Measuring the Digital Economy at BLS: Focus on Price Index Programs

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U.S. Bureau of Labor Statistics
Federal Economic Statistics Advisory Committee
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Overview

“Digital economy” meaning still evolving – at BLS focus more on various issues that are often mentioned when others talk about digital economy (high-tech goods/services, Gig economy, etc.)

Focus of this presentation on efforts in PPI and CPI programs

► Background/context
► PPI quality adjustment research and improvement for various high-tech goods/services
► CPI – prevalence of e-commerce & recent quality adjustment efforts
Price indexes “in the trenches”

**Goal**
- Best possible monthly indexes of price changes that meet measurement objectives and the needs of data users

**Constraints on methodology**
- Compatible with resources
- Computable and reviewable in 20 days
- Preserve respondent confidentiality
- Avoid undue burden on respondents
- Changes must reduce bias certainly & significantly
# Methods to account for new and improved goods and services

<table>
<thead>
<tr>
<th>Method</th>
<th>Requires demand estimation</th>
<th>Based on characteristics, product or other</th>
<th>In production</th>
<th>Reason not in production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality adjustment from producer</td>
<td>No</td>
<td>Characteristics</td>
<td>Yes; PPI, MXP, CPI***</td>
<td></td>
</tr>
<tr>
<td>Input from other surveys</td>
<td>No</td>
<td>Characteristics</td>
<td>Yes; primarily PPI</td>
<td></td>
</tr>
<tr>
<td>Explicit hedonic quality adjustment</td>
<td>No</td>
<td>Characteristics</td>
<td>Yes; CPI*, PPI**, MXP**</td>
<td></td>
</tr>
<tr>
<td>Time dummy hedonic index</td>
<td>No</td>
<td>Characteristics</td>
<td>No#</td>
<td>Restrictive assumptions</td>
</tr>
<tr>
<td>Imputed hedonic index</td>
<td>No</td>
<td>Characteristics</td>
<td>No</td>
<td>Requires larger sample sizes</td>
</tr>
<tr>
<td>Discrete choice</td>
<td>Yes</td>
<td>Characteristics</td>
<td>No</td>
<td>High computational intensity and cost; poor timeliness</td>
</tr>
<tr>
<td>Consumer surplus</td>
<td>Yes</td>
<td>Product</td>
<td>No</td>
<td>Endogeneity problems (under investigation); high cost</td>
</tr>
<tr>
<td>Disease-based price indexes</td>
<td>No</td>
<td>Treated disease</td>
<td>Partial; BEA and BLS experimental indexes</td>
<td>Do not yet adjust for differences in outcomes</td>
</tr>
</tbody>
</table>

* See [https://www.bls.gov/cpi/quality-adjustment/home.htm](https://www.bls.gov/cpi/quality-adjustment/home.htm) for CPI items that are quality adjusted using hedonic models.
** PPI and MXP do explicit hedonic quality adjustment for computers.
*** For example, this is done for new vehicles in the CPI and PPI.
#PPI is currently working on first use of time dummy variable in building hedonic QA model
PPI Quality Adjustment Research & Improvements

- Microprocessors – research & development (but almost ready for first use in production)
- Broadband Services - in production since January 2017
- Cloud computing services – in research & development
PPI Microprocessors - Motivations

- Price trends in PPI for microprocessors (matched model methodology)
  - 2000-2009: -33.66 percent per year
  - 2009-2014: -6.28 percent per year

- Industry changes in recent years present measurement challenges

- Byrne, Oliner, Sichel (BOS) work using two-year overlapping time-dummy models found -42 percent per year price change, on average, from 2009-2013
PPI Microprocessors – R & D

- First replicated BOS model with data available to PPI
- Used data set to explore BOS results
- Looked at other product characteristics besides performance benchmark focused on by BOS
- Developed PPI microprocessor hedonic model
  - Based off BOS methodology
  - Use quarterly data for 2009-2017
  - Replace SPEC benchmarks with PassMark benchmark
  - Modified BOS use of “early prices” to include all microprocessors introduced within 15 months of a given quarter
Results: Counterfactual indexes – Microprocessors

Microprocessors

- Min BIC
- Min MSE
- Official PPI
Results: Counterfactual indexes – Semiconductors

Semiconductors - Primary Products

- Min BIC
- Min MSE
- Official PPI
PPI Microprocessors – Next Steps

- Results shown today reflect updates from CRIW summer workshop feedback & subsequent discussions
- Made some adjustments in approach but nothing major
- Getting ready to introduce new hedonic model for microprocessors in production soon
- Novel approach for PPI and BLS
  - First use of a time dummy hedonic model & application of statistical learning methods in PPI
  - Potential template for hedonic QA for other industries that see rapid technological change
PPI – Broadband Services

- With release of PPI data for December 2016, began using hedonic QA for broadband items with PPI for internet access services (DSL, cable, & fiber optic services)
- Rapid technological change – need to determine VQA for increased broadband download or upload speed
- Hard to get information from survey participants so developed and now use hedonic model to estimate
- Plan to re-estimate model annually
PPI – Cloud Computing

- R & D on hedonic QA model for cloud computing
- Use product & price data from Amazon Web Services (AWS), Microsoft Azure, & Google Cloud
- Impacts PPI for Hosting, ASP, & other IT infrastructure provisioning services
- So far developed preliminary linear model to derive MSE for several price determining characteristics
## CPI – E-Commerce Statistics

<table>
<thead>
<tr>
<th>Year</th>
<th>Quarter</th>
<th>Retail Sales (Census)</th>
<th>TPOPS Sample Frame*</th>
<th>CPI C&amp;S Initiation Sample (Feb and Aug)</th>
<th>Initiation Sample Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>Q4</td>
<td>7.5%</td>
<td>8.6%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>Q1</td>
<td>7.8%</td>
<td>9.6%</td>
<td>8.1%</td>
<td>Feb16</td>
</tr>
<tr>
<td>2016</td>
<td>Q2</td>
<td>8%</td>
<td>9.6%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>Q3</td>
<td>8.2%</td>
<td>8.7%</td>
<td>9.2%</td>
<td>Aug16</td>
</tr>
<tr>
<td>2016</td>
<td>Q4</td>
<td>8.2%</td>
<td>8.9%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>Q1</td>
<td>8.5%</td>
<td>10.2%</td>
<td>8.3%</td>
<td>Feb17</td>
</tr>
<tr>
<td>2017</td>
<td>Q2</td>
<td>8.9%</td>
<td>9.2%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>Q3</td>
<td>9.1%</td>
<td>8.5%</td>
<td>10.9%</td>
<td>Aug17</td>
</tr>
</tbody>
</table>

*TPOPs value is a percentage of eligible outlets reported (denominator excludes garage sales, commissaries, etc. that are not eligible in CPI).

### Percent of CPI Field Collected Data that is collected via the Web (Oct 2015 - Nov 2017)

- 2015: 7.5%
- 2016 Q1: 7.8%
- 2016 Q2: 8%
- 2016 Q3: 8.2%
- 2016 Q4: 8.2%
- 2017 Q1: 8.5%
- 2017 Q2: 8.9%
- 2017 Q3: 9.1%

*Data collected via the Web from Oct 2015 to Nov 2017.*
CPI Quality Adjustment Research & Improvements

- Collaboration with BEA – focus on new data sources/ division of labor
- Wireless telephone services
- Cell phones
- Cable, internet, & landline (“wireline services”)
CPI: Wireless Telephone Services

- Refined quality adjustment process in early 2017, reducing the rate of non-comparable substitution
  - Better estimation of price of data plans with included data amounts not offered to customers in previous period using data from Whistle Out site
- Work with JD Household data shared by BEA
  - Potential to guide field item selection procedures & substitution frequency
- Research Whistle Out data for potential data collection replacement
CPI: Cell Phones

- Using datasets from BEA, BLS built a new QA hedonic model—targeted for introduction in production starting in January 2018
- Directed substitutions 2x/year, as major new smart phone models are released (5/2018 for first)
- QA hedonic models will be updated twice yearly to correspond with release dates
**CPI: Cable, Internet, & Landline (“wireline services”)**

- Researching alternative data set shared by BEA
  - Cover standalone and triple-play bundled versions of these wireline services
  - Potential for development of QA models if viable
  - Potential for replacing/supplementing data collection

- JD Household data may be helpful here too
  - Improve field procedures (item selection & substitution frequency)
Conclusions

- One potential drawback – offer prices vs. transaction prices in data sources
- Many similar challenges to use of other alternative data sources (cost of data to refresh models, can be labor intensive, etc.)
- Obtaining corporate data may still be the best answer if possible
- Will continue efforts to improve our price measurement of digital economy-related areas
Contact Information

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Other Slides supplementing main presentation in case they are needed
Overview of BLS Price Indexes

- **Consumer Price Index (CPI)**—prices paid by urban consumers

- **Producer Price Index (PPI)**—prices received by domestic producers

- **Import and Export Prices (MXP)**—prices related to trade between US & rest of world
Impact of estimated biases to Personal Consumption Expenditures deflators on measured real GDP growth, 2000-2015

<table>
<thead>
<tr>
<th>Expenditure Category</th>
<th>Share of GDP</th>
<th>Lebow-Rudd est. bias</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical care:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prescription drugs</td>
<td>1.3% 1.6% 1.9% 2.3%</td>
<td>1.20%</td>
</tr>
<tr>
<td>Nonprescription drugs</td>
<td>0.2% 0.2% 0.3% 0.3%</td>
<td>0.50%</td>
</tr>
<tr>
<td>Medical care services*</td>
<td>9.8% 10.9% 12.2% 12.5%</td>
<td>0.76%</td>
</tr>
<tr>
<td>PC services (incl. internet)**</td>
<td>0.2% 0.2% 0.4% 0.6%</td>
<td>6.50%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Medical care:</th>
<th>Contributions to real GDP growth (percentage points per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prescription drugs</td>
<td>-0.02 -0.02 -0.02 -0.03</td>
</tr>
<tr>
<td>Nonprescription drugs</td>
<td>0.00 0.00 0.00 0.00</td>
</tr>
<tr>
<td>Medical care services</td>
<td>-0.07 -0.08 -0.09 -0.09</td>
</tr>
<tr>
<td>PC services (incl. internet)</td>
<td>-0.01 -0.01 -0.03 -0.04</td>
</tr>
<tr>
<td>All other PCE categories</td>
<td>-0.10 -0.10 -0.10 -0.09</td>
</tr>
<tr>
<td>All PCE categories</td>
<td>-0.20 -0.22 -0.24 -0.26</td>
</tr>
</tbody>
</table>

* Bias estimate for medical care services has been adjusted based on data from AHRQ (2017).
** Bias estimate for PC services (including internet) is based on Greenstein and McDevitt (2011).
NOTE: Total for All PCE categories may not add exactly to the sub-components shown in the columns due to rounding.
### Impact of estimated biases to Private Fixed Investment deflators on measured real GDP growth, 2000-2015

<table>
<thead>
<tr>
<th>Equipment type</th>
<th>Share of GDP</th>
<th>Byrne, Fernald, and Reinsdorf estimated bias</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication equipment</td>
<td>1.2%</td>
<td>0.7%</td>
</tr>
<tr>
<td>Computers and peripherals</td>
<td>1.0%</td>
<td>0.6%</td>
</tr>
<tr>
<td>Other info. systems equipment</td>
<td>0.7%</td>
<td>0.7%</td>
</tr>
<tr>
<td>Software</td>
<td>1.8%</td>
<td>1.7%</td>
</tr>
</tbody>
</table>

#### Contributions to real GDP growth (percentage points/year)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication equipment</td>
<td>-0.07</td>
<td>-0.04</td>
<td>-0.03</td>
<td>-0.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computers and peripherals</td>
<td>-0.08</td>
<td>-0.05</td>
<td>-0.04</td>
<td>-0.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other info. systems equipment</td>
<td>-0.05</td>
<td>-0.06</td>
<td>-0.06</td>
<td>-0.06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Software</td>
<td>-0.03</td>
<td>-0.02</td>
<td>-0.02</td>
<td>-0.03</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| All PFI categories       | -0.23| -0.17| -0.16| -0.15|           |           |

Note: The contributions to GDP growth for 2000 and 2005 are calculated using the bias estimates for 1995–2004; the contributions for 2010 and 2015 use the bias estimates for 2004–2014. Total for All PFI categories may not add exactly to sub-components shown in columns due to rounding.
A PPI Perspective: Growth in NAICS 454110

454110 Electronic and Mail Order Shopping Value of Shipment (VOS) Data

<table>
<thead>
<tr>
<th></th>
<th>454110 VOS</th>
<th>Retail Trade VOS</th>
<th>% of Retail Trade VOS</th>
<th>In Scope VOS</th>
<th>% of In Scope VOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>$122,409,558</td>
<td>$1,206,742,161</td>
<td>10.1438%</td>
<td>$23,397,286,985</td>
<td>0.5232%</td>
</tr>
<tr>
<td>2007</td>
<td>$87,547,853</td>
<td>$1,175,745,286</td>
<td>7.4462%</td>
<td>$21,793,963,662</td>
<td>0.4017%</td>
</tr>
</tbody>
</table>
CPI – Prevalence of E-Commerce

- For first five months of 2017, 12.1% of item/price data collected by field was from the internet ("Web") – compared with 11.9% for all twelve months in 2016
- ??% of data collected in National Office was also from "Web"
- As of Q3 2016, E-COMM percent in TPOPS Sample Frame was 8.0%, 8.1% in C&S Initiation Sample

*(NOTE: This info is preliminary – subject to update by FESAC meeting.)*