Use of Consumer Expenditure Survey Data in the Consumer Price Index

ROB CAGE
Division of Consumer Prices and Price Indexes

BUREAU OF LABOR STATISTICS
2 Massachusetts Avenue NE Room 3615 | Washington | DC | 20212
Phone 202.691.6959 | Fax 202.691.6999
cage.rob@bls.gov
www.bls.gov
Agenda

- CPI Overview
  - Estimation methods
  - Data sources

- Current CPI requirements of CE
  - Expenditure weights for index estimation
  - Expenditure weights for item sample selection
  - Adjustments made to CE data to meet CPI needs

- Possible future CPI information needs
CPI Overview

CPI = measure of average change over time in the prices paid by consumers

\[
IX^C_{[0;t]} = \min \sum_i P_t \times_i Q_t \left| \frac{U=U_0}{\sum_i P_0 \times_i Q_0}\right.
\]

The minimum expenditure \((P_tQ_t)\) on a set of consumption items \((i)\) required in comparison period \((t)\) to attain the same level of satisfaction or utility \((U_0)\) achieved in base period \((0)\), divided by the actual expenditure \((P_0Q_0)\) on those items \((i)\) in base period \((0)\)
CPI Overview

\[
IX_{[0;t]}^C = \min_i \frac{\sum_i P_t \times_i Q_t}{\sum_i P_0 \times_i Q_0} \bigg| \text{U} = U_0
\]
CPI Overview - Formulas

Geometric Mean Index:

\[ iIX_{[t-1,t]}^G = e^{\left(\sum_i PQ_i \ln\left(\frac{P_t}{P_{t-1}}\right)\right)} \]

\[ \frac{\sum_i PQ_i \ln\left(\frac{P_t}{P_{t-1}}\right)}{\sum_i PQ_i} \]

Laspeyres Index:

\[ iIX_{[0;1]}^C = \min_{u=U_0} \frac{\sum_i P_i \times Q_i}{\sum_i P_0 \times Q_0} \]

Tornqvist Index:

\[ iIX_{[t-1,t]}^T = e^{\left(\sum_i \frac{PQ_{t-1}}{2} \ln\left(\frac{P_t}{P_{t-1}}\right) + \sum_i \frac{PQ_t}{2} \ln\left(\frac{P_t}{P_{t-1}}\right)\right)} \]

\[ \frac{\sum_i PQ_{t-1} \ln\left(\frac{P_t}{P_{t-1}}\right)}{\sum_i PQ_{t-1}} + \frac{\sum_i PQ_t \ln\left(\frac{P_t}{P_{t-1}}\right)}{\sum_i PQ_t} \]
CPI Overview - Formulas

### Geometric Mean Index:

\[
i IX_{[t-1,t]}^G = \prod_i \left( \frac{P_t}{P_{t-1}} \right)^{iS_b}
\]

### Laspeyres Index:

\[
i IX_{[t-1,t]}^L = \frac{\sum_i \left( \frac{P_t}{P_b} \right) \times iS_b}{\sum_i \left( \frac{P_{t-1}}{P_b} \right) \times iS_b}
\]

### Tornqvist Index:

\[
i IX_{[t-1,t]}^T = \prod_i \left( \frac{P_t}{P_{t-1}} \right)^{\frac{iS_{t-1} + iS_t}{2}}
\]

where:

- \( i = \) calendar period of expenditure weight;
- \( t = \) month

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Weights

Prices
CPI Overview - Surveys

1. Point-of-Purchase Survey (TPOPS)
   - Outlet sampling frame for C&S Pricing Survey
   - Primary source of weights at the basic level of index estimation

2. Pricing Survey (C&S)
   - Source of prices for goods and services

3. Housing Survey (HOUSING)
   - Source of prices for rent and owner’s equivalent rent

4. Consumer Expenditure Surveys (CE)
   - Exclusive source of weights at aggregate level of estimation
   - Also used to select the categories of items to price in C&S
CPI Overview – Estimation Steps

C&S
prices
130,000 quotes

HOUSING
rents
36,000 units

BASIC INDEXES
8,018 cells
(211 items x 38 areas)

CE
AGGREGATION WEIGHTS
8,018 cells
(211 items x 38 areas)

Population: U Only
Period: Monthly
Populations: U, W, E
Periods: Biennial, Monthly

News
United States Department of Labor
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CPI Data Requirements

- Demographics
  - Urban non-institutional population for the CPI-U
    - 88% of total U.S. population
  - Consumer units living in urban areas for which a majority of income is earned in wage-earning or clerical occupations for the CPI-W
    - 29% of total U.S. population
  - Consumer units where the reference person or spouse is 62 years of age or older for the CPI-E
    - 16% of total U.S. population
CPI Data Requirements

- Expenditures
  - Net out-of-pocket expenses for all consumer products and services within CPI’s scope, at the appropriate level of:
    - Consumption detail
    - Geography
    - Periodicity
  - Acquisition approach to ‘expenditure’ definition
    - Exception: Owner’s Equivalent Rent
  - Timeliness
    - September 1 deadline for all expenditure data for the previous calendar year (for calculation of January indexes of the following year, published in February)
### CPI Data Requirements: Consumption Item Detail

#### Set of all consumer expenses

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>n</th>
<th>CODE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Universe</td>
<td>∞</td>
<td></td>
<td>All consumer expenses</td>
</tr>
<tr>
<td>Market Basket Items</td>
<td>∞</td>
<td></td>
<td>Eligible goods and services</td>
</tr>
<tr>
<td>All CPI Items</td>
<td>1</td>
<td>SA0</td>
<td>All-items</td>
</tr>
<tr>
<td>Major Group</td>
<td>8</td>
<td>SAH</td>
<td>Housing</td>
</tr>
<tr>
<td>Expenditure Class</td>
<td>70</td>
<td>SEHK</td>
<td>Appliances</td>
</tr>
<tr>
<td>Item Stratum</td>
<td>211</td>
<td>SEHK01</td>
<td>Major Appliances</td>
</tr>
<tr>
<td>Entry Level Item</td>
<td>303</td>
<td>SEHK011</td>
<td>Refrigerators and freezers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SEHK012</td>
<td>Washers and Dryers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SEHK013</td>
<td>Stoves and cooktops</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SEHK014</td>
<td>Microwave ovens</td>
</tr>
<tr>
<td>Sampled quote</td>
<td>130,000</td>
<td></td>
<td>LG front-loading, energy-star washer</td>
</tr>
</tbody>
</table>
CPI Data Requirements: Geographic Detail

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>n</th>
<th>CODE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Universe</td>
<td>3,143</td>
<td></td>
<td>All counties in the United States</td>
</tr>
<tr>
<td>Urban counties</td>
<td>1,863</td>
<td></td>
<td>Eligible counties w/ urban population</td>
</tr>
<tr>
<td>All CPI Areas</td>
<td>10000</td>
<td></td>
<td>U.S. City Average</td>
</tr>
<tr>
<td>Region</td>
<td>40300</td>
<td></td>
<td>South</td>
</tr>
<tr>
<td>Index Area</td>
<td>38</td>
<td>X300</td>
<td>South X-size cities</td>
</tr>
<tr>
<td>Stratum</td>
<td>87</td>
<td>B344</td>
<td>Norfolk, VA</td>
</tr>
<tr>
<td>and selected</td>
<td></td>
<td></td>
<td>Fayetteville, NC</td>
</tr>
<tr>
<td>Primary Sampling Unit</td>
<td></td>
<td></td>
<td>Greenville, NC</td>
</tr>
<tr>
<td>PSU</td>
<td>950</td>
<td>B344</td>
<td>Norfolk, VA</td>
</tr>
<tr>
<td>Sampled Outlet</td>
<td>40,000</td>
<td></td>
<td>General Store, Main St., Norfolk VA</td>
</tr>
</tbody>
</table>
CPI Data Requirements: Geography
CPI Data Requirements: Periodicity

Periodicity

CPI-U (Urban population)
- Base-period expenditures required for Laspeyres index (CPI-U)
  - Ideal: previous-month for ‘true’ Laspeyres
  - Current: annualized expenditures from 2-year lagged biennial period
- Monthly expenditures required for Tornqvist index (C-CPI-U)
  - Ideal: publish 2-3 weeks after end of calendar month
  - Current: publish 14-25 months after end of calendar month; annualized CPI-U expenditures used in Geometric Mean index for preliminary versions of C-CPI-U, until final monthly weights become available

CPI-W and CPI-E
- Same periodicity requirements as CPI-U
CPI Data Requirements: Item Sample Selection

- **Four-year sample life:**
  - Each ITEM-PSU ‘cell’ has a new sample selected once every 4 years; once initiated into the Pricing Survey, each sampled quote is priced monthly or bimonthly for 4 years

- **Multi-step sample selection process:**
  - Select a sample of outlets to represent each PSU (TPOPS)
  - Select ELI’s to represent each ITEM STRATA
    - 70% of ITEMS are single-ELI
    - 30% require ELI selection based upon expenditures (CE)
  - Combine selected ELIs with selected outlets
  - Select a unique, well-specified good or service (quote)
CPI Data Requirements: Item Sample Selection - Example

- ITEM = Major Appliances (HK01)
- PSU = Washington, DC (A312)
- SAMPLE ROTATED = August 2011
- OUTLET HITS = 2
- ITEM HITS = 4
- TOTAL SAMPLE SIZE = 8

<table>
<thead>
<tr>
<th>ELI</th>
<th>TITLE</th>
<th># Reports (A312)</th>
<th># Reports (South Region)</th>
<th>Share of Total Expenditures</th>
<th>Selected ELIs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>HK011 Refrigerators &amp; Freezers</td>
<td>19</td>
<td>401</td>
<td>14.8%</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>HK012 Washers &amp; Dryers</td>
<td>34</td>
<td>661</td>
<td>65.9%</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>HK013 Ranges &amp; Cooktops</td>
<td>11</td>
<td>215</td>
<td>4.6%</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>HK014 Microwave Ovens</td>
<td>14</td>
<td>328</td>
<td>14.7%</td>
<td>1</td>
</tr>
</tbody>
</table>

CE data from years 2007 and 2008 used to calculate selection probabilities.
CPI Data Requirements: Item Sample Selection - Example

- **ELI = Washers and Dryers (HK012)**

- **CLUSTERS**
  - 01b Washers
  - 02b Dryers

- **SPECS (for Washers)**
  - Type
    - Top-loading or front-loading
  - Brand
  - Capacity in cubic-feet
  - Control interface
  - Screen type
  - Control types
  - Manufacturer warranty
  - Number of wash cycles
  - Special wash cycles
  - Max spin speed
  - Number of water levels
  - Automatic dispensers
  - Washtub material
  - Color
  - Country of origin
CPI Data Requirements: Adjustments

- Insufficient expenditures collected at required consumption item detail

  ▶ Motor Fuels
  - CPI requires expenditures for 5 ELIs:
    - 3 Gasoline ELIs: Regular Unleaded, Mid-grade, Premium
    - 2 Alternative Fuel ELIs: Diesel, Other Motor Fuels
  - Sales data from C&S Survey used to allocate CE total into the 5 required ELIs

  ▶ Food at home items
  - Diary is exclusive source for 61 ITEM STRATA, but excludes trip expenses
  - Global food questions from Interview used to adjust Diary reports

  ▶ Medical Care
  - CPI requires net out-of-pocket expense, but outlays and reimbursements collected separately and unmatched in CE
  - Aggregate totals for calendar year used to estimate net expense for each CU
CPI Data Requirements: Adjustments

Insufficient Sample Size

- **Base-period Expenditures for CPI-U, CPI-W, and CPI-E**
  - Annual estimates required, for each elementary ITEM in each elementary AREA
  - Currently, a two-year period is used to produce annualized CPI-U, CPI-W, and CPI-E expenditure weights
  - Each ITEM-AREA expenditure estimate is also composite-estimated with the corresponding ITEM-REGION-SIZE expenditure estimate, to lower variance

- **Monthly Expenditures for C-CPI-U**
  - Required for each elementary ITEM in each elementary AREA
  - For each ITEM, data are summed to the U.S. level each month, then allocated into the 38 areas using rolling 12-month period allocation factors

- **ELI Selection Probabilities for Item Sample Selection**
  - Required at the ELI-PSU level, annually
  - Currently, annualized probabilities are derived at the ELI-REGION level, using two-years of CE data
# CPI Data Requirements: Sample Size

## CE sample size per year, 2007-2008

<table>
<thead>
<tr>
<th></th>
<th>INTERVIEW</th>
<th></th>
<th></th>
<th>DIARY</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Interviews</td>
<td>Unique</td>
<td></td>
<td>Diaries</td>
<td>Unique</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Consumer Units</td>
<td></td>
<td></td>
<td>Consumer Units</td>
<td></td>
</tr>
<tr>
<td>CPI-U</td>
<td>25,520</td>
<td>13,111</td>
<td></td>
<td>12,758</td>
<td>6,890</td>
<td></td>
</tr>
<tr>
<td>CPI-W</td>
<td>7,343</td>
<td>3,836</td>
<td></td>
<td>4,882</td>
<td>2,057</td>
<td></td>
</tr>
<tr>
<td>CPI-E</td>
<td>6,655</td>
<td>3,283</td>
<td></td>
<td>3,517</td>
<td>1,752</td>
<td></td>
</tr>
</tbody>
</table>

## Per Elementary Area:

<table>
<thead>
<tr>
<th></th>
<th>INTERVIEW</th>
<th></th>
<th></th>
<th>DIARY</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Interviews</td>
<td>Unique</td>
<td></td>
<td>Diaries</td>
<td>Unique</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Consumer Units</td>
<td></td>
<td></td>
<td>Consumer Units</td>
<td></td>
</tr>
<tr>
<td>CPI-U</td>
<td>672</td>
<td>345</td>
<td></td>
<td>336</td>
<td>181</td>
<td></td>
</tr>
<tr>
<td>CPI-W</td>
<td>193</td>
<td>101</td>
<td></td>
<td>128</td>
<td>54</td>
<td></td>
</tr>
<tr>
<td>CPI-E</td>
<td>175</td>
<td>86</td>
<td></td>
<td>93</td>
<td>46</td>
<td></td>
</tr>
</tbody>
</table>
### CPI Data Requirements: Sample Size

Number of CE expenditure records per elementary CPI cell, 2007-2008

<p>| Item-Area- | Item-Area- |</p>
<table>
<thead>
<tr>
<th>Biennial</th>
<th>Monthly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>0</td>
</tr>
<tr>
<td>10%</td>
<td>11</td>
</tr>
<tr>
<td>25%</td>
<td>34</td>
</tr>
<tr>
<td>Median 50%</td>
<td>99</td>
</tr>
<tr>
<td>75%</td>
<td>318</td>
</tr>
<tr>
<td>90%</td>
<td>1,221</td>
</tr>
<tr>
<td>Maximum</td>
<td>24,354</td>
</tr>
<tr>
<td>% of cells with 0 reports</td>
<td>1.5%</td>
</tr>
<tr>
<td>% of cells &lt; 30 reports</td>
<td>22%</td>
</tr>
</tbody>
</table>
CPI Data Requirements: Summary

- **Weights for Index Estimation:**
  - Annual expenditure detail for matrix of elementary item-area cells:
    - 211 ITEMS x 38 AREAs = 8,018 cells
    - Urban (CPI-U), Wage-earner (CPI-W), and Elderly (CPI-E) populations
  - Monthly expenditure detail for same elementary matrix
    - Urban population only (C-CPI-U)

- **Weights for Item Sample Selection:**
  - Annual expenditure detail for matrix of 303 ELIs x 87 PSUs
    - Urban population only
Possible Future CPI Information Needs

- Use of CE to identify the frame or a portion of the frame of retail outlets for collection of prices in the C&S Pricing Survey
  - Need to improve or replace the Telephone Point of Purchase Survey (TPOPS)
  - Possible use of the Census of Retail Trade, Centers for Medicare and Medicaid Services data, and other administrative sources for a portion of TPOPS.
  - Use of CE or some other survey to collect the balance of retail outlet information.
Possible Future CPI Information Needs

- Use of CE to collect key price-determining characteristics (SPECS) of exactly what is purchased
  - Process of collecting information on sales from store managers is difficult and burdensome
  - CE data at the CLUSTER or SPEC level could absorb some of the burden now on the C&S respondent
  - Would allow separate item sample selection for the CPI-W and CPI-E
  - If performed in conjunction with collecting the point-of-purchase, could permit separate outlet sample selection for CPI-W and CPI-E
Possible Future CPI Information Needs

- **Sample size**
  - Adequate to support annual ELI-PSU expenditure detail, for the urban population
  - Adequate to support monthly ITEM-AREA expenditure detail, for the urban population
  - Adequate to support various demographic indexes

- **Timeliness**
  - Ideal goal: receipt of data for calendar month (t) by the end of the first week of following month
CPI Item Weights

Relative importance of CPI Item Strata, 2005-2006 Biennial Period

- Owner's Equivalent Rent: 23.72%
- Rent: 5.63%
- New Cars: 4.93%
- Gasoline: 4.44%
- Full-service Restaurants: 2.99%
- Electricity: 2.70%
- Other Lodging: 2.58%
- Fast Food: 2.40%
- Car Insurance: 2.04%
- Other items: 26.67%

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Contact Information

Rob Cage
Economist
Division of Consumer Prices
www.bls.gov/cpi/
202-691-6959
cage.rob@bls.gov