Inflation at the Household Level

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Overview

- We estimate inflation rates household by household.
- Lots of heterogeneity: interquartile range of annual rates varies between 6.2 and 9.0 percentage points.
  - When aggregate inflation is 2%, at least half of households have inflation rates above 5% or below -1%.
- Sources of heterogeneity:
  - Different weights on broad consumption categories. **(small)**
  - Different product choices within categories. **(big, new)**
  - Different prices for identical products. **(big, new)**
- Aggregate inflation accounts for less than 1/10 of variability in household inflation over time.

Outline

- Data and inflation calculations.
- Cross-sectional properties of household inflation.
- Time-series properties of household inflation.

Data and calculations

Data

- Kilts-Nielsen Consumer Panel (KNCP).
- Panel of 50,000 households, replenished for attrition.
- Consumption of **goods with barcodes**.
- Each shopping trip (including online shopping):
  record barcode and price of each item purchased.
  - Price = average at store for the week if Nielsen covers store.
  - Otherwise, household records price.

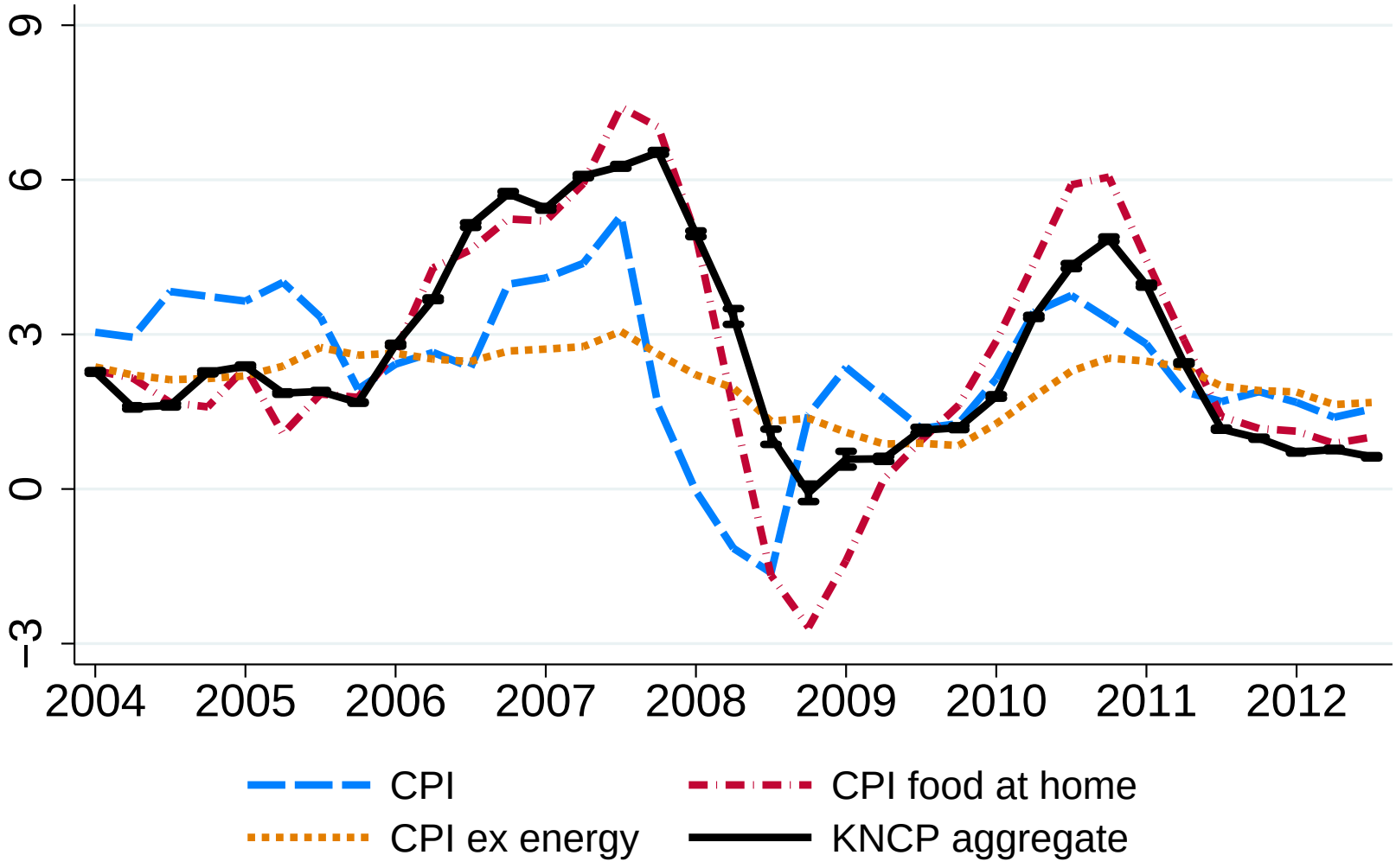
Estimating household inflation rates

- Need to
  - Define household-level consumption bundles.
  - Measure change in *household's price* for each good between two dates $\Rightarrow$ must see household buy good at both dates.
- Aggregate purchases to quarterly frequency.
- To remove (most) seasonality, compare two quarters one year apart.
- Exclude product if household's price changes by factor > 3.
- Exclude households with < 5 matched barcodes.
  - 77% of HH that buy something at t also buy something at $t + 4$, 72% at least 5 matched barcodes.

Distribution of spending (%)

		KNCP	
	CPI-U	all spending	5+ matched barcodes
Food and beverages	15.26	61.22	74.38
Food	14.31	58.08	67.61
Food at home	8.60	53.87	64.77
Food away from home	5.71	4.22	2.83
Alcoholic beverages	0.95	3.13	6.78
Housing	41.02	9.03	5.11
Apparel	3.56	8.40	-
Transportation	16.85	0.22	0.14
Medical care	7.16	6.92	4.85
Recreation	5.99	6.57	5.85
Education and communication	6.78	-	-
Other	3.38	7.64	9.67
Tobacco and smoking products	0.81	1.87	6.46

Inflation rates with CPI vs. KNCP bundles



All indexes use CPI prices.

Four ways to construct household inflation indexes

- **Household-level prices:**
  - Household's consumption bundle at barcode level.
  - Household's price paid for each barcode.
- **Barcode-average prices:**
  - Household's consumption bundle at barcode level.
  - National average price paid for each barcode.
- **CPI prices:**
  - Household's consumption bundle at level of broad categories.
  - Item stratum price indexes from CPI.
  - Comparable to previous literature.
- **Shopping-trip prices (in progress):**
  - Price when household shopped, whether it bought UPC or not.

Household inflation indexes

- Notation: household i, UPC j, date t.
- Laspeyres with household-level prices:

$$\pi^{L}_{it,t+4} = \frac{\sum_{j:\ q_{ijt},q_{ij,t+4}>0} q_{ijt}p_{ij,t+4}}{\sum_{j:\ q_{ijt},q_{ij,t+4}>0} q_{ijt}p_{ijt}}$$

- Laspeyres with barcode-average prices:

$$\pi^{L,BC}_{it,t+4} = \frac{\sum_{j:\ q_{ijt},q_{ij,t+4}>0} q_{ijt}\bar{p}_{j,t+4}}{\sum_{j:\ q_{ijt},q_{ij,t+4}>0} q_{ijt}\bar{p}_{jt}}$$

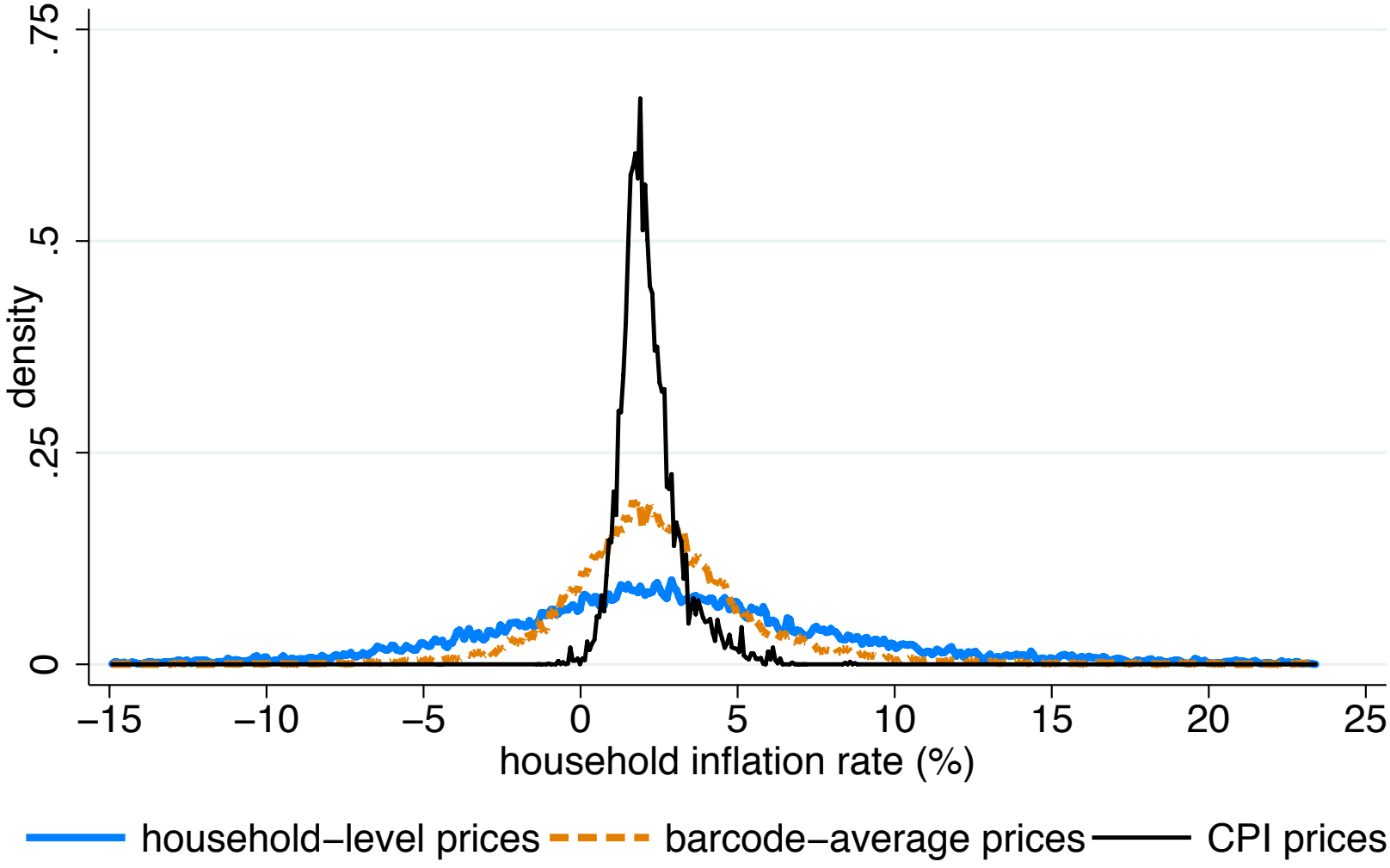
- Laspeyres with CPI prices:

$$\pi^{L,CPI}_{it,t+4} = \sum_{j:\ q_{ijt},q_{ij,t+4}>0} s^{L}_{ijt,t+4}\ (p^{CPI}_{k(j),t+4}/p^{CPI}_{k(j),t})$$

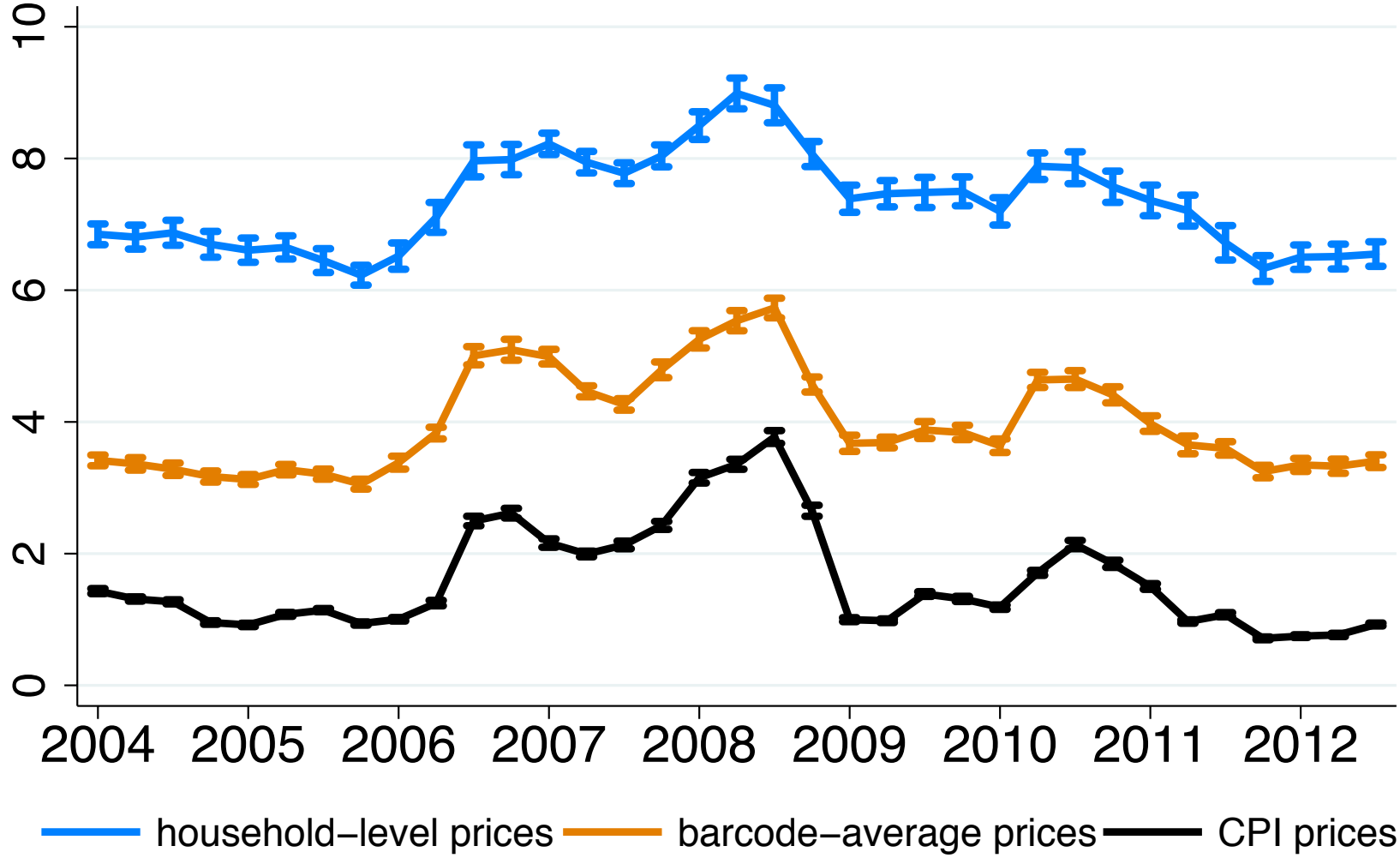
$k(j)$: CPI item stratum, s^{L}_{j}: initial budget share of UPC j.

Cross-sectional properties of household inflation

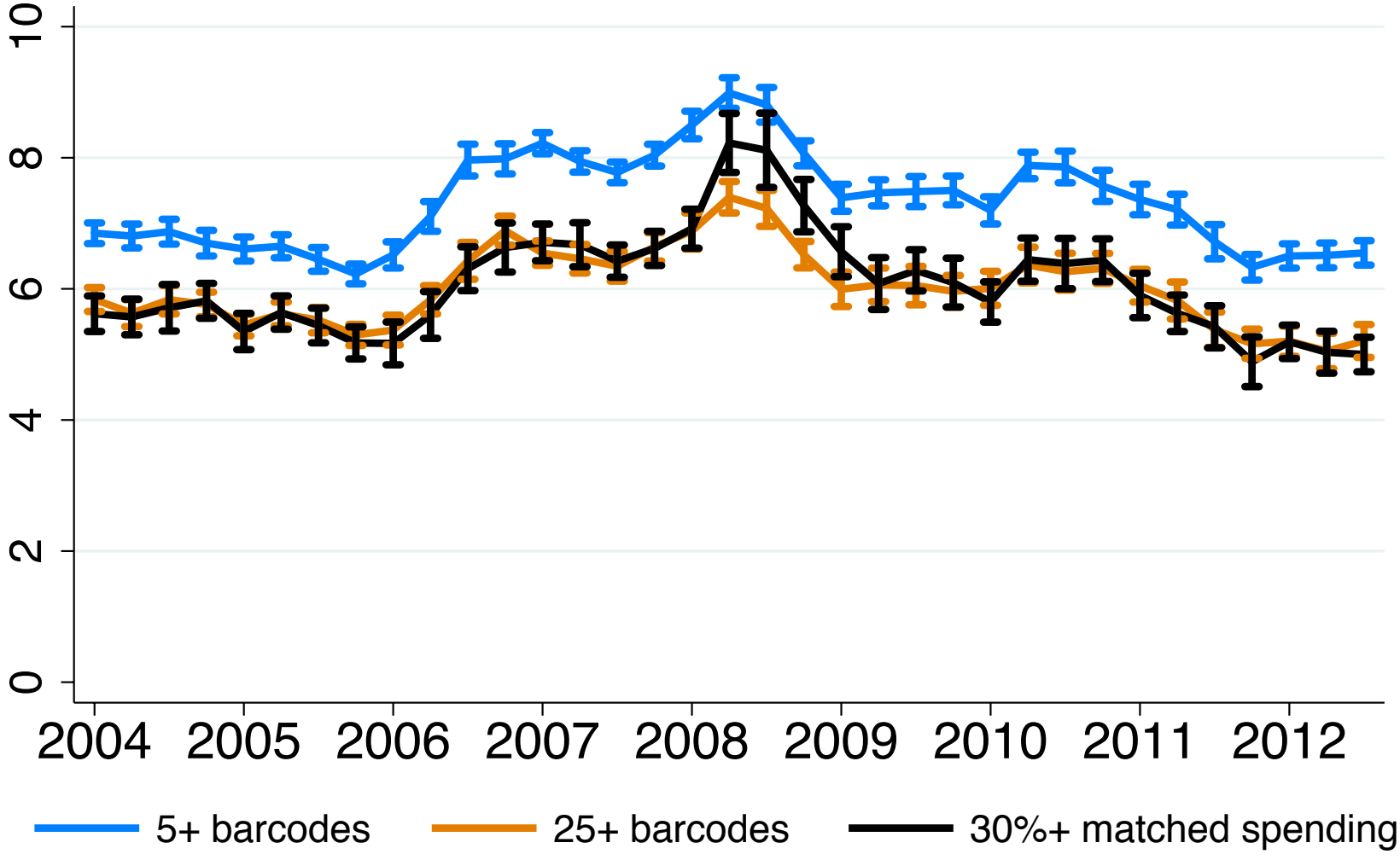
Inflation distribution, 2004q4–2005q4



Interquartile range of inflation rates

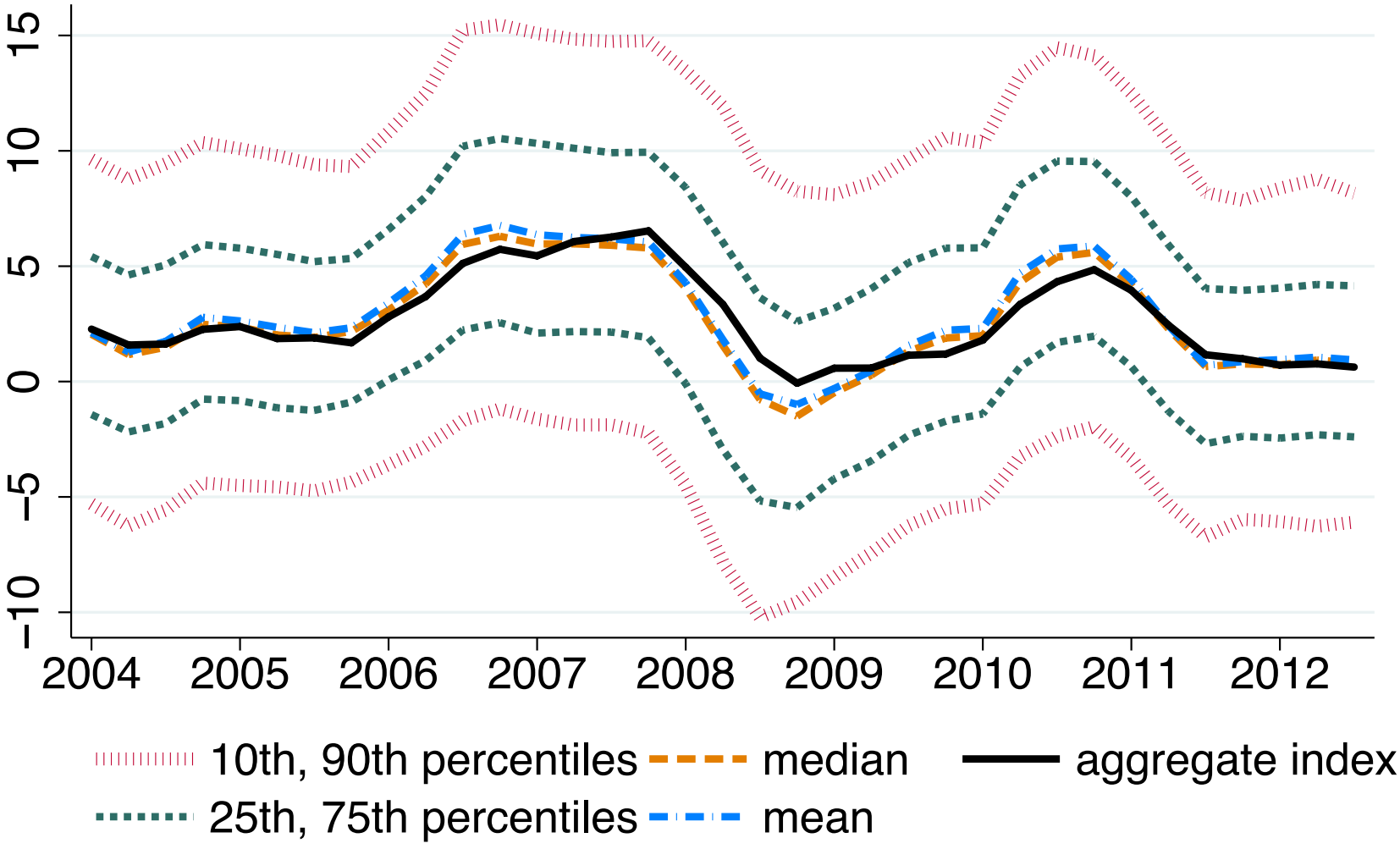


Bundles with few UPCs don’t drive dispersion

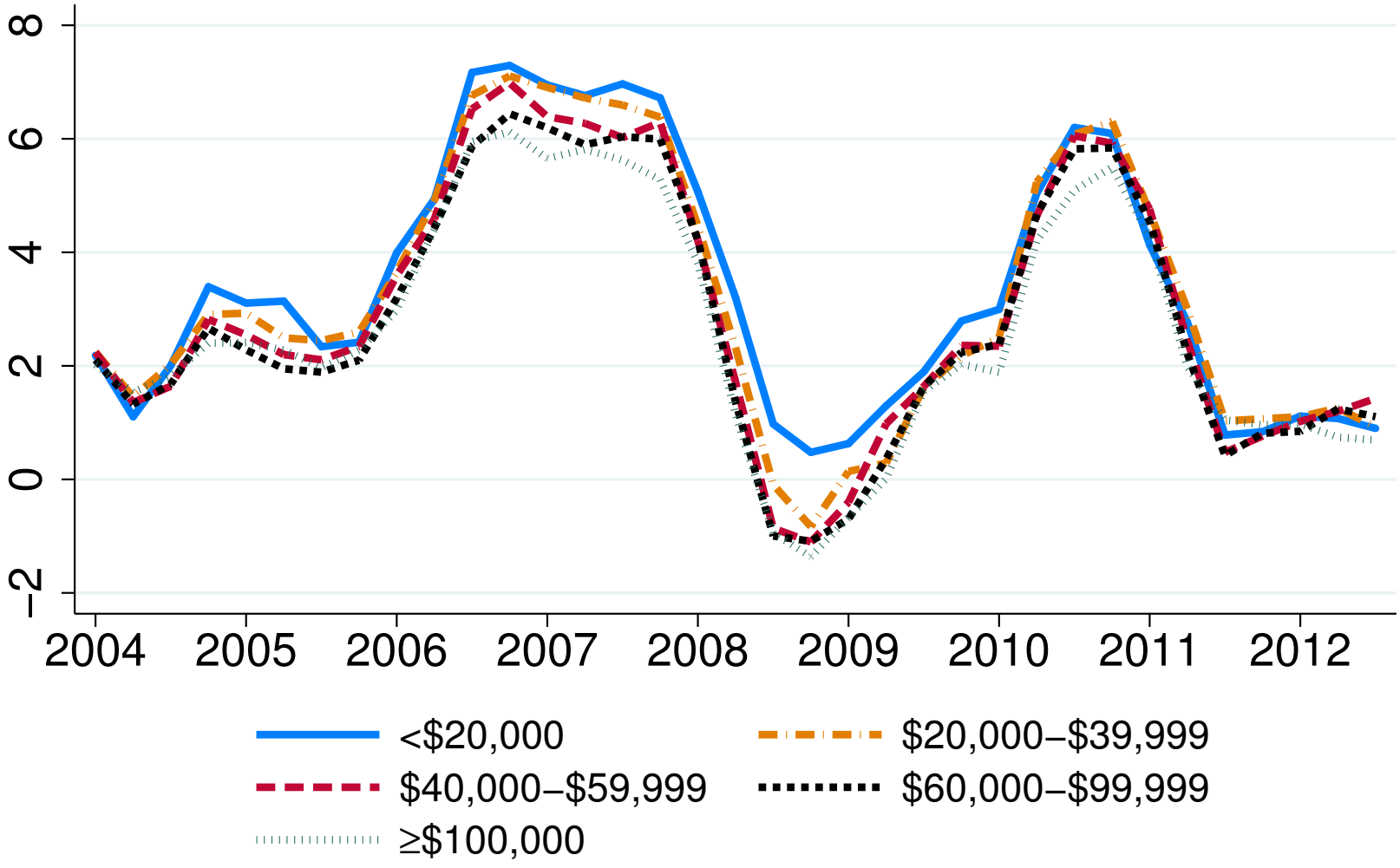


IQR with household-level prices

Evolution of the inflation distribution



Low-income households usually have higher inflation rates



How much heterogeneity do demographics explain?

- OLS and quantile regressions of $\pi^{L}_{it,t+4} - \pi^{L,CPI}_{t,t+4}$ on large vector of demographics:
  - Household income
  - Age of head(s)
  - Education of head(s)
  - Region
  - Household size and composition
  - Race
- Control for time dummies.
- 835,386 household-quarter observations.
- Most variance remains unexplained:
  - OLS R^2, time dummies only: 0.009
  - OLS R^2, time dummies plus all demographics: 0.012

Inflation vs. income and education

	household π - aggregate π					
	(1) OLS		(2) Median		(3) IQR	
	coeff.	std. err.	coeff.	std. err.	coeff.	std. err.
household income						
$<$\$20,000	-	-	-	-	-	-
\$20,000–\$39,999	-0.206	(0.055)	-0.126	(0.039)	-0.399	(0.079)
\$40,000–\$59,999	-0.420	(0.052)	-0.257	(0.041)	-0.597	(0.085)
\$60,000–\$99,999	-0.587	(0.059)	-0.468	(0.045)	-0.706	(0.086)
$\geq$\$100,000	-0.731	(0.065)	-0.597	(0.050)	-0.873	(0.096)
highest education of household head(s)						
$<$ high school	-	-	-	-	-	-
high school diploma	-0.064	(0.127)	-0.029	(0.108)	-0.280	(0.167)
some college	-0.138	(0.127)	-0.102	(0.107)	-0.118	(0.165)
bachelor's degree	-0.251	(0.128)	-0.163	(0.110)	-0.099	(0.180)
graduate degree	-0.285	(0.139)	-0.137	(0.118)	0.024	(0.185)

Other controls: age, region, HH size/composition, race, time dummies

Search theory: bargain hunting

- Equilibrium models of search and price dispersion hold that households pay lower prices when they observe more prices.

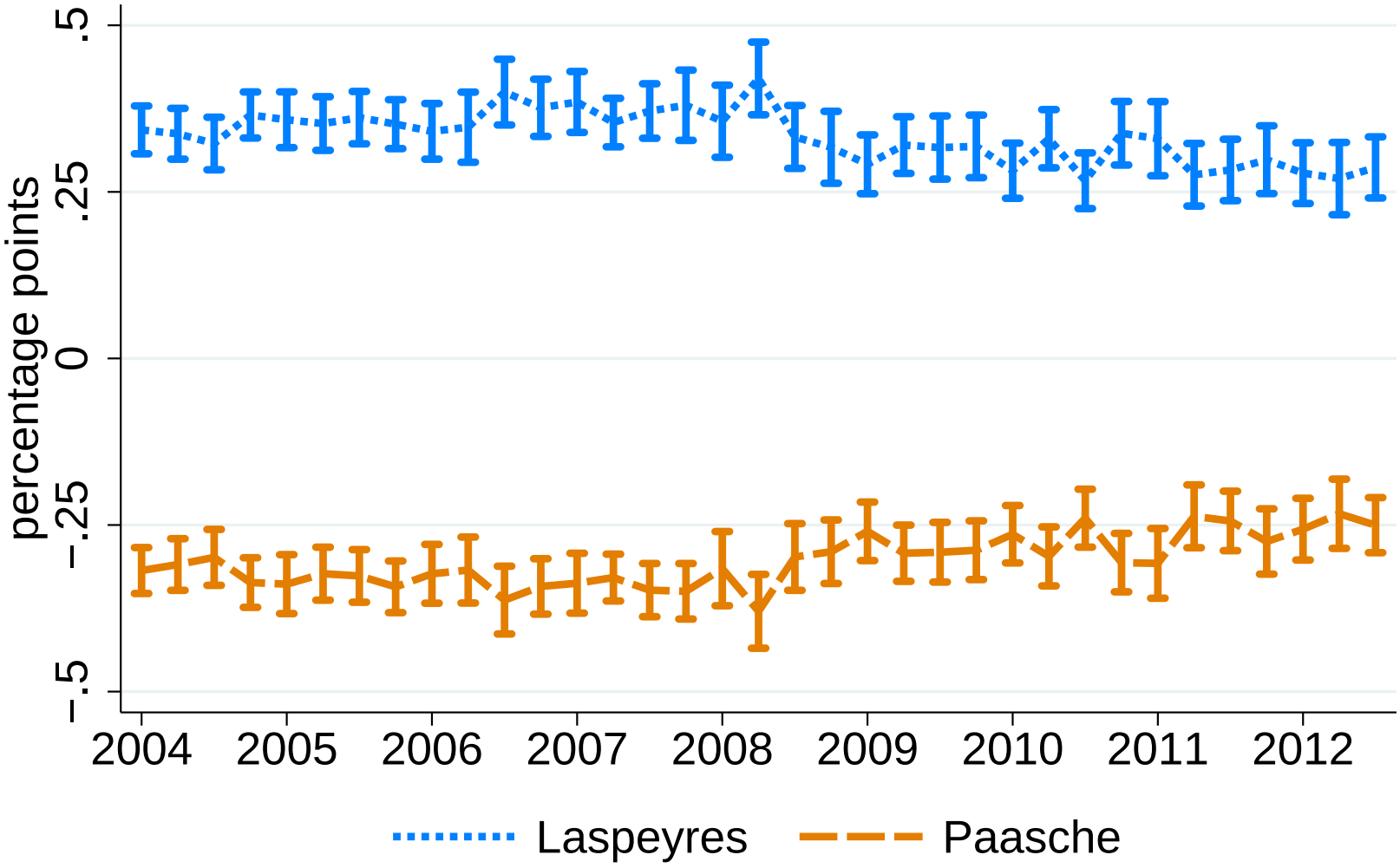
	household π - aggregate π			
	(1) Median		(2) IQR	
	coeff.	std. err.	coeff.	std. err.
log(# of shopping trips)				
initial quarter	0.352	(0.042)	-0.194	(0.047)
final quarter	-0.409	(0.038)	-0.506	(0.049)
+ demographic controls & time dummies				

- Coefficients imply that households who make more shopping trips pay lower prices and have less-dispersed inflation rates.

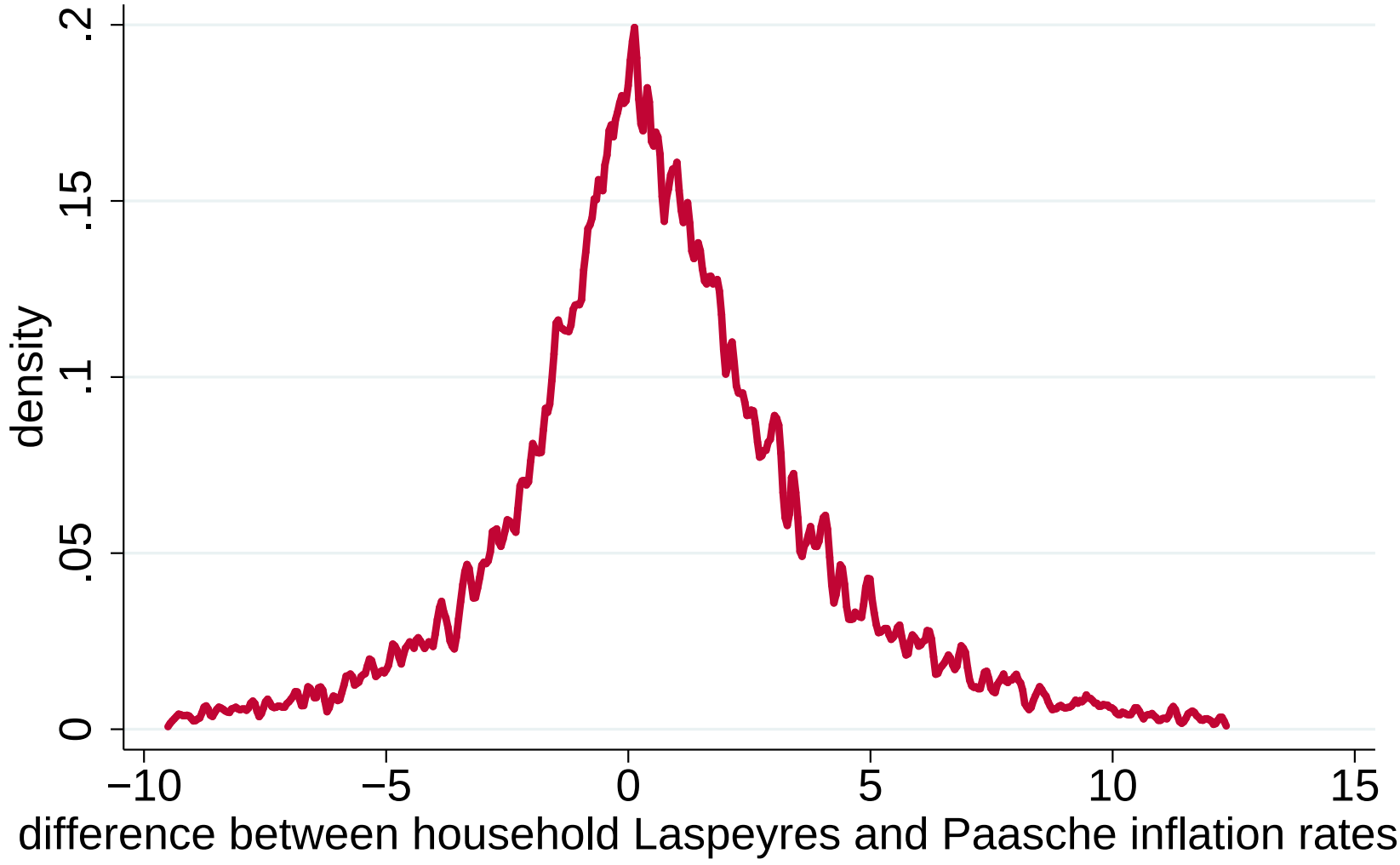
Demand theory: substitution between goods

- As prices change, households should substitute toward goods whose relative prices have fallen.
- Implies $\pi^L > \pi^F > \pi^P$ because Laspeyres uses initial-period bundle and Paasche uses final-period bundle.
- $\pi^L - \pi^F$ = substitution bias.
  - Boskin Commission: 0.4 percentage point in aggregate CPI.
- What are the substitution patterns in KNCP data?

Mean differences from Fisher index



Laspeyres vs. Paasche inflation rates, 2004q4–2005q4



Intertemporal choice: do households buy more when they face a lower price level?

- Growth rate of spending:

$$\ln x_{i,t+4} - \ln x_{it} = \ln \pi_{it,t+4} + \ln q_{i,t+4} - \ln q_{it}$$

  $\Rightarrow$ recover quantity index $\Delta \ln q$ given spending x and inflation π.

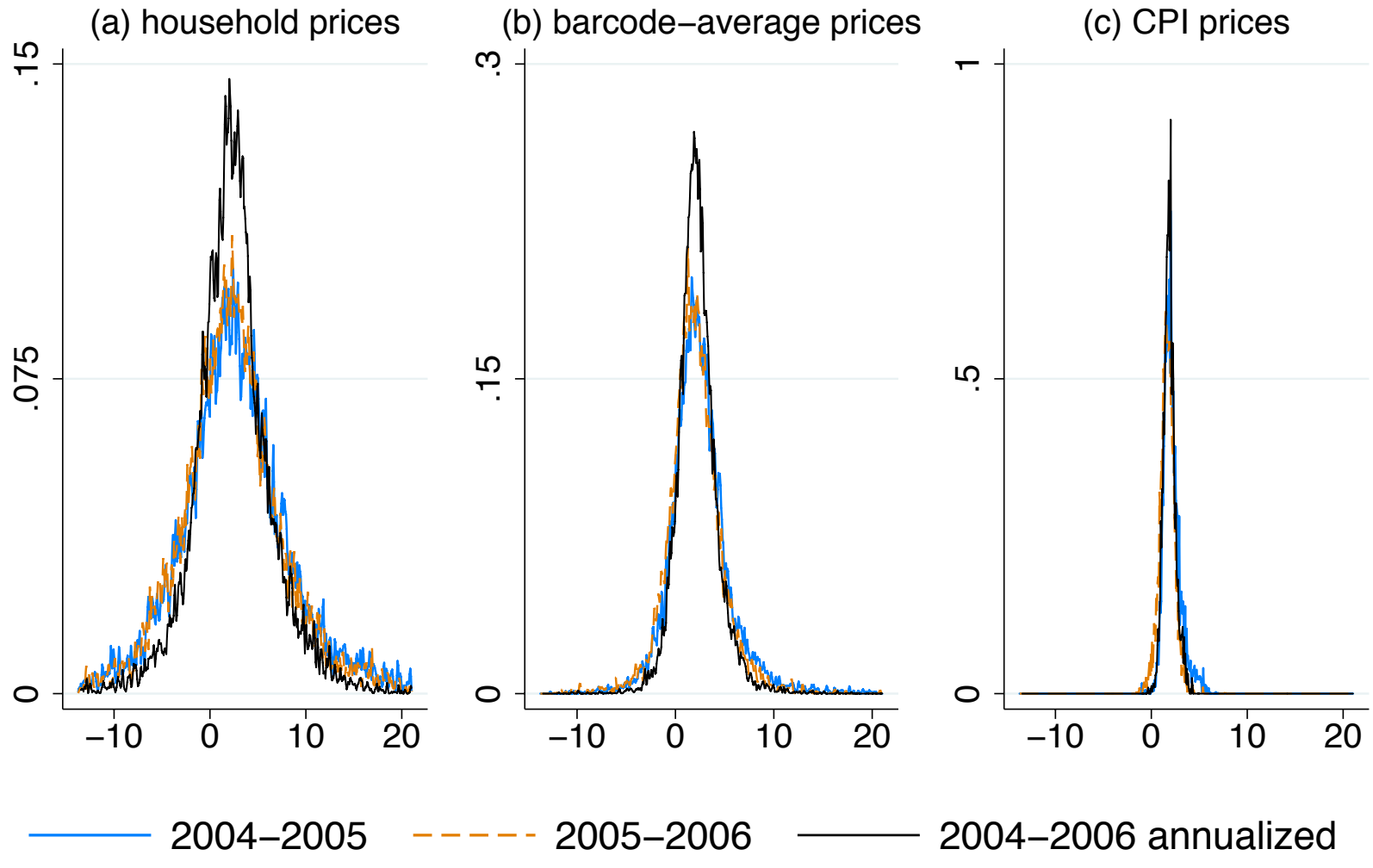
- Variance decomposition (on average across quarters):

$\mathrm{Var}(\ln \pi_{it,t+4})$	0.007
$+\mathrm{Var}(\ln q_{i,t+4} - \ln q_{it})$	0.113
$+\mathbf{2Cov}(\ln \pi_{it,t+4}, \ln q_{i,t+4} - \ln q_{it})$	**-0.004**
$= \mathrm{Var}(\ln x_{i,t+4} - \ln x_{it})$	0.116

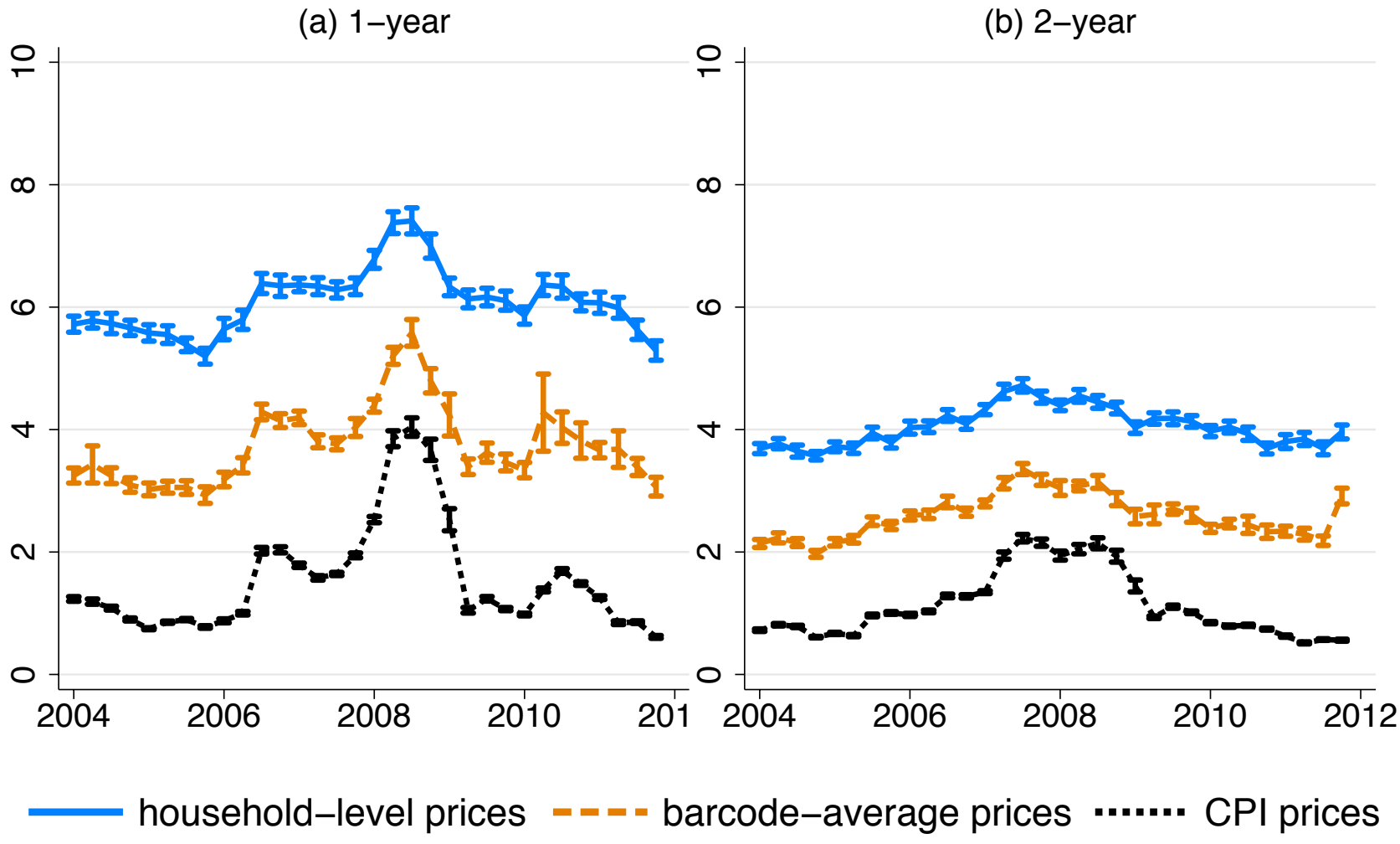
- In a structural model, could recover EIS from this covariance.

Time-series properties of household inflation

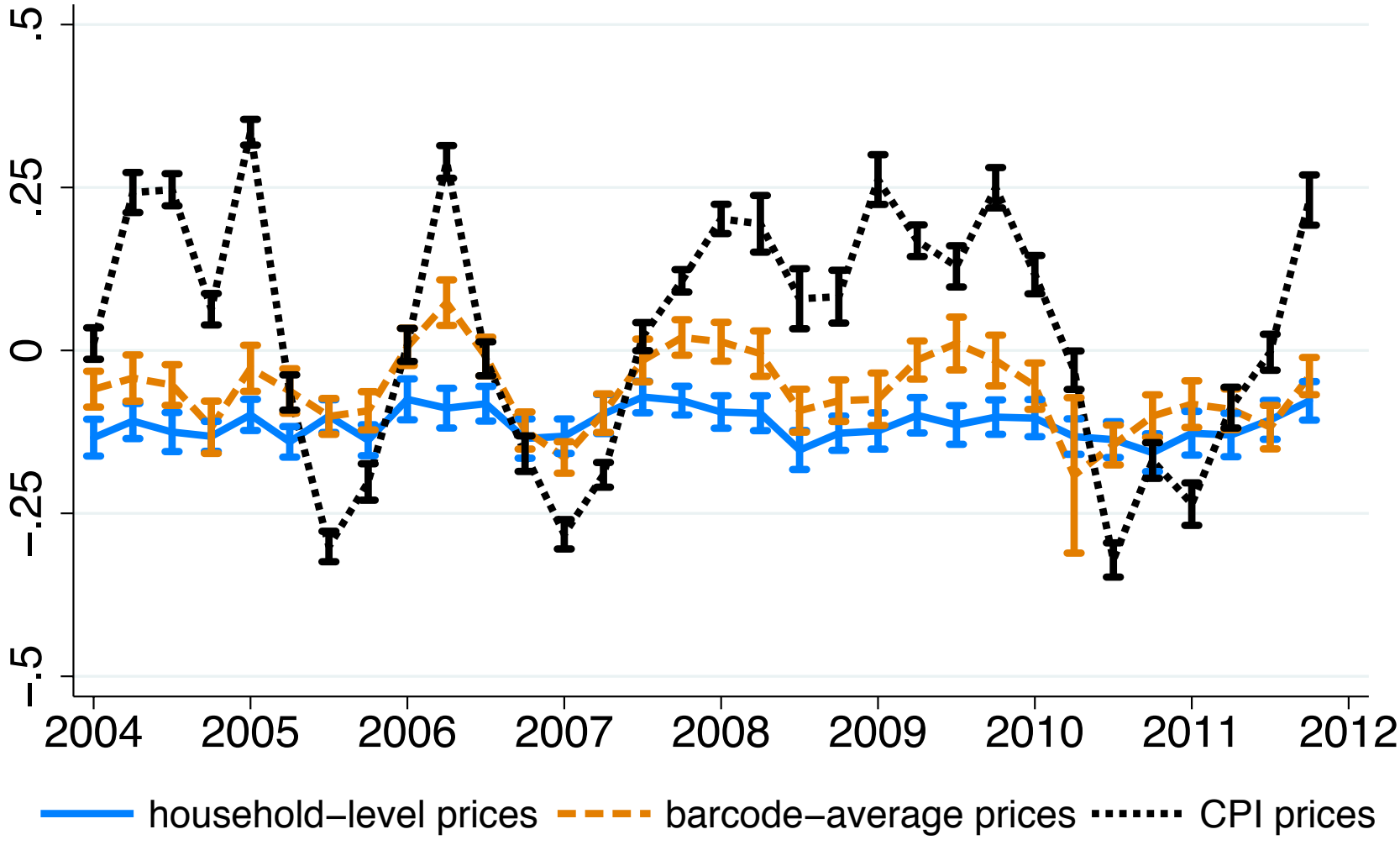
Distribution of 1- and 2-year inflation rates



Standard deviations of inflation rates



Serial correlation of 1-year inflation rates



A simple model of the stochastic process

- Log deviation of HH price level from aggregate: FE plus AR(1)

$$\log P_{it} - \log P_t = \mu_i + z_{it}$$
$$z_{it} = \rho z_{i,t-4} + \epsilon_{it}$$

- Assume initial conditions from ergodic distribution. Then

$$\rho = 1 + 2\text{Corr}(\pi_{it}, \pi_{i,t-1})$$

$$\textbf{Corr}(\pi_{it}, \pi_{i,t-1}) = -0.1 \quad \Rightarrow \quad \rho = 0.8$$

- Variance decomposition of π_{it}:
  - Cross-sectional s.d. of π_{it}: 6.2 percentage points.
  - Time-series s.d. of aggregate π: 1.9 percentage points.
  - $\Rightarrow$ 91% of variance of π_{it} comes from heterogeneity.

Conclusion

Implications

- Household inflation rates are highly heterogeneous.
- Household price levels deviate persistently from aggregate price level.
- Could use results to calibrate models of individual inference about aggregate inflation.
  - Lucas 1972, Angeletos/La'O 2009, . . .
  - Shopping-trip prices may be helpful here.
- Challenges for monetary economics:
  - Welfare with heterogeneous inflation rates?
  - Heterogeneous real interest rates for given nominal interest rate?
  - How well can households forecast their own inflation rates?

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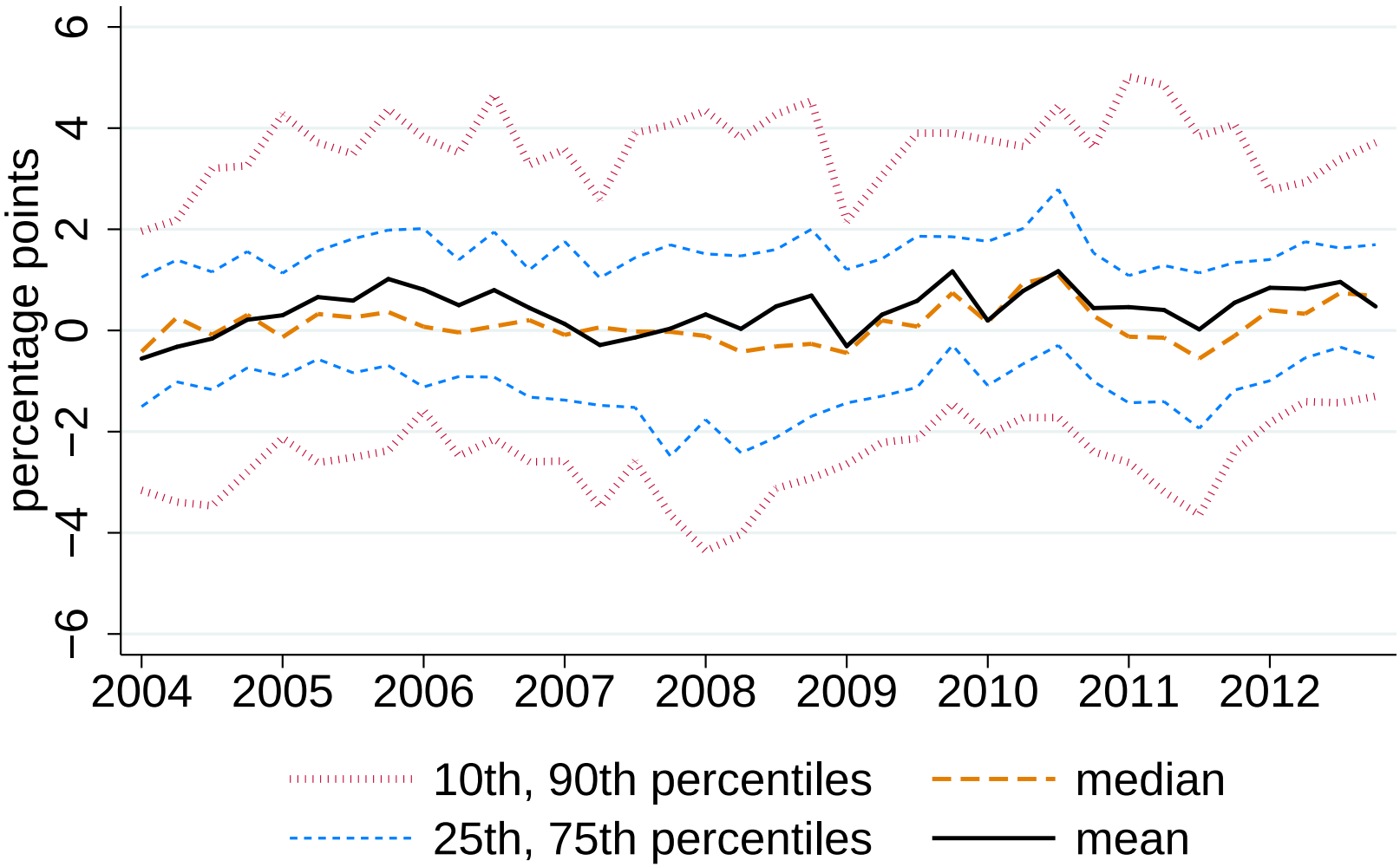
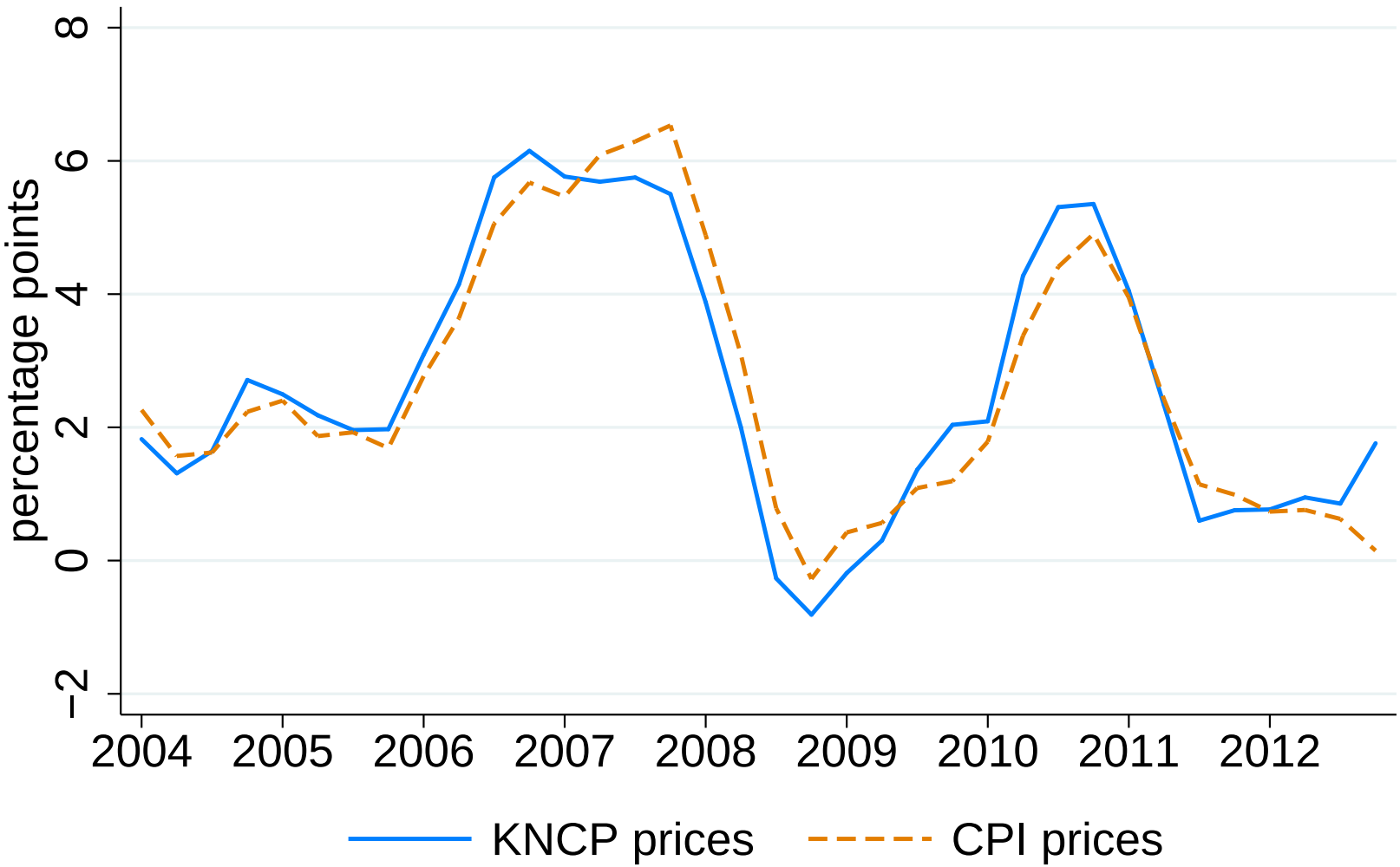
Distribution of deviations between KNCP and CPI stratum inflation rates

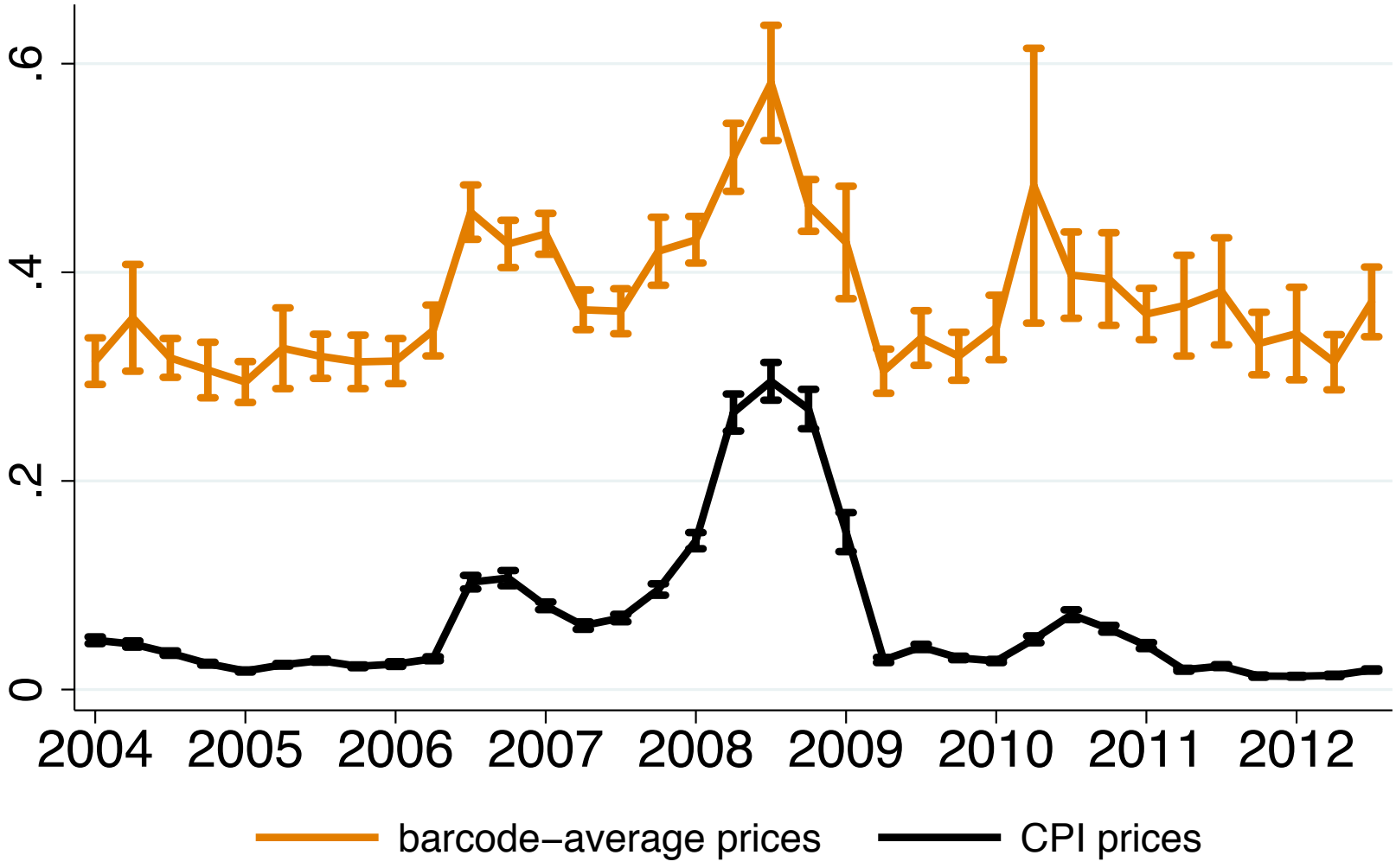


Aggregate inflation rates computed with KNCP and CPI stratum prices



Both indexes use KNCP bundle.

Share of variance from common prices



Interquartile range with different indexes

	mean	s.d.	min	max
Household-level prices:				
Laspeyres	7.33	0.74	6.23	8.99
Fisher	7.13	0.72	6.12	8.92
Paasche	7.37	0.76	6.34	9.18
Barcode-average prices:				
Laspeyres	3.99	0.77	3.06	5.73
Fisher	3.87	0.75	2.95	5.68
Paasche	3.98	0.76	3.03	5.81
Stratum-average prices:				
Laspeyres	1.96	0.95	0.89	3.96
Fisher	1.83	0.88	0.91	3.84
Paasche	1.95	0.92	0.92	3.92
CPI prices:				
Laspeyres	1.61	0.80	0.71	3.77
Fisher	1.57	0.77	0.70	3.53
Paasche	1.62	0.78	0.71	3.42

Averages from 2004q1 through 2012q3 of IQR for each date.

Quantile regression of household inflation on aggregate inflation

Decile	Coefficient on aggregate index	Intercept
1	1.011 (0.015)	−7.602 (0.058)
2	1.013 (0.009)	−4.609 (0.039)
3	1.026 (0.008)	−2.810 (0.031)
4	1.052 (0.008)	−1.448 (0.027)
5	1.093 (0.007)	−0.264 (0.026)
6	1.137 (0.009)	0.944 (0.030)
7	1.198 (0.010)	2.286 (0.034)
8	1.243 (0.012)	4.189 (0.046)
9	1.305 (0.019)	7.491 (0.066)

835,386 household-quarter observations.

Bootstrap standard errors in parentheses.

Low-income households have higher inflation

	cumulative inflation (%) over 9 years ending in			fraction of
	2013q1	2013q2	2013q3	population
Household income				
<$20,000	**34.35**	**33.25**	**32.96**	0.17
	(0.90)	(0.66)	(0.86)	
$20,000–$39,999	32.37	31.11	30.61	0.25
	(0.58)	(0.57)	(0.64)	
$40,000–$59,999	29.90	28.26	27.64	0.19
	(0.60)	(0.63)	(0.60)	
$60,000–$99,999	27.84	25.86	25.72	0.22
	(0.55)	(0.56)	(0.60)	
≥$100,000	**25.74**	**24.23**	**24.98**	0.16
	(0.65)	(0.71)	(0.63)	

Calculated with Laspeyres indexes and household-level prices.

Bootstrap standard errors in parentheses.