Use of Consumer Expenditure Survey Data in the Consumer Price Index
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

\[ \min \sum_{i} P_t \times Q_t | U = U_0 \]

\[ \sum_{i} P_0 \times Q_0 \]

The minimum expenditure \((P_t Q_t)\) 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 \((P_0 Q_0)\) on those items \((i)\) in base period \((0)\)
CPI Overview

\[ i \mathcal{IX}^{C}_{[0,t]} = \min \left\{ \sum_{i} P_{t} \times_{i} Q_{t} \right\} \bigg|_{U=U_{0}} \frac{\sum_{i} P_{0} \times_{i} Q_{0}}{\sum_{i} P_{0} \times_{i} Q_{0}} \]
CPI Overview - Formulas

Geometric Mean Index:

\[
IX_{[t-1,t]}^G = e^{\sum_i \frac{PQ |_{t-1} \times \ln \left(\frac{P_t}{P_{t-1}}\right)}{\sum_i PQ |_{t-1}}}
\]

Laspeyres Index:

\[
IX_{[0:t]}^L = \min_{U=U_0} \left( \sum_i P_i X_i \frac{Q_t}{Q_U} \right)
\]

Tornqvist Index:

\[
IX_{[t-1,t]}^T = e^{\left( \sum_i \frac{PQ |_{t-1} \times \ln \left(\frac{P_t}{P_{t-1}}\right)}{\sum_i PQ |_{t-1}} + \sum_i \frac{PQ |_t \times \ln \left(\frac{P_t}{P_{t-1}}\right)}{\sum_i PQ |_t} \right)}
\]

\[
IX_{[t-1,t]}^C = e^{\left( \sum_i \frac{PQ |_{t-1} \times \ln \left(\frac{P_t}{P_{t-1}}\right)}{\sum_i PQ |_{t-1}} \right)}
\]
CPI Overview - Formulas

Geometric Mean Index:

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

Tornqvist Index:

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

Laspeyres Index:

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

Weights

Prices

b = calendar period of expenditure weight; t = month
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

130,000 quotes

8,018 cells (211 items x 38 areas)

8,018 cells (211 items x 38 areas)

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

BLS
United States Department of Labor
Washington, D.C. 20212

C&S
prices

HOUSING
rents

CE
AGGREGATION WEIGHTS

130,000 quotes

36,000 units

8,018 cells (211 items x 38 areas)
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

<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

### Diagram:
- **CPI**
- **REGION**
- **AREA**
- **STRATUM**
- **PSU**
- **Outlet**

### Table:

<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 with 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>4</td>
<td>0300</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

CE data from years 2007 and 2008 used to calculate selection probabilities

<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>HK011</td>
<td>Refrigerators &amp; Freezers</td>
<td>19</td>
<td>401</td>
<td>14.8%</td>
<td>1</td>
</tr>
<tr>
<td>HK012</td>
<td>Washers &amp; Dryers</td>
<td>34</td>
<td>661</td>
<td>65.9%</td>
<td>2</td>
</tr>
<tr>
<td>HK013</td>
<td>Ranges &amp; Cooktops</td>
<td>11</td>
<td>215</td>
<td>4.6%</td>
<td>0</td>
</tr>
<tr>
<td>HK014</td>
<td>Microwave Ovens</td>
<td>14</td>
<td>328</td>
<td>14.7%</td>
<td>1</td>
</tr>
</tbody>
</table>
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>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Interviews</td>
<td>Unique Consumer Units</td>
<td>Diaries</td>
<td>Unique Consumer Units</td>
<td></td>
</tr>
<tr>
<td>CPI-U</td>
<td>25,520</td>
<td>13,111</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>4,882</td>
<td>2,057</td>
<td></td>
</tr>
<tr>
<td>CPI-E</td>
<td>6,655</td>
<td>3,283</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>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Interviews</td>
<td>Unique Consumer Units</td>
<td>Diaries</td>
<td>Unique Consumer Units</td>
<td></td>
</tr>
<tr>
<td>CPI-U</td>
<td>672</td>
<td>345</td>
<td>336</td>
<td>181</td>
<td></td>
</tr>
<tr>
<td>CPI-W</td>
<td>193</td>
<td>101</td>
<td>128</td>
<td>54</td>
<td></td>
</tr>
<tr>
<td>CPI-E</td>
<td>175</td>
<td>86</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

<table>
<thead>
<tr>
<th></th>
<th>Item-Area-Biennial</th>
<th>Item-Area-Monthly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10%</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>25%</td>
<td>34</td>
<td>1</td>
</tr>
<tr>
<td>Median 50%</td>
<td>99</td>
<td>5</td>
</tr>
<tr>
<td>75%</td>
<td>318</td>
<td>16</td>
</tr>
<tr>
<td>90%</td>
<td>1,221</td>
<td>60</td>
</tr>
<tr>
<td>Maximum</td>
<td>24,354</td>
<td>1,266</td>
</tr>
<tr>
<td>% of cells with 0 reports</td>
<td>1.5%</td>
<td>15%</td>
</tr>
<tr>
<td>% of cells &lt; 30 reports</td>
<td>22%</td>
<td>83%</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
Importance of Weights

CPI-U: Laspeyres  Initial C-CPI-U: Geomean  Final C-CPI-U: Tornqvist


Relative Importance of Gasoline in Washington, DC
Contact Information

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