2016 Inflation: Drivers and Dynamics
Federal Reserve Bank of Cleveland

Sectoral Inflation Measures and Cyclically Sensitive Inflation

September 30, 2016

James Stock, Harvard Economics
Mark Watson, Princeton University
1. What is the current value of the rate of price inflation?

U.S. PCE inflation, headline and core, 1960q1-2016q2
U.S. PCE inflation, headline and core, 2000m1-2016m3

<table>
<thead>
<tr>
<th></th>
<th>PCE</th>
<th>Core PCE</th>
<th>CPI</th>
<th>Core CPI</th>
<th>17-component trend</th>
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<td>1.3</td>
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<td>1.4</td>
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<td>2016q2</td>
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<td>1.6</td>
<td>1.1</td>
<td>2.2</td>
<td>1.3</td>
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</table>
2. Where is the cyclical pressure on inflation?
1. Motivation & literature

2. PCE components: selective discussion

3. Measuring trend inflation using components

4. Cyclically sensitive inflation
   a) Cyclical behavior of different sectors
   b) methods
   c) results (preliminary/in progress)

5. Next steps
Selected literature

- **Productivity measurement:** Byrne, Fernald, & Reinsdorf (2015), Feldstein (2016)
- **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)
- **Inflation forecasting:** vast
2. PCE inflation components: Data and Review of BLS and BEA Methods
### PCE components and their shares, sorted by 2000-2014 share

<table>
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</thead>
<tbody>
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<td>Housing and utilities</td>
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<tr>
<td>Food and beverages for off-premises consumption</td>
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<tr>
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<tr>
<td>Motor vehicles and parts</td>
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<td>0.04</td>
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<td>Furnishings and durable household equipment</td>
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<td>Final consumption expenditures of nonprofit institutions serving households (NPISHs)</td>
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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
  - Main sampling rotation structures:
    - food at home, lodging, most consumer end-energy goods, telephone services, used cars, some odds and ends: Single panel sample monthly
    - Everything else except rent (most regions): 2 panels, alternating months
    - rent: 6 panels, each sampled every 6 months
  - 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 (a) hedonic regression or, if not possible, (b) production cost
The PCE-PI and the CPI are 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 end-consumer legal service (e.g. will), with a fixed production function (hours of attorney, legal aide, etc) and changing input wages;
    - or, 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)
- However, many services have market prices (Red Sox ticket; a room at Sonesta)

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)
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
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.
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.
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

1960q1 1980q1 2000q1 2020q1
% at annual rate

-5 0 5 10 15 20
Other nondurable goods (0.08)

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tobacco</td>
<td>CPI-tobacco</td>
</tr>
<tr>
<td>Pharmaceuticals</td>
<td>CPIs for prescription &amp; OTC drugs, CPI for med. eqpt sold to consumers</td>
</tr>
<tr>
<td>Recreational nondurables</td>
<td>CPIs for toys, plants &amp; flowers, pets, photographic supplies,…</td>
</tr>
<tr>
<td>Personal care</td>
<td>Various CPIs for personal care items</td>
</tr>
<tr>
<td>Misc. home goods</td>
<td>CPIs: newspapers &amp; magazines, household supplies</td>
</tr>
<tr>
<td>Spending abroad</td>
<td>(net, including in-kind personal remittances) complicated, non-mkt</td>
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### Other services (0.09)

<table>
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<th>Category</th>
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<tr>
<td>Communication</td>
<td>CPI for wireless phone service, CPI for land line phone service</td>
</tr>
<tr>
<td>Internet</td>
<td>CPI for internet services</td>
</tr>
<tr>
<td>Education</td>
<td>CPI for college education; CPI for private primary &amp; secondary schools</td>
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<td>Legal, accounting</td>
<td>Cost basis (cost of 1 hr law office time, or mix of time for given service)</td>
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<td>Social services</td>
<td>Cost basis, some CPI (child care)</td>
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<tr>
<td>Misc.</td>
<td>CPI for postage, CPI for funeral services, CPI for haircuts; net foreign</td>
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<tr>
<td></td>
<td>travel (complicated)</td>
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</table>
Market purchased clothing
Various CPIs. Note new/replacement goods issue however.

Military & uniforms
Cost-based
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)
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
# PCE price index measurement: Summary

<table>
<thead>
<tr>
<th>Sector</th>
<th>Share (2000s)</th>
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<tbody>
<tr>
<td><strong>A. Well-measured</strong></td>
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<td>Housing - energy utilities component</td>
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<td>Gasoline and other energy goods</td>
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<td><strong>Subtotals</strong></td>
<td><strong>0.34</strong></td>
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<tr>
<td><strong>B. Some information content</strong></td>
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<td>Other services</td>
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<td><strong>Subtotals</strong></td>
<td><strong>0.29</strong></td>
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<td><strong>C. Poorly measured</strong></td>
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<td>Financial services and insurance</td>
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<tr>
<td><strong>Subtotals</strong></td>
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3. Estimating Trend Inflation Using Components:
   Time-series smoothing (trend)
   + cross-section signal extraction (core)
Unobserved component/stochastic volatility model

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

\[ \pi_t = \tau_t + \varepsilon_t \]  
\[ \tau_t = \tau_{t-1} + \sigma_{\Delta \tau_{,t}} \eta_{\tau_{,t}} \]  
\[ \varepsilon_t = \sigma_{\varepsilon_{,t}} \eta_{\tau_{,t}} \]  
\[ \Delta \ln(\sigma_{\Delta \tau_{,t}}^2) = \gamma_{\Delta \tau} \nu_{\Delta \tau_{,t}} \]  
\[ \Delta \ln(\sigma_{\varepsilon_{,t}}^2) = \gamma_{\varepsilon} \nu_{\varepsilon_{,t}} \]  
\[ \left( \eta_{\varepsilon_{,t}}, \eta_{\tau_{,t}}, \nu_{\varepsilon_{,t}}, \nu_{\Delta \tau_{,t}} \right) \text{ i.i.d. } N(0, I_4) \]  
\[ s_t = \begin{cases} 1 \text{ with probability } p \\ U[2,10] \text{ with probability } 1-p \end{cases} \]  

- The model has a TV-IMA(1,1) representation (TV Nelson-Schwert (1977))
- 3 parameters: \( \gamma_{\varepsilon}, \gamma_{\Delta \tau}, p \), 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:

\[
\begin{bmatrix}
\pi_{1t} \\
\pi_{2t} \\
\vdots \\
\pi_{nt}
\end{bmatrix} =
\begin{bmatrix}
\alpha_{1t} \\
\alpha_{2t} \\
\vdots \\
\alpha_{nt}
\end{bmatrix} \tau^C_t +
\begin{bmatrix}
\beta_{1t} \\
\beta_{2t} \\
\vdots \\
\beta_{nt}
\end{bmatrix} \varepsilon^C_t +
\begin{bmatrix}
\tau_{1t} \\
\tau_{2t} \\
\vdots \\
\tau_{nt}
\end{bmatrix} +
\begin{bmatrix}
\varepsilon_{1t} \\
\varepsilon_{2t} \\
\vdots \\
\varepsilon_{nt}
\end{bmatrix}
\]

- 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 \(w_{it}\)

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

- full Bayes estimation
- note that cointegration of components is possible but not imposed
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-xE and 17-component trend estimate (quarterly)
Smoothed estimates of $\tau_t$: PCE-all, 17 components (updated 9/26/16)

<table>
<thead>
<tr>
<th>Date</th>
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<th>.50</th>
<th>.67</th>
<th>.95</th>
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<td>3.14</td>
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<td>1.38</td>
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<td>…</td>
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<td>1.69</td>
</tr>
</tbody>
</table>

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

#### UCSVO Univariate Smoothed Values

<table>
<thead>
<tr>
<th>Date</th>
<th>PCE-xE</th>
<th>Mean</th>
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### PCE-xFE

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Cyclical Properties of Components and “Cyclically Sensitive Inflation”
Motivating question: is there any evidence of cyclical movements in inflation now that we are approaching/at full employment?

We propose “cyclically sensitive inflation”

- 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 quality considerations (BLS methods) and time series techniques

- Organization:
  - Quick tour of cyclical properties of selected components
  - CSI: methods and preliminary estimates
\( \pi_t - \pi_{t-4} \) vs. \( u_{gap_t} \)

4-qtr change in 4-qtr inflation (PCE\textsubscript{ExE}) v. unemployment gap
1960-83 (dots) 1984-99 (diamond) 2000-2016 (triangle)
$\pi_t - \pi_{t-4}$ vs. $u_{gap_t}$

4-qtr change in 4-qtr inflation (PCExE) v. unemployment gap
1960-83 (dots) 1984-99 (diamond) 2000-2016 (triangle)
$\pi_t - \pi_{t-4}$ vs. $u_{gap_t}$

4-qtr change in 4-qtr inflation (PCE\text{ExE}) v. unemployment gap

1960-83 (dots) 1984-99 (diamond) 2000-2016 (triangle)
Cyclical Properties of Components

- Do components have different cyclical properties?
- Do some components observe a more stable relation between changes in inflation and the unemployment rate/gap?
- If so,
  - have cyclical properties of components changed over time?
  - how does the cyclicality of measured component inflation relate to the measurement quality of that component?

**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)
Phillips Curve Scatterplot: 4-qtr changes v. lagged short-term unemployment rate

Housing ex energy
PC slopes, 60-83: -0.23 (0.18); 84-99: -0.28 (0.08); 00-16: -0.61 (0.20)
Band-pass filtered components and GDP (6-32 qtrs, standardized)
Phillips Curve Scatterplot: 4-qtr changes v. lagged short-term unemployment rate

Food services & accommodations

PC slopes, 60-83: -0.79 (0.25); 84-99: -0.21 (0.16); 00-16: -0.26 (0.20)

1960-1983
1984-1999
2000-2016
Band-pass filtered components and GDP (6-32 qtrs, standardized)
Recreation services

PC slopes, 60-83: -0.51 (0.22); 84-99: -0.33 (0.21); 00-16: 0.02 (0.14)
Band-pass filtered components and GDP (6-32 qtrs, standardized)
Phillips Curve Scatterplot: 4-qtr changes v. lagged short-term unempl

Food & beverages off-premises

PC slopes, 60-83: -0.80 (0.46); 84-99: 0.21 (0.28); 00-16: -0.74 (0.64)
Band-pass filtered components and GDP (6-32 qtrs, standardized)
Phillips Curve Scatterplot: 4-qtr changes v. lagged short-term unemployment

Other nondurable goods

PC slopes, 60-83: -0.98 (0.59); 84-99: -1.03 (0.26); 00-16: -0.43 (0.33)

1960-1983
1984-1999
2000-2016
Band-pass filtered components and GDP (6-32 qtrs, standardized)
Phillips Curve Scatterplot: 4-qtr changes v. lagged short-term unemployment rate

Other services

PC slopes, 60-83: -0.57 (0.23); 84-99: -0.22 (0.17); 00-16: -0.33 (0.16)
Band-pass filtered components and GDP (6-32 qtrs, standardized)
Clothing & footwear

PC slopes, 60-83: -0.67 (0.31); 84-99: -0.08 (0.28); 00-16: 0.36 (0.36)
Band-pass filtered components and GDP (6-32 qtrs, standardized)
Phillips Curve Scatterplot: 4-qtr changes v. lagged short-term unemployment

Financial services & insurance

PC slopes, 60-83: 0.31 (0.55); 84-99: -0.41 (0.98); 00-16: 2.14 (0.75)

1960-1983
1984-1999
2000-2016
Band-pass filtered components and GDP (6-32 qtrs, standardized)
Phillips Curve Scatterplot: 4-qtr changes v. lagged short-term unemployment

NPISH

PC slopes, 60-83: -1.41 (0.77); 84-99: 0.86 (0.66); 00-16: 0.48 (0.32)

1960-1983
1984-1999
2000-2016
**Exploratory regressions: components Phillips curves, 1984q1-2016q1**

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- **Direct 4-qtr ahead forecasting regression**
- Dependent variable is cumulative 4-qtr inflation over next 4 quarters
- Predictors are 4 lags of $\Delta \pi$, $u$
- *No out-of-sample!*
- Entries are p-values on lags of the unemployment rate (HAC SEs)
Cyclically Sensitive Inflation
o **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

o **Define cyclically sensitive inflation** to be the weighted average of inflation that provides the most co-movement with a cyclical indicator.

o **Incorporate judgmental assessment of measurement quality**
  - Eliminate four categories based on *a-priori* concerns about measurement:
    - Recreational goods & vehicles
    - Clothing & footwear
    - Financial services & insurance
    - NPISH
Cyclically sensitive inflation: Methods (exploratory/preliminary)

Using the remaining 13 components:
- Maximize the $R^2$ of the regression:

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

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
- PC scatter for the series + TV weights and share weights by component
- Rolling R2 (unadjusted) and R2 of comparison series
- Cyclically sensitive inflation
PC plot and CSI share weights: Housing ex energy utilities

PC slopes, 60-83: -0.23 (0.18); 84-99: -0.28 (0.08); 00-16: -0.61 (0.20)
PC plot and CSI share weights: Food services & accommodations (0.06)

Food services & accommodations
PC slopes, 60-83: -0.79 (0.25); 84-99: -0.21 (0.16); 00-16: -0.26 (0.20)

PC slopes, 60-83: -0.79 (0.25); 84-99: -0.21 (0.16); 00-16: -0.26 (0.20)
PC plot and CSI share weights: Recreation services (0.04)

Recreation services
PC slopes, 60-83: -0.51 (0.22); 84-99: -0.33 (0.21); 00-16: 0.02 (0.14)

4qtr chge of 4-qtr inflation

Short-term unemployment rate

1975q1 1980q1 1985q1 1990q1 1995q1 2000q1 2005q1 2010q1 2015q1
PC plot and CSI share weights: Food & beverages off-premises (0.08)

Food & beverages off-premises

PC slopes, 60-83: -0.80 (0.46); 84-99: 0.21 (0.28); 00-16: -0.74 (0.64)
PC plot and CSI share weights: Other nondurable goods (0.08)

**Other nondurable goods**

PC slopes, 60-83: -0.98 (0.59); 84-99: -1.03 (0.26); 00-16: -0.43 (0.33)
PC plot and CSI share weights: Other services (0.09)

Other services
PC slopes, 60-83: -0.57 (0.23); 84-99: -0.22 (0.17); 00-16: -0.33 (0.16)
PC plot and CSI share weights: Gasoline & other energy goods (0.03)

Gasoline & energy goods
PC slopes, 60-83: -2.70 (1.63); 84-99: 1.49 (1.91); 00-16: 15.26 (5.29)
Rolling $R^2$s: BP inflation on 0-3 lags of BP unemployment rate
Rolling PCE\textsubscript{ExE} and CSI (4 quarter inflation)
Recent values: rolling CSI (quarterly inflation)
Summary

1. Components seem to have useful but time-varying information:
   • Considerable changes in component series
   • There are measurement-grounded reasons to allow the weights of core to evolve
   • Automatic (hands-free) outlier adjustment useful & justified
   • There is a case for including food-at-home in core (PCE-xE)
   • There is no case for including energy in a trend/core estimate

2. Cyclical behavior varies substantially across components.
   • Cyclically synchronized components:
     • Housing ex energy (rent + OER)
     • Food services & accommodations
     • Recreation services
     • Food & beverages off-premises
   • Common features of these series:
     • These cyclical series are a mix of durables and nondurables
     • They are all generally well-measured
     • They are generally goods produced locally (not internationally priced)
   • Some clearly not synchronized: durables + poorly-measured 4
1. **“Proper” time series model**
   - Rabbit hole problem: e.g., handling the 6-month rotating panel for rent, mixed 1-/2-month problem for other series, etc.

2. **Out of sample stability**
   - This could include forecasting (e.g. Tallman and Zaman (2015) but note that we have cast this as a measurement/detection issue, not a forecasting problem

3. **Further disaggregation?**
   - e.g. well-measured components of recreational services, or of food services & accommodations
Additional Slides
$\pi_t - \pi_{t-4}$ vs. short-term unemployment rate: CSI

4-qtr change in 4-qtr inflation (CSI) v. short-term un. rate
1960-83 (dots) 1984-99 (diamond) 2000-2016 (triangle)
\[ \pi_t - \pi_{t-4} \text{ vs. short-term unemployment rate: PCEExE} \]

4-qtr change in 4-qtr inflation (PCEExE) v. short-term un. rate
1960-83 (dots) 1984-99 (diamond) 2000-2016 (triangle)
Smoothed estimates of \( \tau_t \): PCE-all, 17 components (updated 5/23/16)

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<tr>
<th>Date</th>
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- Actuals are 3-month percentage changes ending final month of quarter (saar).
- Average width of 67% Interval = 1.04 (2008-2014)
Smoothed estimates of $\tau_t$: PCE-xE, PCE-xFE (updated 5/23/16)

### PCE-xE

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### PCE-xFE

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PCE-xFE and Market-based PCE-xFE

- Personal consumption expenditures: Market-based PCE excluding food and energy (chain-type price index)
- Personal Consumption Expenditures Excluding Food and Energy (Chain-Type Price Index)
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
Housing: energy utilities

<table>
<thead>
<tr>
<th>Energy Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>CPI for electricity</td>
</tr>
<tr>
<td>Natural gas</td>
<td>CPI for utility-provided natural gas</td>
</tr>
</tbody>
</table>

**Graph:**

- X-axis: Quarters (1960q1 to 2020q1)
- Y-axis: % at annual rate
- Data series: CPI for electricity (in red) and CPI for utility-provided natural gas (in green)
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

<table>
<thead>
<tr>
<th>PPI concept</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PPI concept</td>
<td>PPI usually first transaction price rec’d by producer. For health care, PPI since 1993 is DRG-based, broken out by service providers</td>
</tr>
<tr>
<td><strong>PCE: Physician services</strong></td>
<td>PPI for physician offices. Unit is office visit for a given condition</td>
</tr>
<tr>
<td><strong>PCE: hospital services</strong></td>
<td>PPI for hospitals. Unit is a hospital episode for a given condition</td>
</tr>
<tr>
<td><strong>PCE: nursing homes</strong></td>
<td>PPI for nursing homes. Cost of inputs basis (hourly wages etc.)</td>
</tr>
<tr>
<td><strong>PCE: paramedical</strong></td>
<td>PPI for paramedical</td>
</tr>
<tr>
<td><strong>Dental &amp; other medical</strong></td>
<td>Uses CPIs for dental services, for other medical services</td>
</tr>
</tbody>
</table>
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
Recreational goods & vehicles (0.03)

<table>
<thead>
<tr>
<th>Category</th>
<th>CPI Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Video, audio, home computers</td>
<td>Various CPIs including CPI for home computers, CPI for computer software and accessories, and CPI for consumer digital communications and information processing eqpt</td>
</tr>
<tr>
<td>Sporting eqp</td>
<td>CPI for sporting eqpt</td>
</tr>
<tr>
<td>Recreational books</td>
<td>CPI for recreational books</td>
</tr>
<tr>
<td>Musical instruments</td>
<td>CPI for musical instruments</td>
</tr>
</tbody>
</table>
Gasoline & other energy goods (0.03)

- **Motor fuels**: CPI for motor fuels
- **Other fuels**: CPIs for propane, kerosene, wood
Transportation services (0.03)

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Airline travel</strong></td>
<td>PPI (cost-based: passenger revenues/total passenger-miles) (however CPI is based on actual prices, currently sampled off the Web)</td>
</tr>
<tr>
<td><strong>Intracity</strong></td>
<td>CPI (covers taxis, busses, etc.)</td>
</tr>
<tr>
<td><strong>Intercity busses, trains</strong></td>
<td>CPI (market prices)</td>
</tr>
<tr>
<td><strong>Water</strong></td>
<td>CPI (ferries, etc.)</td>
</tr>
</tbody>
</table>
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
Other durable goods (0.02)

Misc. durable goods
- Watches, jewelry, educational books, luggage, telephone equipment.
- All based on CPIs (market prices)
$\pi_t - \pi_{t-4}$ vs. Short-term unemployment rate_t

4-qtr change in 4-qtr inflation (PCEExE) v. short-term un. rate

1960-83 (dots) 1984-99 (diamond) 2000-2016 (triangle)
\( \pi_t - \pi_{t-4} \text{ vs. Short-term unemployment rate}_t \)

4-qtr change in 4-qtr inflation (PCE\textsubscript{ExE}) v. short-term un. rate

1960-83 (dots) 1984-99 (diamond) 2000-2016 (triangle)
$\pi_t - \pi_{t-4}$ vs. Short-term unemployment rate$_t$

4-qtr change in 4-qtr inflation (PCEExE) v. short-term un. rate

1960-83 (dots) 1984-99 (diamond) 2000-2016 (triangle)
Band-pass filtered components and GDP (6-32 qtrs, standardized)
Phillips Curve Scatterplot: 4-qtr changes v. lagged short-term unempl

Housing: Gas & electric util

PC slopes, 60-83: -1.21 (0.46); 84-99: -0.76 (0.76); 00-16: 1.72 (1.50)

1960-1983
1984-1999
2000-2016

4qtr chge of 4-qtr inflation
Short-term unemployment rate
Band-pass filtered components and GDP (6-32 qtrs, standardized)
Phillips Curve Scatterplot: 4-qtr changes v. lagged short-term unempl

Health care

PC slopes, 60-83: -0.67 (0.19); 84-99: -0.39 (0.16); 00-16: -0.11 (0.13)
Band-pass filtered components and GDP (6-32 qtrs, standardized)
Phillips Curve Scatterplot: 4-qtr changes v. lagged short-term unemployment rate

Motor vehicles & parts

PC slopes, 60-83: -1.00 (0.38); 84-99: 0.70 (0.32); 00-16: 1.45 (0.92)

1960-1983
1984-1999
2000-2016
Band-pass filtered components and GDP (6-32 qtrs, standardized)
Phillips Curve Scatterplot: 4-qtr changes v. lagged short-term unempl

Other durable goods

PC slopes, 60-83: -1.31 (0.66); 84-99: 0.45 (0.41); 00-16: -0.67 (0.34)
Band-pass filtered components and GDP (6-32 qtrs, standardized)
Recreational goods & vehicles

Phillips Curve Scatterplot: 4-qtr changes v. lagged short-term unemployment

PC slopes, 60-83: -0.68 (0.29); 84-99: 0.34 (0.34); 00-16: -0.46 (0.38)

1960-1983
1984-1999
2000-2016
Band-pass filtered components and GDP (6-32 qtrs, standardized)
Phillips Curve Scatterplot: 4-qtr changes v. lagged short-term unempl

Gasoline & energy goods

PC slopes, 60-83: -2.70 (1.63); 84-99: 1.49 (1.91); 00-16: 15.26 (5.29)

1960-1983
1984-1999
2000-2016
Band-pass filtered components and GDP (6-32 qtrs, standardized)
Transportation services

PC slopes, 60-83: -1.29 (0.35); 84-99: 0.23 (0.25); 00-16: -0.29 (0.45)

1960-1983
1984-1999
2000-2016
Band-pass filtered components and GDP (6-32 qtrs, standardized)
Phillips Curve Scatterplot: 4-qtr changes v. lagged short-term unemployment

Furnishings & durable household goods

PC slopes, 60-83: -0.97 (0.51); 84-99: -0.01 (0.18); 00-16: -0.70 (0.51)
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)
Furnishings & durable household goods

PC slopes, 60-83: -0.97 (0.51); 84-99: -0.01 (0.18); 00-16: -0.70 (0.51)
Housing: energy utilities
Health care (0.16)
Other services (0.09)
Gasoline & other energy goods (0.03)
Transportation services (0.03)
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