9th ECB Workshop on Forecasting Techniques:
Forecast Uncertainty and Macroeconomic Indicators

Components of Inflation, Inflation Forecasting, and the Phillips Relation

June 4, 2016

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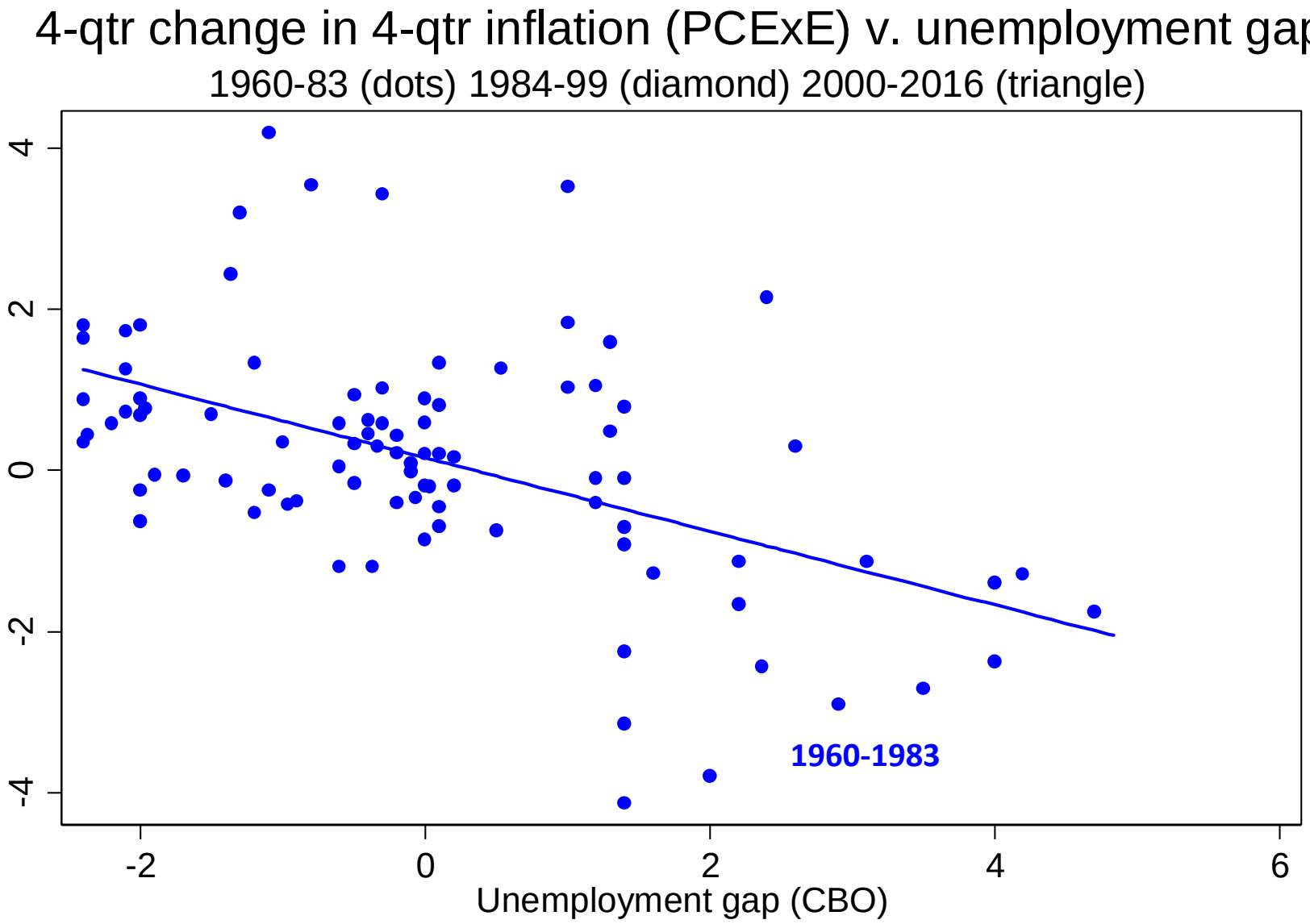
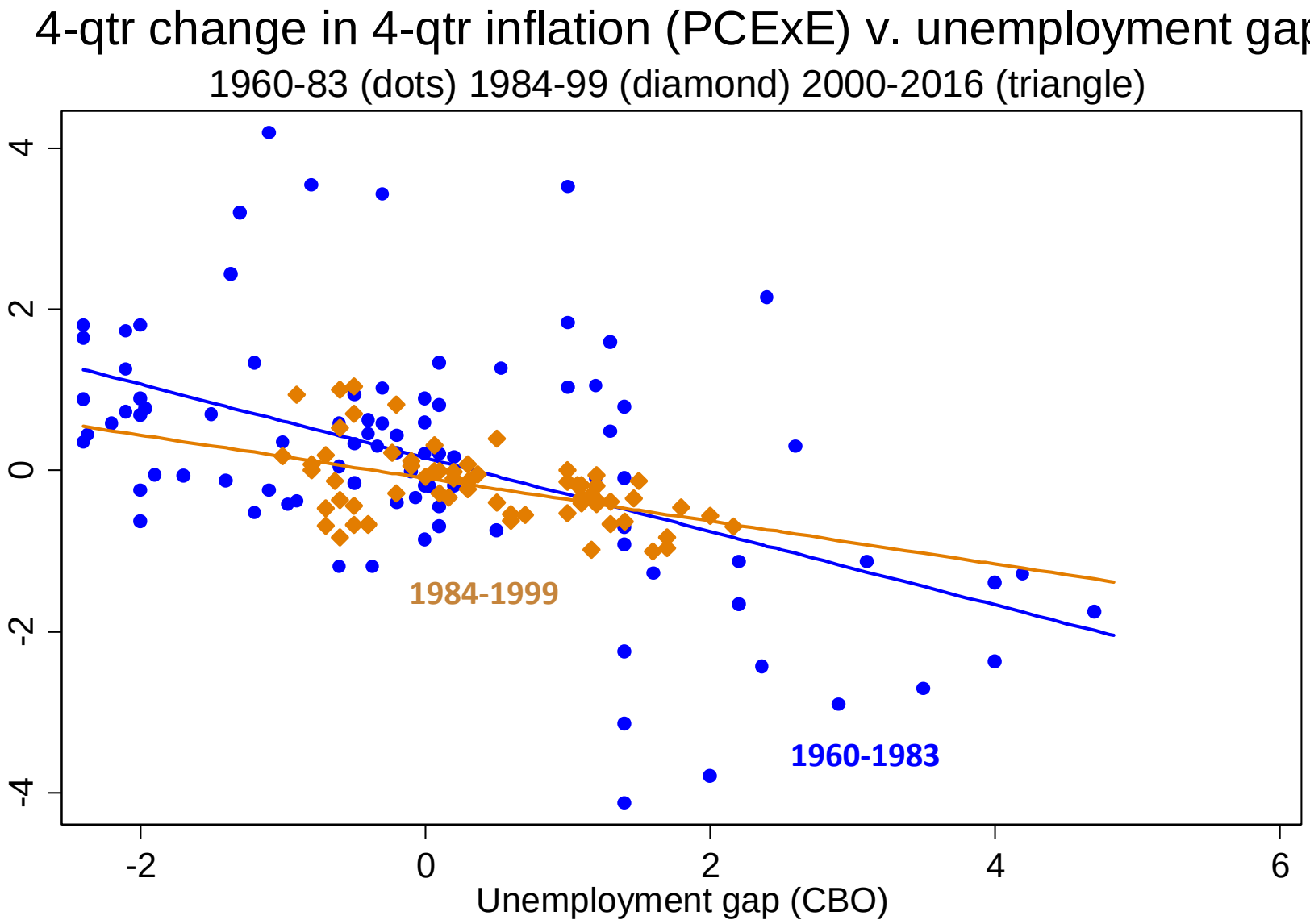
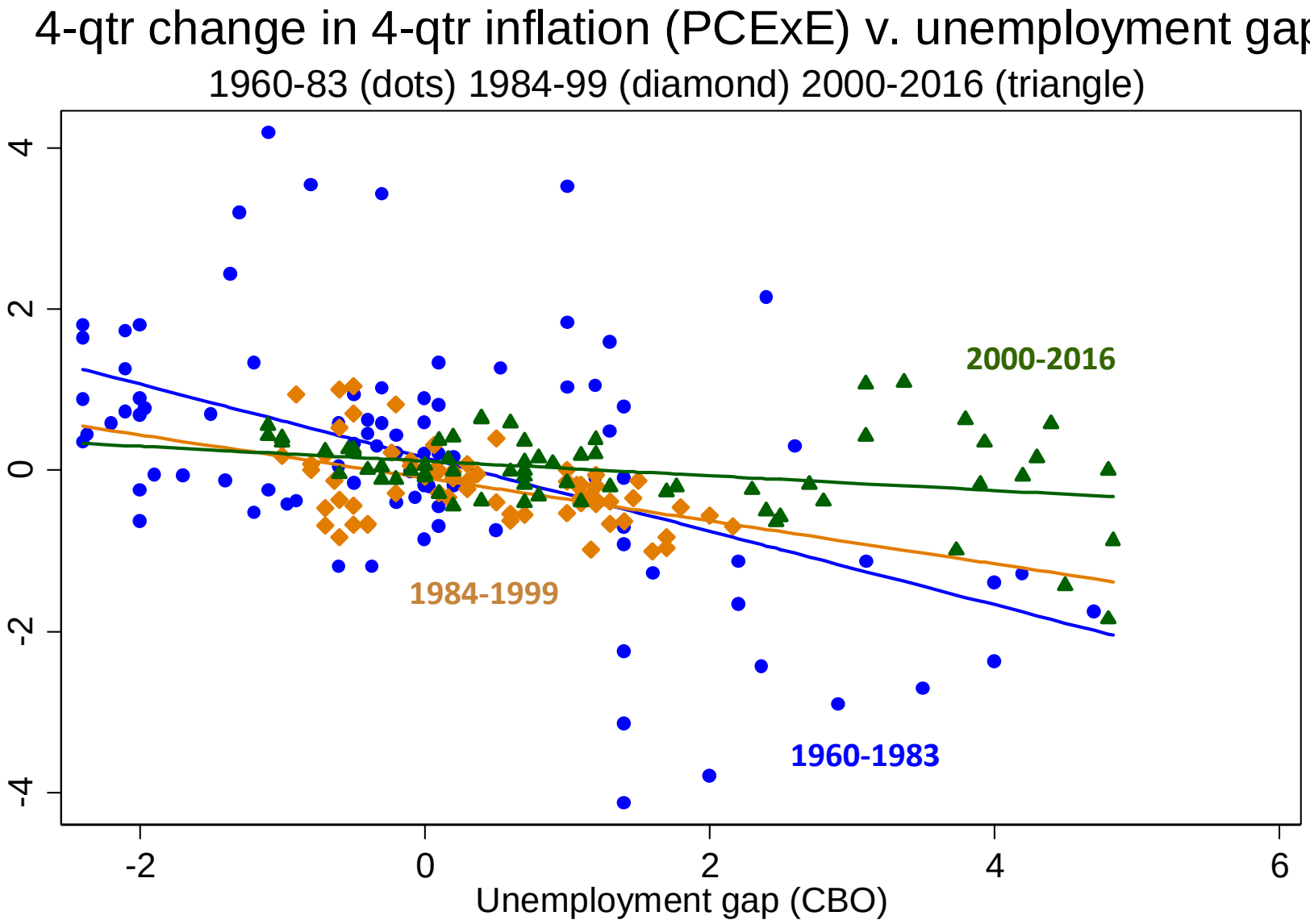
$\pi_t - \pi_{t-4}$ vs. $ugap_t$



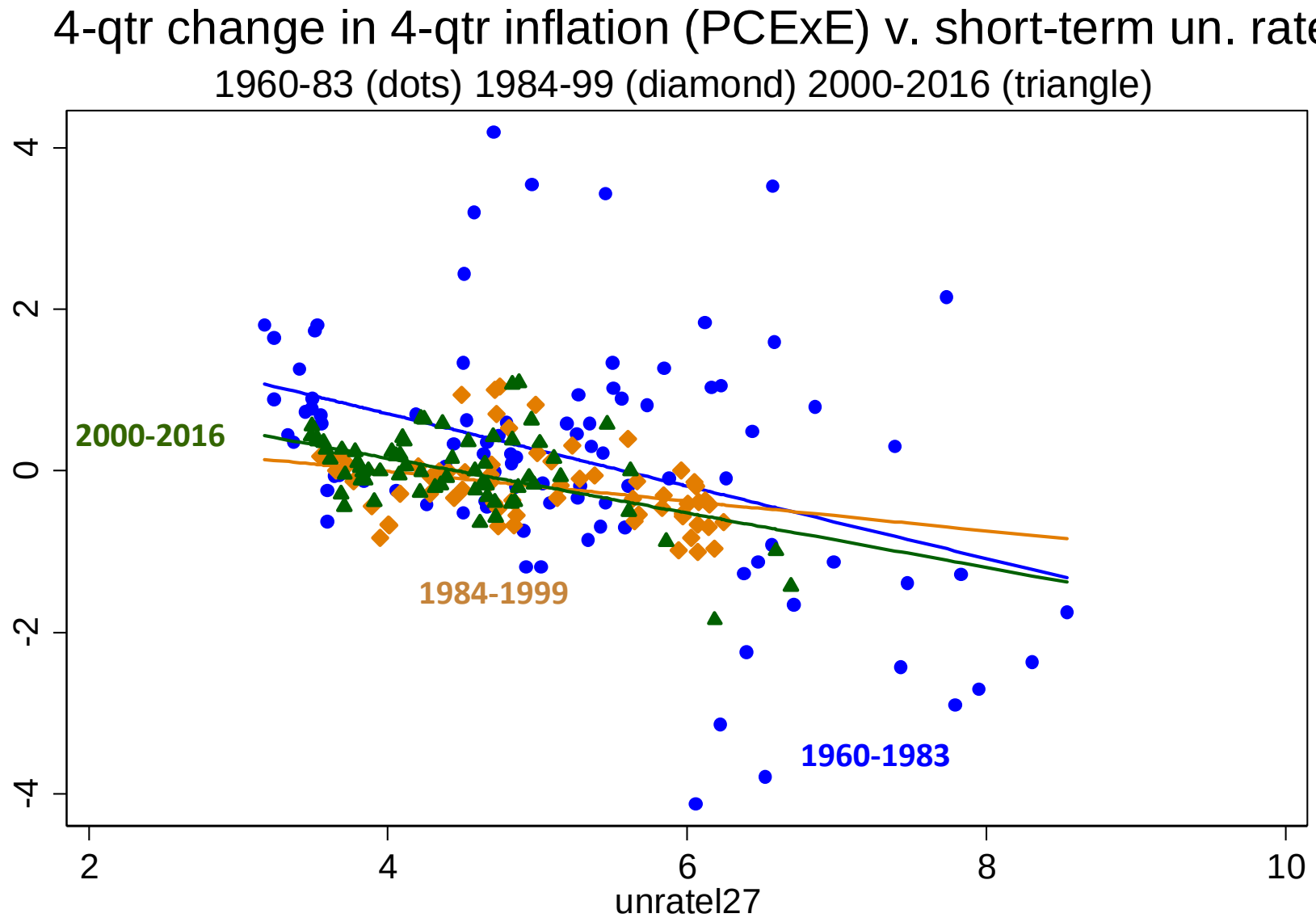
$\pi_t - \pi_{t-4}$ vs. $ugap_t$



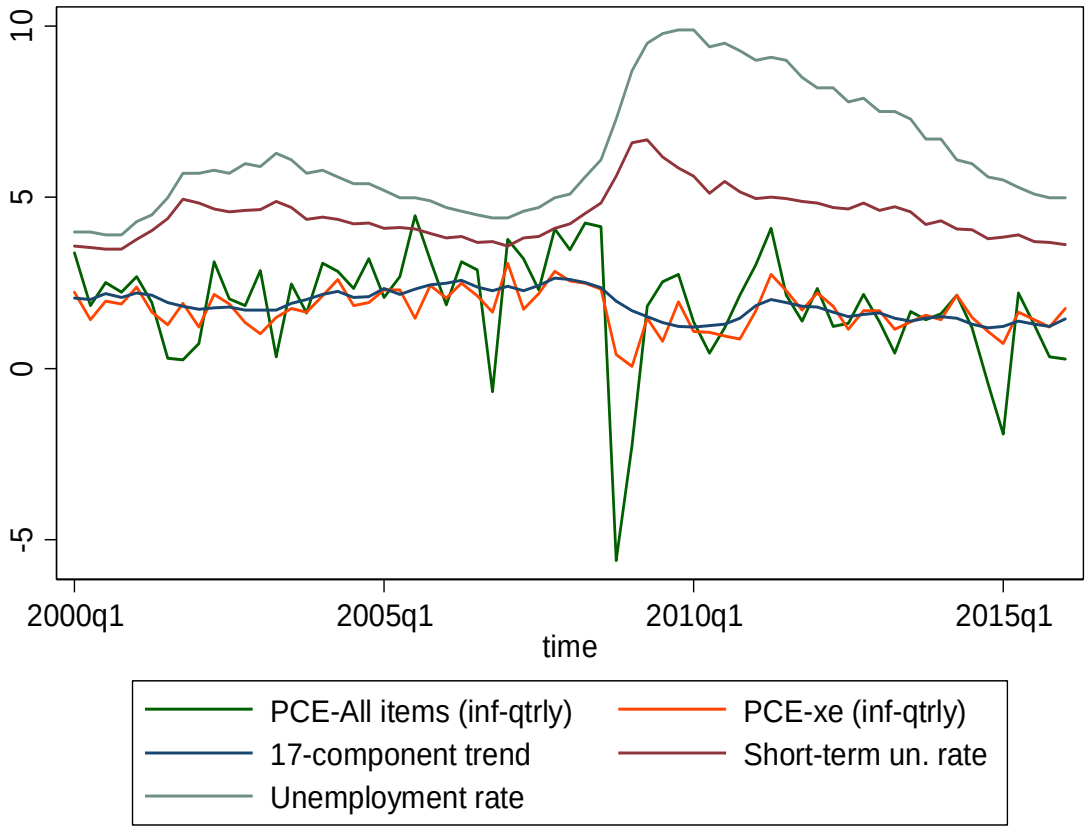
$\pi_t - \pi_{t-4}$ vs. $ugap_t$



$\pi_t - \pi_{t-4}$ vs. Short-term unemployment rate$_t$



Where is the cyclical pressure on inflation?



	Quarterly inflation at annual rate				
	PCE	Core PCE	CPI	Core CPI	17-component trend
2015q2	2.2	1.9	2.4	2.3	1.4
2015q3	1.3	1.4	1.4	1.8	1.3
2015q4	0.3	1.3	0.8	2.2	1.2
2016q1	0.3	2.1	-0.3	2.7	1.5

This paper: Cyclically Sensitive Inflation

- This paper introduces "cyclically sensitive inflation" and provides a preliminary estimate

- Treat the Phillips curve as a statistical measurement problem
  - Some components of inflation are poorly measured
  - We would expect other components to exhibit extreme price sluggishness
  - Other components of inflation would be expected to have a very low signal-to-noise ratio – so their demand/Phillips response would be difficult to decipher

- Combine measurement facts (BLS methods) and time series techniques

Outline

1. Cyclically sensitive inflation: motivation
2. Literature
3. Components: review of BLS methods
4. Components: cyclical properties
5. Measuring trend inflation using components
6. Cyclically sensitive inflation
   a) methods
   b) time variation
7. Next steps

Selected literature

- **Phillips curve post-2009:** Ball-Mazumder (2011, 2014), Stock (2011), Gordon (2013), Watson (2014), Kiley (2015), Blanchard (2016), many others

- **Core inflation & disaggregated inflation**: Gordon (1975), Eckstein (1981), Bryan and Cecchetti (1993); Cristadoro, Forni, Reichlin, Veronese (2005), Boivin, Giannoni, and Mihov (2009), Reis and Watson (2010)

- **Trend inflation**: Stock and Watson (2007), Cecchetti, Hooper, Kasman, Schoenholtz, and Watson (2007), Mertens (2012), Cogley, Primiceri, and Sargent (2010), Cogley and Sargent (2015), Chan, Koop, and Potter (2013), Garnier, Mertens, and Nelson (2013), Mertens and Nason (2015)

- **Inflation forecasting**: Atkeson-Ohanian (2000), many others

- **Closest:** this work extends Stock and Watson ("Core Inflation and Trend Inflation" forthcoming) which uses the 17 components to estimate trend inflation. Here, the goal is estimation of cyclically sensitive inflation, not trend inflation

3. Components:
Data and Review of BLS and BEA Methods

Price index measurement: introductory comments

- **It is well known that there are major challenges with price index construction**
  - Discussed below

- **These defects matter for applications in which a correct reading of the rate of inflation matters.**
  - Policies and projections that involve some real and some nominal components, e.g. indexing policies, Social Security funding projections, etc.
  - Generally not for purely nominal projections (e.g., debt-GDP ratio)
  - Monetary policy: not obvious.
    - Is deflation the problem (unobserved), or ZLB (observed)?
  - This paper: not concerned with the rate of inflation, but changes in the rate of inflation.
    - Bias doesn't matter as long as the bias is unrelated to real economic activity
    - Measurement noise is just a statistical nuisance
    - Measurement bias that is related to real economic activity because of index construction bias is a problem, want to eliminate

The PCE price index: a brief review of methods

- **The PCE price index is computed by the Bureau of Economic Analysis (BEA)**
  - Most component price series are CPI indexes for components, computed by the Bureau of Labor Statistics (BLS)
  - Differences between PCE-PI and CPI:
    - PCE concept is final consumption, CPI is "out of pocket" spending
    - Share weights are from the NIPA surveys
    - PCE-PI is revised for methodological changes (if possible), CPI is not
    - Some divergence in price concepts, in which PCE uses PPI not CPI prices

- **The market price component of the CPI has 211 item strata**
  - Goods and services. Nondurables: < 3 yrs life. Services: cannot be inventoried.
  - Single panel sample monthly: food at home, lodging, most consumer end-energy goods, telephone services, used cars, some odds and ends
  - 2 panels, each sampled every other month: everything else except rent, at least in some regions
  - 6 panels, each sampled every 6 months: rent
  - The market price component of the CPI has 211 item strata
  - Market-based CPI has several well-known problems
    - New goods problem: no quality adjustment, just skip first month price
    - Replacement goods problem: quality adjustment by production cost or hedonic regression

The PCE price index: a brief review of methods, ctd.

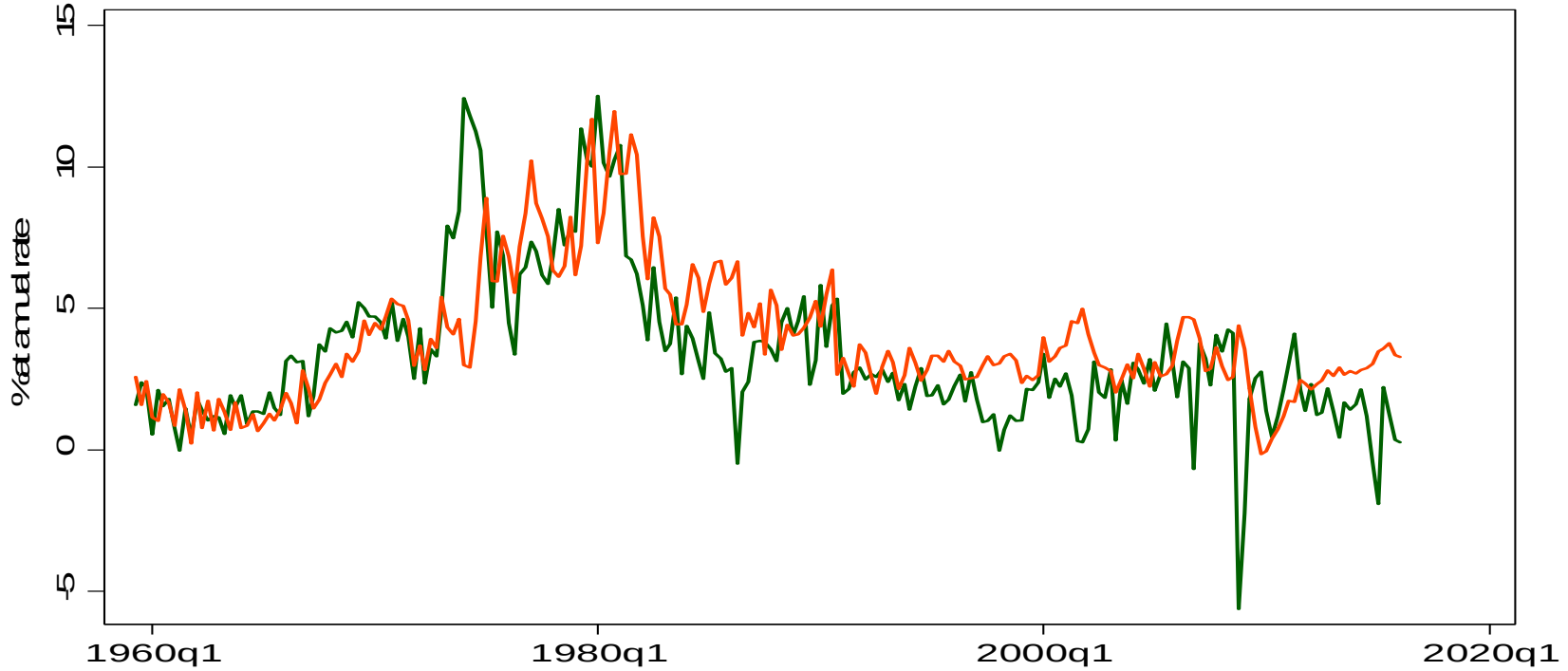
- **The CPI is also computed for sectors without posted market prices. There are various methodologies:**
  - The first step is defining the unit to be priced. For example
  - For legal services: an hour of a law office's time
  - For hospital services: a service bundle (e.g., 2 day stay + 1 cardiac catheterization + 2 EKGs + 2 IV doses blood thinner drug + …)
  - These are priced from (randomly selected) bills or interviews
  - Other price indexes for unpriced services include unpriced services of nonprofits (religious institutions, etc.), unpriced banking services (liquidity services)

- **Special indexes:**
  - PCE-xE: excludes gasoline & other energy goods + energy utilities component of housing
  - PCE-xFE: also excludes food at home (but not food at restaurants)
  - Market-based CPI (excludes all non-market price estimates)

PCE components and their shares, sorted by 2000-2014 share

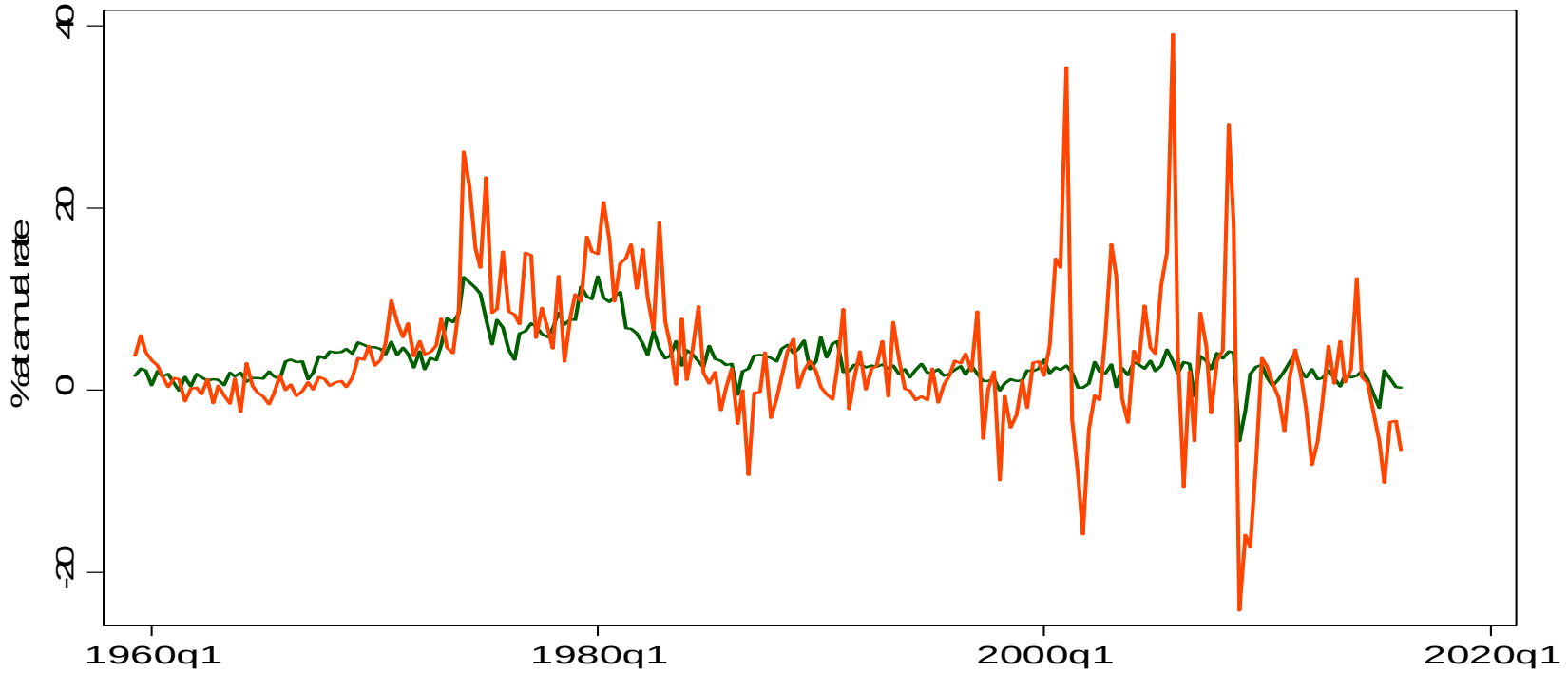
Sector	1960-2014	1960-1979	1980-1999	2000-2014
Housing and utilities	0.18	0.17	0.18	0.18
Health care	0.11	0.07	0.13	0.16
Other services	0.08	0.08	0.08	0.09
Other nondurable goods	0.08	0.08	0.07	0.08
Food and beverages for off-premises consumption	0.12	0.16	0.10	0.08
Financial services and insurance	0.06	0.05	0.07	0.08
Food services and accommodations	0.06	0.06	0.07	0.06
Motor vehicles and parts	0.05	0.06	0.05	0.04
Recreation services	0.03	0.02	0.03	0.04
Clothing and footwear	0.05	0.07	0.05	0.03
Recreational goods and vehicles	0.03	0.03	0.03	0.03
Gasoline and other energy goods	0.04	0.04	0.04	0.03
Transportation services	0.03	0.03	0.03	0.03
Furnishings and durable household equipment	0.04	0.04	0.03	0.03
Final consumption expenditures of nonprofit institutions serving households (NPISHs)	0.02	0.02	0.02	0.03
Other durable goods	0.02	0.02	0.02	0.02

PCE (green) and component (orange): Housing ex energy util. (qtrly)



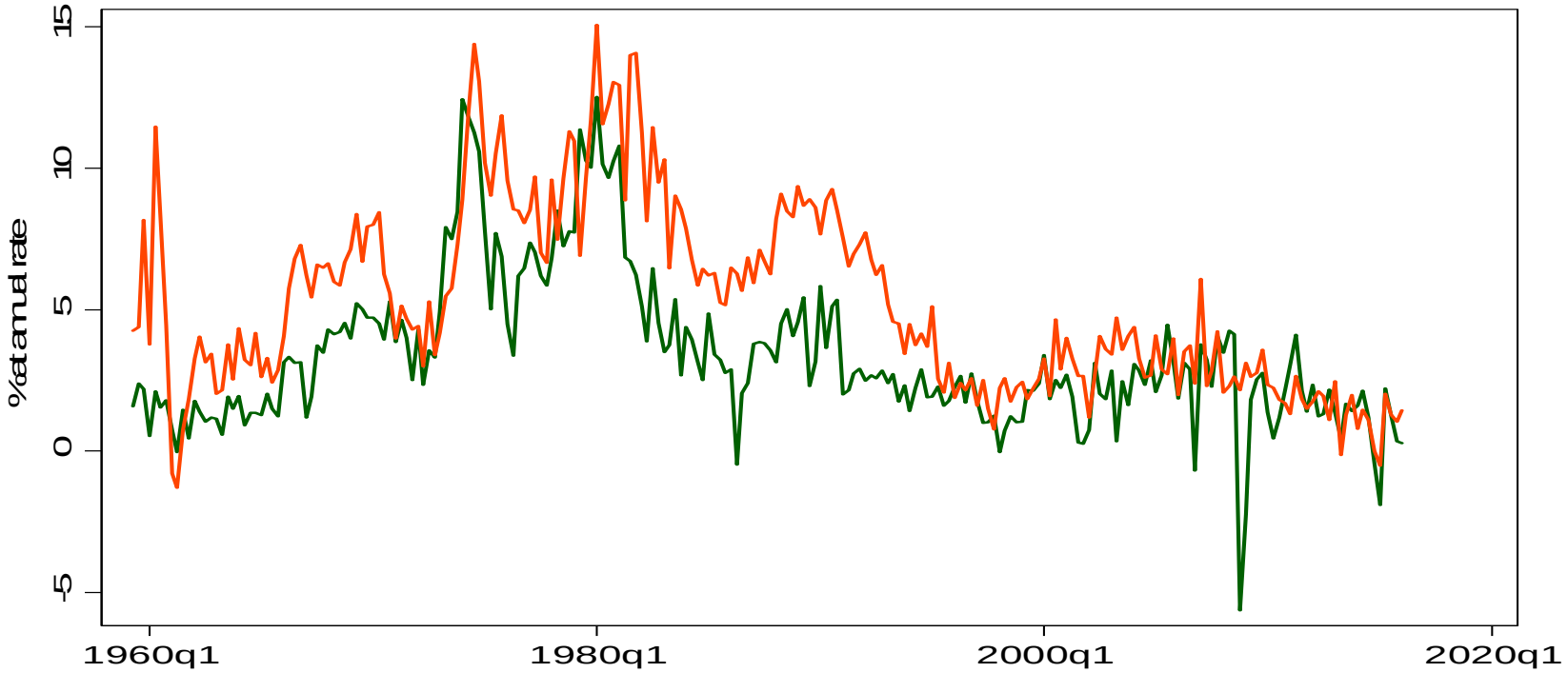
Rent paid by renters	Actual market rent excluding utilities 6 rotating panels, surveyed every 6 months Price index(t) = This month's panel price relative × price index(t-1)
Owner-equivalent rent	Post-1983: Actual market rent excluding utilities Pre-1983: Payment flows (mortgage payments, etc) 6 rotating panels, index construction as for renters
Misc.	Surveyed units fractionally represent rental and owned units Boarding schools, group homes use renter's rent index Utilities: CPI for water & sewer maint; CPI for garbage & trash collection

Housing: energy utilities



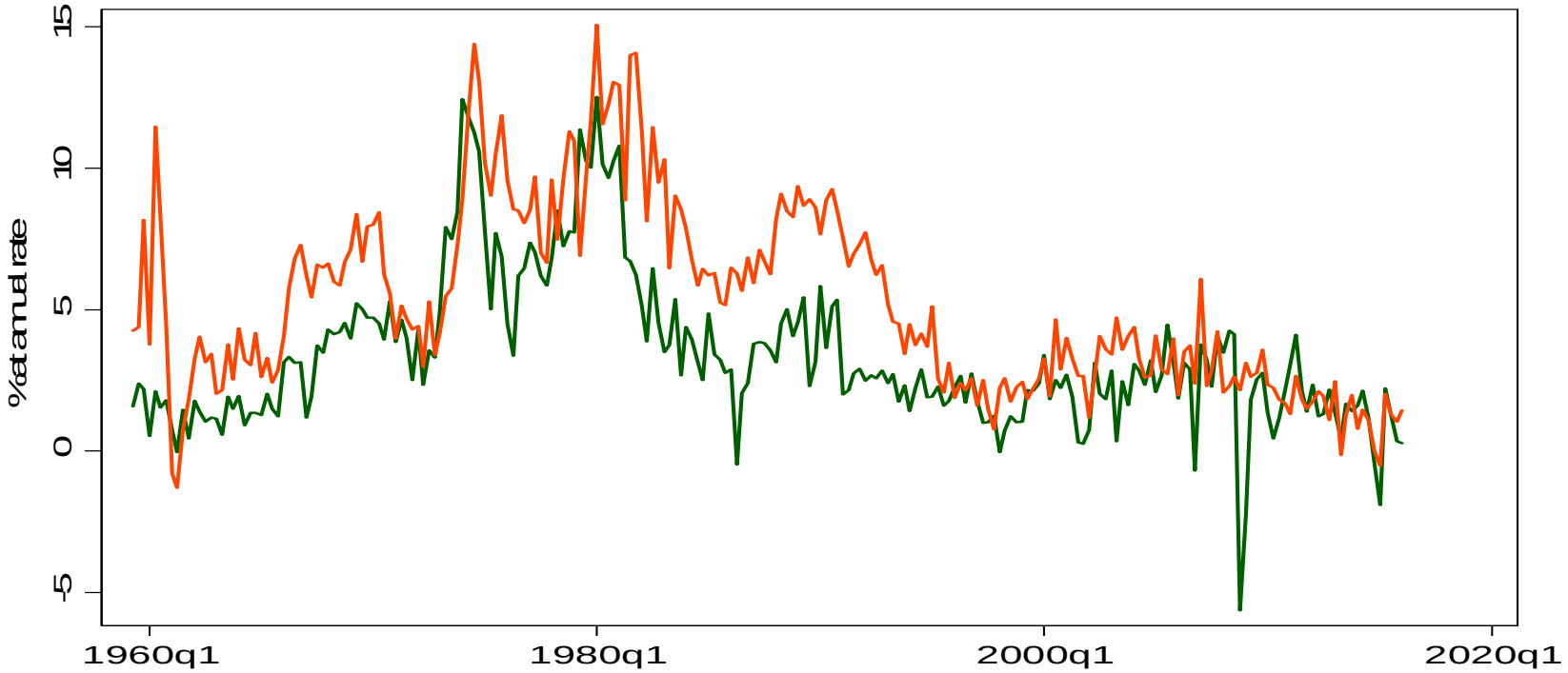
Electricity	CPI for electricity
Natural gas	CPI for utllity-provided natural gas

Health care (expenditure share 2000-2016 = 0.16): CPI



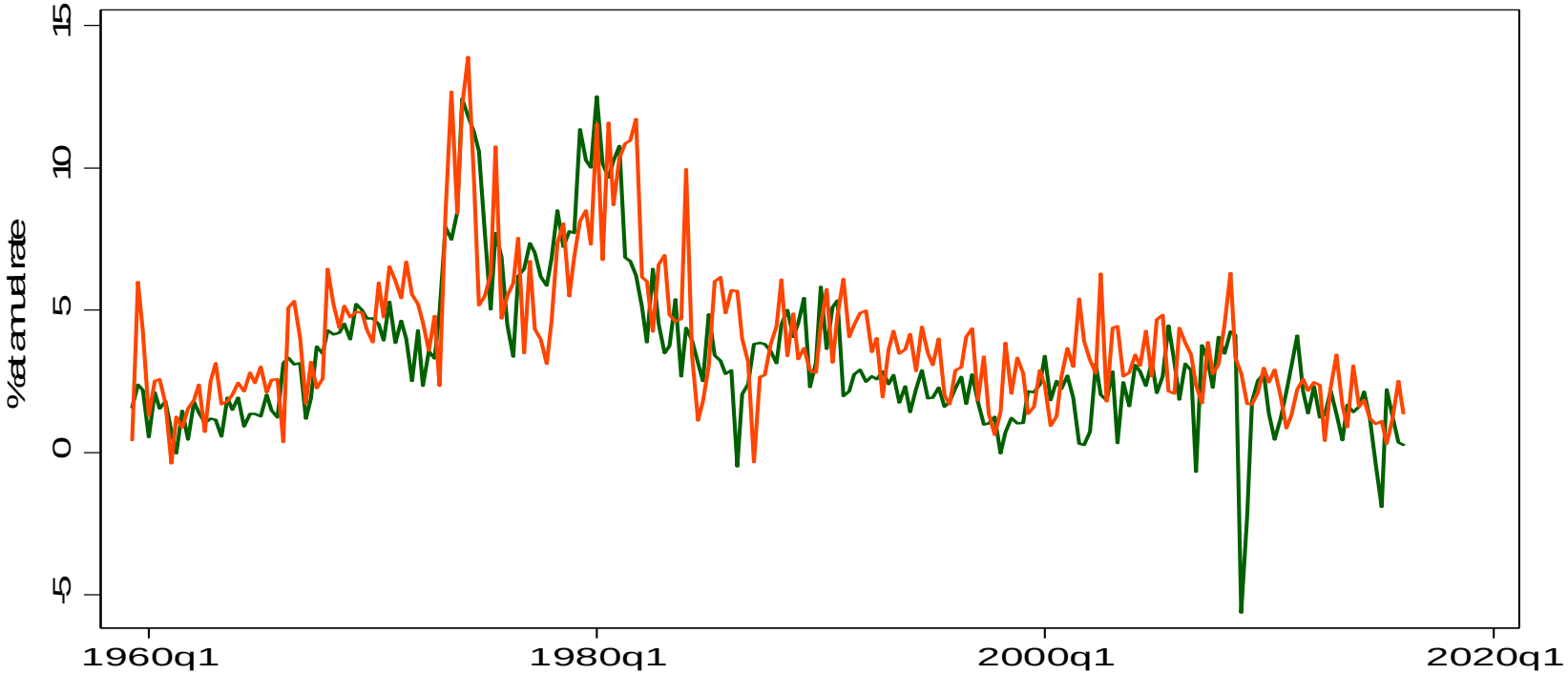
CPI v. PCE	CPI covers out-of-pocket medical (paid by consumers). PCE covers consumption of medical services. Most medical services in the U.S. do not have a market price – they are negotiated health plan prices
CPI: Outpatient physician's services, paramedics, hospitals, nursing homes	Provision-of-services concept. CPI outpatient: price of visit for a specific illness. CPI hospital (post-87): price of bundle of services provided (3-day stay + 1 catheterization + 2 EKGs +…) by insurer reimbursement category. CPI pharma: by drug. Pre-87: cost of hospital inputs
Dental & other medical	CPI for dental services, CPI for other medical services

Health care (0.16): PCE



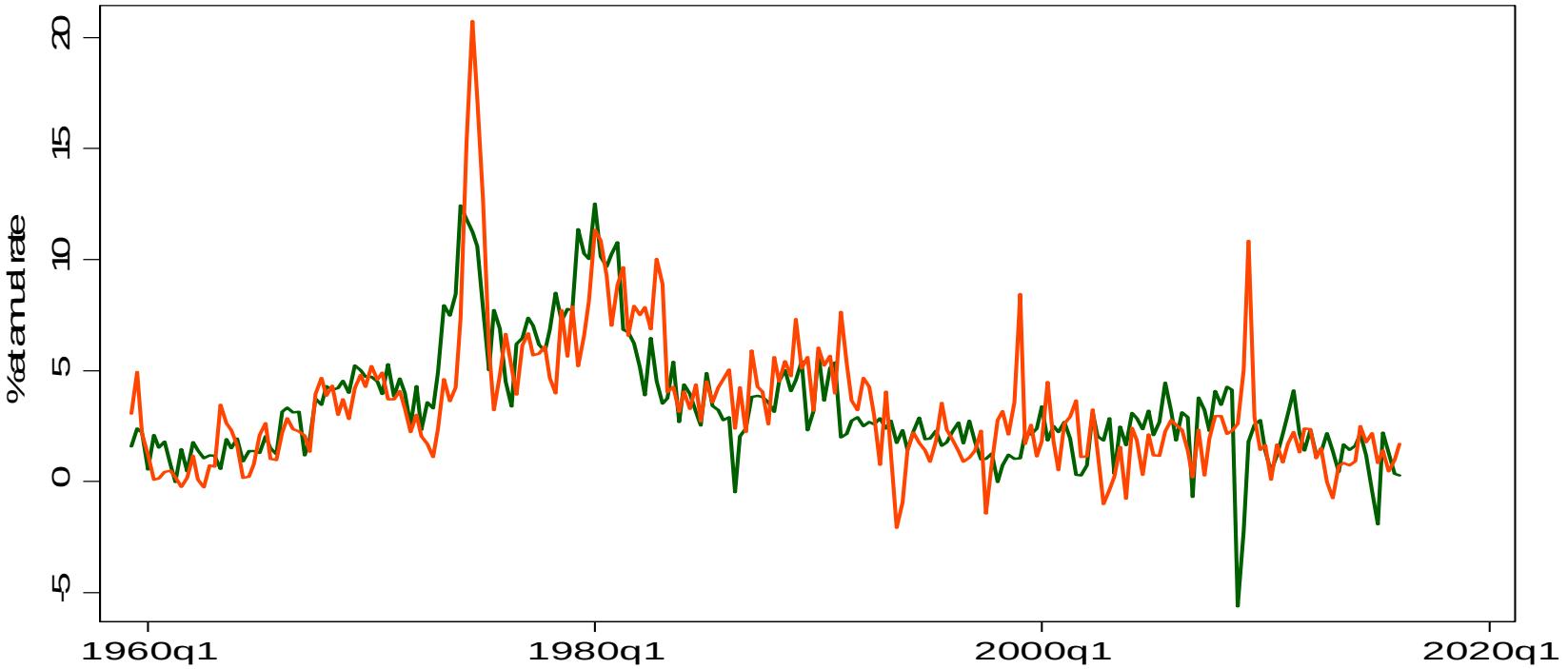
PPI concept	PPI usually first transaction price rec'd by producer. For health care, PPI since 1993 is DRG-based, broken out by service providers
PCE: Physician services	PPI for physician offices. Unit is office visit for a given condition
PCE: hospital services	PPI for hospitals. Unit is a hospital episode for a given condition
PCE: nursing homes	PPI for nursing homes. Cost of inputs basis (hourly wages etc.)
PCE: paramedical	PPI for paramedical
Dental & other medical	Uses CPIs for dental services, for other medical services

Other services (0.09)



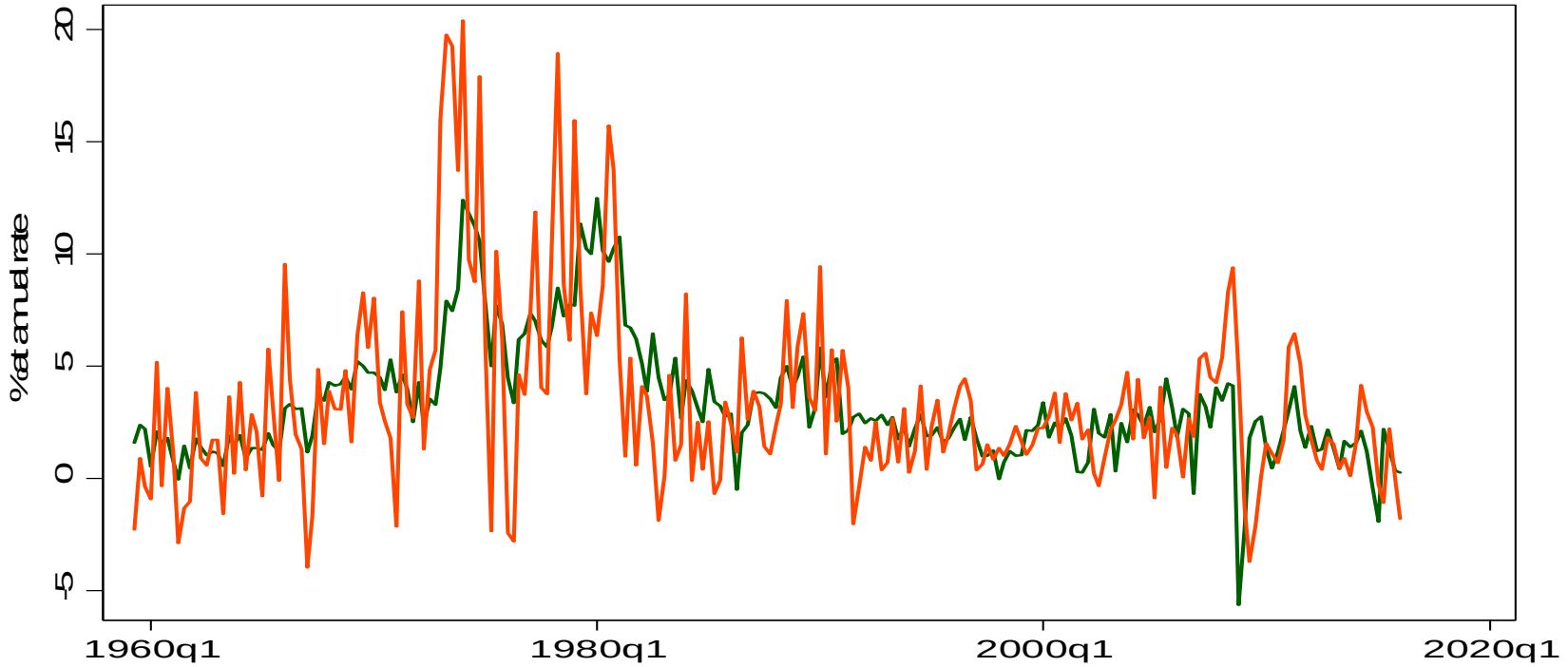
Communication	CPI for wireless phone service, CPI for land line phone service
Internet	CPI for internet services
Education	CPI for college education; CPI for private primary & secondary schools
Legal, accounting	Cost basis (cost of 1 hr lawyer's time)
Social services	Cost basis, some CPI (child care)
Misc.	CPI for postage, CPI for funeral services, CPI for haircuts; net foreign travel (complicated)

Other nondurable goods (0.08)



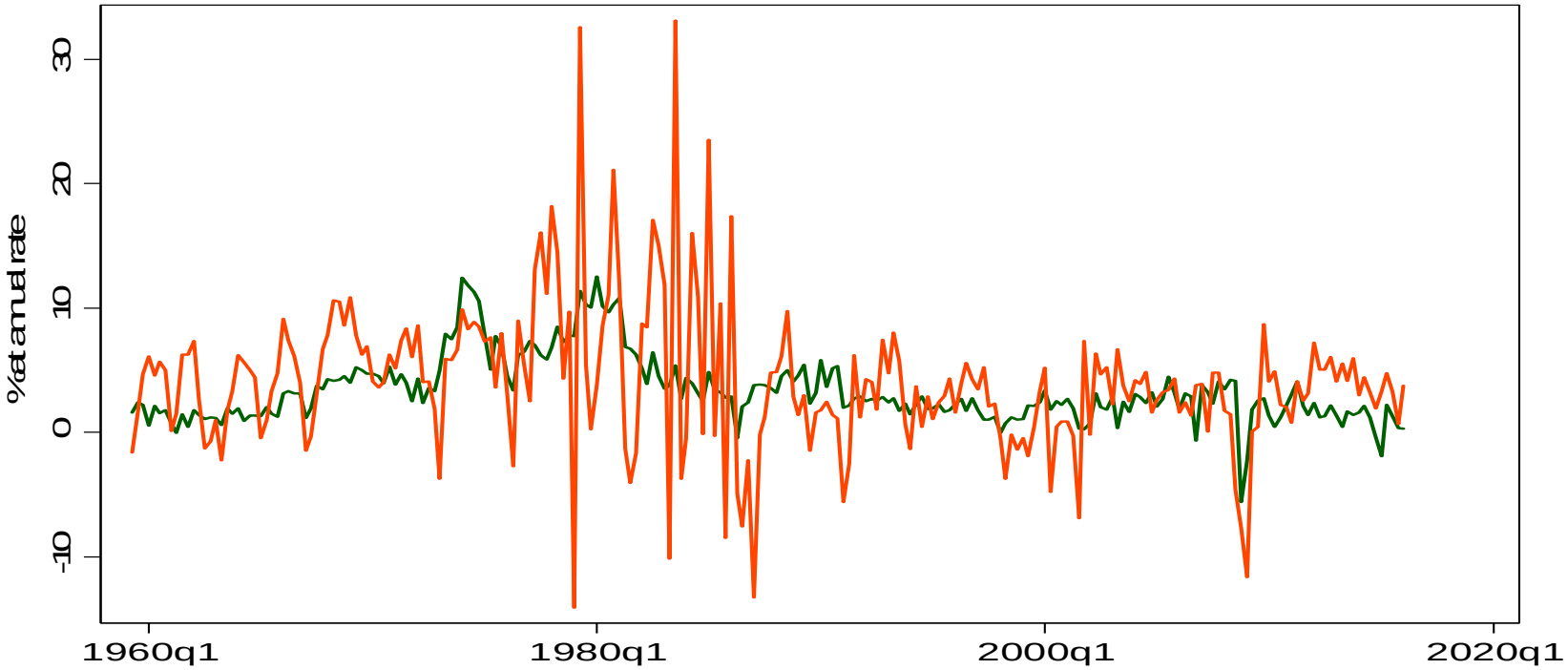
Tobacco	CPI-tobacco
Pharmaceuticals	CPIs for prescription & OTC drugs, CPI for med. eqpt sold to consumers
Recreational nondurables	CPIs for toys, plants & flowers, pets, photographic supplies,…
Personal care	Various CPIs for personal care items
Misc. home goods	CPIs: newspapers & magazines, household supplies
Spending abroad	(net, including in-kind personal remittances) complicated, non-mkt

Food & beverages off-premises (0.08)



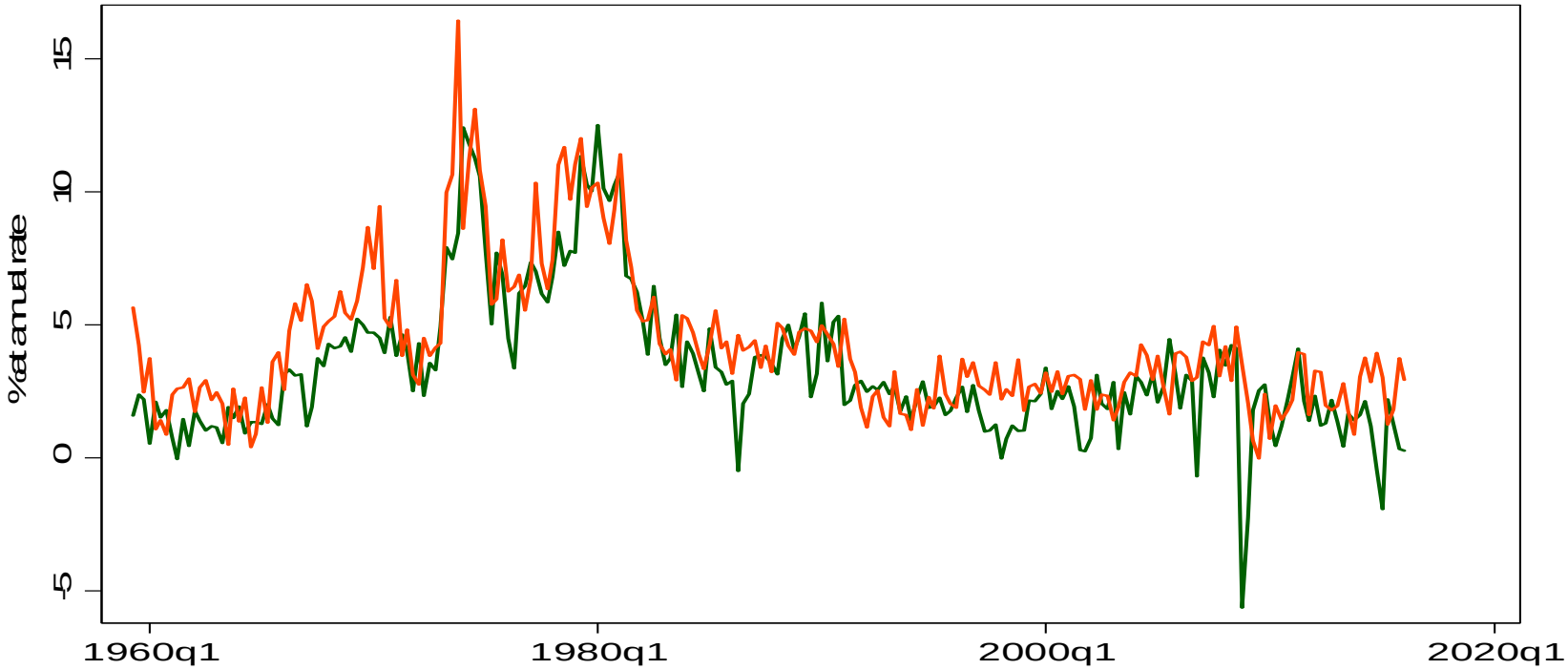
Food & nonalcoholic beverages, off-premises	Detailed price components for food at home
Alcohol, off-premises	Various CPIs (beer, wine, distilled spirits) for off-premises

Financial services & insurance (0.08)



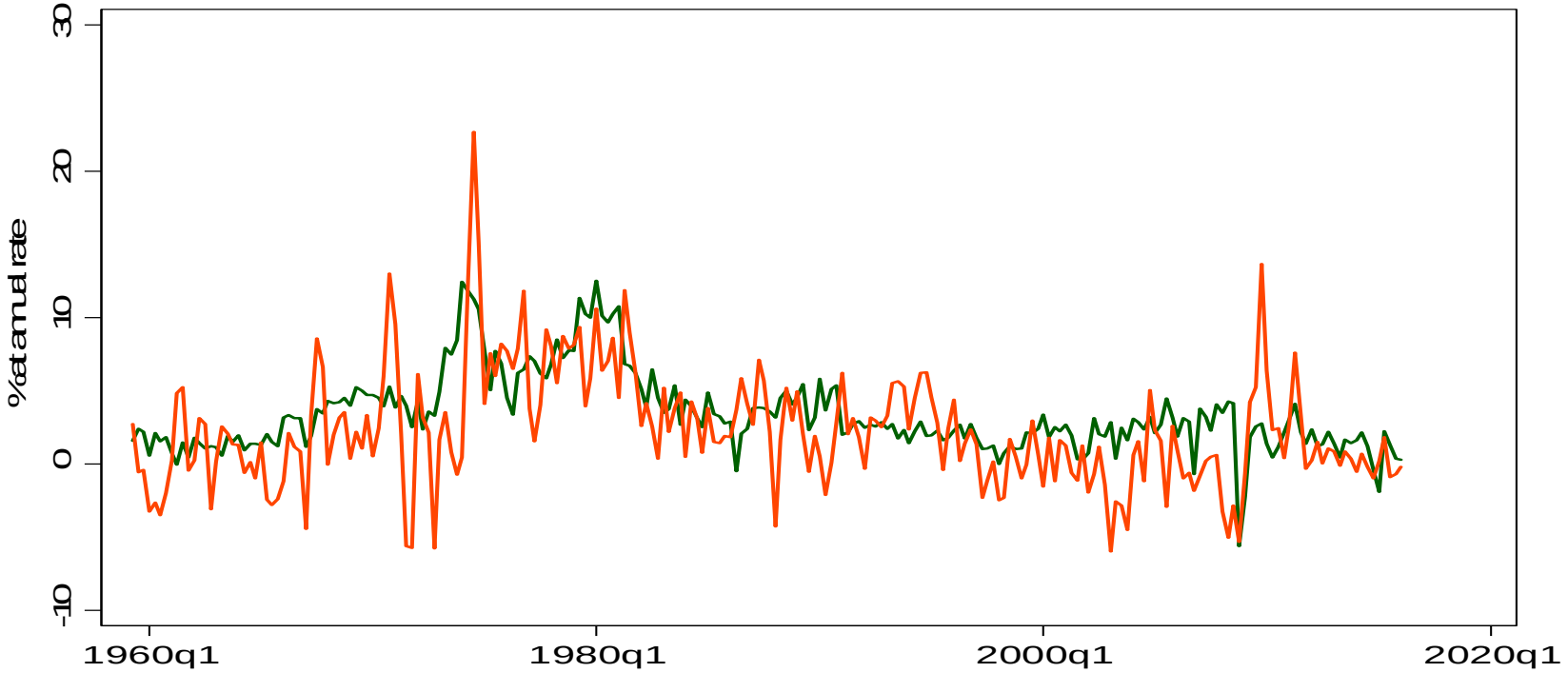
Financial services provided w/out payment	Estimated based on imputed below-market interest on checking account. Alternative interest rate changed to "stabilized" (smoothed) rate in 2013, revised back to 1985
Financial fees	CPI for checking account and other bank services (market prices).
Insurance	Price index is for the value of insurance services provided (risk pooling, intermediation) = all premiums – expected losses; cost-based using PPI
Brokers' fees	PPI (cost-based)

Food services & accommodations (0.06)



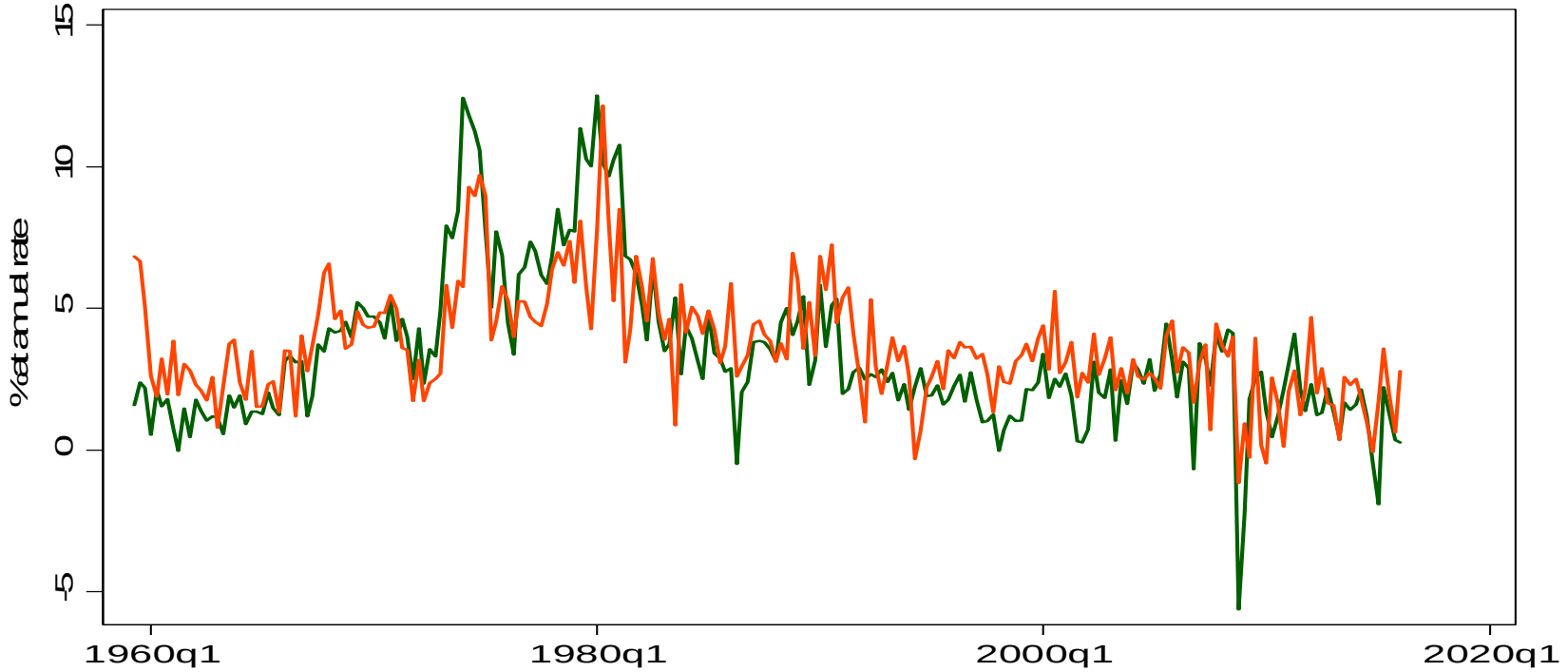
Purchased meals & beverages	CPI for categories of purchased meals & beverages (restaurant meals, bars, fast food, etc)
Institutional food & drink	Use market-based CPI for purchased meals & beverages by category
Accommodations	CPI for purchased lodging away from home. Boarding at schools: separate (market-price) CPI

Motor vehicles & parts (0.04)



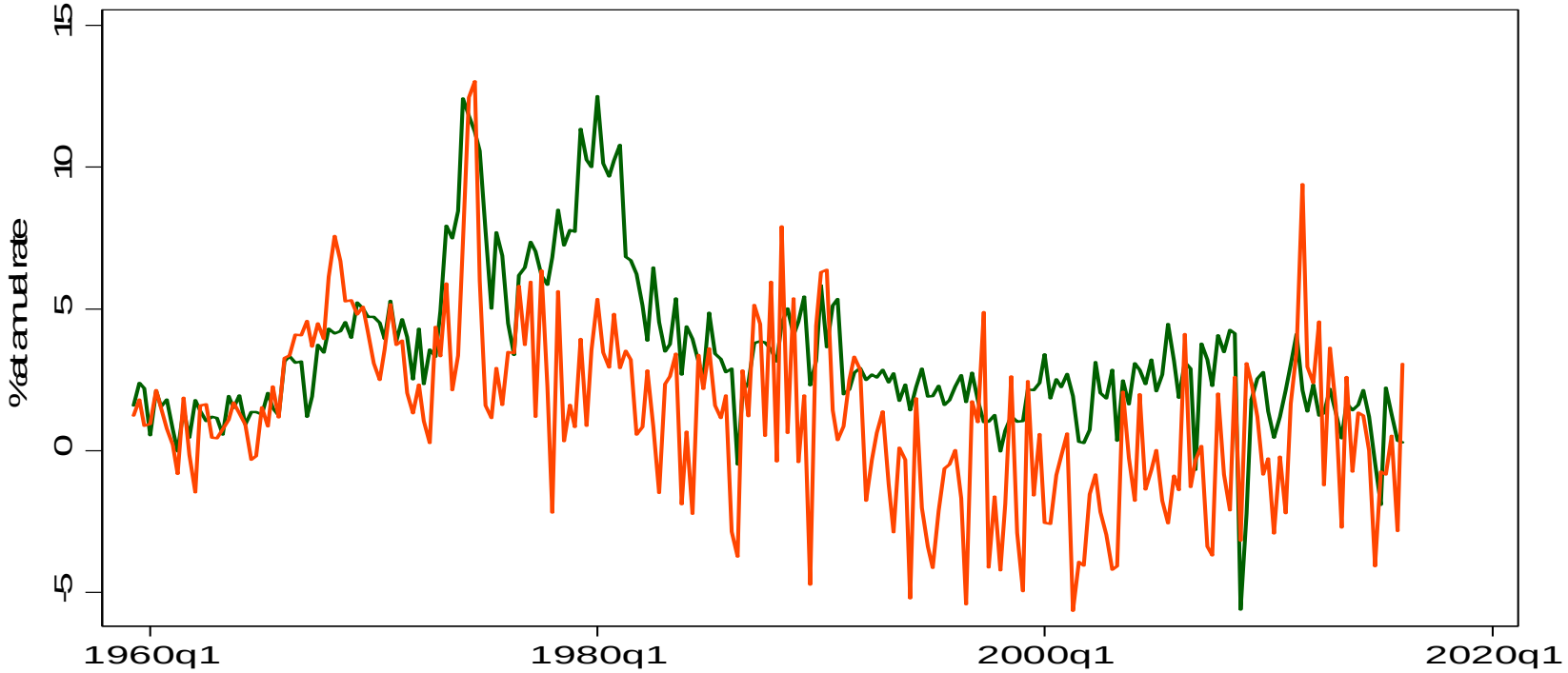
New cars & trucks	CPI-new cars: sticker price + 30-day average dealer markup or discount. Year to year quality changes priced on production cost.
Used cars & trucks	Secondary source price data, with quality adjustments when new
Parts	CPI for tires; CPI for parts

Recreation services (0.04)



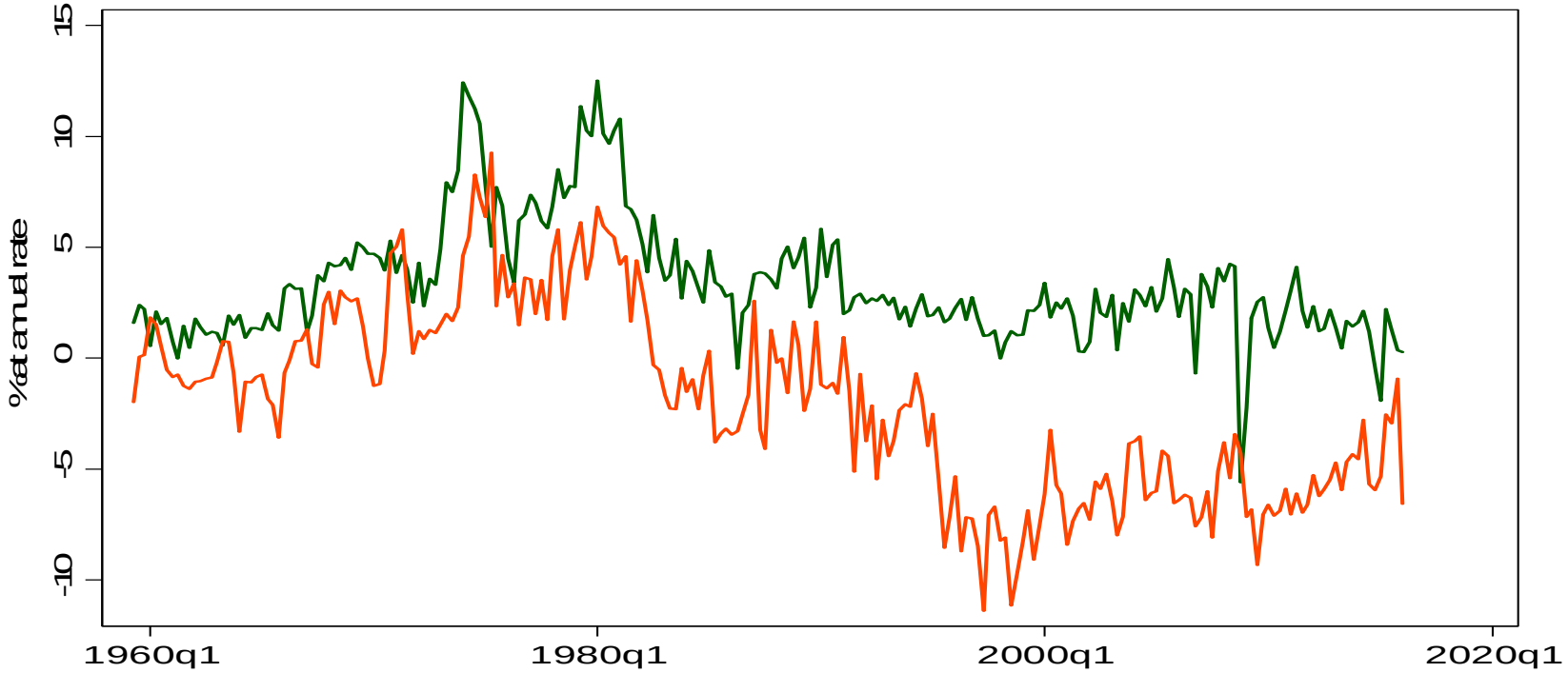
Sports centers & clubs, theaters, museums, etc.	CPI for specific categories, e.g. club dues and fees; admission to sporting events. Monthly/bi-monthly/6-month sample
Audio/video & info processing services	CPI for cable & satellite TV; CPI for film processing; CPI for video/audio rental
Other	Gambling: CPI-U; pet care: CPI-veterinary services, etc.

Clothing & footwear (0.03)



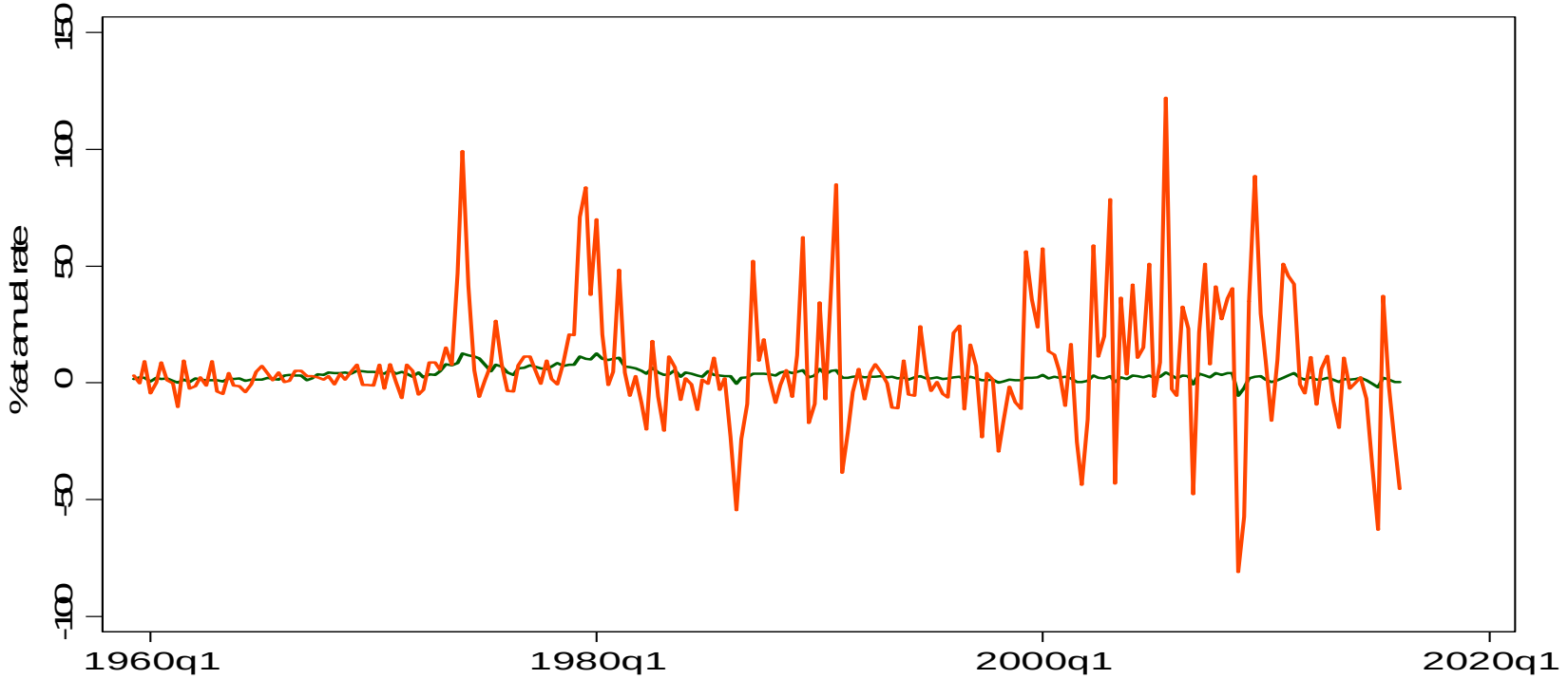
Market purchased clothing	Various CPIs. Note new/replacement goods issue however.
Military & uniforms	Cost-based

Recreational goods & vehicles (0.03)



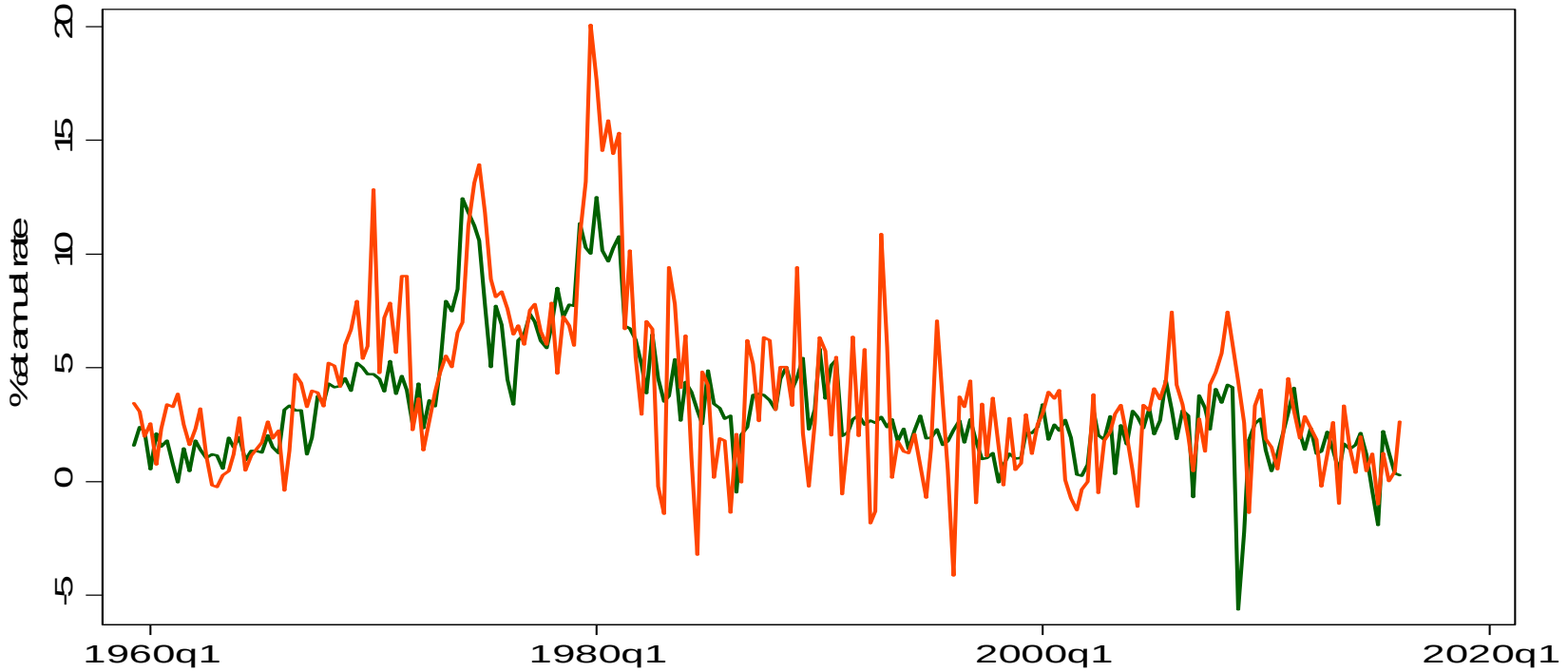
Video, audio, home computers	Various CPIs including CPI for home computers, CPI for computer software and accessories, and CPI for consumer digital communications and information processing eqpt
Sporting eqp	CPI for sporting eqpt
Recreational books	CPI for recreational books
Musical instruments	CPI for musical instruments

Gasoline & other energy goods (0.03)



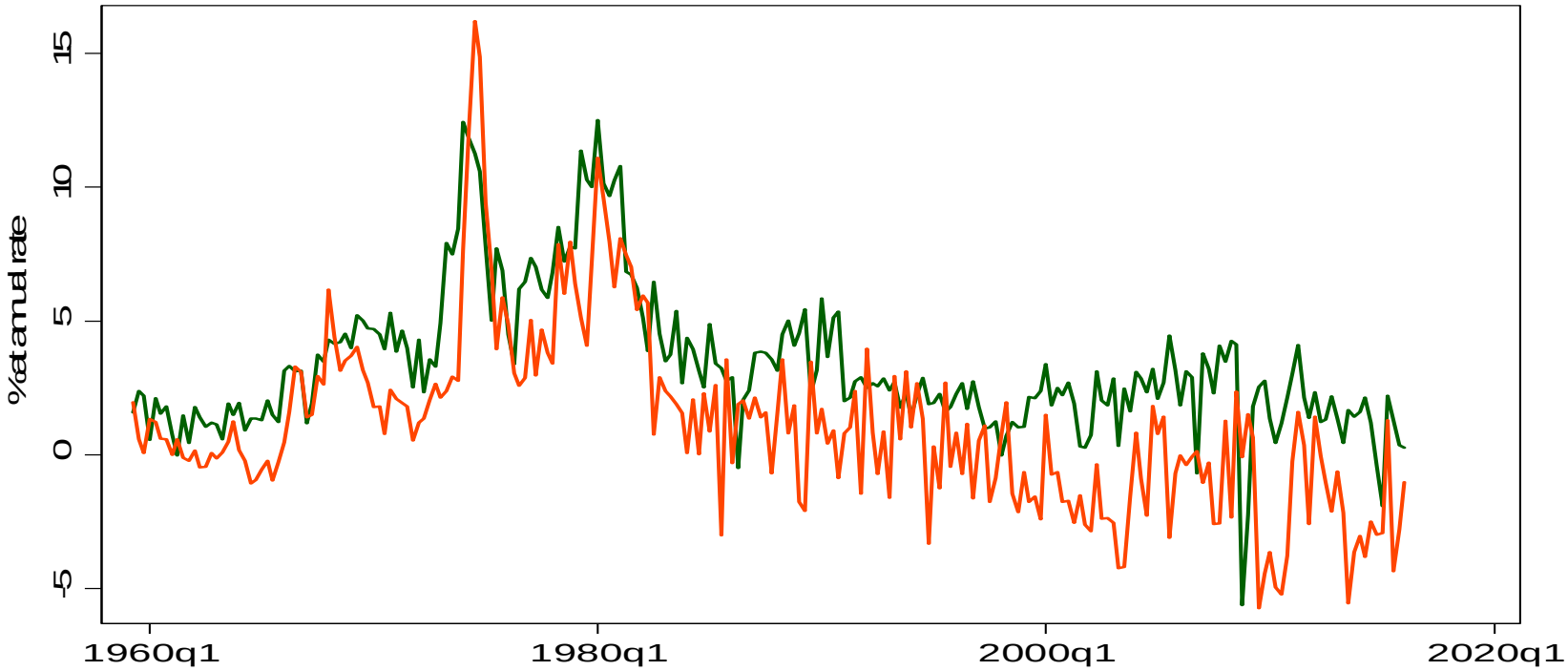
Motor fuels	CPI for motor fuels
Other fuels	CPIs for propane, kerosene, wood

Transportation services (0.03)



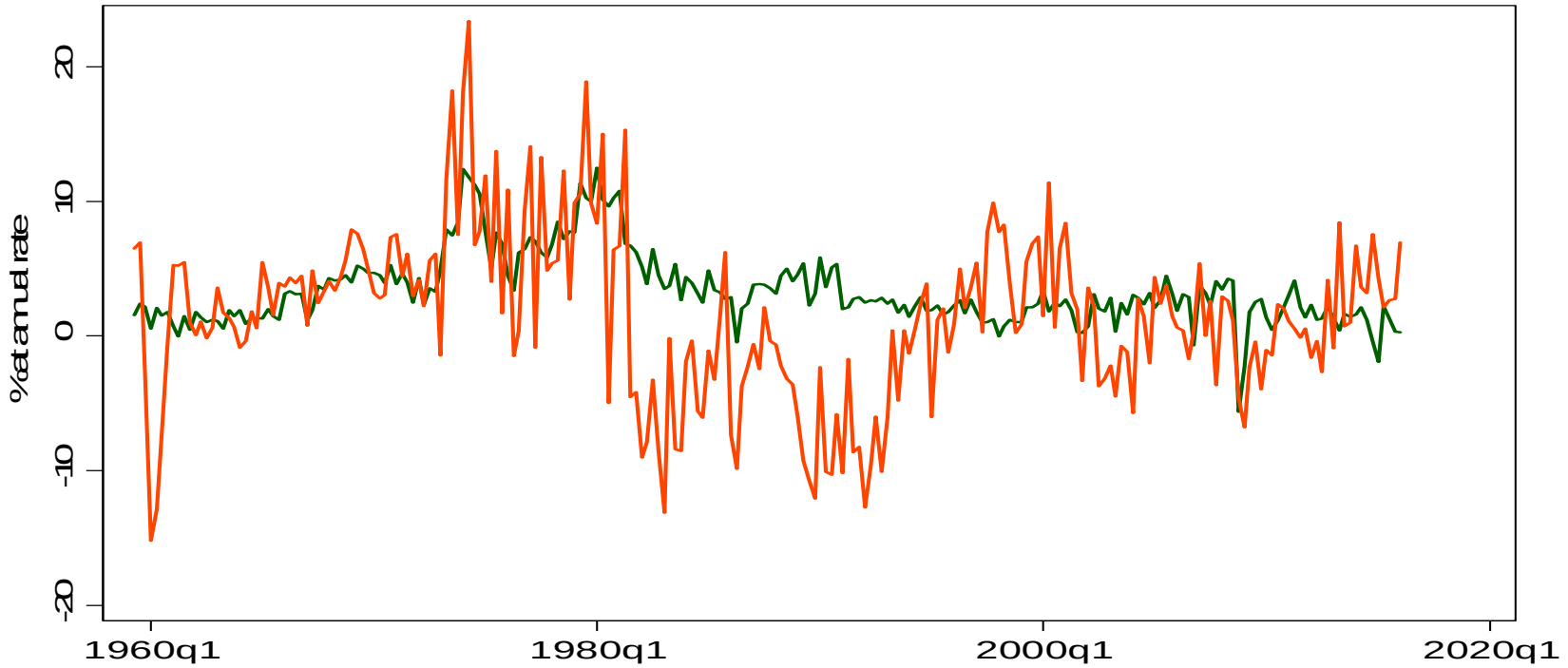
Airline travel	PPI (cost-based)
Intracity	CPI (covers taxis, busses, etc)
Intercity busses, trains	CPI (market prices)
Water	CPI (ferries, etc.)

Furnishings & household durables (0.03)



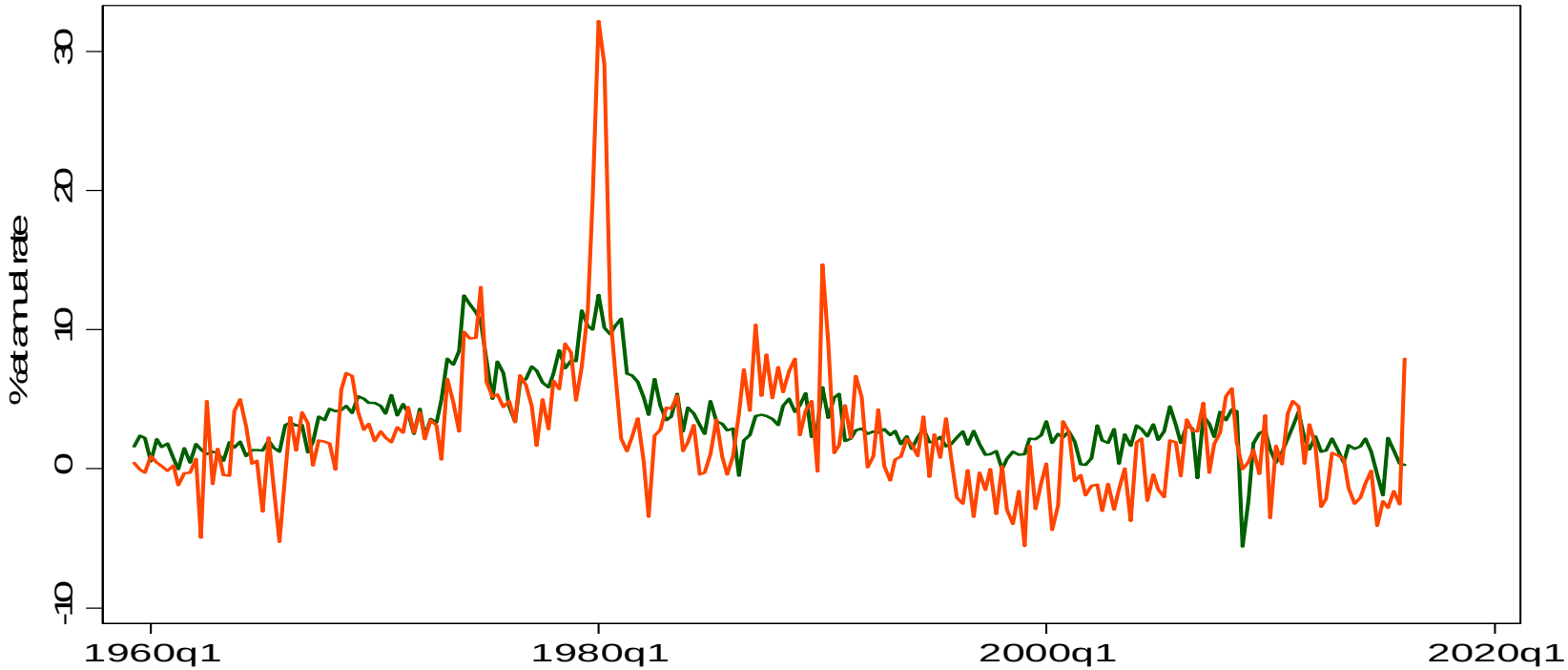
Furniture & bedding	CPI for furniture & bedding; CPI for clocks & lamps; related CPIs
Household appliances	Various CPIs
Tools, house & garden eqpt	Various CPIs

Final consumption expenditures of nonprofit institutions serving households (NPISHs) (0.03)



NPISH definition	Current operating expenditures by nonprofits less sales to households and other sectors.
Prices	By construction, essentially everything in NPISHs does not have a market price, so costs of inputs are used for priced outputs. Example: price of 1 hour of a minister's time = minister's hourly wage

Other durable goods (0.02)



Misc. durable goods	Watches, jewelry, educational books, luggage, telephone equipment. All based on CPIs (market prices)

4. Estimating Trend Inflation using Components

Unobserved component/stochastic volatility model

Stock-Watson (2007) UC-SV model, extended for internally handled outliers

$$\pi_t = \tau_t + \varepsilon_t$$ trend + stationary component

$$\tau_t = \tau_{t-1} + \sigma_{\Delta\tau,t}\eta_{\tau,t}$$ random walk trend

$$\varepsilon_t = \sigma_{\varepsilon,t} s_t \eta_{\tau,t}$$ stationary component serially uncorrelated

$$\Delta \ln(\sigma^2_{\Delta\tau,t}) = \gamma_{\Delta\tau}\nu_{\Delta\tau,t}$$ stochastic volatility in trend

$$\Delta \ln(\sigma^2_{\varepsilon,t}) = \gamma_{\varepsilon}\nu_{\varepsilon,t}$$ stochastic volatility in stationary

$\left(\eta_\varepsilon, \eta_\tau, \nu_\varepsilon, \nu_{\Delta\tau}\right)$ i.i.d. $N(0, I_4)$

normal errors, except for:

$$s_t = \begin{cases} 1 \text{ with probability } p \\ U[2,10] \text{ with probability } 1\text{-}p \end{cases}$$ outlier adjustment (new)

- The model has a TV-IMA(1,1) representation (TV Nelson-Schwert (1977))
- 3 parameters: γ_ε, $\gamma_{\Delta\tau}$, p, estimated by Bayes methods (diffuse prior over parameters)

Multivariate extension: smooth over time and components

Data: 17 top-level components of PCE (housing divided into energy and ex-E)

MUCSVO model:

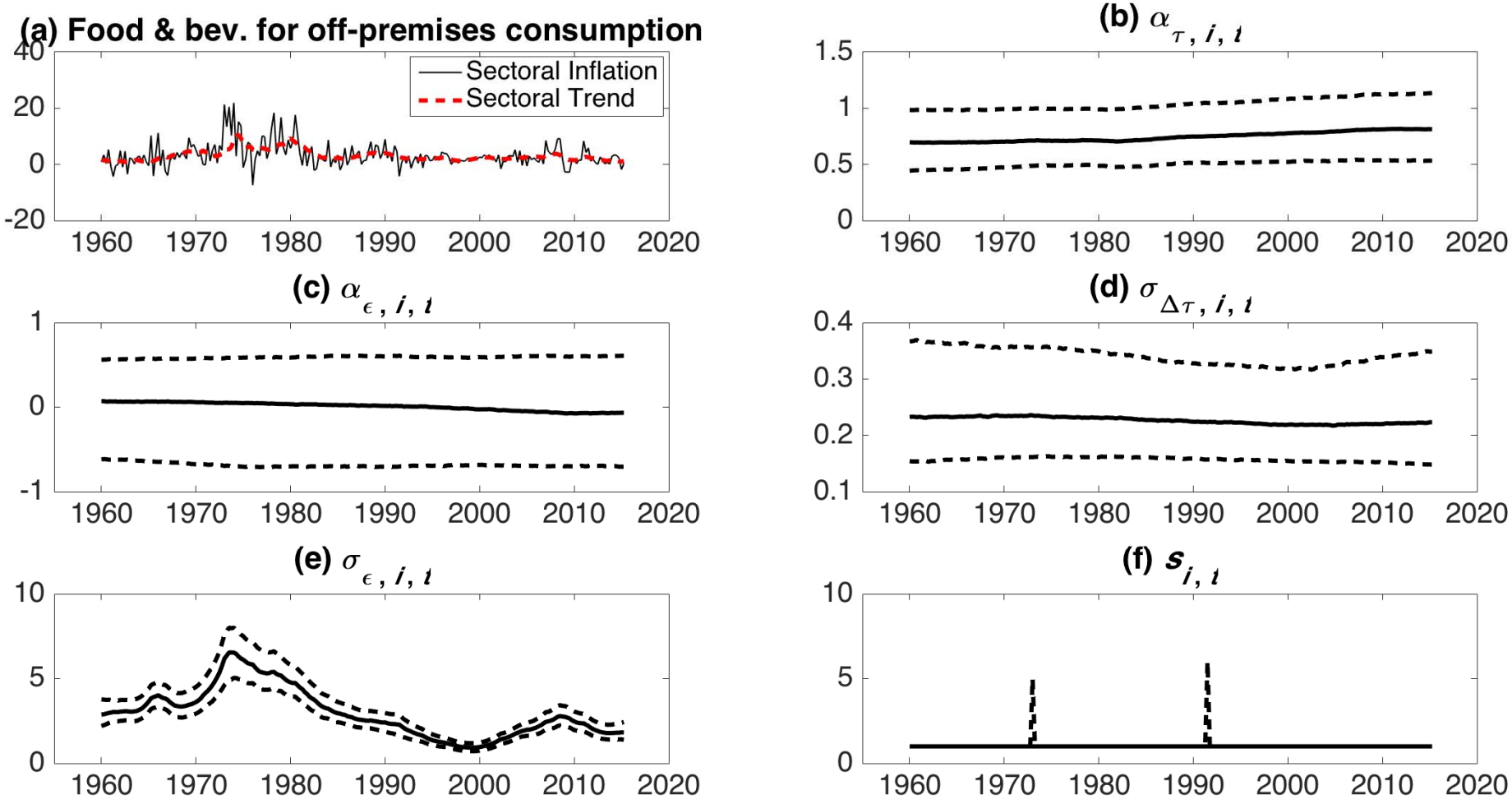
$$\begin{bmatrix} \pi_{1t} \\ \pi_{2t} \\ \vdots \\ \pi_{nt} \end{bmatrix} = \begin{bmatrix} \alpha_{1t} \\ \alpha_{2t} \\ \vdots \\ \alpha_{nt} \end{bmatrix} \tau_t^c + \begin{bmatrix} \beta_{1t} \\ \beta_{2t} \\ \vdots \\ \beta_{nt} \end{bmatrix} \varepsilon_t^c + \begin{bmatrix} \tau_{1t} \\ \tau_{2t} \\ \vdots \\ t_{nt} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \vdots \\ \varepsilon_{nt} \end{bmatrix}$$

- trend *i* and common trend follow random walk with SV
- stationary *i* and common stationary are serially uncorrelated with SV
- trend and stationary components follow SV processes (like univariate)
- outliers indicators s_{it} are independent
- Aggregate (average) inflation and trend is computed using share weights w_{it}

$$\tau_t = \sum_{i=1}^{16} w_{it} \left(\alpha_{i,\tau,t} \tau_{c,t} + \tau_{i,t} \right)$$

- full Bayes estimation
- note that cointegration of components is possible but not imposed

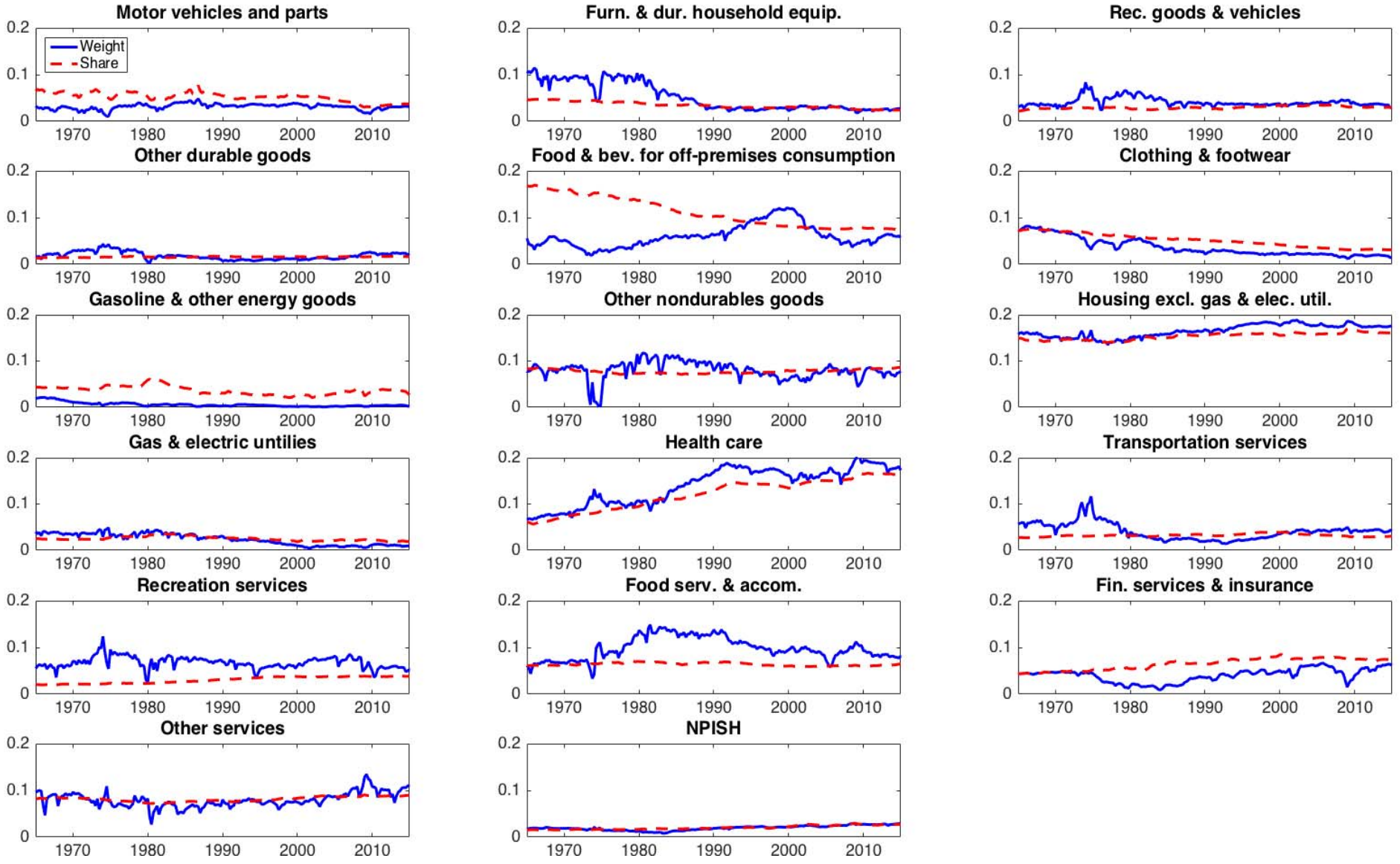
MUCSVO estimates: Food & bev. off-premises



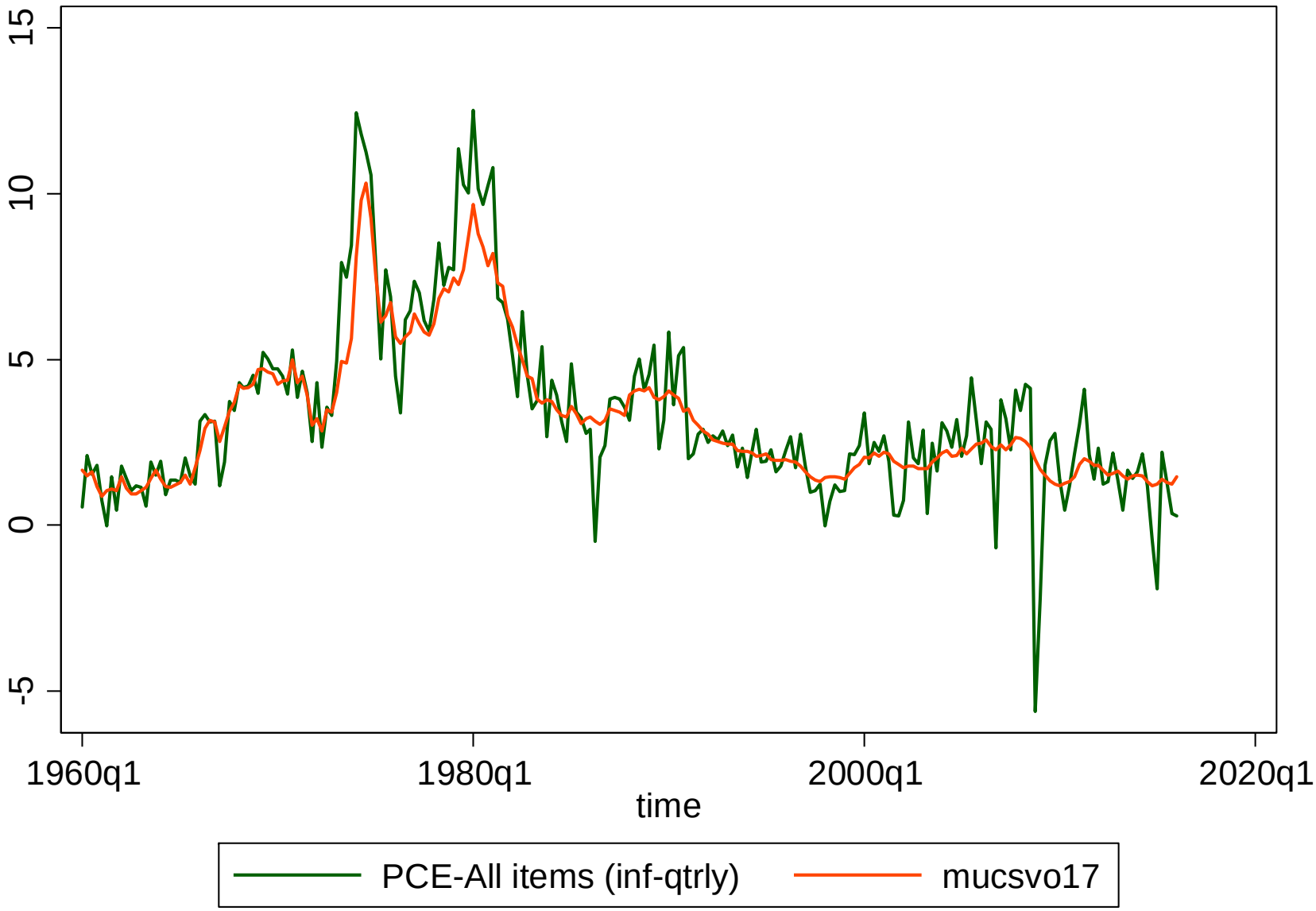
Notes: Panel (a) inflation is the sector shown in the figure heading and the full-sample posterior mean of the sectoral trend. The other panels plot the full-sample posterior median and (point-wise) 67% intervals for the sector-specific parameters

Approximate weights: MUCSVO-17 and expenditure share

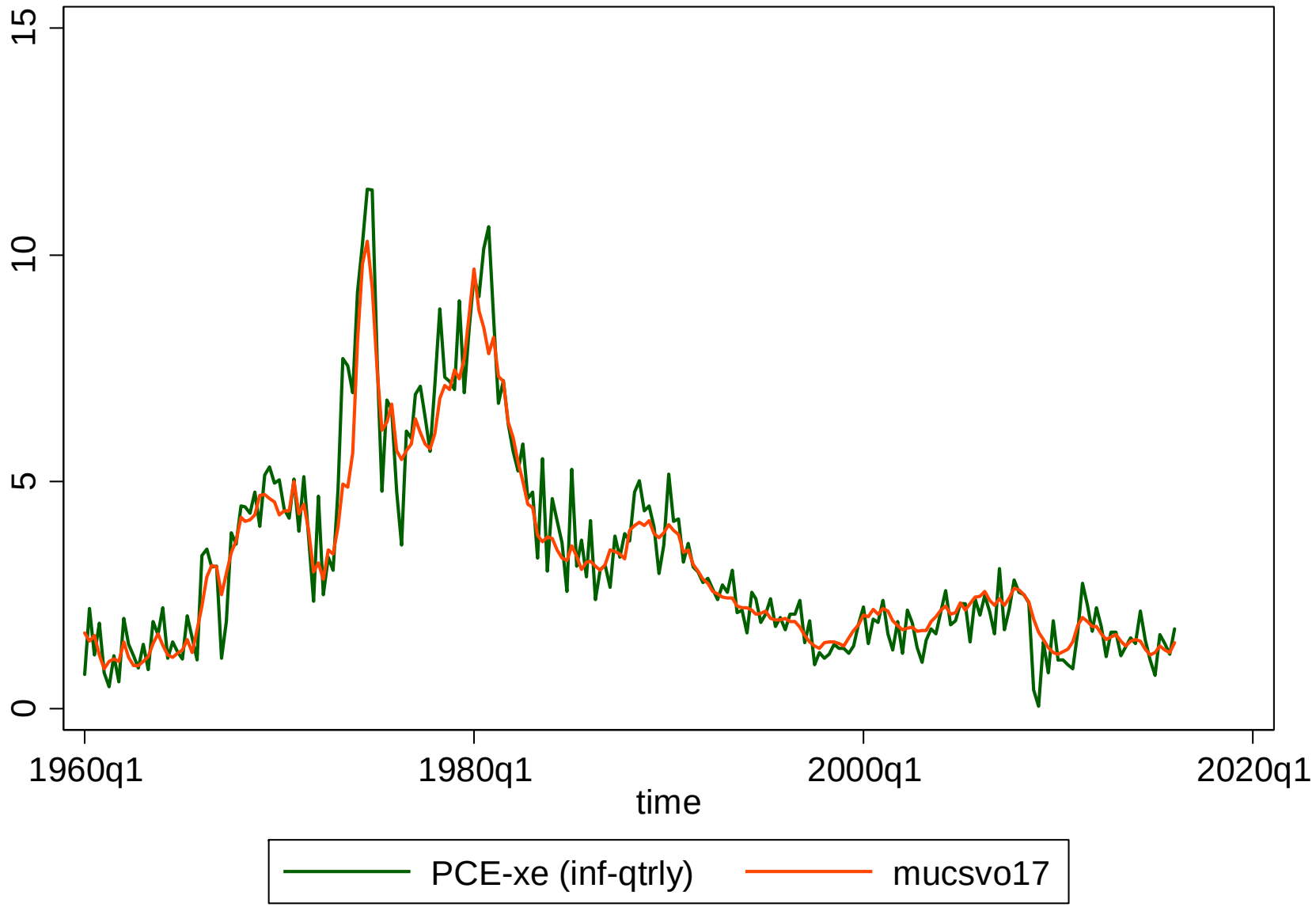
——— MUCSVO weight - - - - - Expenditure share



PCE-all and 17-component trend estimate (quarterly)



PCE-xE and 17-component trend estimate (quarterly)



5. Components:
Cyclical Properties

Cyclical Properties of Components

Phillips curves, component-wise

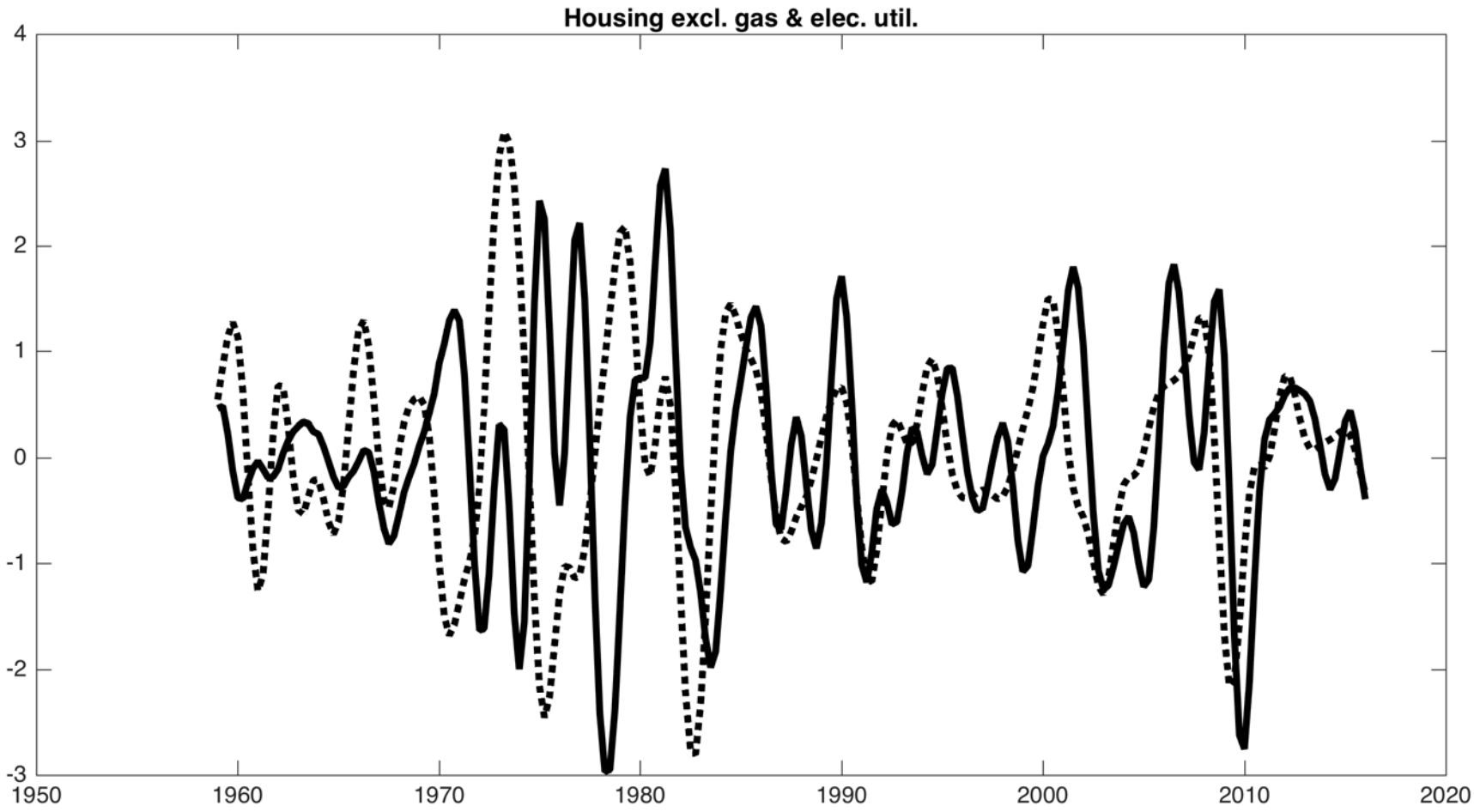
- Do components have different cyclical properties?
- Do some components observe a Phillips relation?
- If so,
  - how do cyclical properties of components change over time?
  - does that relate to measurement quality?

Figures

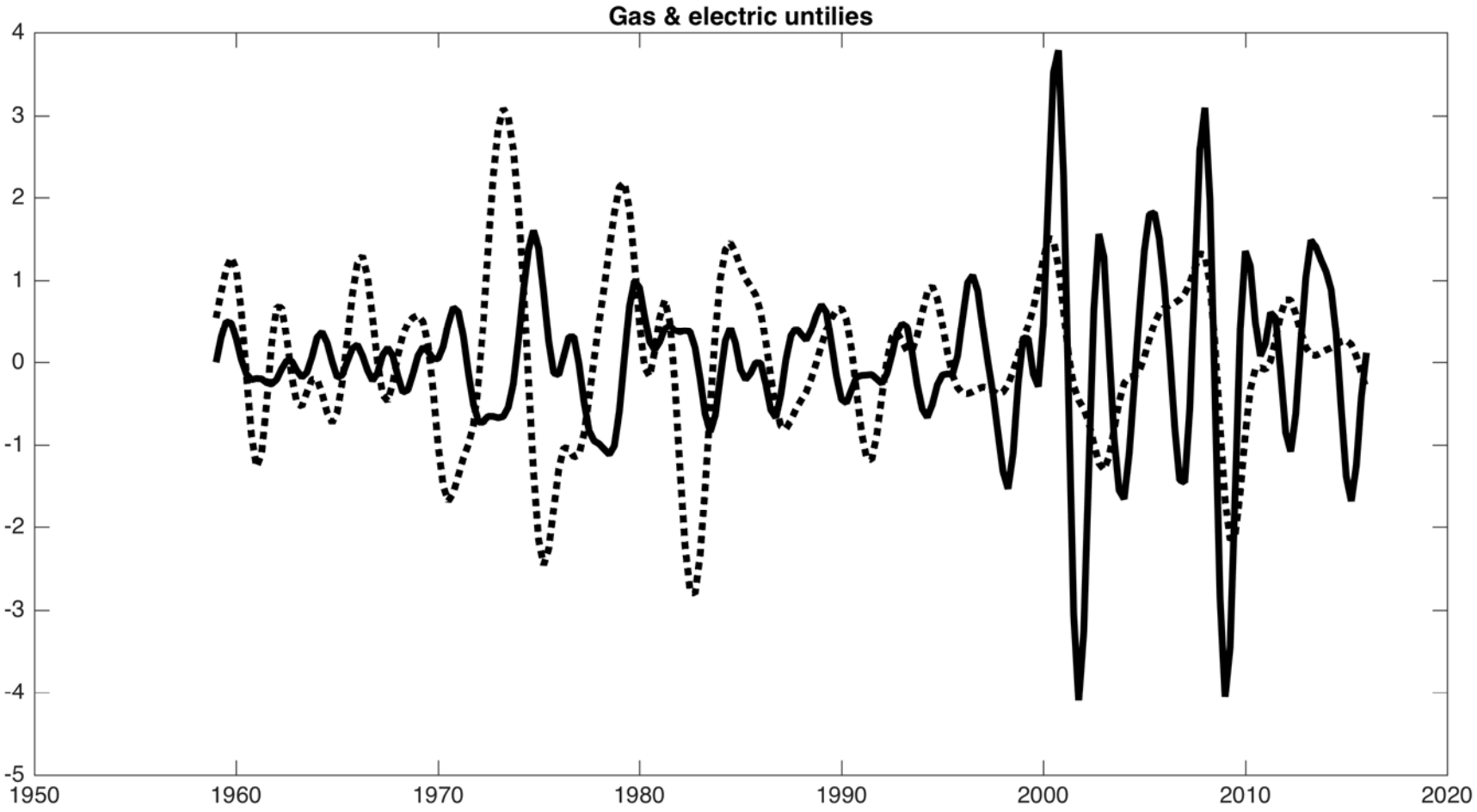
Band-pass filtered component rates of inflation (quarterly) and GDP growth

- 6-32 quarter pass band
- "cyclical component of inflation and statistical estimate of GDP gap"

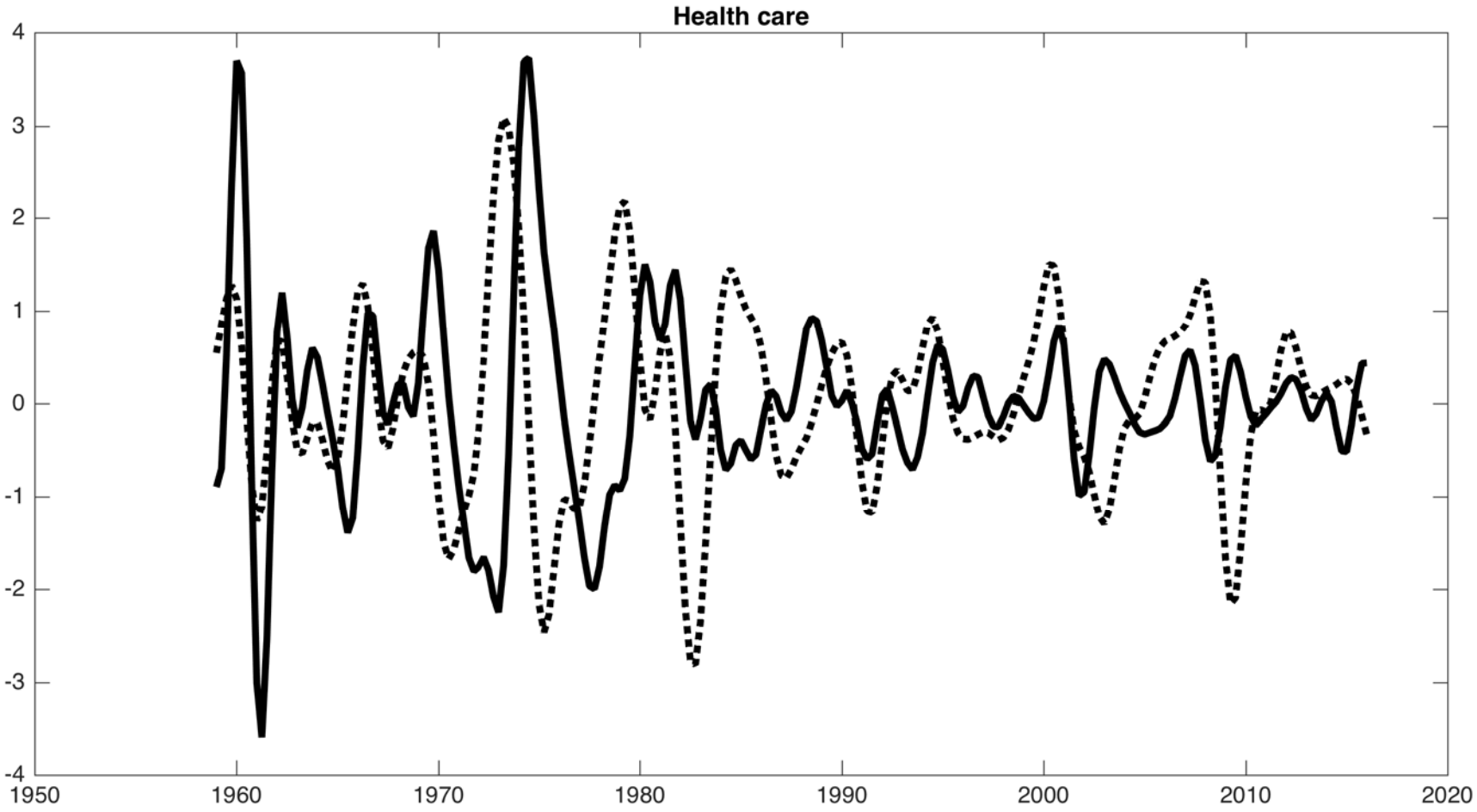
Band-pass filtered components and GDP (6-32 qtrs, standardized)



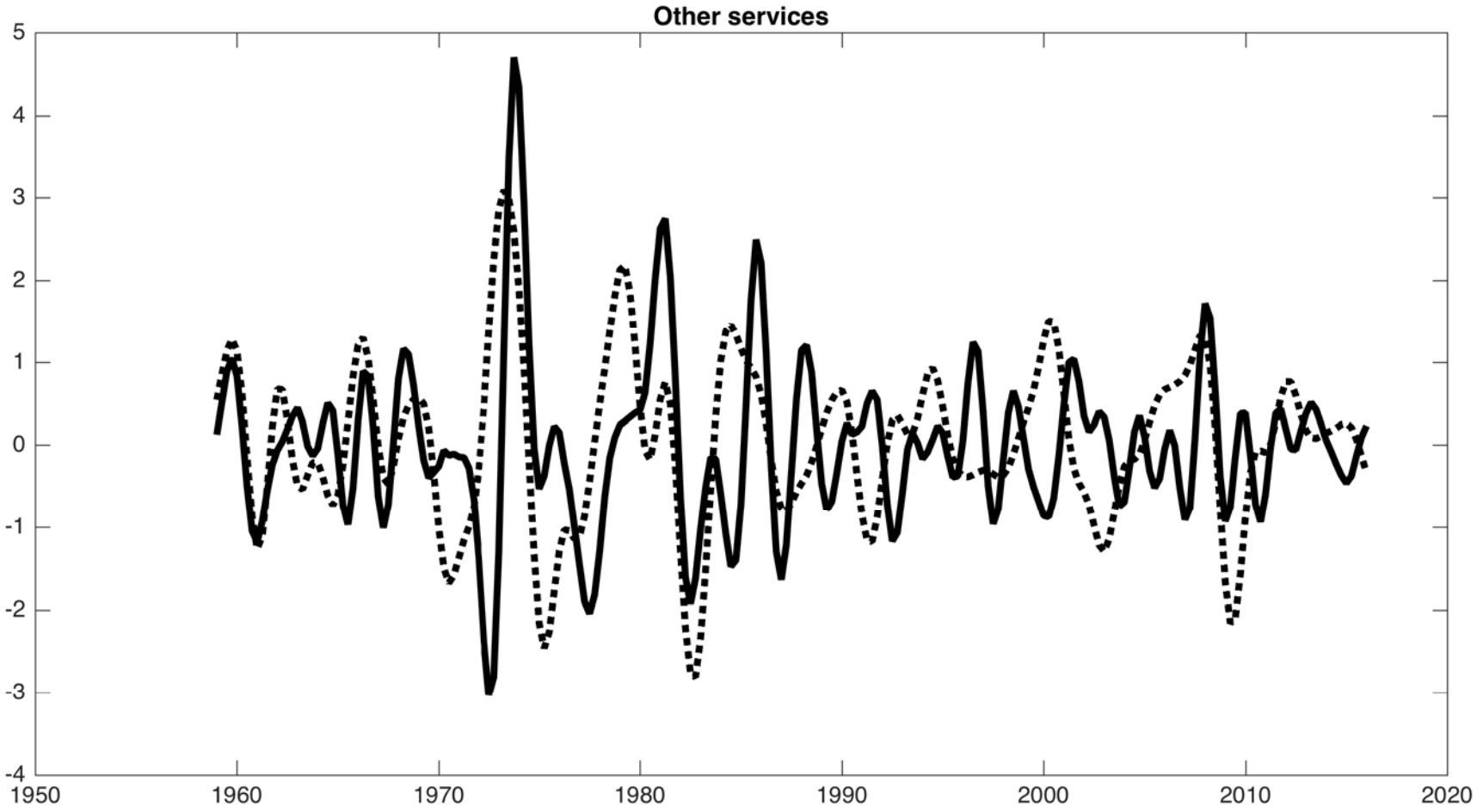
Band-pass filtered components and GDP (6-32 qtrs, standardized)



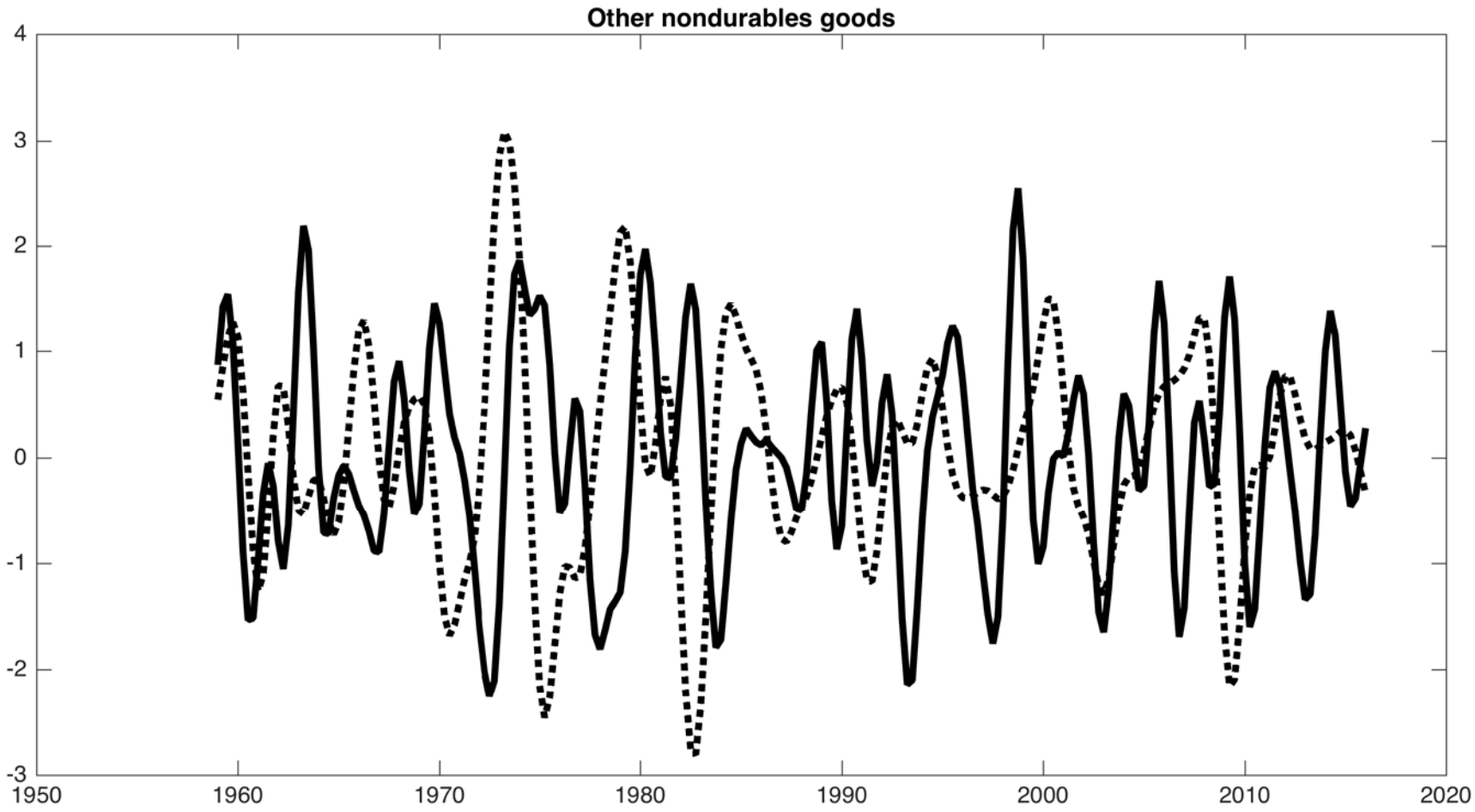
Band-pass filtered components and GDP (6-32 qtrs, standardized)



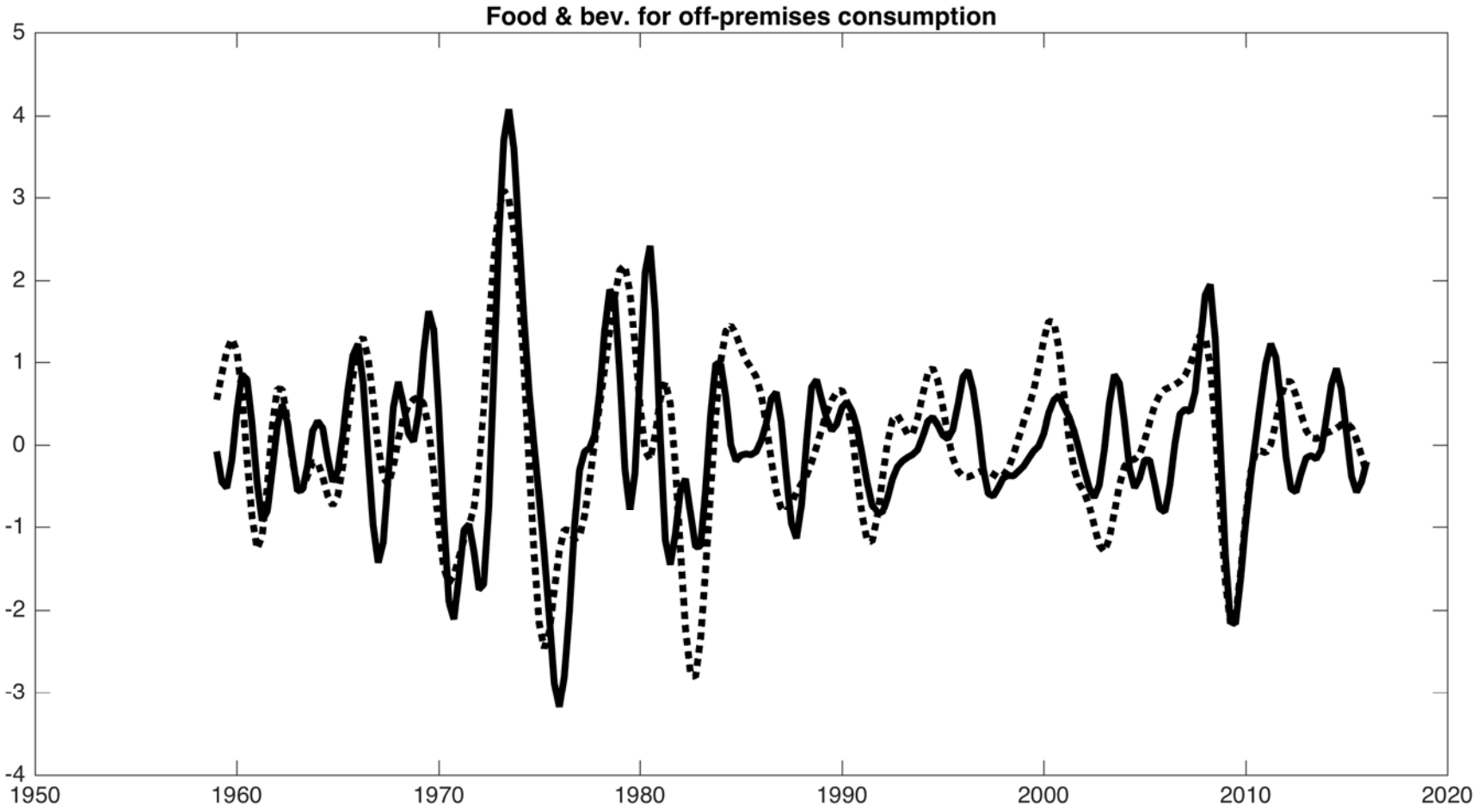
Band-pass filtered components and GDP (6-32 qtrs, standardized)



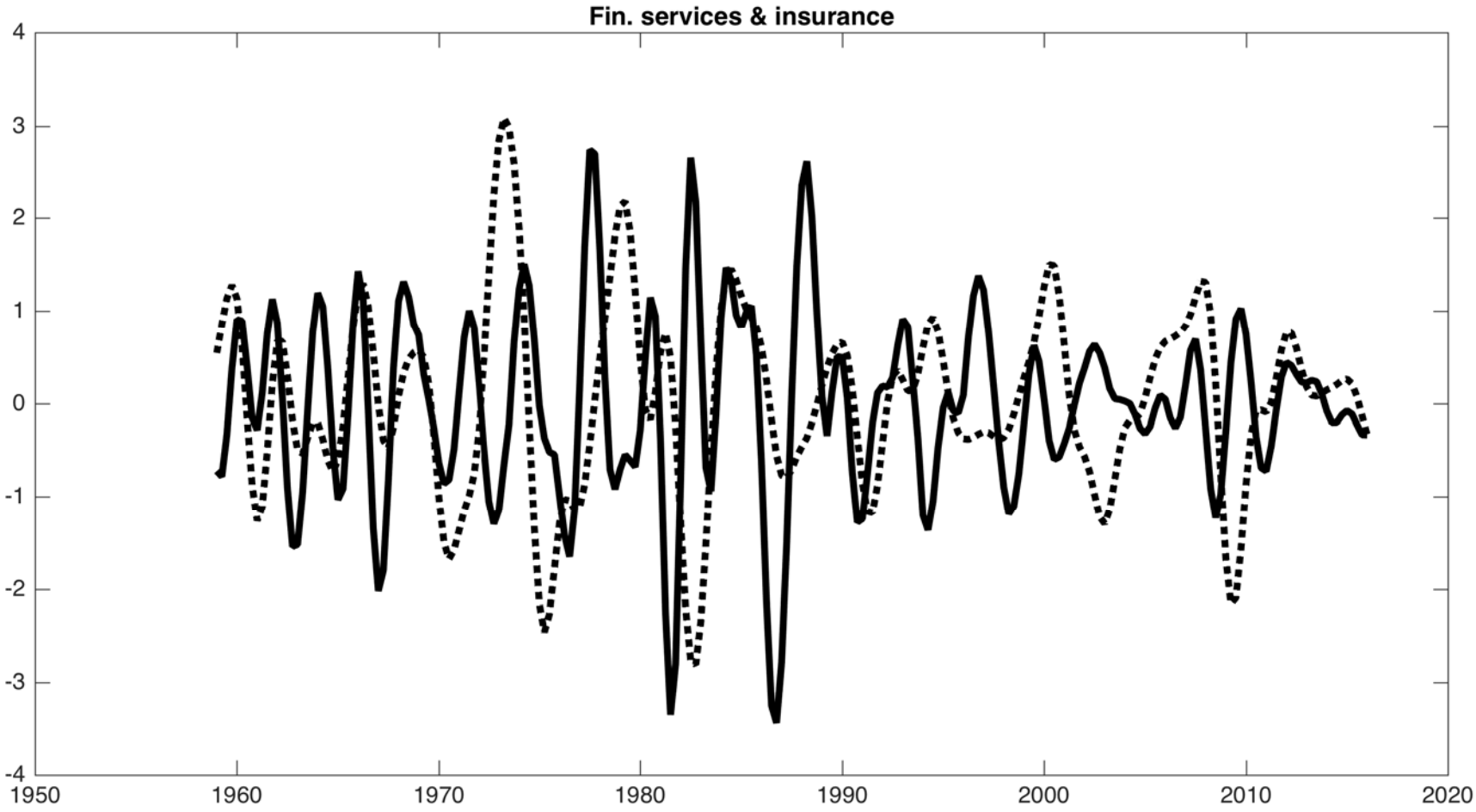
Band-pass filtered components and GDP (6-32 qtrs, standardized)



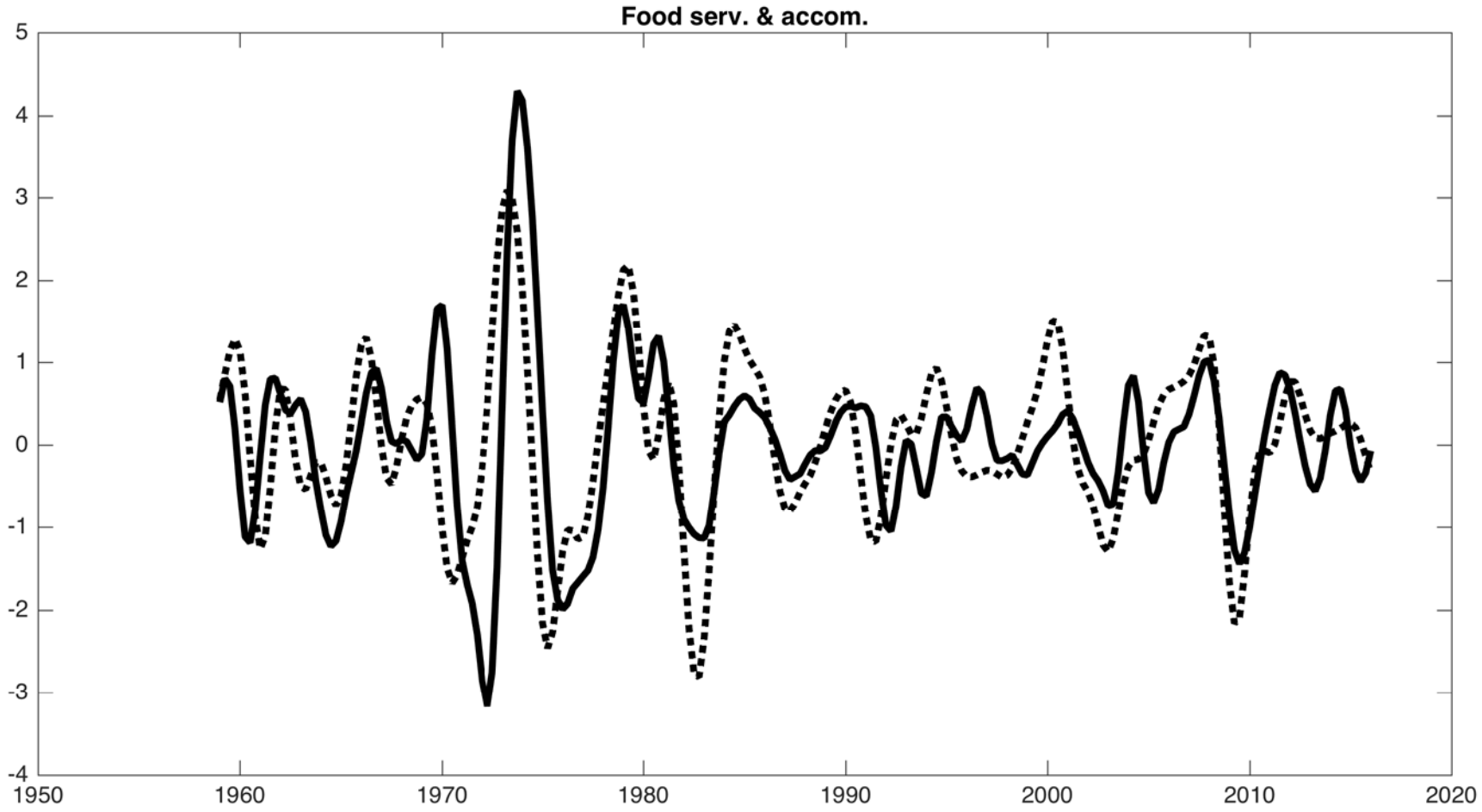
Band-pass filtered components and GDP (6-32 qtrs, standardized)



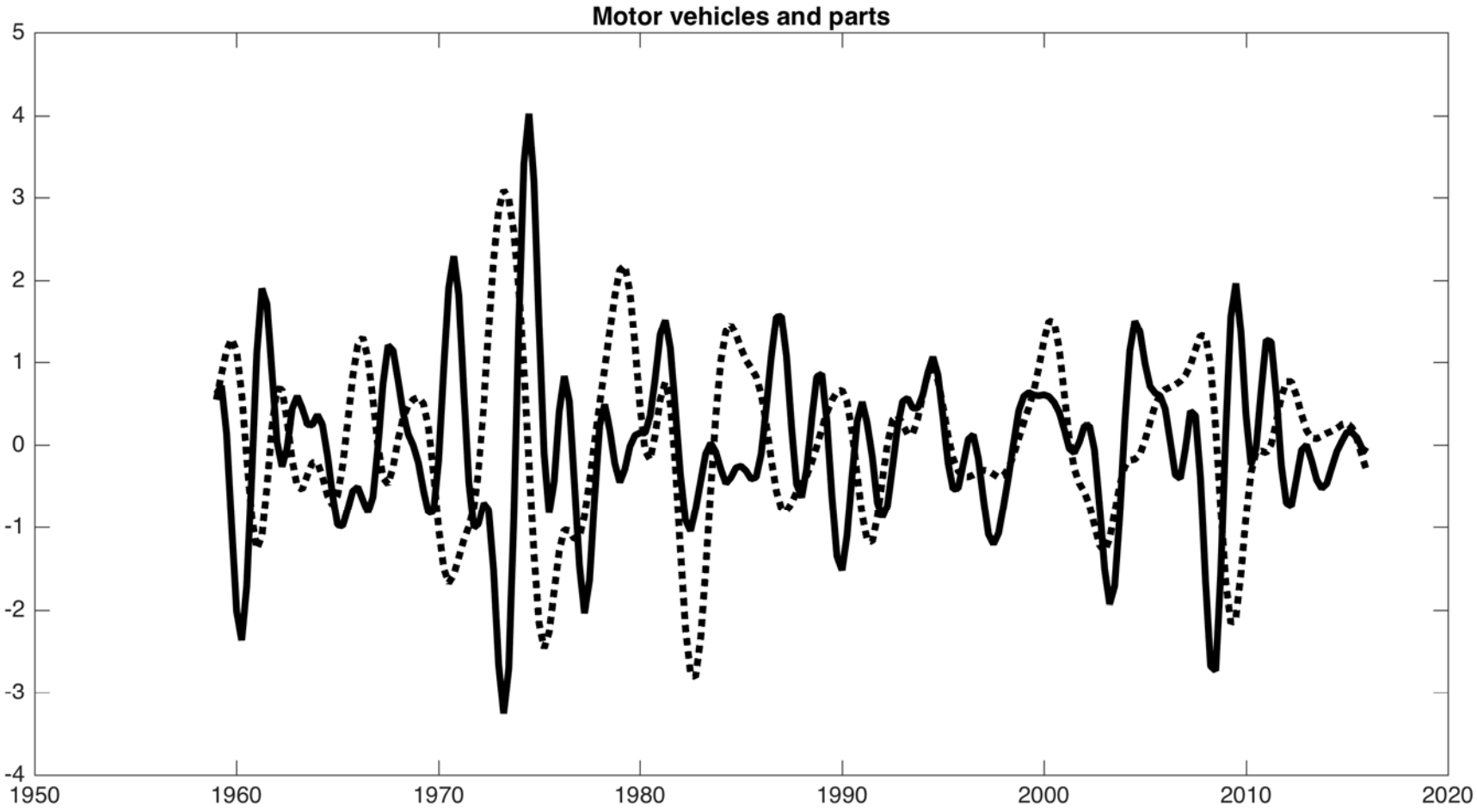
Band-pass filtered components and GDP (6-32 qtrs, standardized)



Band-pass filtered components and GDP (6-32 qtrs, standardized)

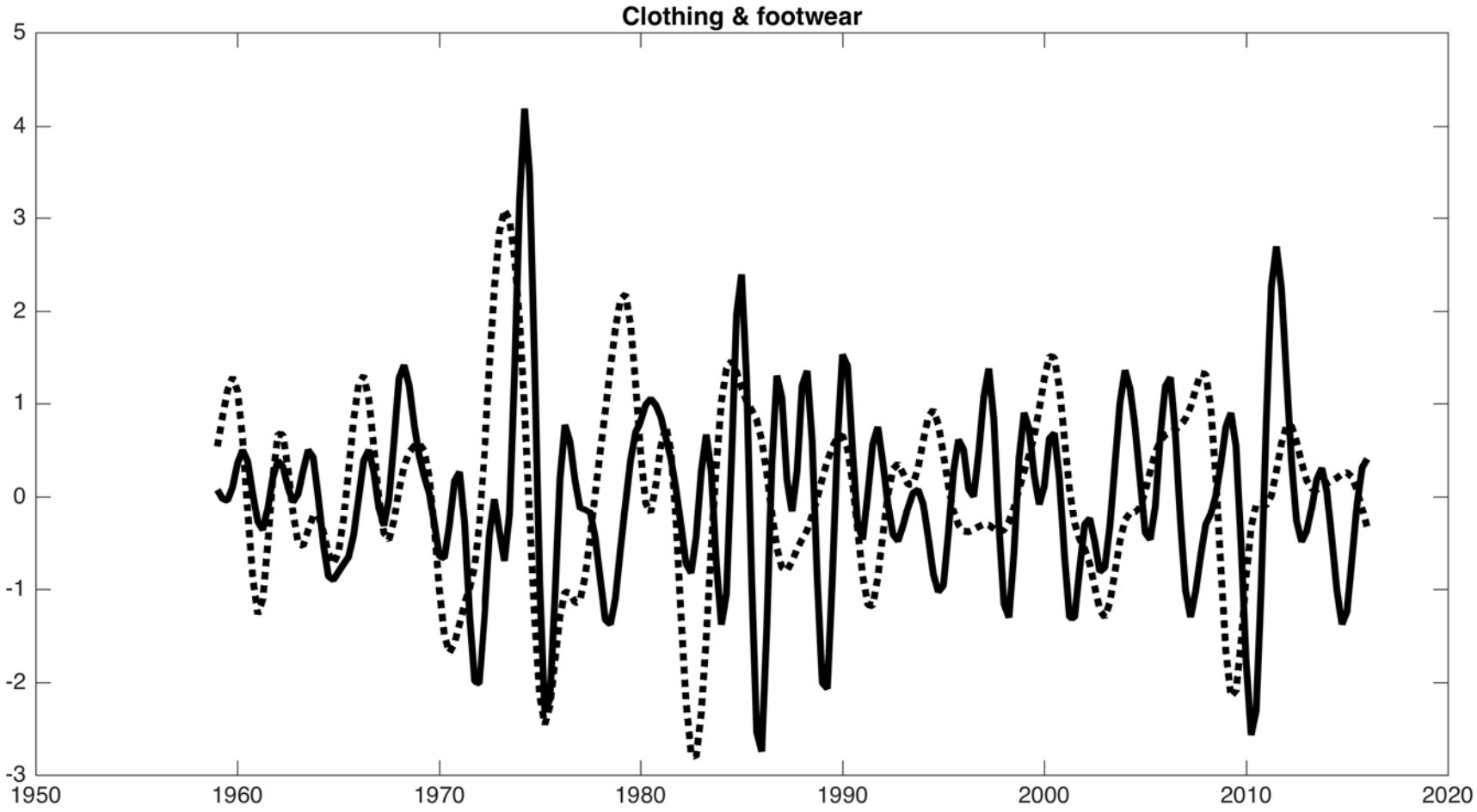


Band-pass filtered components and GDP (6-32 qtrs, standardized)

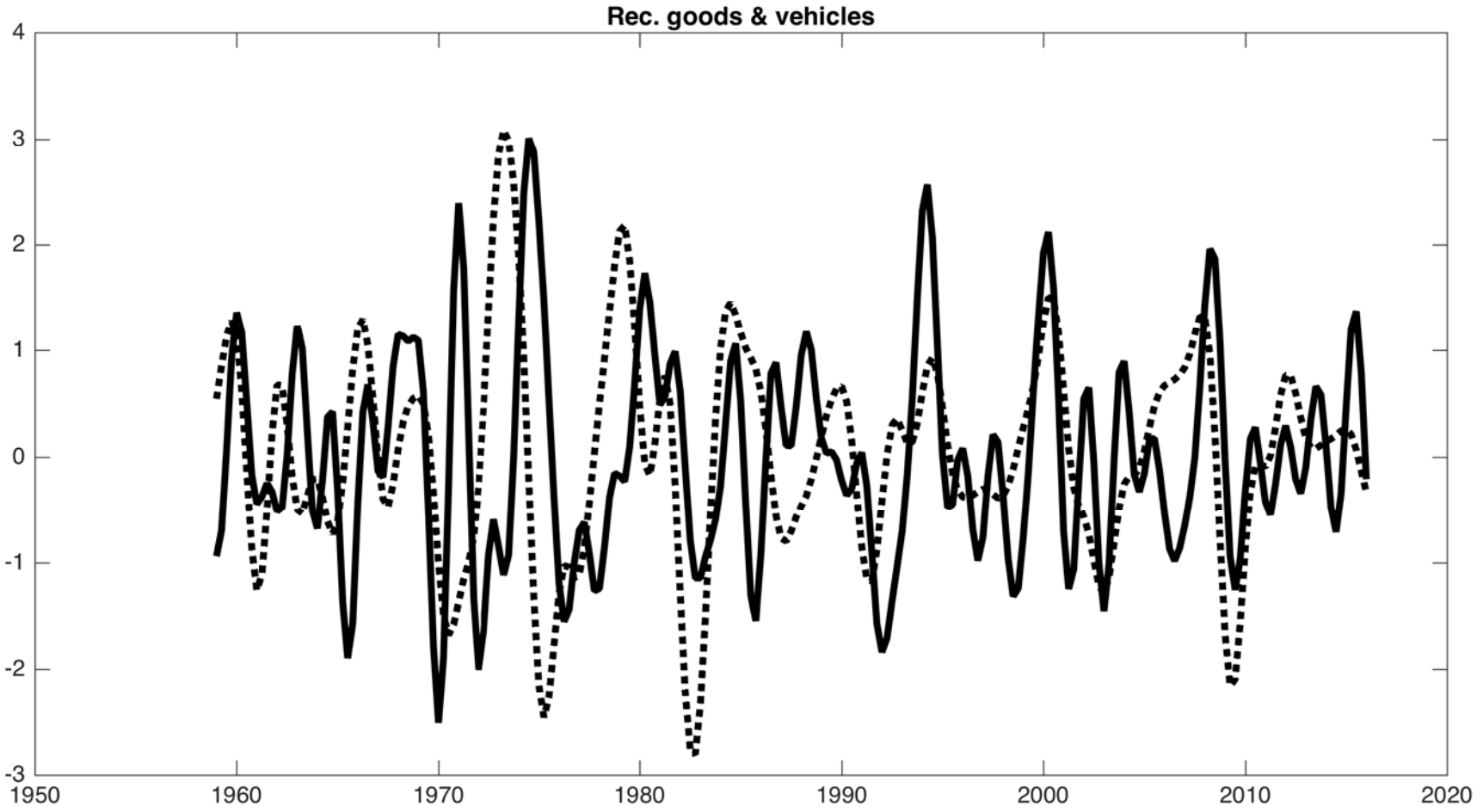


Band-pass filtered components and GDP (6-32 qtrs, standardized)

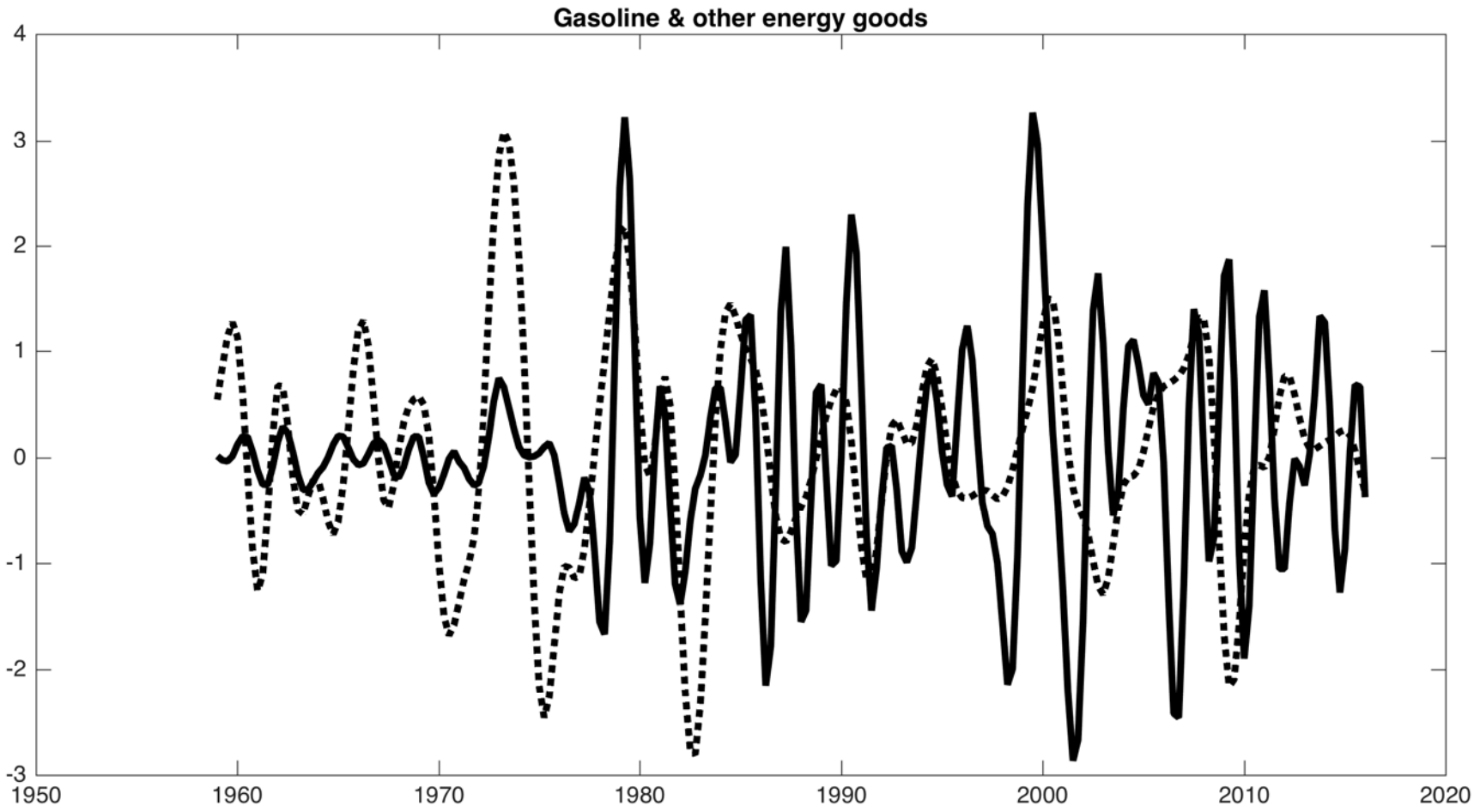
Band-pass filtered components and GDP (6-32 qtrs, standardized)



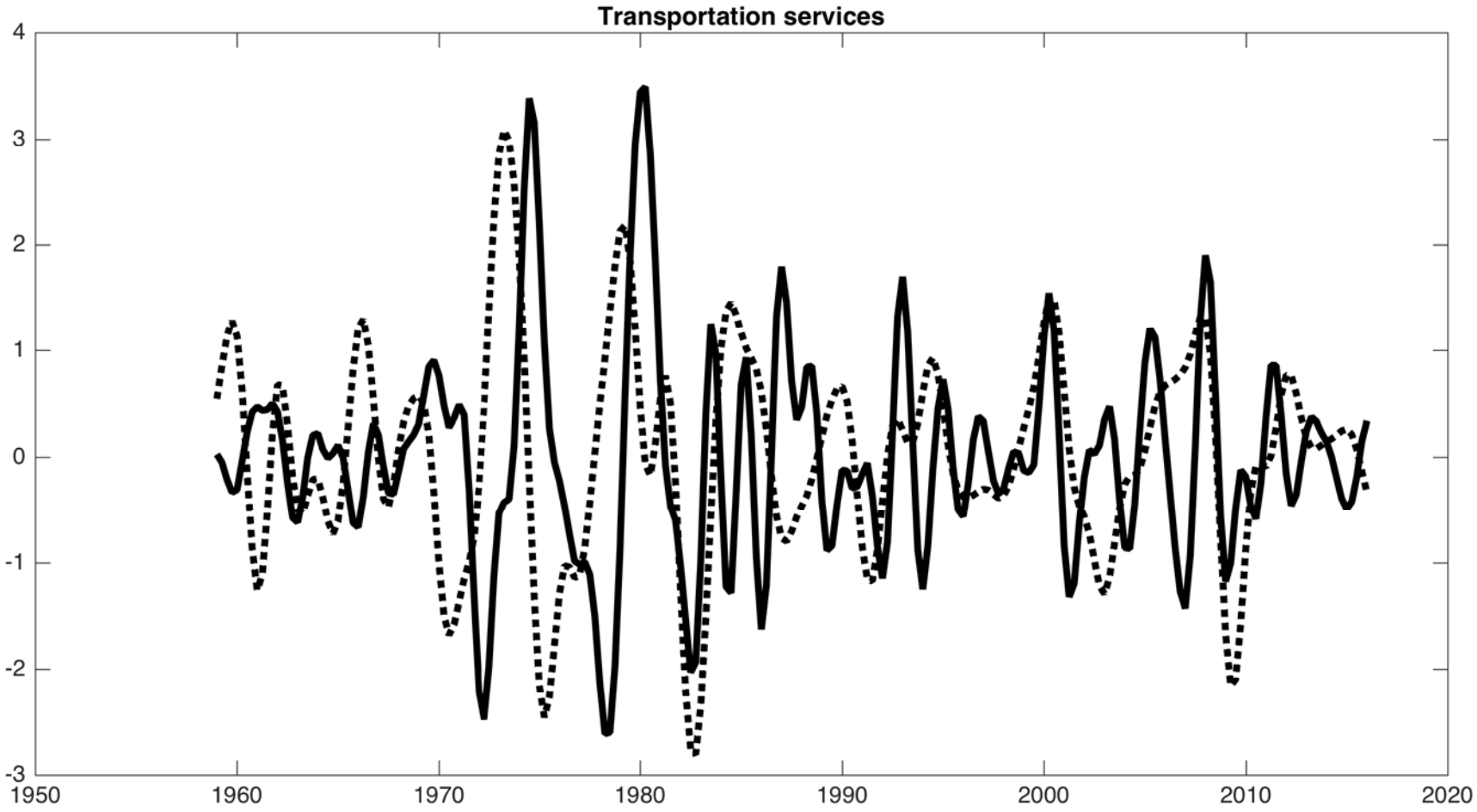
Band-pass filtered components and GDP (6-32 qtrs, standardized)



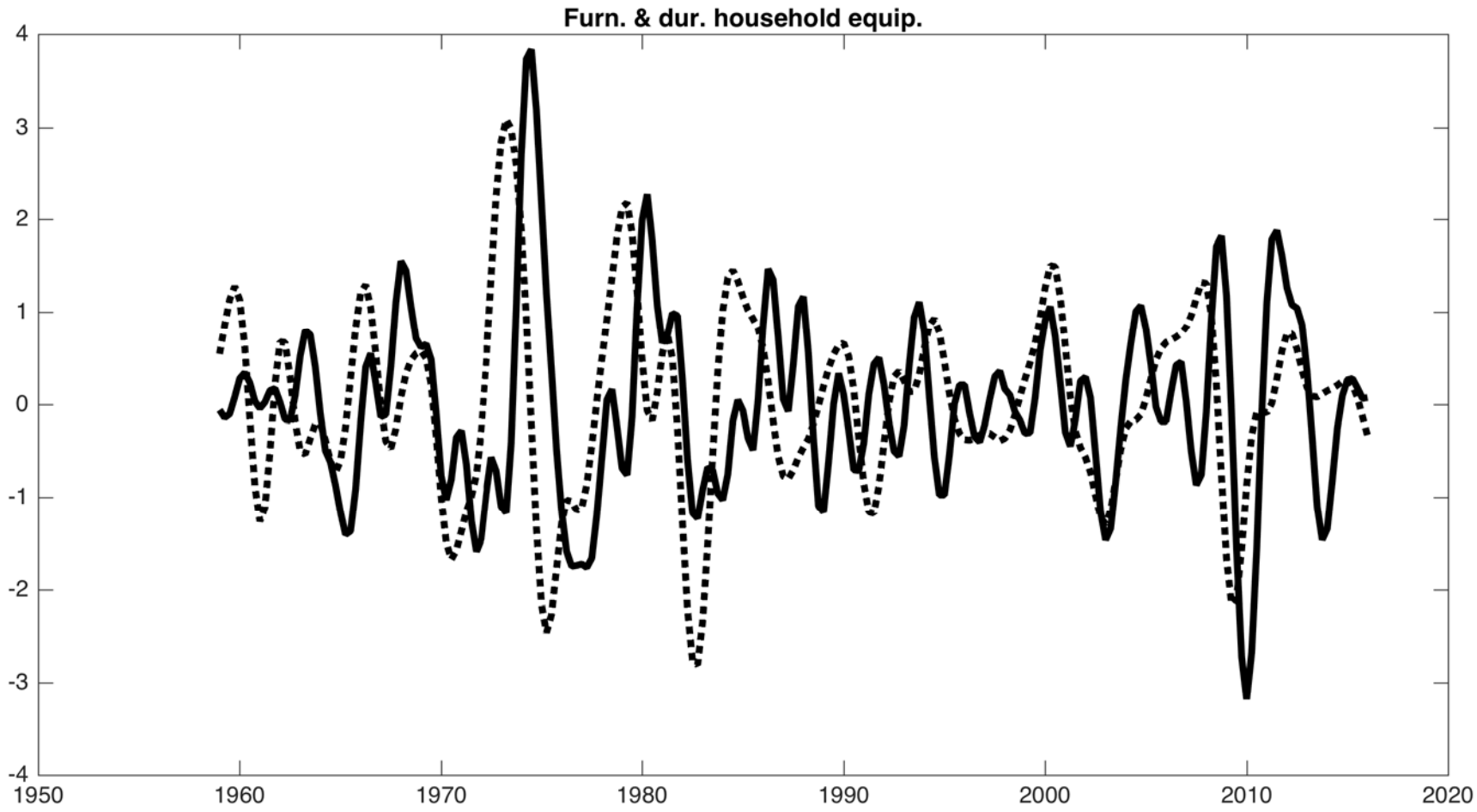
Band-pass filtered components and GDP (6-32 qtrs, standardized)



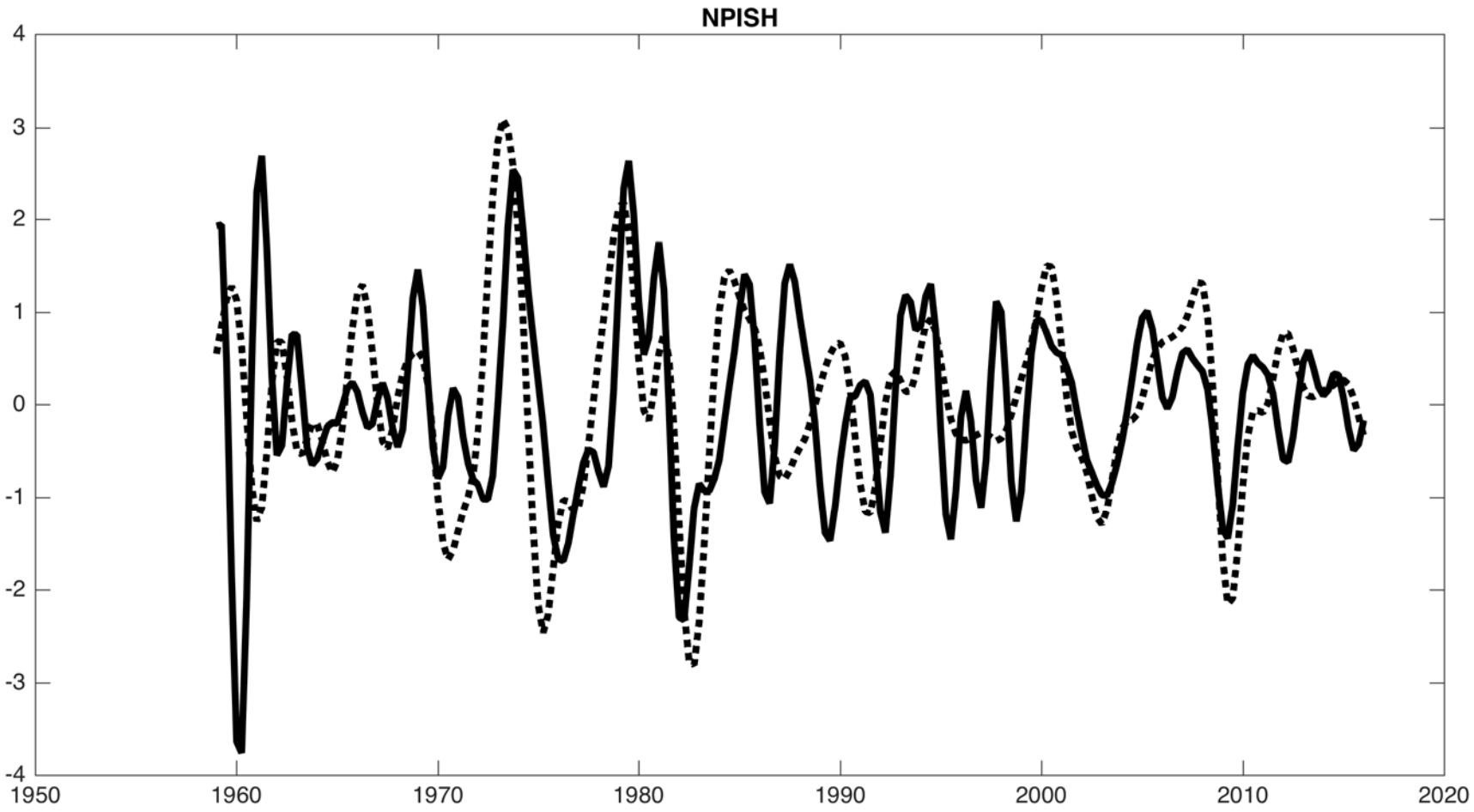
Band-pass filtered components and GDP (6-32 qtrs, standardized)



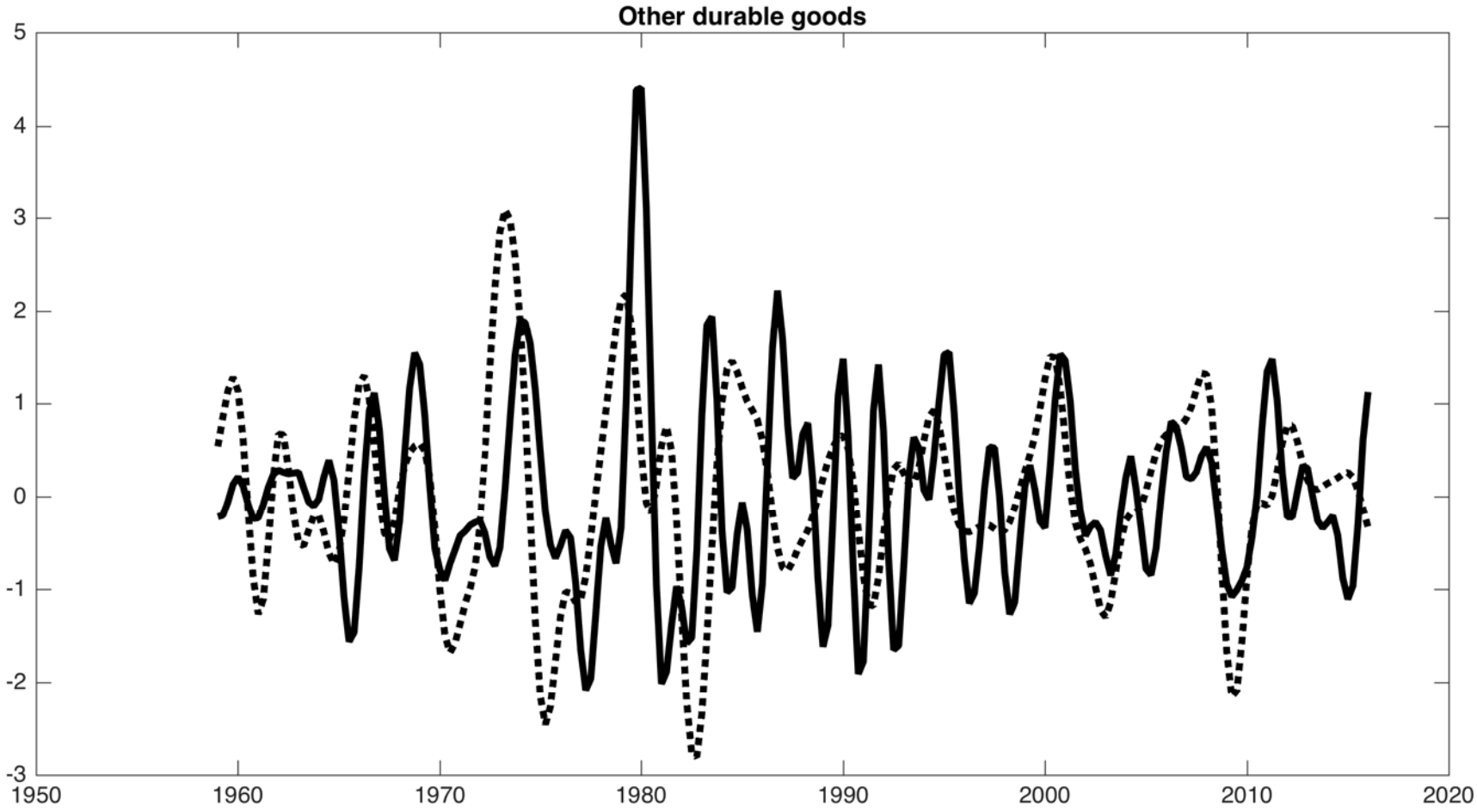
Band-pass filtered components and GDP (6-32 qtrs, standardized)



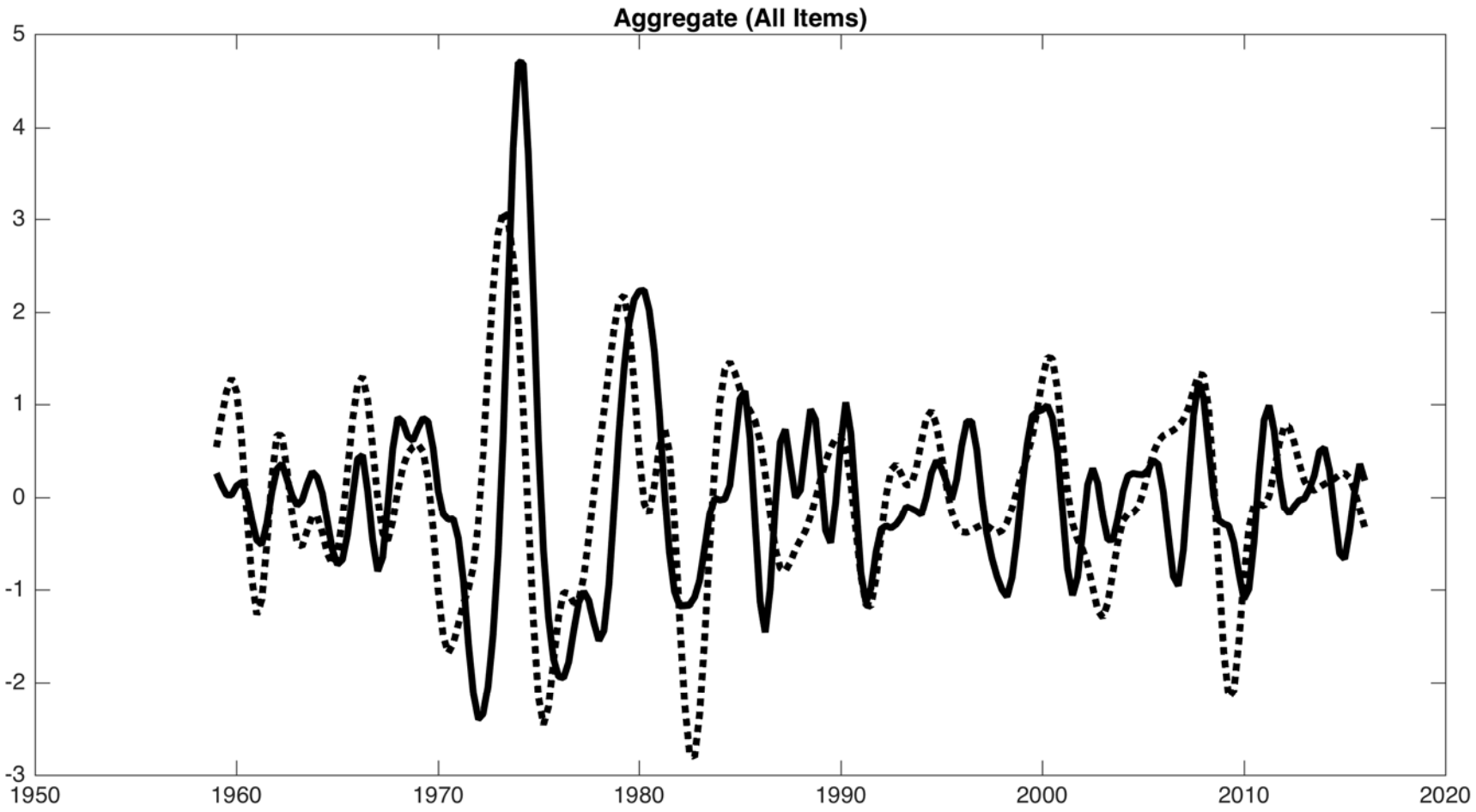
Band-pass filtered components and GDP (6-32 qtrs, standardized)



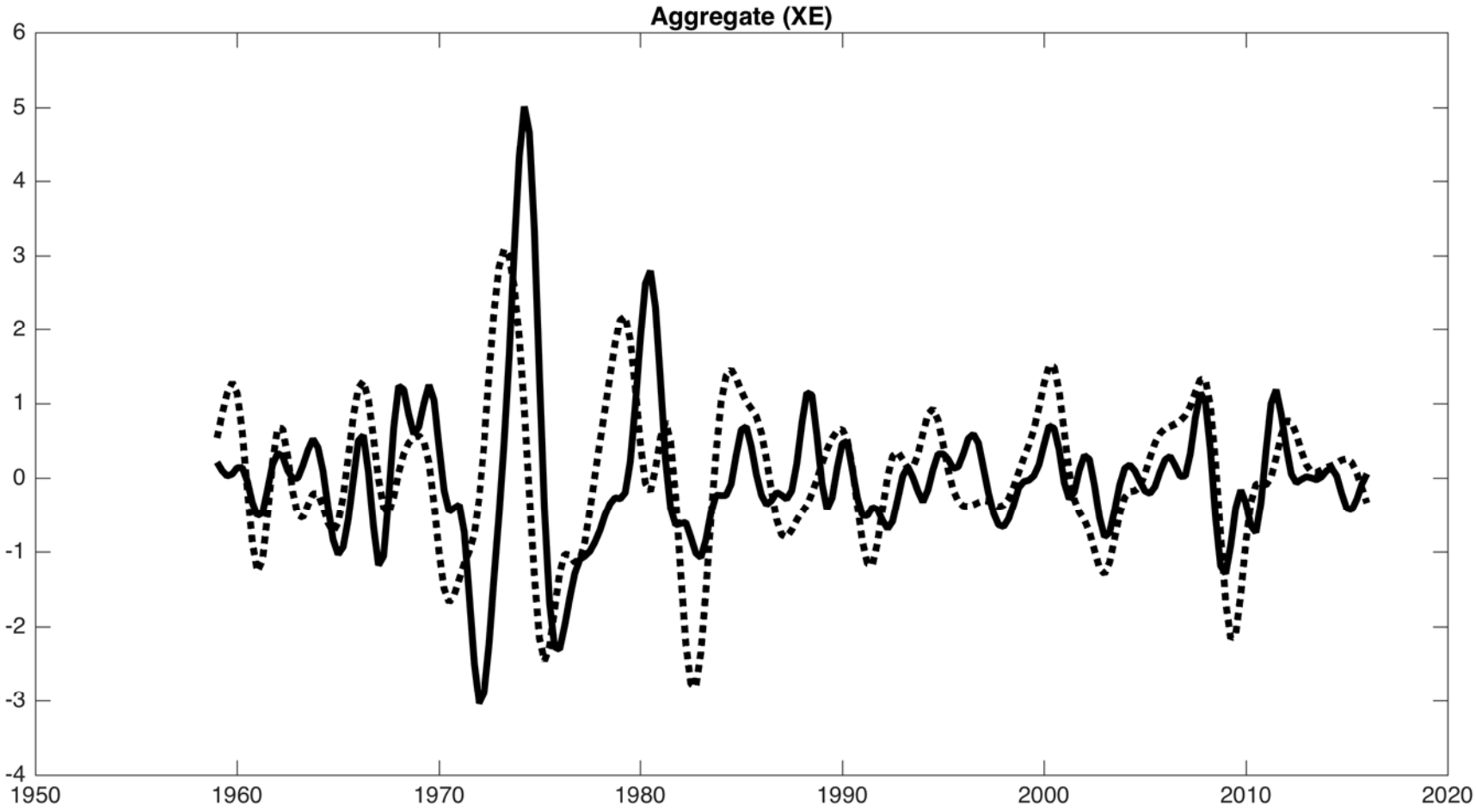
Band-pass filtered components and GDP (6-32 qtrs, standardized)



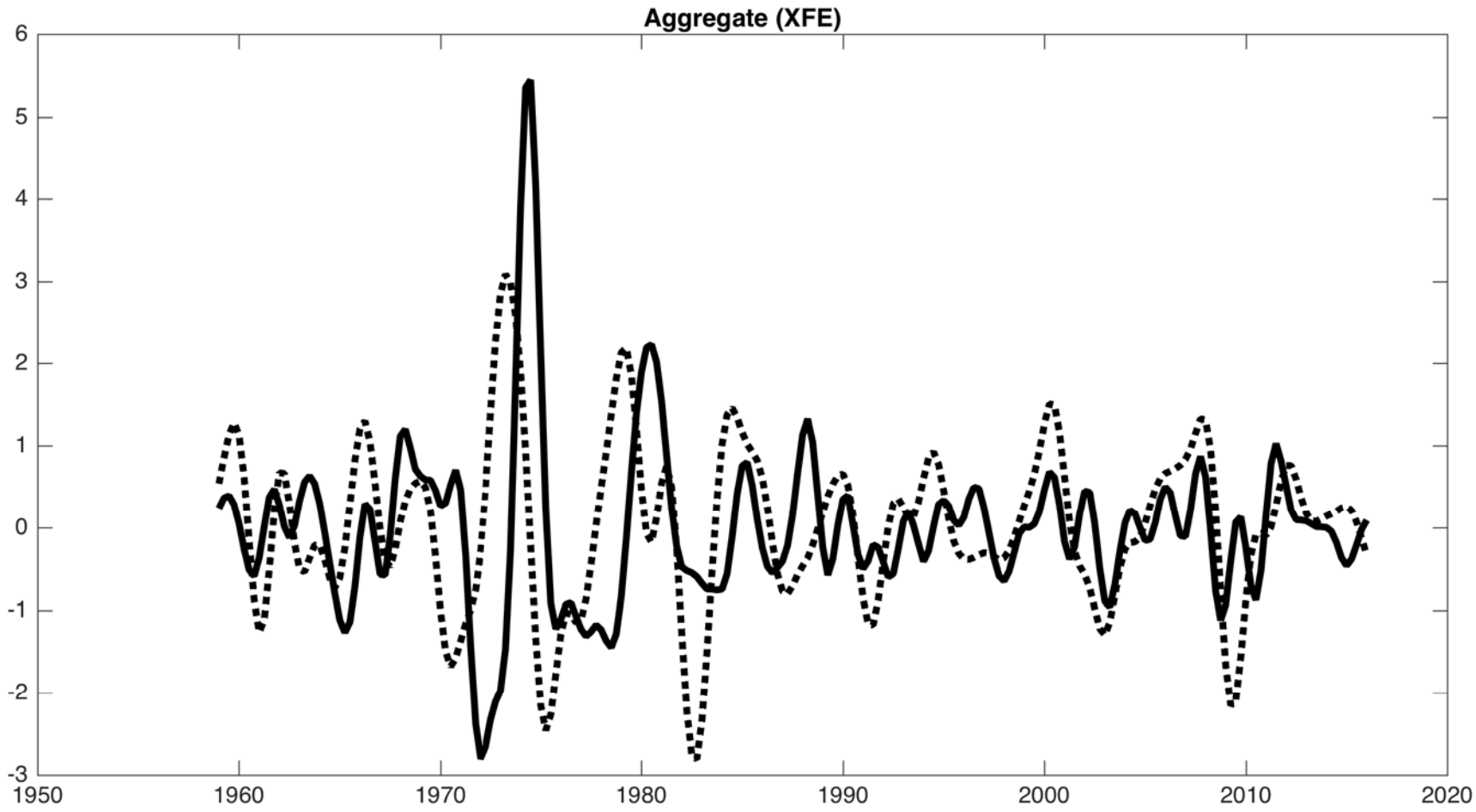
Band-pass filtered PCE-xE and GDP (6-32 qtrs, standardized)



Band-pass filtered PCE-xE and GDP (6-32 qtrs, standardized)



Band-pass filtered PCE-xE and GDP (6-32 qtrs, standardized)



Full-sample exploratory regressions: components Phillips curves

- **Direct 4-qtr ahead forecasting regression**
- Dependent variable is cumulative 4-qtr inflation over next 4 quarters
- Predictors are 4 lags of $\Delta\pi$, u
- Estimation 1984q1-2016q1 (no out-of-sample)
- **Entries are p-values** on lags of the unemployment rate (HAC SEs)

	Unempl	Ugap-CBO	U<27
Housing ex gas & electric util	**0.000**	**0.000**	**0.000**
Gas & electric util	0.683	0.547	0.205
Health care	**0.006**	0.196	0.121
Other services	0.013	0.033	**0.000**
Other nondurable goods	**0.000**	**0.000**	**0.000**
Food & beverages-off-premises	0.027	0.021	0.022
Financial services & insurance	0.059	0.094	0.309
Food services & accommodations	**0.000**	**0.001**	**0.000**
Motor vehicles and parts	0.078	0.149	0.135
Recreation services	**0.002**	**0.002**	**0.000**
Clothing & footwear	0.026	0.020	**0.000**
Recreational goods & vehicles	0.559	0.635	0.219
Gasoline & other energy goods	0.081	0.011	0.130
Transportation services	0.016	0.042	**0.002**
Furnishings & durable hh eqpt	0.232	0.294	0.012
NPISH	0.022	0.020	0.021
Other durable goods	0.593	0.384	0.326
PCE-all	0.051	0.036	0.060
PCE-xE	0.159	0.115	**0.002**
PCE-xFE	0.024	0.037	**0.006**

6. Cyclically Sensitive Inflation

Cyclically sensitive inflation: methods

Questions

- What series enter "cyclically sensitive inflation"
- What weights do they get and how do those compare to share weights
- How much time variation in weights
- [What is cyclically sensitive inflation reading today?]

Preliminary data restriction

- Eliminate four categories based on *a-priori* concerns about measurement:
  - Recreational goods & vehicles
  - Clothing & footwear
  - Financial services & insurance
  - NPISH

Cyclically sensitive inflation: methods

Using remaining 13 components:

- Maximize the R^2 of the regression:

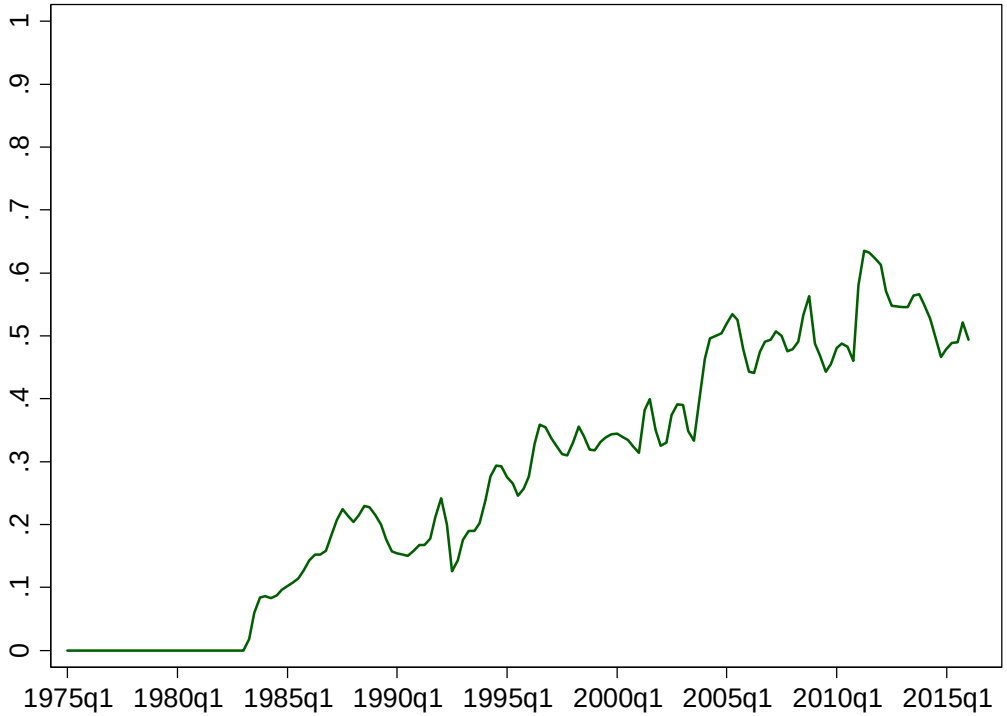
$$\sum_{i=1}^{13} \omega_i \pi_{it}^{BP} = \alpha + \beta(L) x_t^{BP} + v_t \quad \text{s.t.} \quad \sum_{i=1}^{13} \omega_i = 1 \ \text{ and } \ 0 \le \omega_i \le 1$$

  where BP is 6-32 quarter band-pass and *x* is one or more activity variables
- Base case uses 0-3 lags of the unemployment rate
- computed using 15-year rolling windows

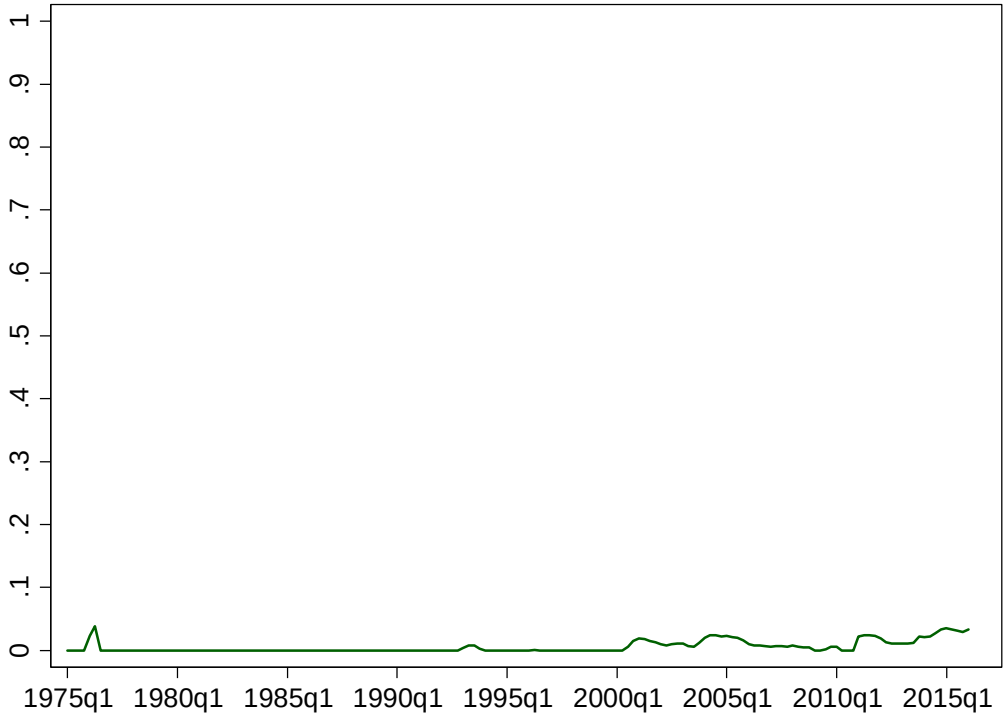
Following figures

- Rolling R2 (unadjusted) and R2 of comparison series
- TV weights and share weights by component
- Cyclically sensitive inflation

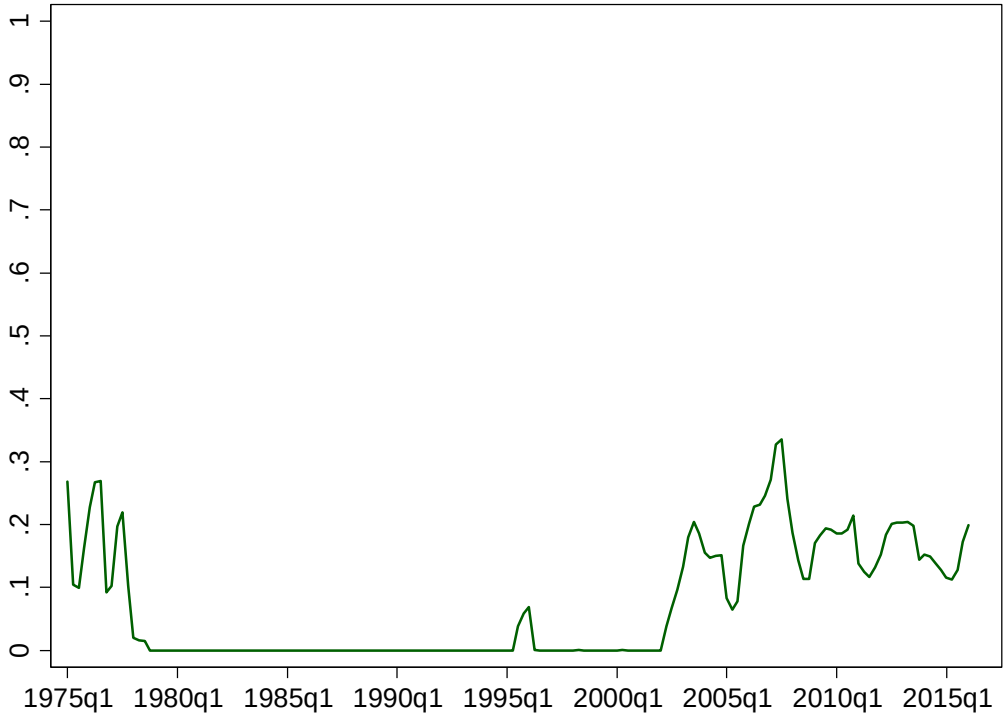
Housing ex energy utilities



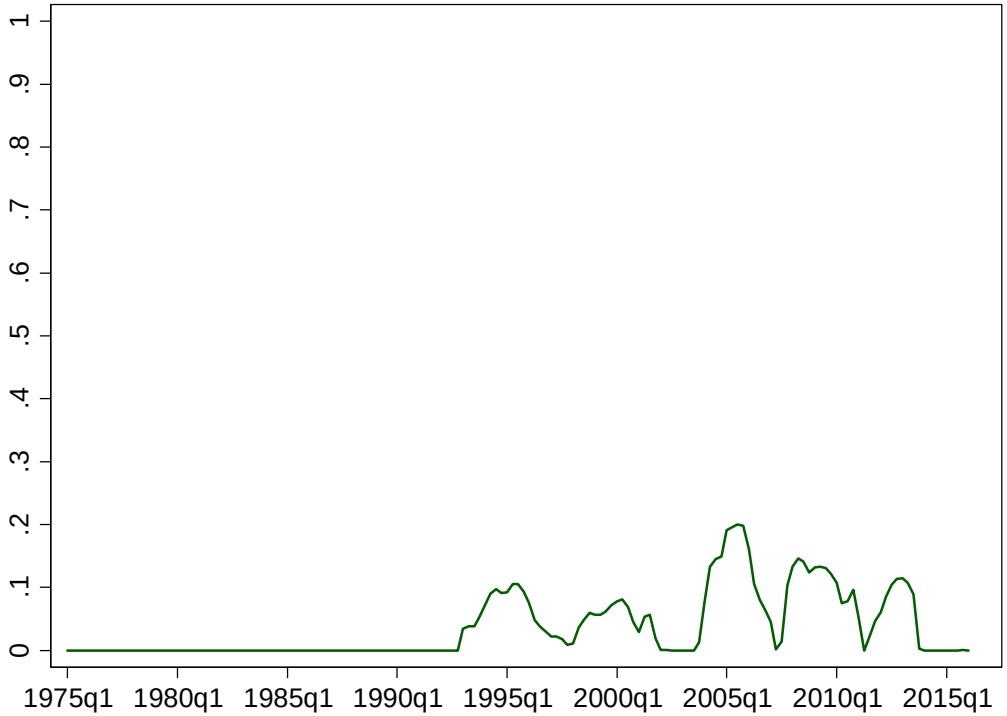
Housing: energy utilities



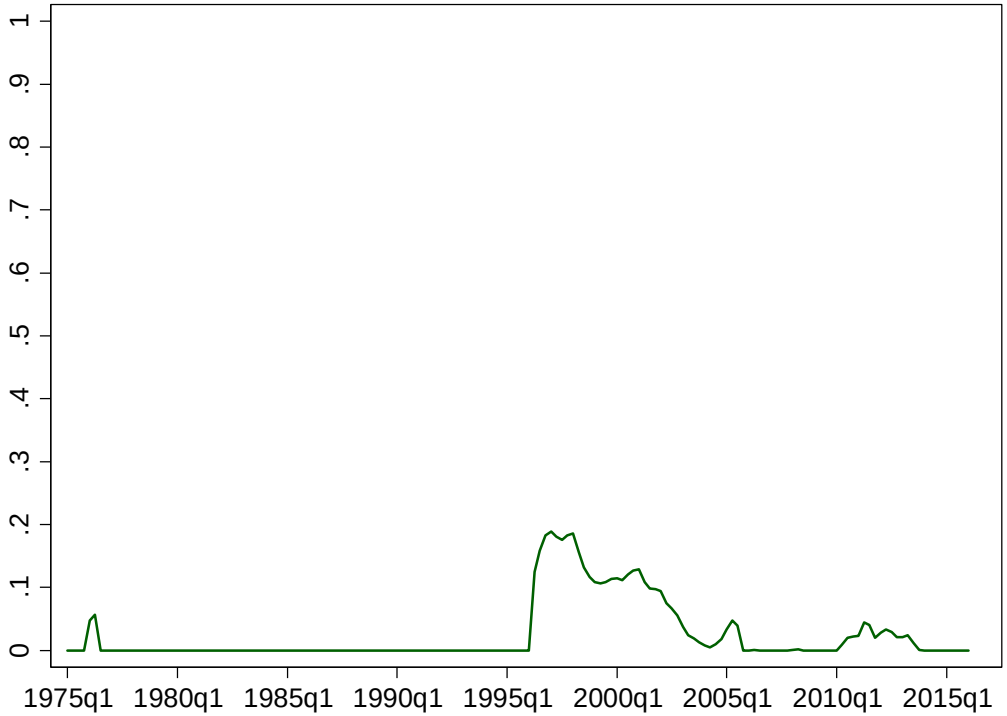
Health care (0.16)



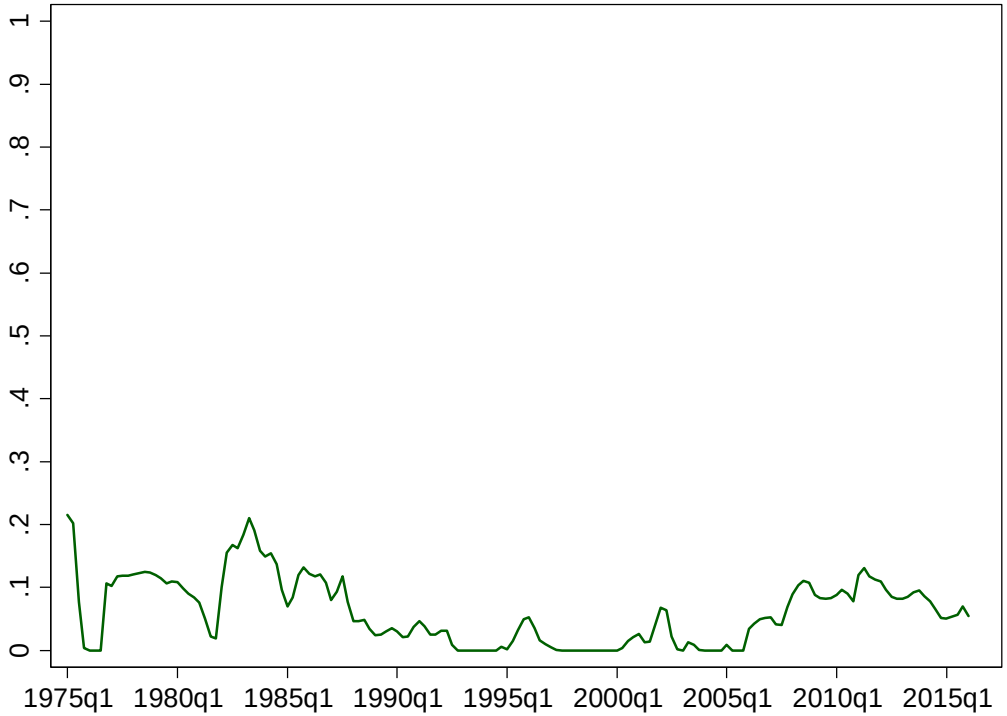
Other services (0.09)



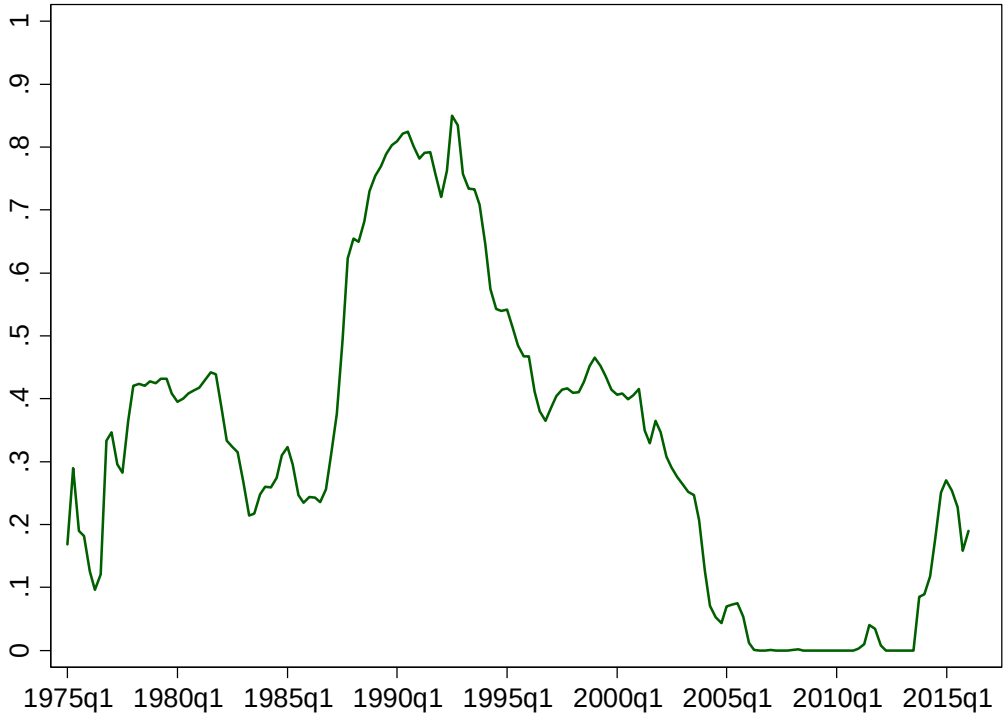
Other nondurable goods (0.08)



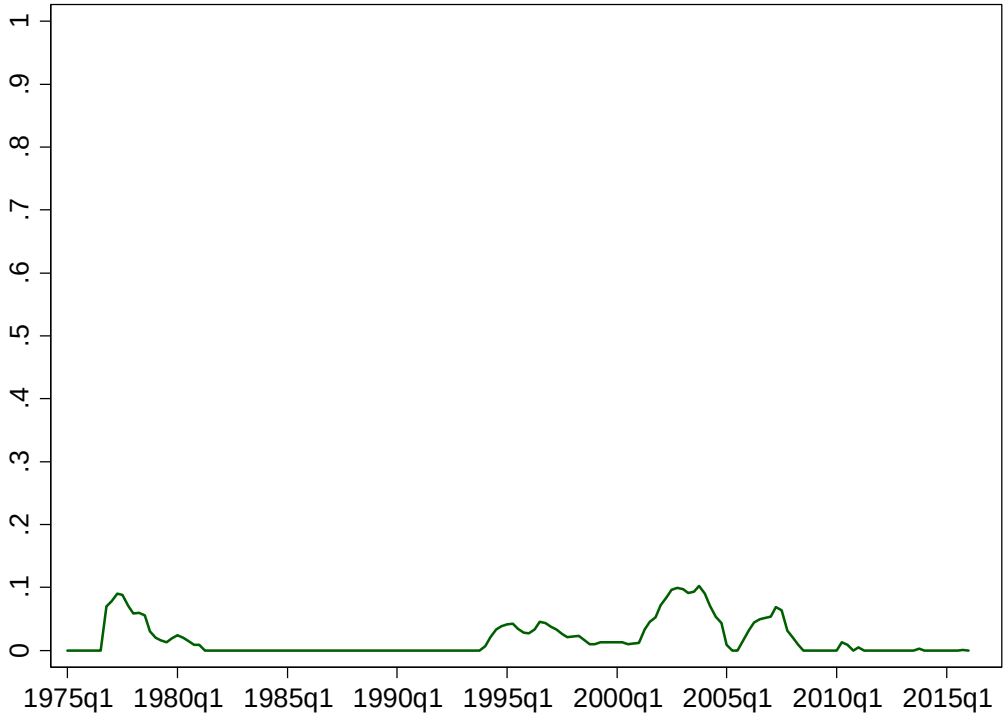
Food & beverages off-premises (0.08)



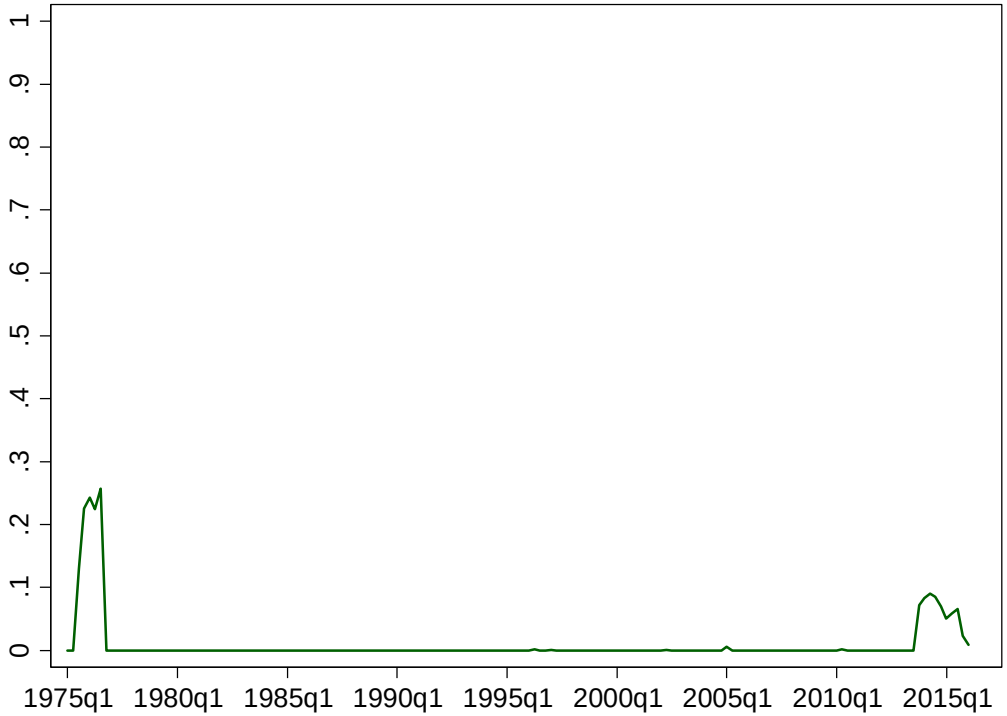
Food services & accommodations (0.06)



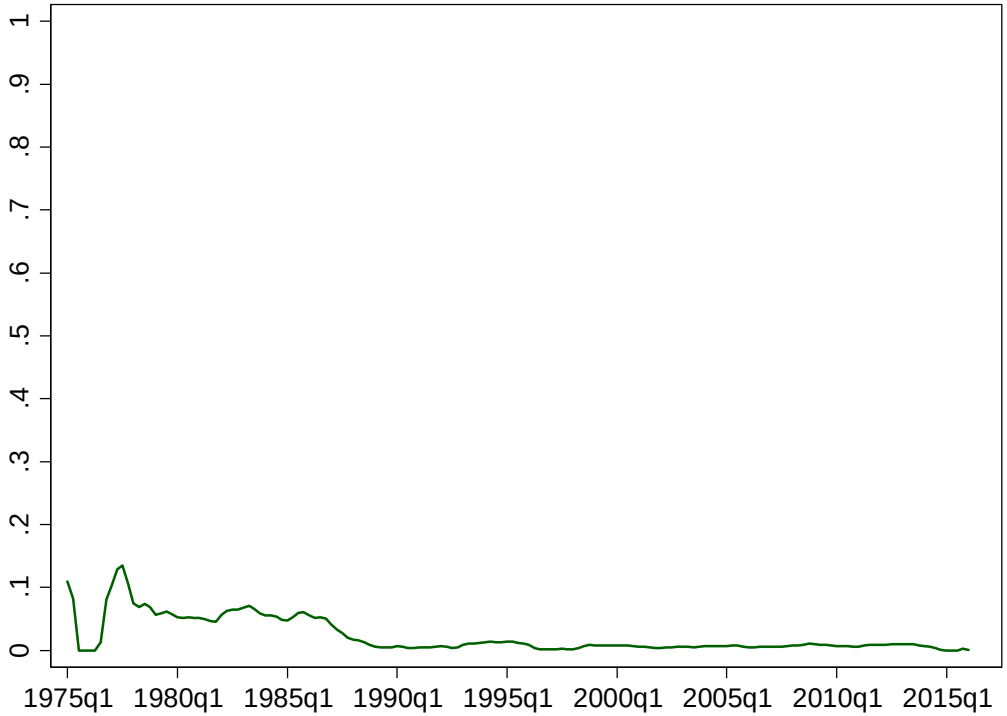
Motor vehicles & parts (0.04)



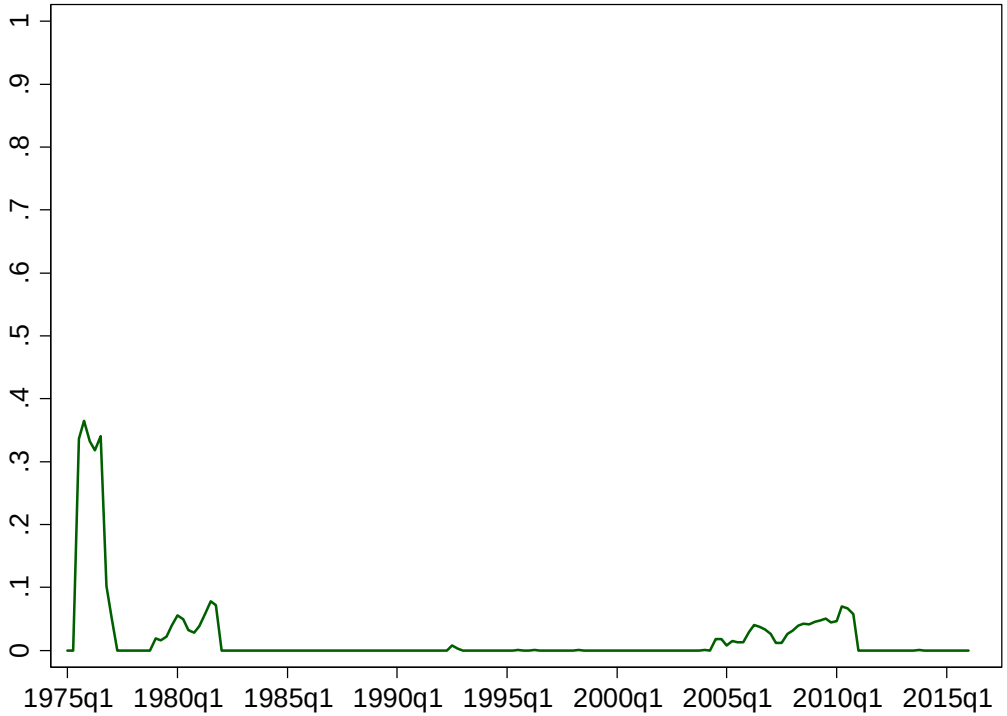
Recreation services (0.04)



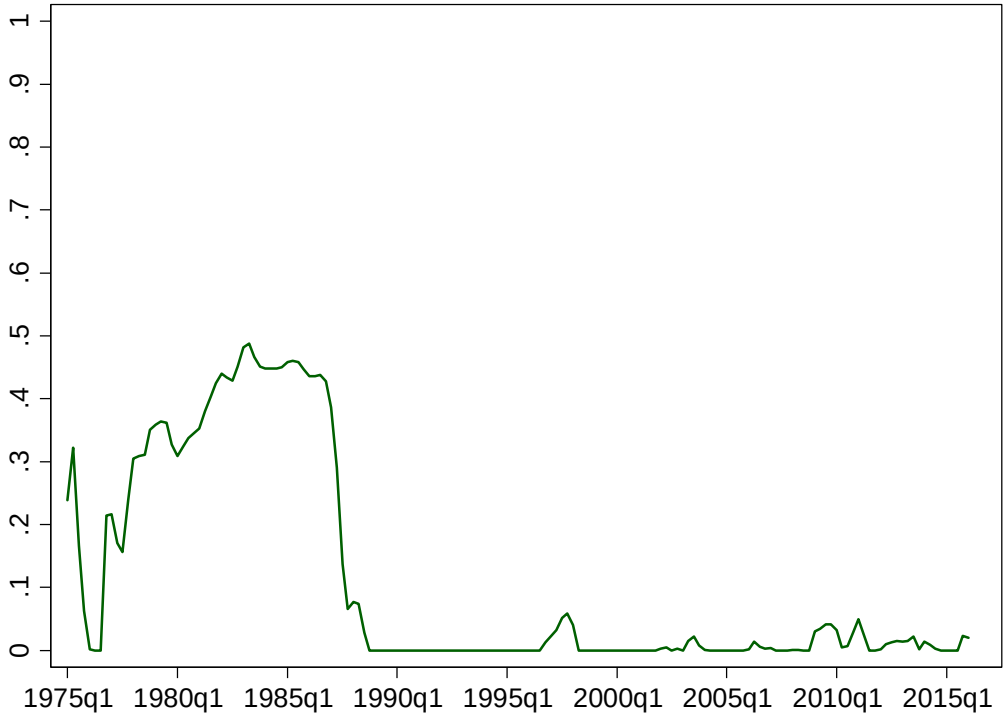
Gasoline & other energy goods (0.03)



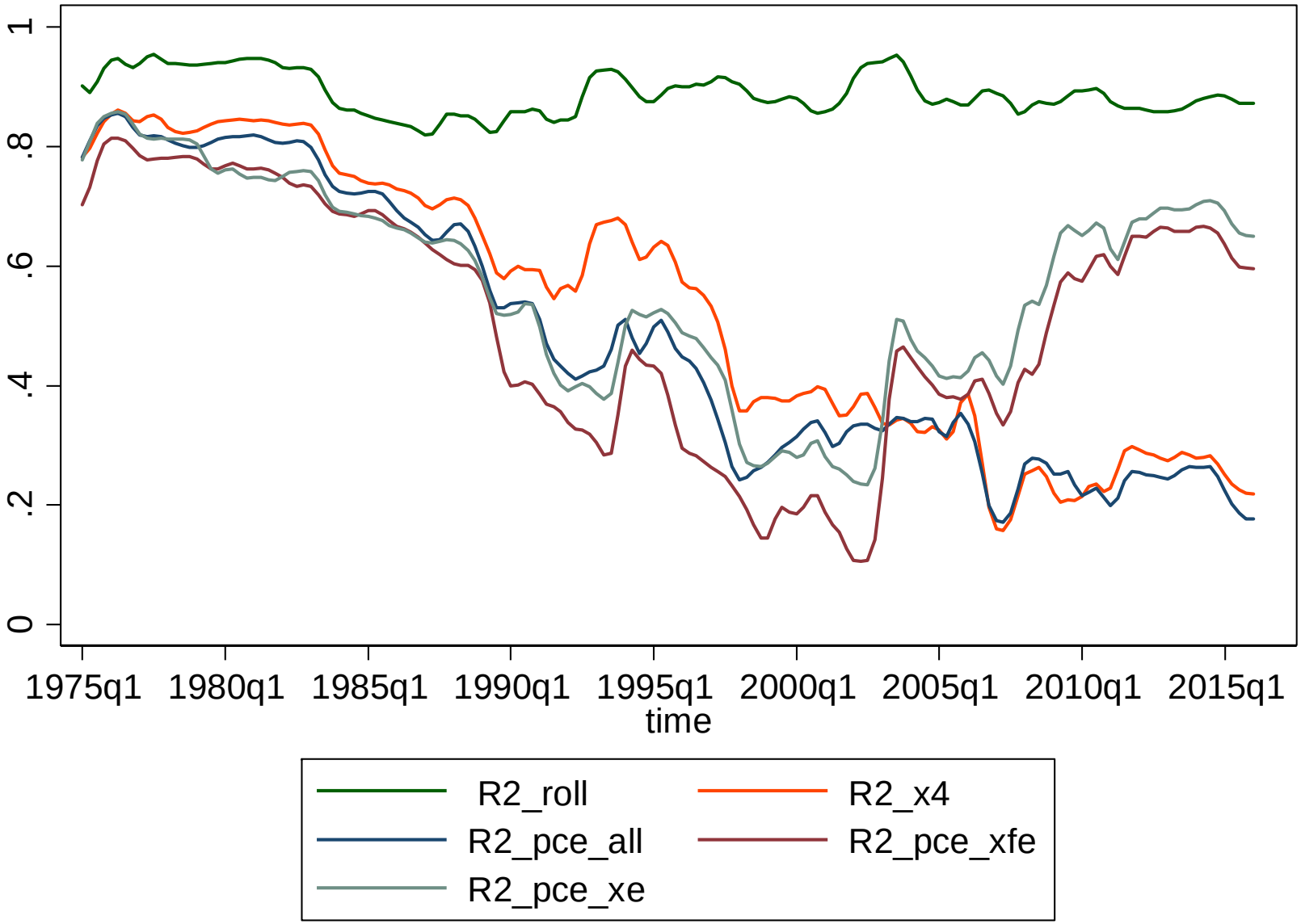
Transportation services (0.03)



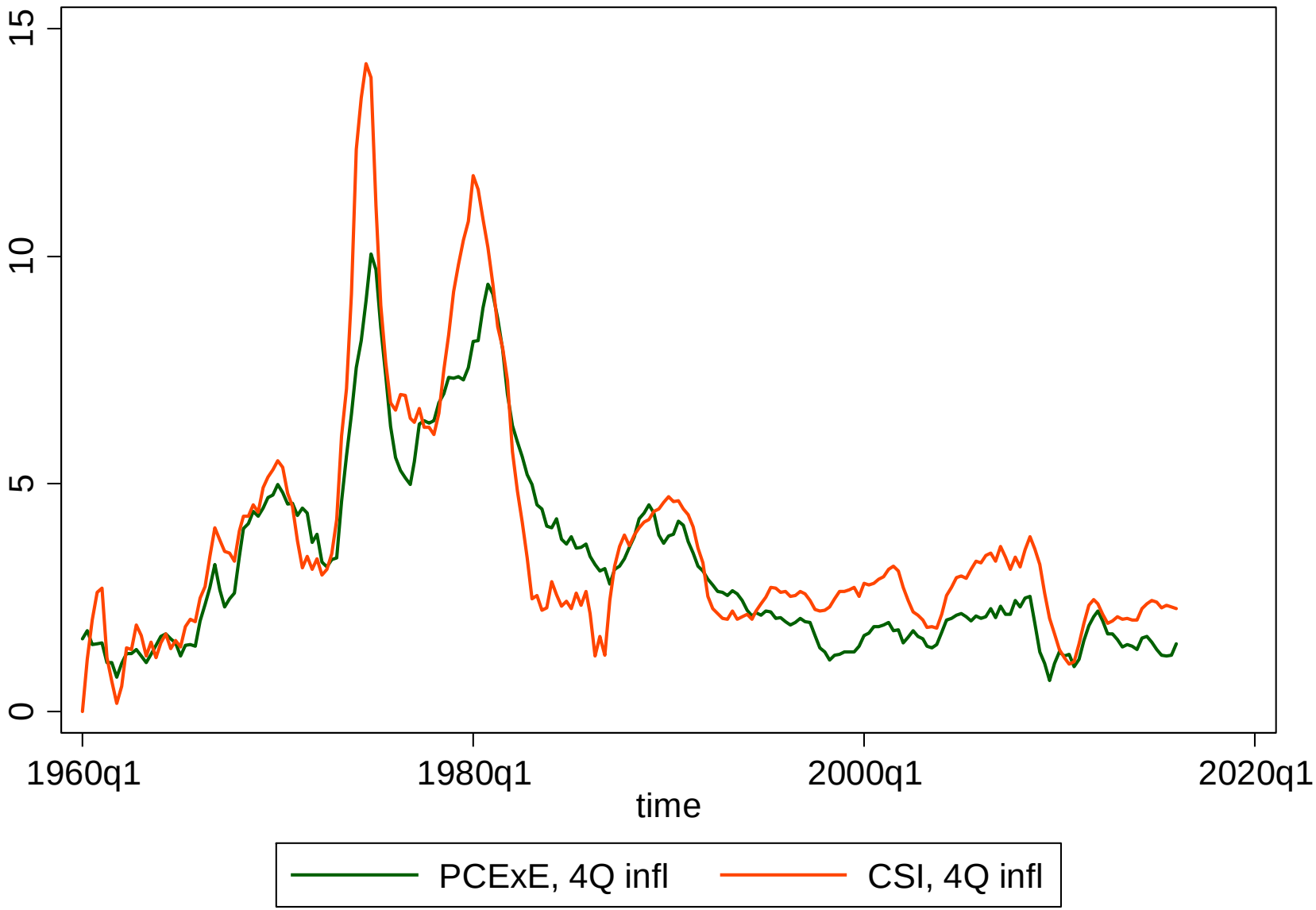
Furnishings & household durables (0.03)



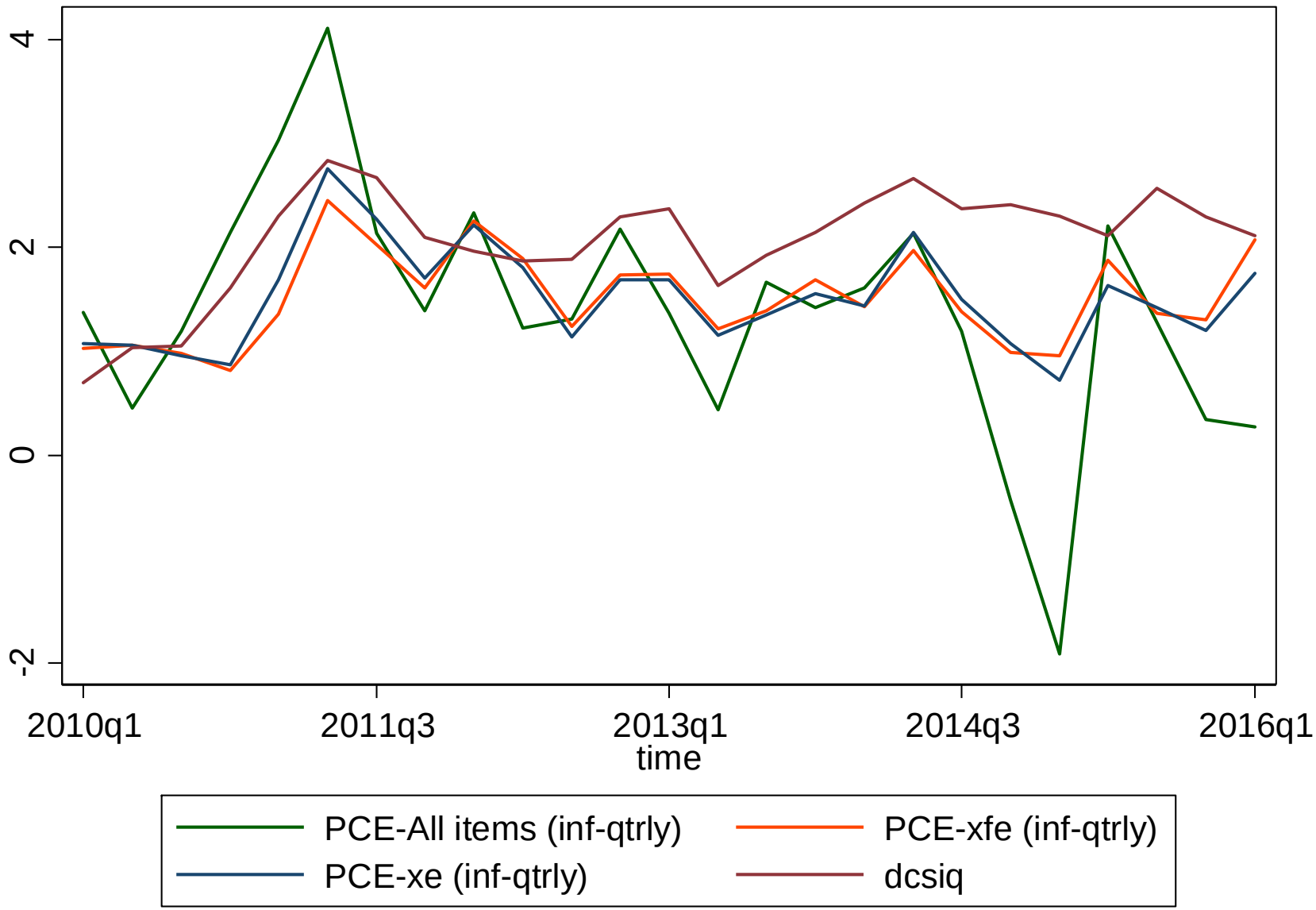
Rolling R^2s: BP inflation on 0-3 lags of BP unemployment rate



Rolling PCExE and CSI (4 quarter inflation)



Recent values: rolling CSI (quarterly inflation)

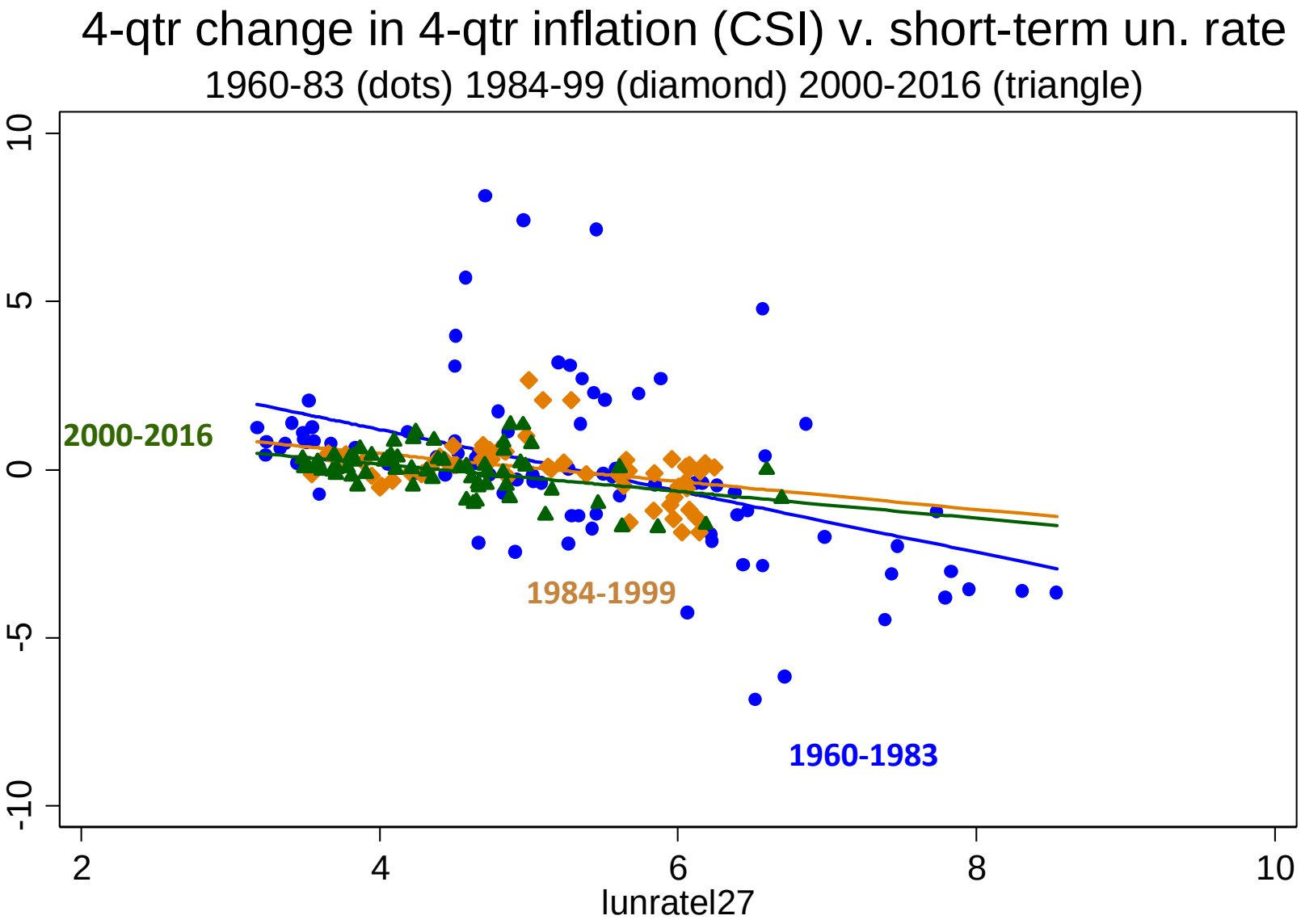


Summary

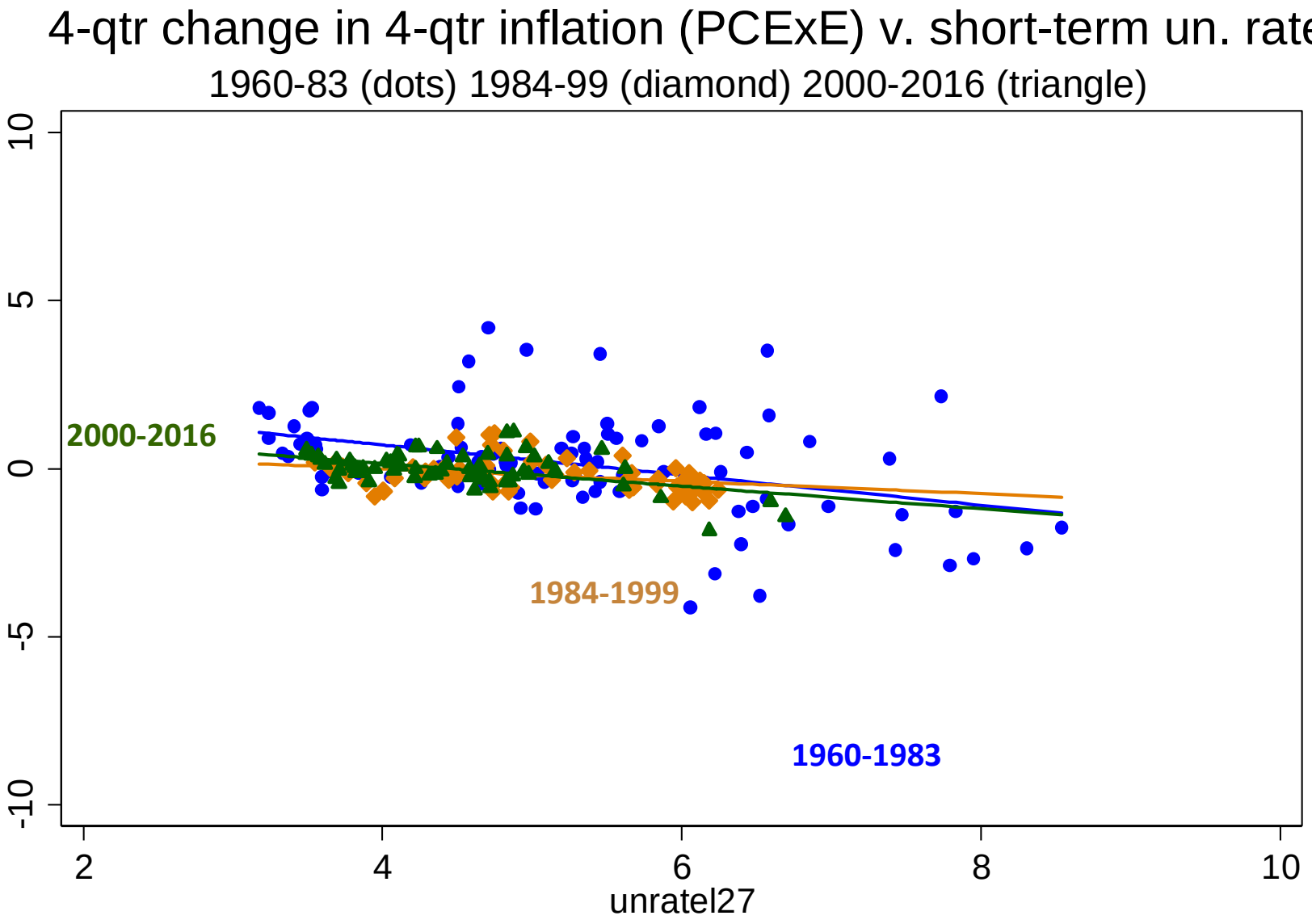
1. **There is significant time variation in univariate inflation processes:** reduced volatility of trend, so optimal trend estimate has more smoothing
2. **Components seem to have useful but time-varying information:**
   - Considerable changes in component series
   - Some of these changes are measurement changes, incomplete revisions, etc
   - Automatic (hands-free) outlier adjustment useful
   - In particular, there is a case for including food-at-home (shift from PCE-xFE to PCE-xE?)
   - There is no case for including energy in a trend/core estimate
3. **Cyclical behavior varies substantially across components.** Some cyclically synchronized components are:
   - Housing ex energy (rent + OER)
   - Food services & accommodations
   - Recreation services
   - Food & beverages off-premises
   - NPISH (?)

Additional Slides

$\pi_t - \pi_{t-4}$ vs. short-term unemployment rate: CSI



$\pi_t - \pi_{t-4}$ vs. short-term unemployment rate: PCExE



Smoothed estimates of τ_t: PCE-all, 17 components (updated 5/23/16)

		MUCSVO 17-component smoothed values					
Date	PCE-all	Mean	.05	.33	.50	.67	.95
2008Q1	3.14	2.61	2.06	2.26	2.59	2.96	3.27
2008Q2	5.47	2.51	1.94	2.15	2.47	2.86	3.18
2008Q3	1.78	2.35	1.80	2.00	2.32	2.70	2.99
2008Q4	-8.91	1.97	1.43	1.65	1.97	2.29	2.54
2009Q1	0.75	1.69	1.15	1.38	1.70	2.00	2.20
2009Q2	3.51	1.52	0.96	1.21	1.53	1.82	2.05
2009Q3	1.54	1.34	0.83	1.05	1.34	1.63	1.85
2009Q4	2.37	1.23	0.74	0.93	1.22	1.52	1.72
…	…	…	…	…	…	…	…
2014Q4	-1.42	1.18	0.62	0.92	1.21	1.46	1.62
2015Q1	-0.32	1.24	0.71	0.99	1.28	1.51	1.67
2015Q2	2.40	1.38	0.86	1.14	1.41	1.64	1.80
2015Q3	0.08	1.29	0.75	1.05	1.32	1.56	1.72
2015Q4	0.47	1.24	0.72	0.99	1.27	1.50	1.66
2016Q1	0.35	1.45	0.91	1.18	1.47	1.73	1.91

- **Actuals are 3-month percentage changes** ending final month of quarter (saar).
- Average width of 67% Interval = 1.04 (2008-2014)

Smoothed estimates of τ_t: PCE-xE, PCE-xFE (updated 5/23/16)

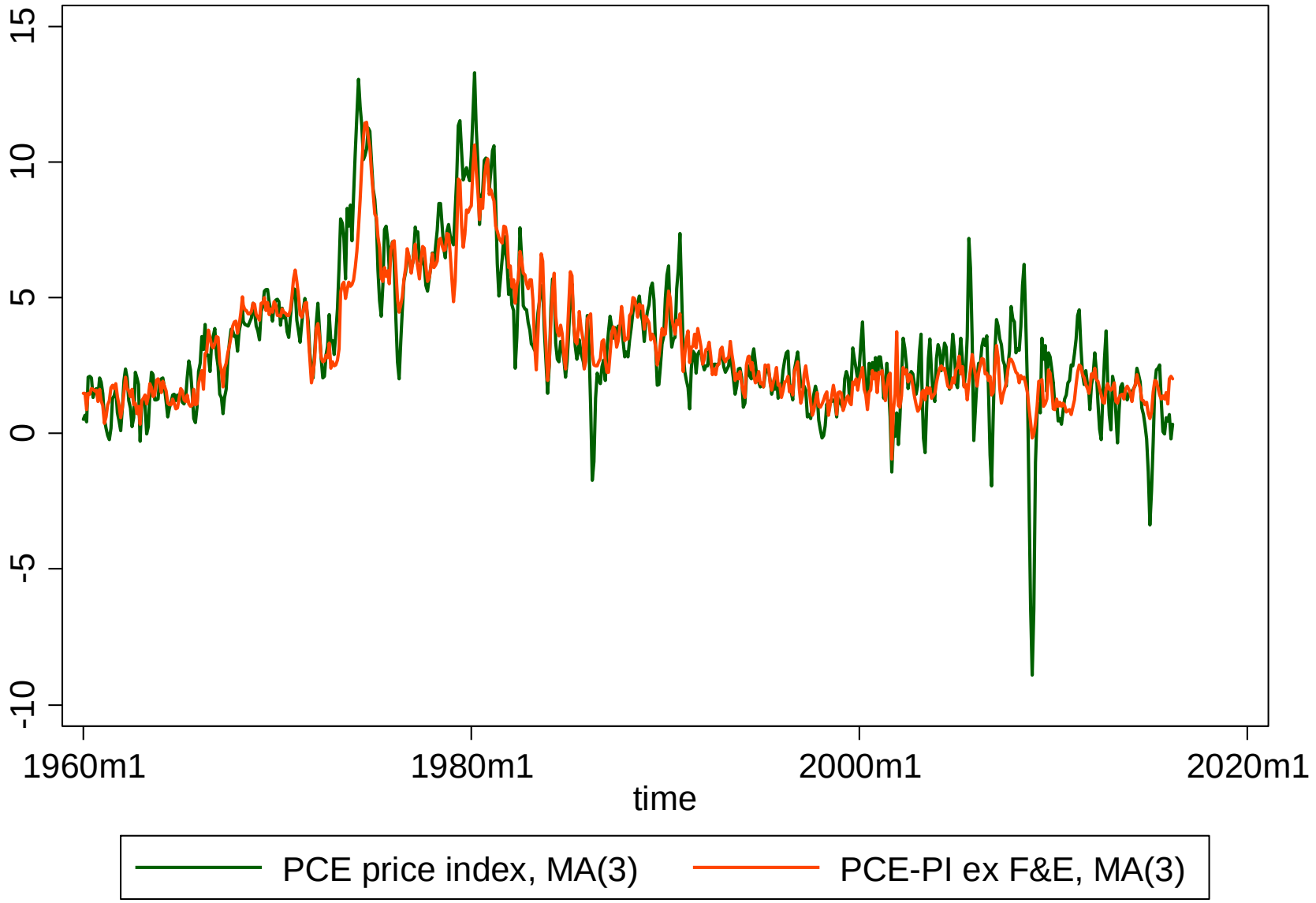
PCE-xE

		UCSVO Univariate Smoothed Values					
Date	PCE-xE	Mean	.05	.33	.50	.67	.95
2014Q4	0.80	1.33	0.97	1.14	1.34	1.52	1.66
2015Q1	1.15	1.34	1.01	1.16	1.35	1.53	1.65
2015Q2	1.58	1.39	1.07	1.21	1.38	1.56	1.70
2015Q3	1.42	1.37	1.03	1.19	1.38	1.56	1.70
2015Q4	0.88	1.34	0.98	1.14	1.35	1.54	1.70
2016Q1	1.72	1.41	1.02	1.19	1.41	1.64	1.81

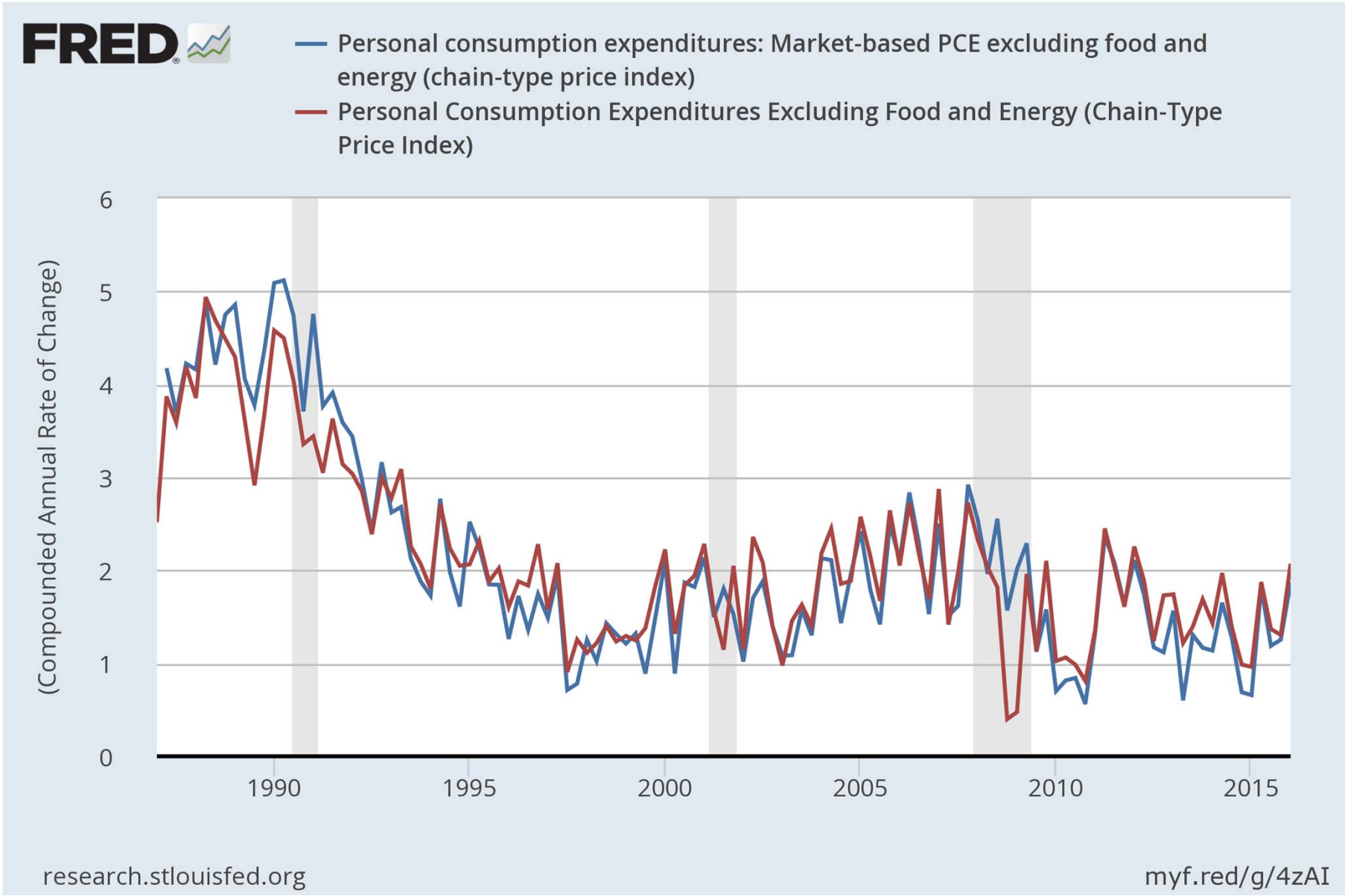
PCE-xFE

		UCSVO Univariate Smoothed Values					
Date	PCE-xFE	Mean	.05	.33	.50	.67	.95
2014Q4	0.73	1.41	1.06	1.22	1.42	1.59	1.70
2015Q1	1.53	1.45	1.15	1.29	1.46	1.62	1.74
2015Q2	1.70	1.48	1.19	1.31	1.48	1.65	1.76
2015Q3	1.38	1.47	1.16	1.3	1.48	1.65	1.77
2015Q4	1.10	1.48	1.14	1.29	1.48	1.66	1.80
2016Q1	2.03	1.55	1.18	1.34	1.54	1.75	1.94

U.S PCE inflation, headline and core (monthly, MA(3))



PCE-xFE and Market-based PCE-xFE



Core Inflation and Trend Inflation

Eckstein (1981), as quoted in Zeldes (1994) and Wynne (2008) defined core inflation as:

> the core rate reflects those price increases made necessary by increases in the trend costs of the inputs to production. The cost increases, in turn, are largely a function of underlying price expectations. These expectations are the results of previous experience, which, in turn, is created by the history of demand and shock inflation

Bryan and Cecchetti (1994): core inflation is an estimate of trend inflation

In practice:

- Trend inflation is a time-series smoothing problem
- Core inflation is implemented as cross-sectional averaging

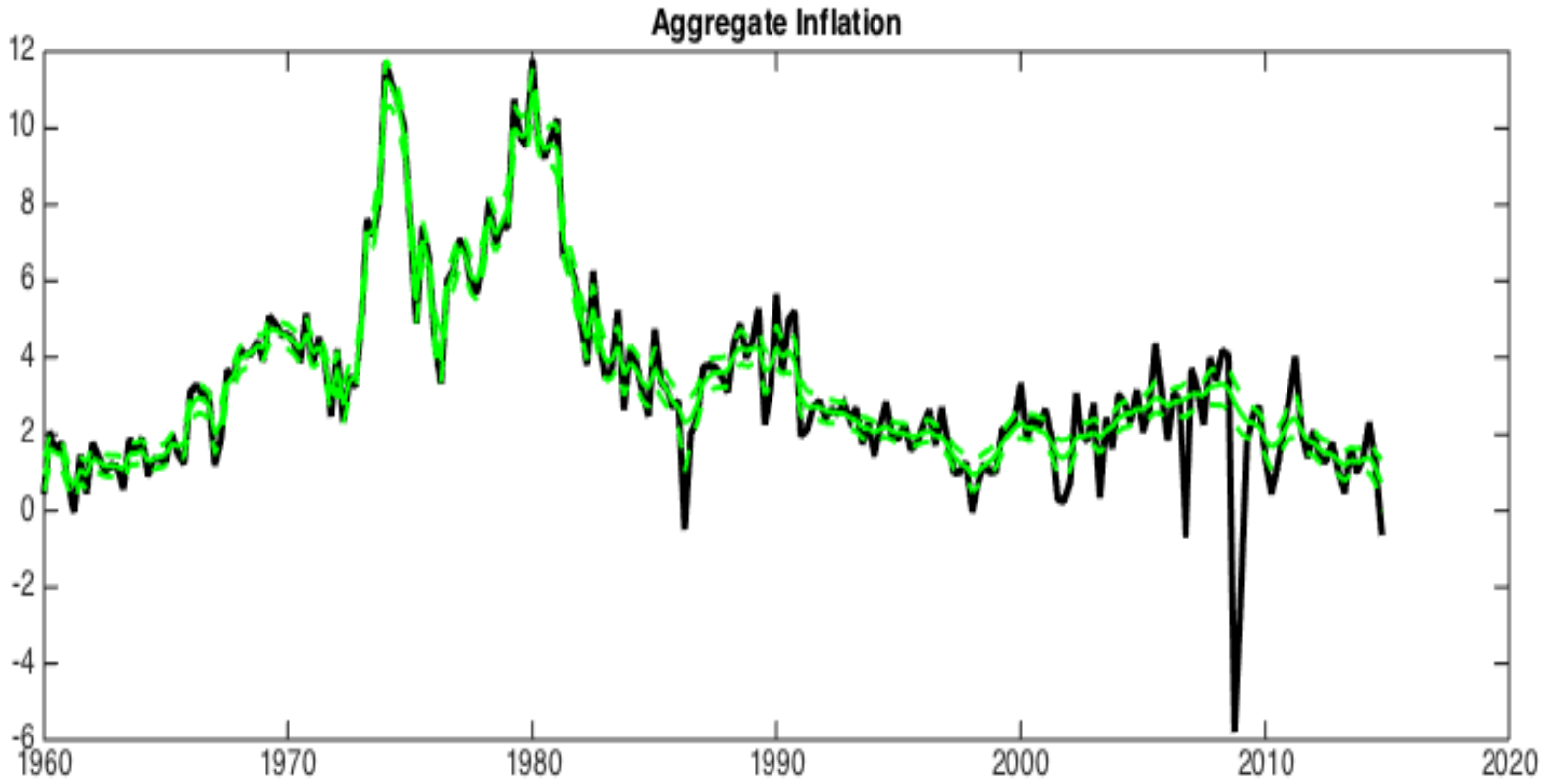
Time variation in the inflation process: trend estimates

There has been a large amount of time variation in the processes for headline and core inflation

a) Decrease in relative volatility of trend component since 70s-80s

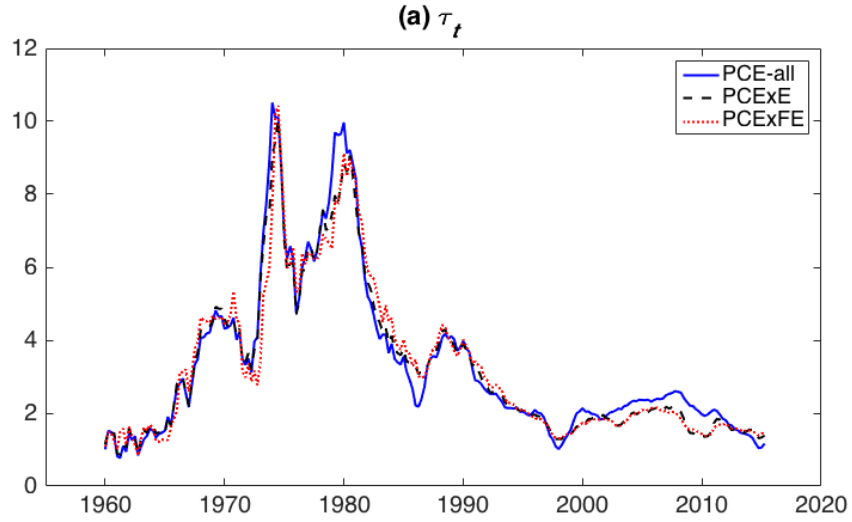
b) This has the effect of increasing optimal amount of smoothing (trend varies less so use longer smoother to reduce transitory noise)

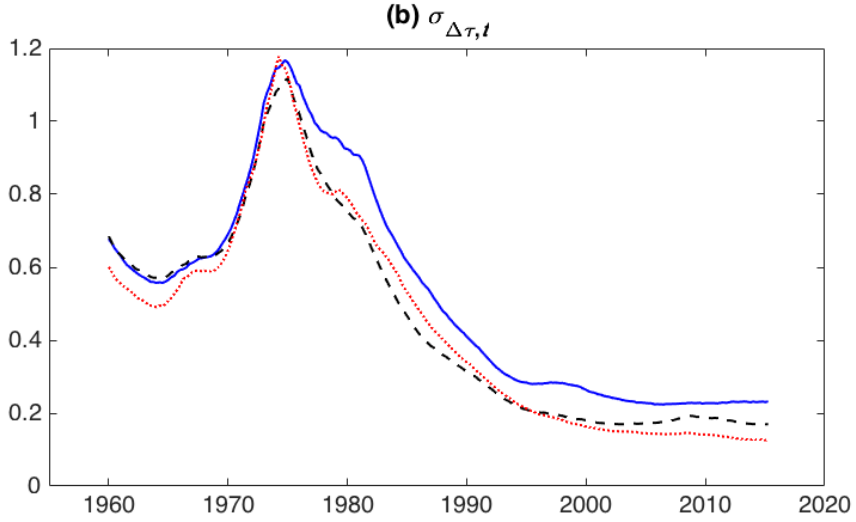
PCE-all, qtrly: Trend estimate (smoothed) and 67% bands

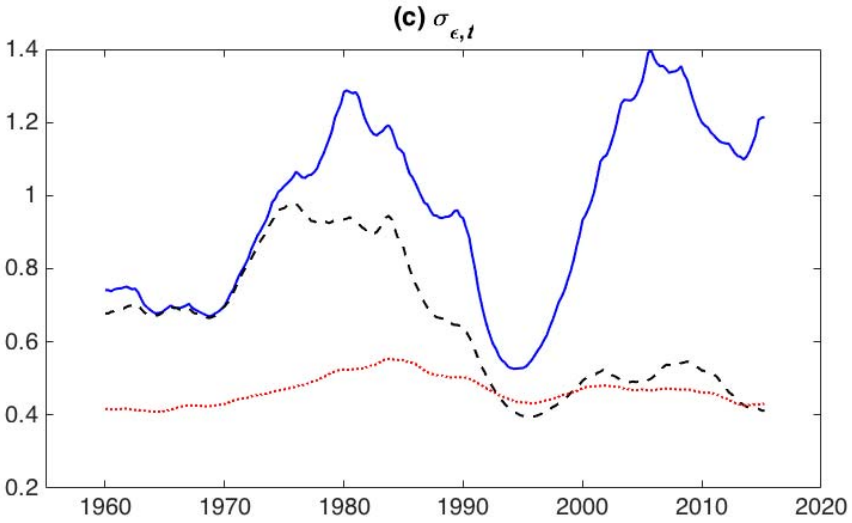


Full-sample posterior for SV processes

PCE-all (blue), PCExE (blue dash), PCExFE (red)







- Trend volatility (above right) has declined sharply from 70s-80s
- for PCE-all, transitory volatility is as high now as in 70s (left) –
- but (left)
  - **XE transitory volatility has fallen**
  - XFE transitory volatility remains low

The components have large time variation in their process

At the level of components, there is even more variation in the process than in aggregate inflation

a) Food at home is especially noteworthy

b) Some of the evolution reflects changes in monetary policy and the economy…

c) But some of the changes are pure measurement effects

… a reminder that the evolution of the headline and core processes reflects measurement effects.

d) Technical comment: outlier adjustment is particularly important at the component level