Delivering insight through data for a better Canada

Statistic’s Canada’s Adjusted Price Index and Monthly Adjusted Consumer Expenditure Basket Weights

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Outline

- Statistics Canada’s CPI and response to COVID-19 pandemic
- new measures
  - monthly basket weights
  - an alternate CPI
- data sources
- methods
- results
The Consumer Price Index and COVID-19 Pandemic

- Statistics Canada’s Consumer Price Index
  - Laspeyres-type Lowe index with fixed basket aggregation structure and quantities updated every 2 years
  - at start of COVID-19 pandemic, CPI 1-m change based on 2017 price-updated expenditures:
    \[ \frac{\sum_{i=1}^{N} p_{2020,m} q_{2020,m}}{\sum_{i=1}^{N} p_{2020,m-1} q_{2020,m-1}} - 1 \]
  - annual expenditures
    - combine monthly patterns
    - CPD was planning to update CPI basket to 2019 expenditure patterns with 202101 CPI
  - assumes stable spending patterns
    - worked well for most periods
  - March 11, 2020 declaration of COVID-19 pandemic
  - abrupt changes found in StatCan’s April 8, 2020 analysis of grocery retailer scanner data
  - searched for new data sources to estimate monthly expenditures
Pandemic’s Impact on Spending and Inflation

- early indications of significant changes on spending and inflation
  - e.g. Alberto Cavallo, “Inflation with Covid Consumption Baskets”, Harvard Business School, May 28, 2020

![Chart showing changes in expenditure over time](image)

![Chart showing US CPI with Covid Expenditure Weights](image)

**Figure 1:** US Changes in Expenditure over time

**Notes:** This graph shows the accumulated expenditure change in a set of standardized categories of goods and services in the US. These estimates are publicly available on the Opportunity Insights (OI) website, [https://opportunityinsights.org/](https://opportunityinsights.org/), and are produced using transactional data collected from credit card transactions in the US, as described in Chetty et al. (2020).

**Figure 2:** US CPI with Covid Expenditure Weights

**Notes:** These graphs show the all-items, US city average, not seasonally adjusted CPI and an equivalent index constructed using estimates of the consumption expenditure shares under lockdown. The vertical grey line marks the start of the Covid Pandemic in January 2020.
### New Measures: Adjusted Price Index and Monthly Adjusted Consumer Expenditure Basket Weights

- **work in spring 2020 to estimate an alternative CPI:**
  - “What would CPI be if we adjusted weights to reflect significant changes in consumer spending?”
- **redevelopment in spring 2021**
  - new CPI basket weights reflect pandemic expenditures in 2020
  - investigate new data sources and methods for Adjusted PI

<table>
<thead>
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<th><strong>Indexes and Weights</strong></th>
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<th><strong>Version 2</strong></th>
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<tbody>
<tr>
<td>release dates</td>
<td>July 13, 2020 (as “Analytical price index”) October 8, 2020 January 12, 2021 April 12, 2021</td>
<td>November 10, 2021 February 24, 2022 May 9, 2022</td>
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</table>

<table>
<thead>
<tr>
<th><strong>Adjusted Price Index</strong></th>
<th><strong>Statistics Canada data table</strong></th>
<th><strong>Version 1</strong></th>
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<tr>
<td>reference periods</td>
<td>2020Q3 to 2021Q2</td>
<td>2021Q6 to 2022Q3</td>
<td></td>
</tr>
<tr>
<td>statistic</td>
<td>index level, 2002=100</td>
<td>1-m % change in index level</td>
<td></td>
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<tr>
<td>index formula</td>
<td>monthly-chained Laspeyres Price Index</td>
<td>Similarity-linked Fisher Price Index</td>
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<tr>
<td>product detail</td>
<td>All-items, 8 major aggregates, 113 analytical series</td>
<td>All-items (only)</td>
<td></td>
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<table>
<thead>
<tr>
<th><strong>Monthly Adjusted Consumer Expenditure Basket Weights</strong></th>
<th><strong>Statistics Canada data table</strong></th>
<th><strong>Version 1</strong></th>
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</thead>
<tbody>
<tr>
<td>reference periods</td>
<td>2020Q2:2021Q1</td>
<td>2021Q6:2022Q3</td>
<td></td>
</tr>
<tr>
<td>statistic</td>
<td>basket share, %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>weight base</td>
<td>2017 expenditures, primarily from Survey of Household Spending</td>
<td>2020 expenditures, primarily from SNA’s Household Final Consumption Expenditures</td>
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<tr>
<td>seasonality</td>
<td>annual concept</td>
<td>raw, not seasonally adjusted</td>
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<tr>
<td>product detail</td>
<td>All-items, 8 major aggregates, 113 analytical series</td>
<td>All-items, 8 major aggregates, 110 analytical series</td>
<td></td>
</tr>
</tbody>
</table>
Expenditure Estimation – Data Sources

<table>
<thead>
<tr>
<th>Supplier type</th>
<th>Data from Statistics Canada programs</th>
<th>Supplier type</th>
<th>Data supplied to Statistics Canada from external provider</th>
<th>Other data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data source</td>
<td>Public or internal-use</td>
<td>Data details</td>
<td>Data periodicity</td>
<td>Used in version 1</td>
</tr>
<tr>
<td>Household Final Consumption Expenditures</td>
<td>internal-use</td>
<td>full-precision current dollar expenditure</td>
<td>quarterly</td>
<td>✓</td>
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<tr>
<td>Retail Commodity Survey</td>
<td>internal-use</td>
<td>sales by product in North American Product Classification System (NAPCS)</td>
<td>monthly</td>
<td>✗</td>
</tr>
<tr>
<td>Monthly Retail Trade Survey</td>
<td>public data</td>
<td>revenues for retail industries in North American Industry Classification System (NAICS)</td>
<td>monthly</td>
<td>✓</td>
</tr>
<tr>
<td>New Motor Vehicle Sales</td>
<td>public data</td>
<td>revenues</td>
<td>monthly</td>
<td>✓</td>
</tr>
<tr>
<td>Population estimates, quarterly</td>
<td>public data</td>
<td>number of people</td>
<td>quarterly</td>
<td>✓</td>
</tr>
<tr>
<td>Monthly Survey of Food Services and Drinking Places</td>
<td>public data</td>
<td>revenues for related industries in NAICS</td>
<td>monthly</td>
<td>✓</td>
</tr>
<tr>
<td>Domestic and international Itinerant aircraft movements</td>
<td>public data</td>
<td>number of flights</td>
<td>weekly</td>
<td>✓</td>
</tr>
<tr>
<td>New Housing Price Index data</td>
<td>public data</td>
<td>price index</td>
<td>monthly</td>
<td>✓</td>
</tr>
<tr>
<td>Passenger bus and urban transit statistics</td>
<td>public data</td>
<td>revenues</td>
<td>monthly</td>
<td>✓</td>
</tr>
<tr>
<td>Electric power generation statistics</td>
<td>public data</td>
<td>volume of electricity available for use</td>
<td>monthly</td>
<td>✓</td>
</tr>
<tr>
<td>Canadian monthly natural gas distribution statistics</td>
<td>public data</td>
<td>revenues for deliveries to residential consumers</td>
<td>monthly</td>
<td>✓</td>
</tr>
<tr>
<td>Consumer Price Index</td>
<td>internal-use</td>
<td>price index levels, full precision</td>
<td>monthly</td>
<td>✓</td>
</tr>
<tr>
<td>Labour Force Survey rent data</td>
<td>internal-use</td>
<td>estimated average price paid by renters</td>
<td>monthly</td>
<td>✓</td>
</tr>
</tbody>
</table>
| Bank of Canada High Frequency Expenditure Network data | internal-use | • year-over-year growth in revenue  
• data from credit card company, bank, & electronic payment processor representing 3/4 of all payment card purchases (≈$600B)  
• mapped to 36 upper-level CPI categories, covering 2/3 of basket, but no data for Shelter, Purchase and leasing of passenger vehicles, some transportation services | monthly | ✓ | ✓ | 60.56 |
| Canada Revenue Agency Goods and Services Tax revenue data | internal-use | revenues for all registered businesses, allocated to NAICS industry | monthly | ✓ | ✓ | 58.97 |
| Grocery retailer scanner data | internal-use | sales by detailed item, labelled to CPI classification using machine learning | daily or weekly | ✓ | ✓ | 15.29 |
| SABRE airline statistics | via subscription | USD revenues for all departure-destination city pairs, converted to CAD | monthly | ✗ | ✓ | 0.26 |
| Office of the Superintendent of Financial Institutions mortgage data | internal-use | mortgage interest outstanding | monthly | ✓ | ✓ | 3.85 |
| Electricity volume data | public data | | hourly | ✓ | ✓ | 2.66 |
| Various news reports | public data | | various | ✓ | ✗ | |

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Expenditure Estimation - Methods

- start with benchmark
  - version 1: CPI basket weights based on Survey of Household Spending, 2017
  - version 2: CPI basket weights based on SNA Household Final Consumption Expenditures, 2020
- project forward using other data sources
- proxy data for 500+ elementary products
  - prices (p), quantities (q), expenditures (pq)
  - levels, growth rates
  - annual, quarterly, monthly, weekly, daily
- version 1
  - annual concept in a monthly estimate
  - seasonally adjusted, unadjusted data
- version 2
  - raw, seasonally unadjusted data
  - estimated monthly expenditures by escalating elementary’s 2020 basket weight using:
    - proxy’s growth rate in revenues vs. 2020
    - proxy’s growth rate in quantities vs. 2020 and different proxy’s growth rate in price vs. 2020
    - proxy’s growth rate in quantities vs. 2020 and elementary’s CPI growth rate in price vs. 2020
    - constrained expenditures to be consistent with HFCE quarterly growth rate from 2020 and HFEN annual growth rate
Expenditures (Version 2) Evolve During Pandemic

- border closures, travel advisories continued to restrict spending on Air transportation

- working and schooling from home prompted Canadians to spend more on Household appliances
Adjusted Price Index – Version 1

- Adjusted Price Index
  - used monthly expenditures starting February 2020
  - used price change from equivalent CPI product
  - a monthly-chained Laspeyres Price Index
    - \(\text{AdjPI} \text{ All-items, 202002} = \text{CPI} \text{ All-items, 202002} \)
    - \(\text{AdjPI} \text{ All-items, 202003} = \text{CPI} \text{ All-items, 202002} \times \sum_{i=1}^{N} (p_{i,202002}q_{i,202002} / p_{i,202002}) \)
    - \(\text{AdjPI} \text{ All-items, 202004} = \text{AdjPI} \text{ All-items, 202003} \times \sum_{i=1}^{N}(p_{i,202003}q_{i,202003} \times p_{i,202004} / p_{i,202003}) \)

- CPI used 2017 quantities
  - CPI 1-m change: \(\sum_{i=1}^{N}p_{2020,m}q_{2017} / \sum_{i=1}^{N}p_{2020,m-1}q_{2017} - 1 \)

- divergence starting April 2020
  - during 1st lockdown, consumers shifted spending towards goods and services with increasing prices

<table>
<thead>
<tr>
<th>Product group</th>
<th>CPI price-updated weight (p202003q2017)</th>
<th>Adjusted PI weight (p202003q202003)</th>
<th>1-m price change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food from stores</td>
<td>11.49%</td>
<td>16.67%</td>
<td>0.9%</td>
</tr>
<tr>
<td>Clothing and footwear</td>
<td>5.40%</td>
<td>3.33%</td>
<td>-5.9%</td>
</tr>
</tbody>
</table>
addressed issue of “chain drift”
- frequent chaining of price indexes
- interaction of prices and quantities
- a monthly-chained Laspeyres does not always return to prior levels even if prices and quantities do
- used Similarity-linked Fisher Price Index
  - Fisher price index is symmetric, makes equal use of weights from earlier and later period
  - Similarity linking overcomes index chain drift
- similarities with BEA’s Personal Consumption Expenditures Price Index (PCE-PI)
  - weights based primarily on business surveys
  - use of Fisher

![Adjusted Price Index - Version 2](image-url)
Similarity Linking Method for Adjusted Price Index (v2)

1. compare prices and quantities across all periods
   - compute Predicted Share measure of relative price dissimilarity:
     \[
     \Delta_{SP}(p^r, p^t, q^r, q^t) = \sum_{n=1}^{N} \left( \frac{p_{n,t}q_{n,t}}{\sum_{n=1}^{N} p_{n,t}q_{n,t}} - \frac{p_{n,r}q_{n,t}}{\sum_{n=1}^{N} p_{n,r}q_{n,t}} \right)^2 + \sum_{n=1}^{N} \left( \frac{p_{n,t}q_{n,r}}{\sum_{n=1}^{N} p_{n,r}q_{n,t}} - \frac{p_{n,r}q_{n,r}}{\sum_{n=1}^{N} p_{n,r}q_{n,r}} \right)^2
     \]
   - compute Predicted Share measure of relative quantity dissimilarity:
     \[
     \Delta_{SQ}(p^r, p^t, q^r, q^t) = \sum_{n=1}^{N} \left( \frac{p_{n,t}q_{n,t}}{\sum_{n=1}^{N} p_{n,t}q_{n,t}} - \frac{p_{n,t}q_{n,r}}{\sum_{n=1}^{N} p_{n,r}q_{n,t}} \right)^2 + \sum_{n=1}^{N} \left( \frac{p_{n,t}q_{n,r}}{\sum_{n=1}^{N} p_{n,r}q_{n,r}} - \frac{p_{n,r}q_{n,t}}{\sum_{n=1}^{N} p_{n,r}q_{n,r}} \right)^2
     \]
   - where
     - \( n \) is an elementary product
     - \( N \) is the total number of elementary products (\( N = 515 \))
     - \( t \) is the later period
     - \( r \) is a prior period
     - \( p_{n,t} \) is the expenditure on elementary product \( n \) in period \( t \)
     - \( p_{n,r} \) is the expenditure on elementary product \( n \) in period \( r \)
     - \( p_{n,t} \) is the expenditure on elementary product \( n \) in period \( t \), multiplied by the change in price on elementary product \( n \) from period \( r \)
     - \( p_{n,r} \) is the expenditure on elementary product \( n \) in period \( r \), multiplied by the change in price on elementary product \( n \) from period \( t \)

2. find minimum of \( \Delta_{SP}(p^r, p^t, q^r, q^t) \) and \( \Delta_{SQ}(p^r, p^t, q^r, q^t) \)
3. select period \( r \) with smallest minimum
4. calculate bilateral Fisher price index between selected \( r \) and \( t \):
   \[
   P_{F(SPQ)} = \left( \frac{\sum_{n=1}^{N} p_{n,r}q_{n,t}}{\sum_{n=1}^{N} p_{n,r}q_{n,t} \cdot \sum_{n=1}^{N} p_{n,t}q_{n,r}} \right)^{1/2}
   \]
5. calculate index level at \( t \) using index at \( r \) and bilateral Fisher price index between \( r \) and \( t \):
   - if \( t = 0 \): \( P_{F(SPQ),0} = 100 \)
   - else if \( t > 0 \): \( P_{F(SPQ),r:t} = P_{F(SPQ),r} \cdot P_{F(SPQ),t} \)
Adjusted Price Index - Version 2

- monthly change in Adjusted PI (v2) closer to CPI’s

<table>
<thead>
<tr>
<th>Month</th>
<th>Product group</th>
<th>CPI price-updated weight, t-1</th>
<th>Adjusted PI weight, t-1</th>
<th>Adjusted PI weight, t-1</th>
<th>CPI 1-m % chg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dec-2021</td>
<td>Video equipment</td>
<td>0.65%</td>
<td>0.99%</td>
<td>0.96%</td>
<td>-3.4%</td>
</tr>
<tr>
<td>Mar-2022</td>
<td>Purchase of passenger vehicles</td>
<td>6.18%</td>
<td>4.90%</td>
<td>5.70%</td>
<td>1.64%</td>
</tr>
</tbody>
</table>
Price and Quantity Change

- calculated monthly correlation coefficient between quantity and price 1-m relatives across all elementary products
- changes in quantities consumed move opposite to change in prices in most months
- negative relationship strengthens in fall & winter, moderates in spring & summer
- April 2020 exceptional, aggregate price and quantity change positively correlated

<table>
<thead>
<tr>
<th>Product group</th>
<th>Change from March 2020 to April 2020</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Derived quantity consumed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gasoline</td>
<td>-43.1%</td>
<td>-15.2%</td>
</tr>
<tr>
<td>Traveller accommodation</td>
<td>-52.4%</td>
<td>-5.1%</td>
</tr>
<tr>
<td>Clothing and footwear</td>
<td>-44.1%</td>
<td>-5.9%</td>
</tr>
</tbody>
</table>
Next Steps

- Statistics Canada to update basket to 2021 expenditures with 202205 CPI
- continue monitoring shifts in consumption to inform decisions about basket updates
- discussions with Bank of Canada about future of Adjusted PI
  - decision whether to continue publishing or keep as an analytical series expected in fall 2022, based on analysis of monthly weights and business value