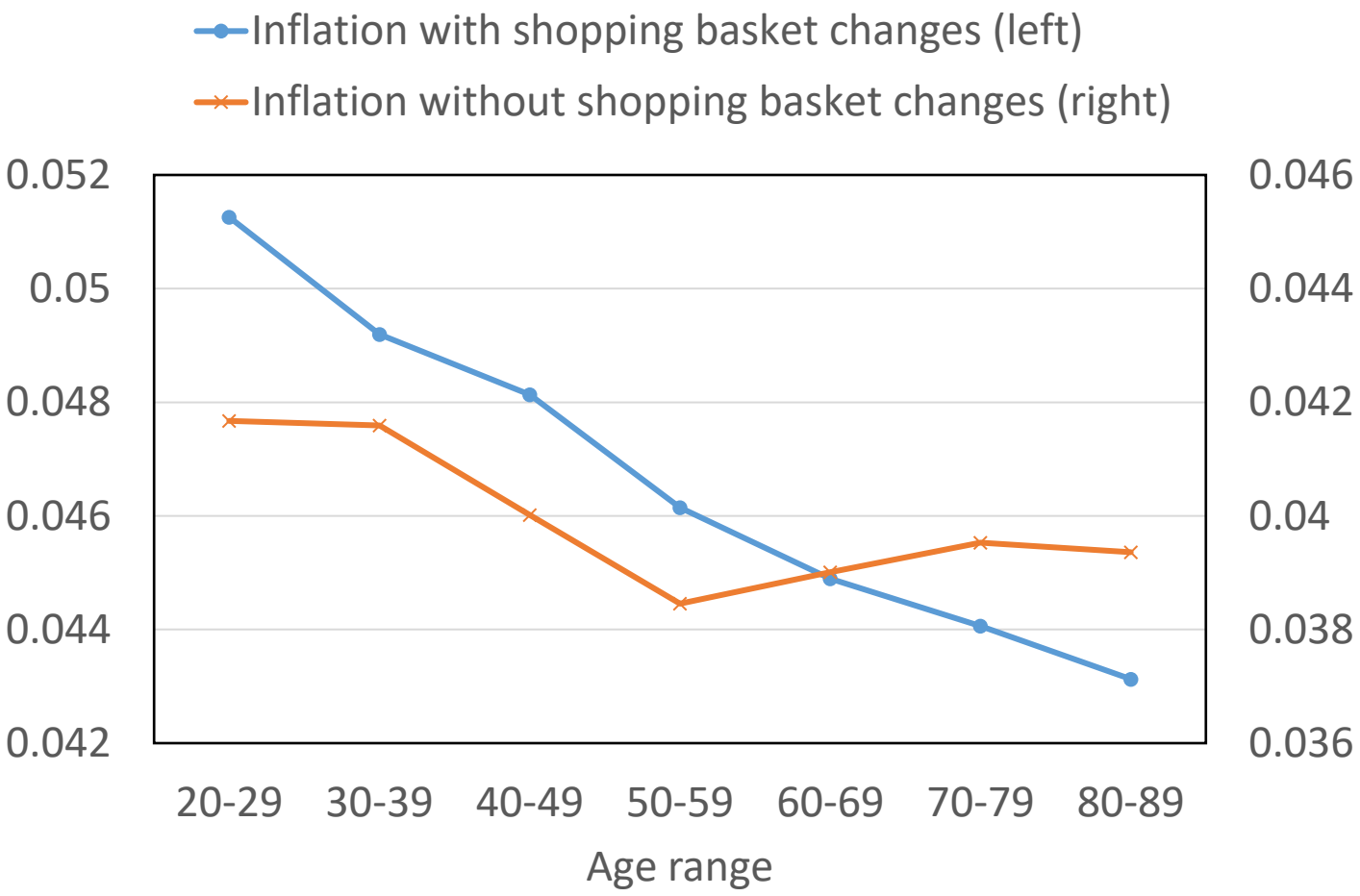
➢ Total no. of observations: 5,292,850

Result I: Price level comparison



For the post-pandemic period, middle-aged consumers face lower prices than both younger and older consumers.

Result II: Inflation inequality



Inflation rates with shopping basket changes decline monotonically over the life cycle.