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

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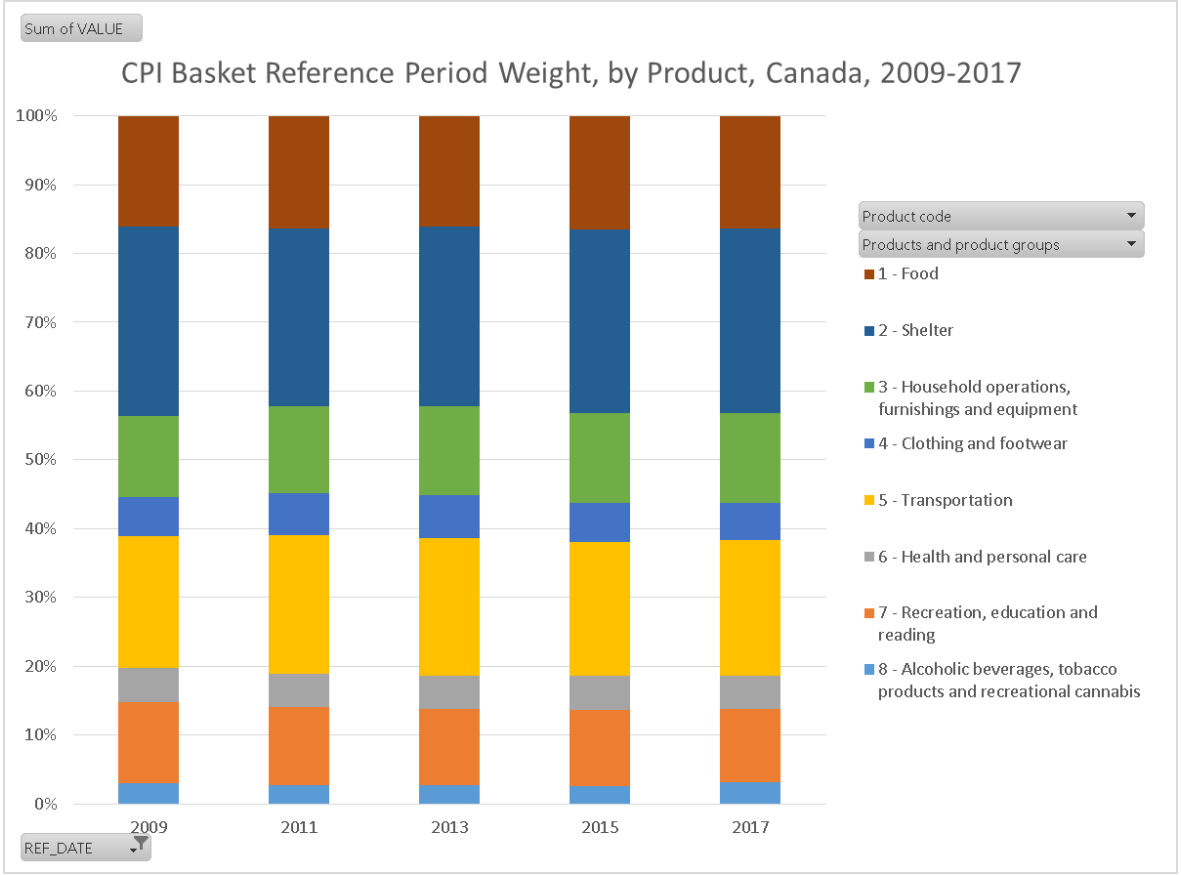
Outline

- 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:

    $\sum_{i=1}^{N} p_{2020,m} q_{2017} / \sum_{i=1}^{N} p_{2020,m-1} q_{2017} - 1$
- 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

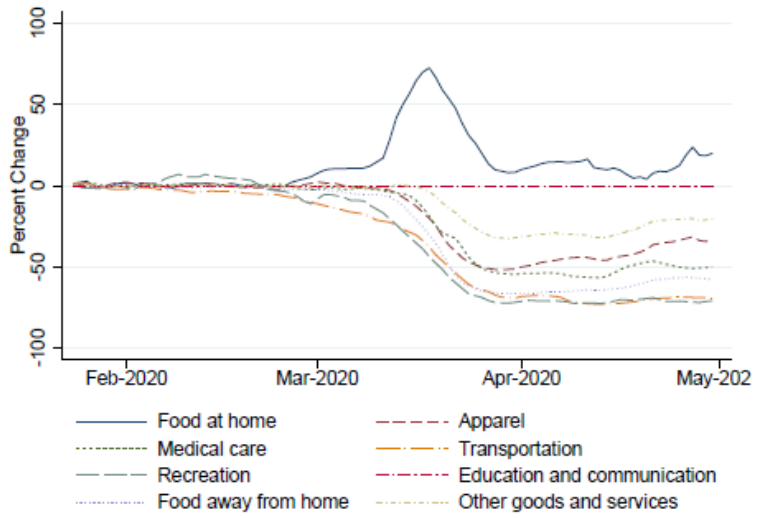
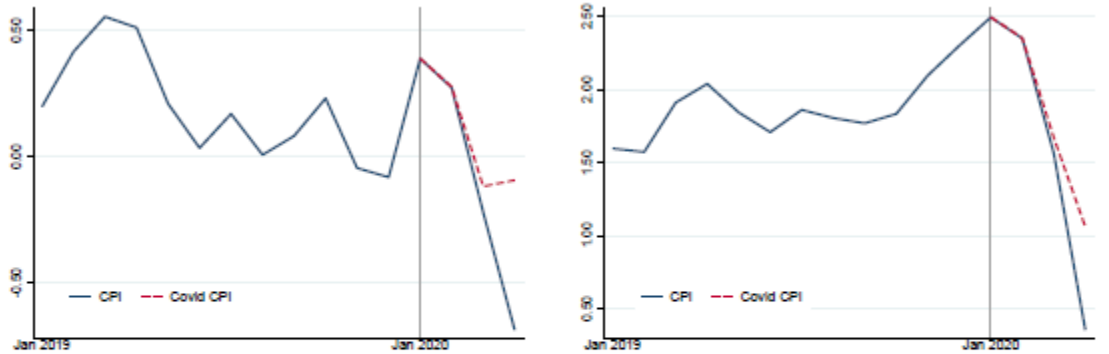


Figure 1: US Changes in Expenditure over time

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



(a) Monthly Inflation Rate (%)

(b) Annual Inflation Rate (%)

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 gray 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

		Version 1	Version 2
Indexes and Weights	release dates	July 13, 2020 (as "Analytical price index") October 8, 2020 January 12, 2021 April 12, 2021	November 10, 2021 February 24, 2022 May 9, 2022
Adjusted Price Index	Statistics Canada data table	18-10-0263-01 Monthly adjusted price index, provisional	18-10-0271-01 Adjusted price index, monthly percentage change
	reference periods	202003 to 202102	202106 to 202203
	statistic	index level, 2002=100	1-m % change in index level
	index formula	monthly-chained Laspeyres Price Index	Similarity-linked Fisher Price Index
	product detail	All-items, 8 major aggregates, 113 analytical series	All-items (only)
Monthly Adjusted Consumer Expenditure Basket Weights	Statistics Canada data table	18-10-0264-01 Monthly Adjusted Consumer Expenditure Basket Weights	
	reference periods	202002:202101	202105:202203
	statistic	basket share, %	
	weight base	2017 expenditures, primarily from Survey of Household Spending	2020 expenditures, primarily from SNA's Household Final Consumption Expenditures
	seasonality	annual concept	raw, not seasonally adjusted
	product detail	All-items, 8 major aggregates, 113 analytical series	All-items, 8 major aggregates, 110 analytical series

Expenditure Estimation – Data Sources

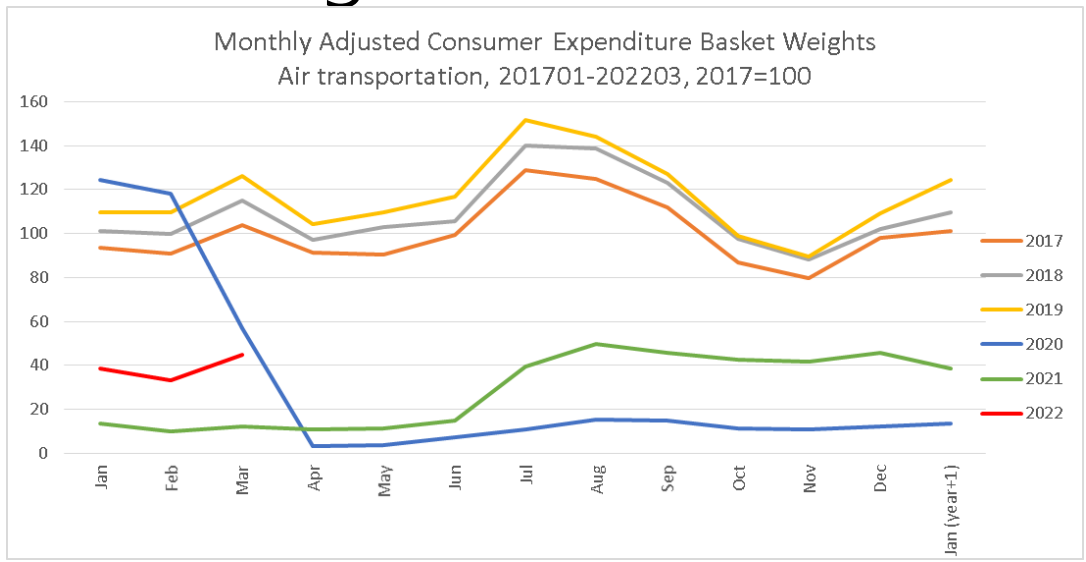
Supplier type	Data source	Public or internal-use	Data details	Data periodicity	Used in version 1	Used in version 2	Basket share of elementary products adjusted using this source in version 2 (%)
Data from Statistics Canada programs	Household Final Consumption Expenditures	internal-use	full-precision current dollar expenditure	quarterly	✓	✓	83.48
	Retail Commodity Survey	internal-use	sales by product in North American Product Classification System (NAPCS)	monthly	×	✓	32.66
	Monthly Retail Trade Survey	public data	revenues for retail industries in North American Industry Classification System (NAICS)	monthly	✓	✓	8.79
	New Motor Vehicle Sales	public data	revenues	monthly	✓	✓	6.31
	Population estimates, quarterly	public data	number of people	quarterly	✓	✓	19.16
	Monthly Survey of Food Services and Drinking Places	public data	revenues for related industries in NAICS	monthly	✓	✓	5.12
	Domestic and international Itinerant aircraft movements	public data	number of flights	weekly	✓	✓	0.26
	New Housing Price Index data	public data	price index	monthly	✓	✓	7.01
	Passenger bus and urban transit statistics	public data	revenues	monthly	✓	✓	0.20
	Electric power generation statistics	public data	volume of electricity available for use	monthly	✓	✓	2.66
	Canadian monthly natural gas distribution statistics	public data	revenues for deliveries to residential consumers	monthly	✓	✓	0.70
	Consumer Price Index	internal-use	price index levels, full precision	monthly	✓	✓	11.14
	Labour Force Survey rent data	internal-use	estimated average price paid by renters	monthly	✓	✓	6.59
Data supplied to Statistics Canada from external provider	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
Other data	Electricity volume data	public data		hourly	✓	✓	2.66
	Various news reports	public data		various	✓	×	

Expenditure Estimation - Methods

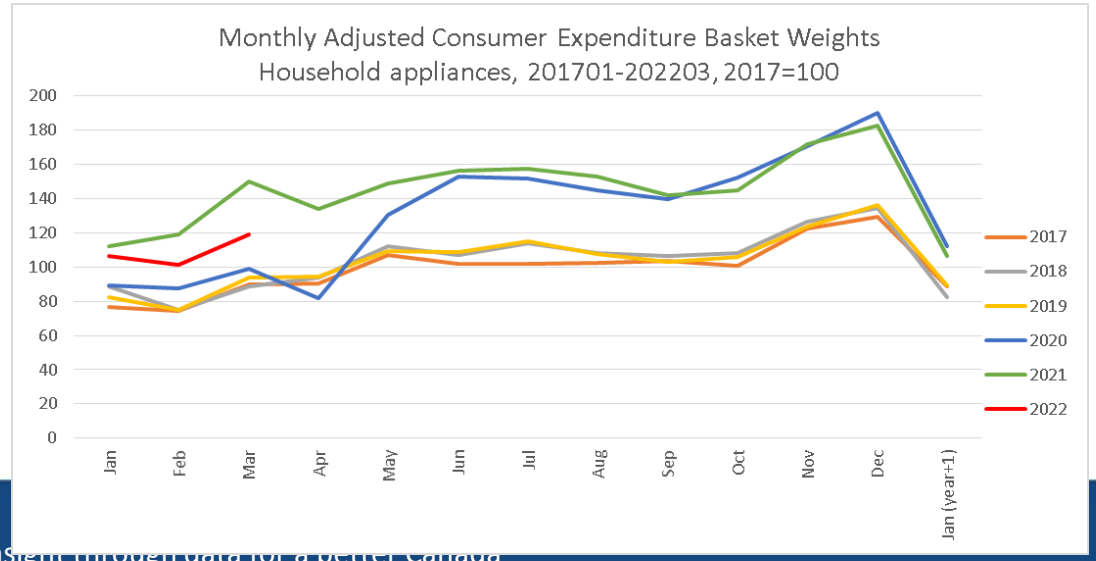
- start with benchmark
  - version 1: CPI basket weights based on Survey of Household Spending, 2017
  - version 2: CPI basket weights based on SNA Household Final Consumption Expenditures, 2020
- project forward using other data sources
- proxy data for 500+ elementary products
  - prices (p), quantities (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



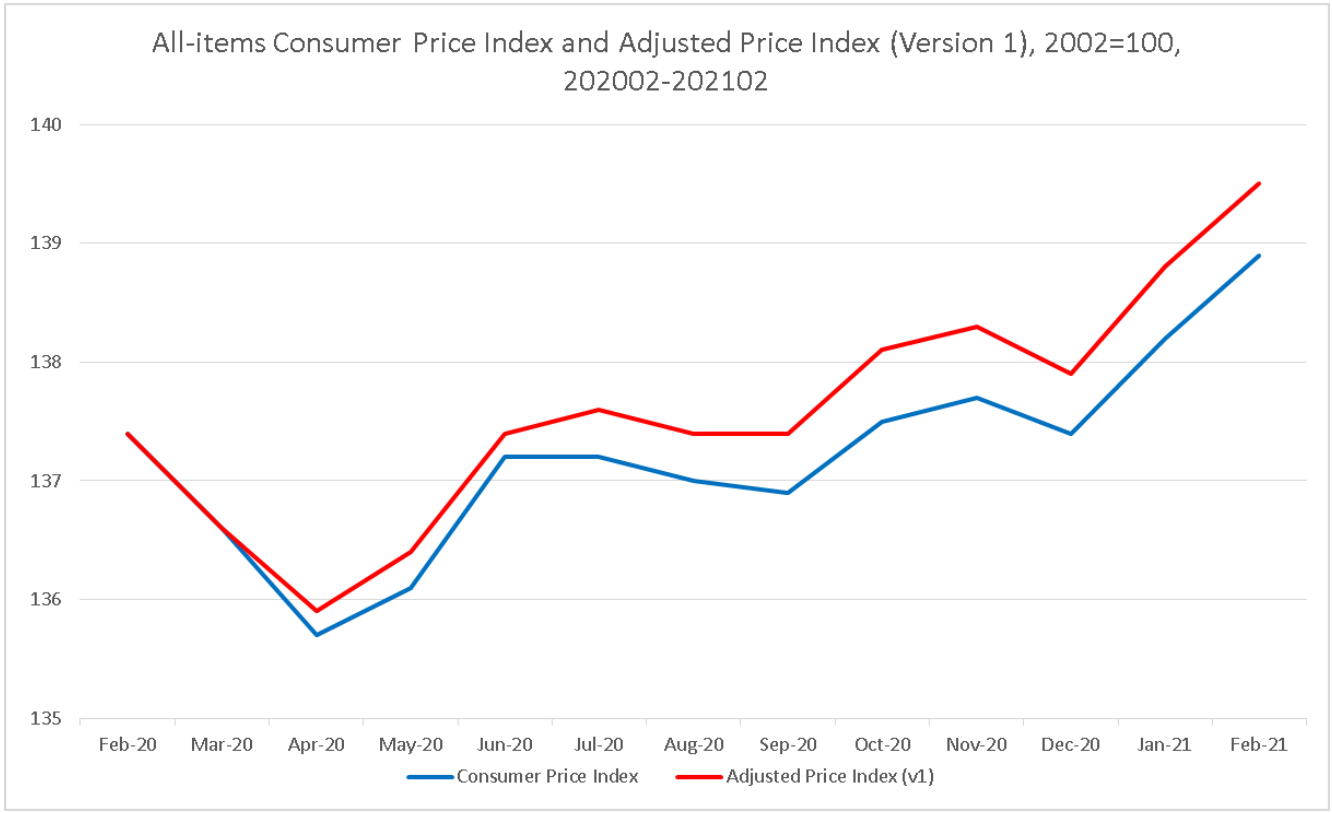
- working and schooling from home prompted Canadians to spend more on Household appliances



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
    - $\text{AdjPI}_{\text{All-items, 202002}} = \text{CPI}_{\text{All-items, 202002}}$
    - $\text{AdjPI}_{\text{All-items, 202003}} = \text{CPI}_{\text{All-items, 202002}} * \sum_{i=1}^{N} (p_{i,202002}q_{i,202002} * p_{i,202003} / p_{i,202002})$
    - $\text{AdjPI}_{\text{All-items, 202004}} = \text{AdjPI}_{\text{All-items, 202003}} * \sum_{i=1}^{N} (p_{i,202003}q_{i,202003} * p_{i,202004} / p_{i,202003})$
- 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

Product group	April 2020		
	CPI price-updated weight (p202003q2017)	Adjusted PI weight (p202003q202003)	1-m price change
Food from stores	11.49%	16.67%	0.9%
Clothing and footwear	5.40%	3.33%	-5.9%



Adjusted Price Index - Version 2

- 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

index name	index formula		t = 0				t = 1							t = 2								
		item	q_0	p_0	p_0q_0	P_0	q_1	p_1	p_1q_1	p_1 / p_0	$p_1q_0 = p_0q_0 * p_1 / p_0$	$p_0q_1 = p_1q_1 / (p_1/ p_0)$	P_1	q_2	p_2	p_2q_2	p_2 / p_1	$p_2 / p_0 = p_1 / p_0 * p_2 / p_1$	$p_2q_1 = p_1q_1 * p_2 / p_1$	$p_1q_2 = p_2q_2 / (p_2 / p_1)$	$p_2q_0 = p_1q_0 * p_2 / p_1$	$p_0q_2 = p_2q_2 / (p_2 / p_0)$	P_2
		beef	1	10	10		2	10	20	1.00	10	20		1	10	10	1.00	1.00	20	10	10	10	
		pork	2	20	40		1	25	25	1.25	50	20		2	20	40	0.80	1.00	20	50	40	40	
		sum			50				45		60	40				50			40	60	50	50	
Fixed-base Laspeyres Price Index	$P_{L(F)} = 100 * \Sigma p_t q_0 / \Sigma p_0 q_0$					100.0							120.0										100.0
Fixed-base Paasche Price Index	$P_{P(F)} = 100 * \Sigma p_t q_t / \Sigma p_0 q_t$					100.0							112.5										100.0
Fixed-base Fisher Price Index	$P_{F(F)} = 100 * ((\Sigma p_t q_0 / \Sigma p_0 q_0) * (\Sigma p_t q_t / \Sigma p_0 q_t))^{1/2}$					100.0							116.2										100.0
Monthly Chained Laspeyres Price Index	when t=0, $P_{L(MCh)} = 100$ when t>0, $P_{L(MCh)} = P_{L(MCh),t-1} * \Sigma p_t q_{t-1} / \Sigma p_{t-1} q_{t-1}$					100.0							120.0										106.7
Monthly Chained Paasche Price Index	when t=0, $P_{P(MCh)} = 100$ when t>0, $P_{P(MCh)} = P_{P(MCh),t-1} * \Sigma p_t q_t / \Sigma p_{t-1} q_t$					100.0							112.5										93.8
Monthly Chained Fisher Price Index	when t=0, $P_{F(MCh)} = 100$ when t>0, $P_{F(MCh)} = P_{F(MCh),t-1} * ((\Sigma p_t q_{t-1} / \Sigma p_{t-1} q_{t-1}) * (\Sigma p_t q_t / \Sigma p_{t-1} q_t))^{1/2}$					100.0							116.2										100.0

Similarity Linking Method for Adjusted Price Index (v2)

- starting with period 1, for each period t and for all prior periods r = 0:t-1

1. compare prices and quantities across all periods
   - compute Predicted Share measure of relative price dissimilarity:

$$\Delta_{SP}(p^r,p^t,q^r,q^t) = \sum_{n=1}^{N} (p_{n,t}q_{n,t}/\sum p_{n,t}q_{n,t} - (p_{n,r}q_{n,t}/\sum p_{n,r}q_{n,t}))^2 + \sum_{n=1}^{N} (p_{n,r}q_{n,r}/\sum p_{n,r}q_{n,r} - (p_{n,t}q_{n,r}/\sum p_{n,t}q_{n,r}))^2$$

   - compute Predicted Share measure of relative quantity dissimilarity:

$$\Delta_{SQ}(p^r,p^t,q^r,q^t) = \sum_{n=1}^{N} (p_{n,t}q_{n,t}/\sum p_{n,t}q_{n,t} - (p_{n,t}q_{n,r}/\sum p_{n,t}q_{n,r}))^2 + \sum_{n=1}^{N} (p_{n,r}q_{n,r}/\sum p_{n,r}q_{n,r} - (p_{n,r}q_{n,t}/\sum p_{n,r}q_{n,t}))^2$$

   - 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
     - $p_{n,t}q_{n,t}$ is the expenditure on elementary product *n* in period *t*
     - $p_{n,r}q_{n,r}$ is the expenditure on elementary product *n* in period *r*
     - $p_{n,r}q_{n,t}$ is the expenditure on elementary product *n* in period *t*, multiplied by the change in price on elementary product *n* from period *t:r*
     - $p_{n,t}q_{n,r}$ is the expenditure on elementary product *n* in period *r*, multiplied by the change in price on elementary product *n* from period *r: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:*

$$P_{F(SPQ),r:t} = (\sum_{n=1}^{N} p_{n,t}q_{n,t} / \sum_{n=1}^{N} p_{n,r}q_{n,t} * \sum_{n=1}^{N} p_{n,t}q_{n,r} / \sum_{n=1}^{N} p_{n,r}q_{n,r})^{1/2}$$

5. calculate index level at *t* using index at *r* and bilateral Fisher price index between *r* and *t:*

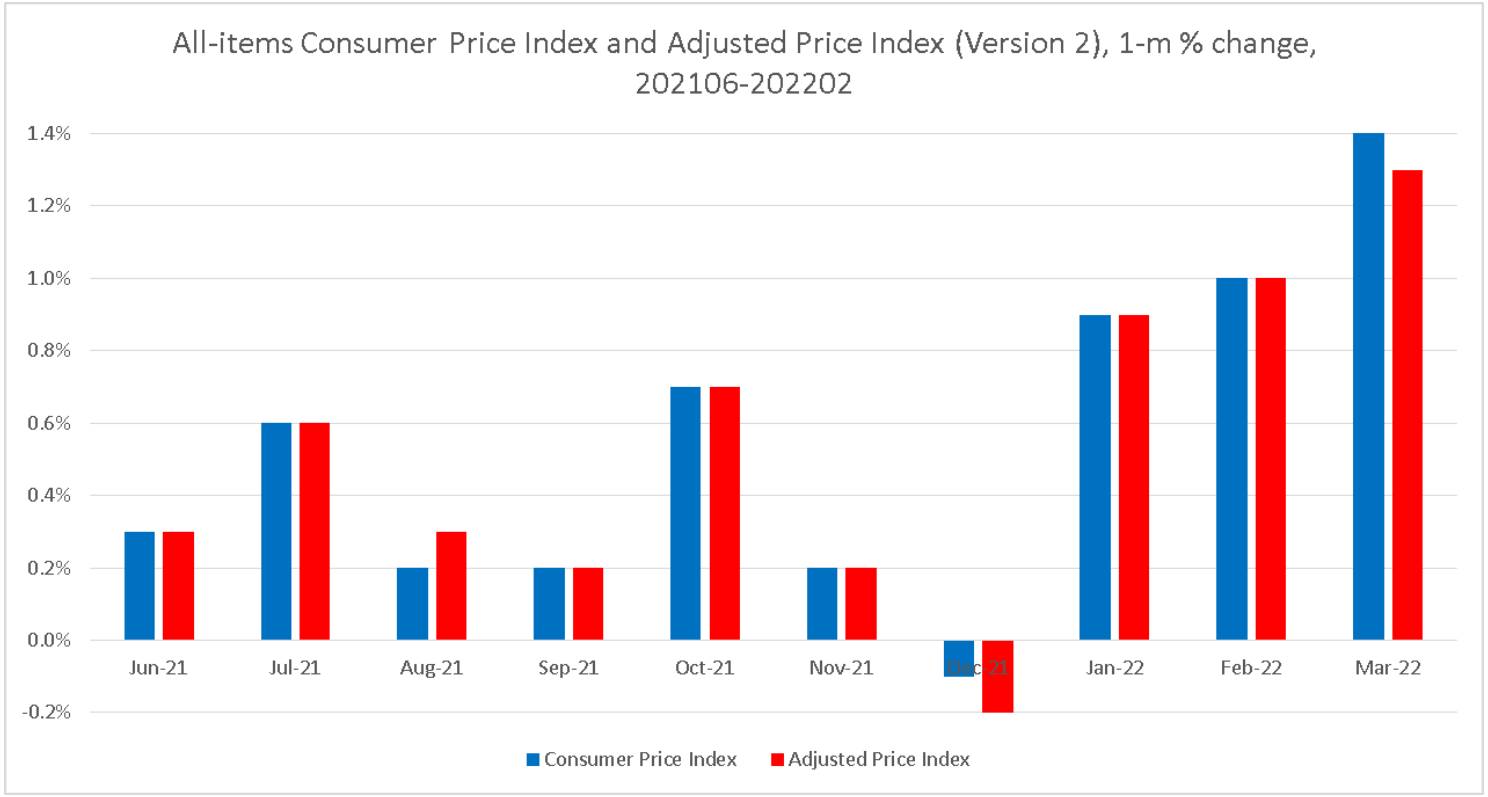
if t = 0: $P_{F(SPQ),0} = 100$
else if t > 0: $P_{F(PSQ),0:t} = P_{F(SPQ),r} * P_{F(SPQ),r:t}$

			period *r*			
			202105	202106	202107	202108
period *t*	Predicted Share measure of relative price dissimilarity	202106	0.000005			
		202107	0.000011	0.000004		
		202108	0.000019	0.000010	0.000006	
		202109	0.000021	0.000010	0.000006	0.000002
	Predicted Share measure of relative quantity dissimilarity	202106	0.000492			
		202107	0.001092	0.000396		
		202108	0.001429	0.000700	0.000107	
		202109	0.000880	0.000625	0.000323	0.000292
	Bilateral Fisher Price Index between period r and t	202106	1.003			
		202107	1.009	1.006		
		202108	1.011	1.008	1.002	
		202109	1.013	1.010	1.004	1.002

Adjusted Price Index - Version 2

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

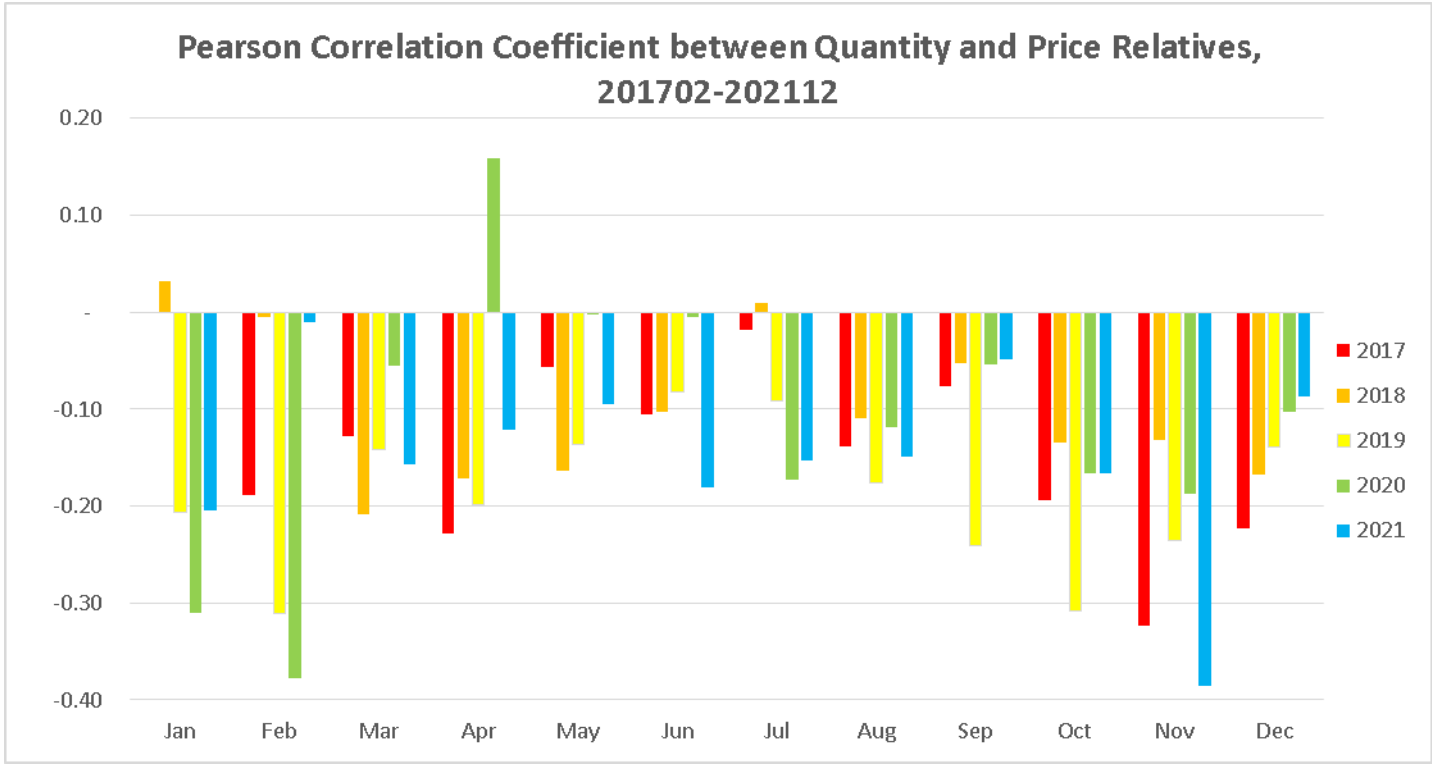
Contributors to monthly divergence between Adjusted PI and CPI					
Month	Product group	CPI price-updated weight, t-1	Adjusted PI weight, t-1	Adjusted PI weight, t	CPI 1-m % chg
Dec-2021	Video equipment	0.65%	0.99%	0.96%	-3.4%
Mar-2022	Purchase of passenger vehicles	6.18%	4.90%	5.70%	1.64%



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

Product group	Change from March 2020 to April 2020	
	Derived quantity consumed	Price
Gasoline	-43.1%	-15.2%
Traveller accommodation	-52.4%	-5.1%
Clothing and footwear	-44.1%	-5.9%



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