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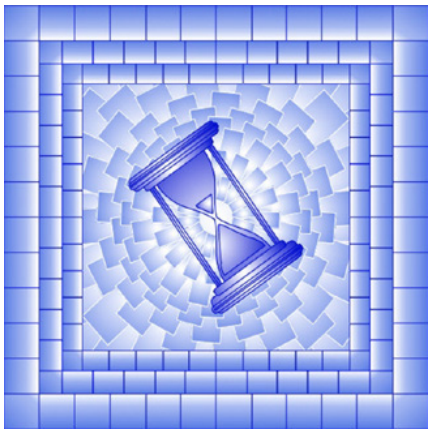
Adjusted Price Index and Monthly Adjusted Consumer Expenditure Basket Weights



by Gerry O'Donnell and Clément Yélou

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Adjusted Price Index and Monthly Adjusted Consumer Expenditure Basket Weights

by **Gerry O'Donnell** and **Clément Yélou**

1. Background: COVID-19 Pandemic and Price Indexes Based on Current Consumer Spending

The COVID-19 outbreak, declared a pandemic on March 11, 2020, has led to economic disruptions that continue to affect financial and labour markets across the globe. At the onset of the pandemic, prices shifted significantly as Canadians entered a sustained period of physical distancing and business closures. As Canadians adapted to staying home and travelling less, demand for a number of consumer goods and services changed, contributing to the first year-over-year decline in the Consumer Price Index (CPI) since 2009. In April and May of 2020, consumer prices were 0.2% and 0.4% lower, respectively, compared with the same months of 2019. While prices for some commodities, such as energy products, have since recovered to pre-pandemic levels, and prices for durable goods, such as passenger vehicles and furniture and services, such as traveller accommodation and real estate commission fees have risen in recent months, the impact of COVID-19 and various measures to contain its spread continue to impact the CPI.

The COVID-19 pandemic created an unprecedented situation where the behaviours of Canadians were significantly altered over a very short period of time, undoubtedly affecting consumption patterns which, by design, are not accounted for in the official CPI fixed basket weights. In order to assess the impact of COVID-19 on Canadian household expenditures, Statistics Canada, in partnership with the Bank of Canada, explored more current sources of expenditure data to estimate basket weights that reflected shifting consumption patterns during the pandemic. These data were supplemented with transaction and survey data as well as subject matter expertise to derive an alternate set of expenditure weights, used to calculate an Adjusted price index series for the months of March 2020 to February 2021. Both the official CPI and the Adjusted price index will continue to play key roles in measuring our highly fluid economy and supporting the trajectory of Canada's post-pandemic economic recovery.

Shifts in household purchasing patterns have implications for the basket weights used in the calculation of the CPI. Typically, expenditure patterns evolve slowly and in a sustained manner over time in response to shifts in relative prices, changes in the level or distribution of household incomes, changing demographics, evolving habits and the availability of new technology. A fixed-basket price index, such as the Canadian CPI, can only reflect these changes when the CPI basket weights are updated. Under normal economic circumstances, any over- or under-estimation of the importance of a given good or service in the CPI is minimized by scheduling basket updates at regular intervals.[1]

On July 13, 2020 Statistics Canada published *Consumer expenditures during COVID-19: An exploratory analysis of the effects of changing consumption patterns on consumer price indexes*,[2] the agency's first publication measuring consumer price trends using basket weights updated to reflect the latest monthly consumer spending patterns. This alternative and experimental price index showed a slightly higher rate of price inflation than the official CPI based on 2017 expenditure patterns when, in the early months of the pandemic, Canadian consumers reduced consumption of goods and services whose prices dropped, such as traveller accommodation and clothing, and increased their consumption of products with above average price increases, such as food and household cleaning products.

As the pandemic evolved, Statistics Canada updated the study with new methods and results, publishing the Adjusted price index and monthly adjusted consumer expenditure basket weights in The Daily, and data tables 18-10-0263 and 18-10-0264 on October 8 2020, and again on January 12 2021 and April 12 2021.

1. The Canadian CPI maintains the fixed basket concept in accordance with best practices established by international price experts and other national statistical agencies, in part because there are no current statistical survey data to inform the magnitude of any change in consumption at the level required for CPI calculation. The CPI basket weights are based primarily on expenditure data from Statistics Canada's Household Final Consumption Expenditures, and are normally updated every two years. The most recent basket update took place with the release of the June 2021 CPI using 2020 expenditure data.
2. Statistics Canada, Catalogue no. 62F0014M.

The monthly adjusted consumer expenditure basket weights made extensive use of aggregate High Frequency Expenditure Network (HFEN) data provided by the Bank of Canada to estimate changes in spending for the majority of products in the 2017 CPI basket. The major component shelter and the sub-component purchase and leasing of passenger vehicles were not covered by the available expenditure data. This data was supplemented by a number of other data sources to estimate monthly expenditures for more than 500 detailed product classes in the CPI.

The Adjusted price index was derived from these monthly expenditures and used a monthly-chained Laspeyres index, a formulation which used estimates of the previous month's expenditures to aggregate current month price changes emanating from the CPI.

The CPI basket weights were updated with the release of the June 2021 CPI.[3] The new basket weight reference period is 2020, based on data from the national Household Final Consumption Expenditures (HFCE) series, in addition to data from the Survey of Household Spending and the provincial HFCE series. Alternative data for 2020 was used to account for pandemic-related shifts at more detailed levels of CPIs and geographies.

At the same time, Statistics Canada was working to redevelop the methods and data sources for the Adjusted price index and monthly adjusted consumer expenditure basket weights. In addition to the use of a broader range of data sources, a new price index formula was applied to aggregate monthly price changes into an All-items Adjusted price index to address important limitations observed with the monthly-chained Laspeyres index.

2. Methodology

2.1 Data

In order to estimate monthly consumer expenditures, a number of data sources and methods have been used to adjust the 2020 weights used in the CPI to reflect the consumption patterns that evolved during the COVID-19 pandemic.

Each of the CPI's 515 elementary product classes was escalated at the Canada-level using one or more of the sources listed in Table 1. Where possible, the sources used were similar to those used to update the CPI basket weights.

3. See Statistics Canada, "An Analysis of the 2021 Consumer Price Index Basket Update, Based on 2020 Expenditures", July 21 2021.

Table 1
Data sources used to estimate monthly adjusted consumer expenditure basket weights[1]

Supplier type	Data source	Type of variable used	Periodicity of data	Latest data available	Basket share $\mathbf{p}_{2020}\mathbf{q}_{2020} / \Sigma\mathbf{p}_{2020}\mathbf{q}_{2020}$ of elementary products adjusted using this source, percent[2]
Data from Statistics Canada programs	**Household Final Consumption Expenditures**	expenditure	quarterly	2021Q2	83.48
	Retail Commodity Survey	revenue	monthly	Jun-21	32.66
	Monthly Retail Trade Survey	revenue	monthly	Aug-21	8.79
	New Motor Vehicle Sales	revenue	monthly	Aug-21	6.31
	Population estimates, quarterly	number of people	quarterly	2021Q3	19.16
	Monthly Survey of Food Services and Drinking Places	revenue	monthly	Aug-21	5.12
	Domestic and international Itinerant aircraft movements	volume	weekly	Sep-21	0.26
	New Housing Price Index data	price index	monthly	Sep-21	7.01
	Passenger bus and urban transit statistics	revenue	monthly	Jul-21	0.20
	Electric power generation statistics	volume	monthly	Jul-21	2.66
	Canadian monthly natural gas distribution statistics	revenue	monthly	Aug-21	0.70
	Consumer Price Index	price index	monthly	Sep-21	11.14
	Labour Force Survey rent data	average price	monthly	Sep-21	6.59
Data supplied to Statistics Canada from an external provider	**Bank of Canada High Frequency Expenditure Network data**	year-over-year growth in revenue	monthly	Sep-21	60.56
	Canada Revenue Agency Goods and Services Tax revenue data	revenue	monthly	Sep-21	58.97
	Grocery retailer scanner data	sales	daily or weekly	Sep-21	15.29
	Airline statistics	revenue	monthly	Sep-21	0.26
	Office of the Superintendent of Financial Institutions mortgage data	mortgage interest outstanding	monthly	Sep-21	3.85
Other published data	**Electricity volume data**	volume	hourly	Sep-21	2.66

1. In most cases, Canada-level data were used. In all cases, non-seasonally adjusted data were used.
2. The rows in this column do not sum to 100. Due to the timeliness of source data, multiple data inputs were used to adjust most products to the most recent reference period of the Adjusted price index.
Source: Consumer Prices program.

In some cases, the individual series from the data source was very similar in coverage to the CPI elementary products. For example, the Monthly Retail Trade Survey's monthly sales estimates for full-service restaurants were used to adjust basket weights for the CPI class food purchased from table-service restaurants. In other cases, the individual proxy series was mapped to a higher-level product class and its monthly expenditure estimates were applied to all lowest product classes. And in a few cases with limited data availability, a proxy series with a different scope was used to escalate a CPI elementary product. One such example was for the shelter utility, water, which was escalated using the Electric power generation survey's total electricity available for use within specific geographic border on the assumption that electricity and water consumption would be similarly impacted by the increased demand from working from home and on-line schooling.

Access to reliable and timely expenditure information at the appropriate level of detail and quality will be required to enable Statistics Canada to monitor shifts in consumer spending and pursue the development of other sought-after indicators, such as measures of inflation for different groups, household types and geography.

This analytical work is experimental and should not be used instead of the official measure of consumer inflation. Updating the weights in the official CPI basket of goods and services to account for consumption changes in the absence of a reliable and robust source of expenditure data would compromise the accuracy of the index values.

2.2 Derivation of monthly adjusted consumer expenditure basket weights

Given the variety of data sources providing indicators about consumer behaviour across the 515 elementary products in the Canadian CPI, a number of techniques were used to estimate monthly consumer expenditures.

The expenditures used in the most recent CPI basket update were based primarily on Statistics Canada's Household Final Consumption Expenditures for 2020. These annual values were then projected forward using proxy series based on data sources in Table 1 by applying the proxy's growth rate between 2020 and the reference period of the Adjusted price index. For most elementary products, the proxy series was measured in the dollar value of revenues, whereas for some products, the projection of expenditures used a combination of changes in quantities and changes in prices.

Projected monthly expenditures were then constrained to be consistent with the quarterly growth rate in Household Final Consumption Expenditures and the 12-month change in High Frequency Expenditure Network estimates.

2.3 Index calculations

The official CPI is calculated using a Laspeyres-type formula at the upper level of price aggregation; this is consistent with the fixed basket concept. The Laspeyres formula expresses the change in the cost between period 0 and period t of buying a fixed basket of goods and services, and is calculated by aggregating the prices of the products in the basket using quantities consumed from the price reference period 0 as weights.[4]

The Adjusted price index series for March 2020 to February 2021 was produced using the same geographic and product aggregation structure as the official CPI. However, unlike the official CPI, a monthly-chained Laspeyres-type index was calculated at the upper level, providing adjusted relatives for the March 2020 to February 2021 Adjusted price index, based on estimated previous month weights in order to reflect COVID-19 consumption patterns.

One of the limitations of a Laspeyres price index is that it uses quantities from an earlier period to aggregate prices. A Paasche price index uses quantities from the current period and often reflects substitutions made by consumers in response to price change. A Fisher price index is the geometric average of the Laspeyres and Paasche price indexes, and makes equal use of weights from the earlier period and current period to aggregate prices. With this release, the Adjusted price index used a Fisher price index formula. Appendix 1 provides further details on the Laspeyres, Paasche and Fisher price index formulae.

Another limitation of a monthly-chained Laspeyres-type index is that the index is subject to chain drift. Chain drift can occur in a chained Laspeyres price index when consumers respond to price increases by reducing quantities consumed, or the reverse, leading to a gap between the chained Laspeyres and fixed-base Laspeyres price index. Appendix 1 provides an example of chain drift.

To overcome the chain drift issue, Statistics Canada redeveloped the Adjusted price index using a Similarity-linked Fisher price index, which is regarded as the most appropriate approach by leading price index experts.[5]

In short, the Similarity-linked Fisher is calculated between two periods t and r such that r is prior to t and has the least dissimilar (or most similar) set of prices or quantities to period t. In our example in Appendix 1, time period 0 has identical prices and quantities to those of period 2, and so period 0 is less dissimilar to period 2 than period 1. The Fisher price index at $t=2$ would be based on the Fisher price index between period 0 and period 2-in our case

4. Source: Canadian Consumer Price Index Reference Paper (2019) Statistics Canada. Section 6.24.
5. See IMF *Consumer Price Index Theory*, 2020, draft, chapter *The Chain Drift Problem and Multilateral Indices* by Erwin Diewert (https://www.imf.org/-/media/Files/Data/CPI/companion-publication/chapter-6-chain-drift-problem-and-multilateral-indices.ashx)

a relative of 1, meaning no price change between period 0 and period 2. Appendix 2 provides details on how the Similarity-linked Fisher price index was calculated up to September 2021.

The Adjusted price index uses Canada-level price changes from the 515 elementary products in the CPI.

3. Results

Using the methods above, monthly adjusted consumer expenditure basket weights (Table 2) and a Similarity-linked Fisher month-over-month change (Table 3) were derived up to September 2021.

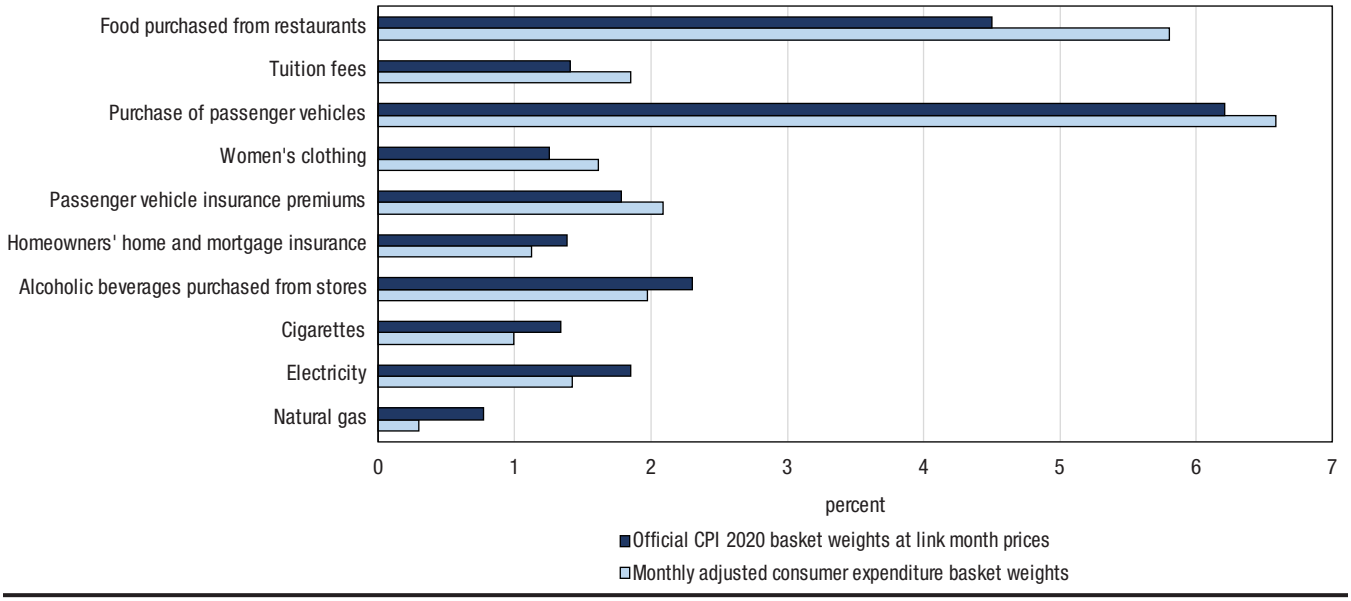
Table 2
Official CPI basket weights and monthly adjusted consumer expenditure basket weights

CPI Component	Official CPI basket weights	Monthly adjusted consumer expenditure basket weights				
	2020 weights expressed at May 2021 (link month) prices	May 2021	June 2021	July 2021	August 2021	September 2021
	percent					
Food	16.24	15.92	15.78	17.24	17.39	16.54
Shelter	30.03	29.28	28.86	27.86	28.34	28.37
Household operations	14.89	16.02	15.69	14.89	14.73	14.91
Clothing and footwear	3.99	3.26	4.58	4.29	4.62	4.57
Transportation	15.96	16.87	16.08	15.97	15.78	16.53
Health and personal care	4.68	4.65	4.50	4.47	4.45	4.60
Recreation, education and reading	9.40	9.36	9.58	10.15	9.77	10.17
Alcoholic beverages, tobacco products and recreational cannabis	4.80	4.64	4.93	5.14	4.93	4.32

Source: Consumer Prices program.

While monthly adjusted consumer expenditure basket weights were calculated between May 2021 and September 2021, the following analysis will focus on weights for September 2021, the most recent period.

Chart 1
Largest differences between official CPI weights at link month prices and monthly adjusted consumer expenditure basket weights for September 2021



Source: Consumer Prices program.

In September 2021, the monthly adjusted basket weight for food purchased from restaurants surpassed its published value, as Canadians eased back into restaurant patios and indoor dining.

The monthly adjusted basket weight for tuition fees exceeded its published value in September as Canadian students returned to in-person and on-line classes.

The monthly adjusted basket weight for women's clothing also rose above the published value. After a year of reduced spending on clothing, Canadians restocked their wardrobes.

For other products such as natural gas, seasonal factors affected the monthly adjusted basket weight, as low demand for home heating in September 2021 reduced Canadian's budget allocation to natural gas compared to its published value.

Statistics Canada calculated price indexes using these monthly adjusted weights and the Similarity-linked Fisher price index formula from May 2021 to September 2021, where May 2021=100. Month-over-month percent change for All-items, Canada are in Table 3.

Table 3
1-month change in the official CPI and the Adjusted price index, All-items, Canada

	Official CPI	Adjusted price index
1-month change	percent	
June 2021	0.3	0.3
July 2021	0.6	0.6
August 2021	0.2	0.2
September 2021	0.2	0.2

Source: Consumer Prices program.

For every reference period, the Adjusted price index and the official CPI had the same month-over-month movements at the all-items level. This confirms that the 2020 basket weights and the monthly adjusted consumer expenditure basket weights yield the same results for the all-items CPI for the June to September reference months.

4. Conclusion

The Adjusted price index provides Canadians with data and insights they need on Canada's shifting consumer prices and expenditures as Canada recovers from the COVID-19 pandemic. This adjusted series provides an alternative estimate of inflation as consumer behaviour and expenditures evolve towards the end of 2021.

While the partnership with the Bank of Canada allows for temporary access to the necessary expenditure data, ongoing access to reliable and timely expenditure information at the appropriate level of detail and quality will enable Statistics Canada to continue monitoring shifts in consumer spending and pursue the development of other sought-after indicators, such as measures of inflation for different groups, household types and geography. Statistics Canada continues to work with price experts, national statistical organizations and other partners to ensure the data and methods used in the calculation of the official CPI and the Adjusted price index are aligned with international standards, as well as to explore new potential sources of expenditure information for future basket updates and to keep Canadians informed with relevant statistics.

Appendix 1: Common Price Index Formulae

Table A1 presents the formulae and example data for the calculation of commonly used price indexes.[6]

Table A1: Common price index formulae, with example

		t = 0				
		item	q_0	p_0	p_0q_0	P_0
		beef	1	10	10	
		pork	2	20	40	
index name	index formula	sum			50	
Fixed-base Laspeyres Price Index	$P_{L(F)} = 100 * \Sigma p_t q_0 / \Sigma p_0 q_0$					100.0
Fixed-base Paasche Price Index	$P_{P(F)} = 100 * \Sigma p_t q_t / \Sigma p_0 q_t$					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
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
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
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

		t = 1						
		item	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
		beef	2	10	20	1.00	10	20	
		pork	1	25	25	1.25	50	20	
index name	index formula	sum			45		60	40	
Fixed-base Laspeyres Price Index	$P_{L(F)} = 100 * \Sigma p_t q_0 / \Sigma p_0 q_0$								120.0
Fixed-base Paasche Price Index	$P_{P(F)} = 100 * \Sigma p_t q_t / \Sigma p_0 q_t$								112.5
Fixed-base Fisher Price Index	$P_{F(F)} = 100 * ((\Sigma p_t q_0 / \Sigma p_0 q_0) * (\Sigma p_t q_t / \Sigma p_0 q_t))^{1/2}$								116.2
Monthly Chained Laspeyres Price Index	when $t = 0,\ P_{L(MCh)} = 100$ when $t > 0,\ P_{L(MCh)} = P_{L(MCh),t-1} * \Sigma p_t q_{t-1} / \Sigma p_{t-1} q_{t-1}$								120.0
Monthly Chained Paasche Price Index	when $t = 0,\ P_{P(MCh)} = 100$ when $t > 0,\ P_{P(MCh)} = P_{P(MCh),t-1} * \Sigma p_t q_t / \Sigma p_{t-1} q_t$								112.5
Monthly Chained Fisher Price Index	when $t = 0,\ P_{F(MCh)} = 100$ when $t > 0,\ P_{F(MCh)} = P_{F(MCh),t-1} * ((\Sigma p_t q_{t-1} / \Sigma p_{t-1} q_{t-1}) * (\Sigma p_t q_t / \Sigma p_{t-1} q_t))^{1/2}$								116.2

6. See also Statistics Canada, *The Canadian Consumer Price Index Reference Paper*, Catalogue no. 62-553-X, February 27, 2019, and International Labour Organization/International Monetary Fund/Organisation for Economic Co-operation and Development/Statistical Office of the European Communities/United Nations/The International Bank for Reconstruction and Development/ The World Bank, *Consumer Price Index Manual: Theory and Practice*, 2004.

Table A1: Common price index formulae, with example

		t = 2					
						$p_2 / p_0 = p_1 / p_0 *$	$p_2q_1 = p_1q_1 *$
item		q_2	p_2	p_2q_2	p_2 / p_1	p_2 / p_1	p_2 / p_1
beef		1	10	10	1.00	1.00	20
pork		2	20	40	0.80	1.00	20
sum				50			40
index name	**index formula**						
Fixed-base Laspeyres Price Index	$P_{L(F)} = 100 * \Sigma p_t q_0 / \Sigma p_0 q_0$						
Fixed-base Paasche Price Index	$P_{P(F)} = 100 * \Sigma p_t q_t / \Sigma p_0 q_t$						
Fixed-base Fisher Price Index	$P_{F(F)} = 100 * ((\Sigma p_t q_0 / \Sigma p_0 q_0) * (\Sigma p_t q_t / \Sigma p_0 q_t))^{1/2}$						
Monthly Chained Laspeyres Price Index	when $t = 0,\ P_{L(MCh)} = 100$ when $t > 0,\ P_{L(MCh)} = P_{L(MCh),t-1} * \Sigma p_t q_{t-1} / \Sigma p_{t-1} q_{t-1}$						
Monthly Chained Paasche Price Index	when $t = 0,\ P_{P(MCh)} = 100$ when $t > 0,\ P_{P(MCh)} = P_{P(MCh),t-1} * \Sigma p_t q_t / \Sigma p_{t-1} q_t$						
Monthly Chained Fisher Price Index	when $t = 0,\ P_{F(MCh)} = 100$ when $t > 0,\ P_{F(MCh)} = P_{F(MCh),t-1} * ((\Sigma p_t q_{t-1} / \Sigma p_{t-1} q_{t-1}) * (\Sigma p_t q_t / \Sigma p_{t-1} q_t))^{1/2}$						

		t = 2			
		$p_1q_2 = p_2q_2 / (p_2 / p_1)$	$p_2q_0 = p_1q_0 * p_2 / p_1$	$p_0q_2 = p_2q_2 / (p_2 / p_0)$	
item					P_2
beef		10	10	10	
pork		50	40	40	
sum		60	50	50	
index name	**index formula**				
Fixed-base Laspeyres Price Index	$P_{L(F)} = 100 * \Sigma p_t q_0 / \Sigma p_0 q_0$				100.0
Fixed-base Paasche Price Index	$P_{P(F)} = 100 * \Sigma p_t q_t / \Sigma p_0 q_t$				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
Monthly Chained Laspeyres Price Index	when $t = 0,\ P_{L(MCh)} = 100$ when $t > 0,\ P_{L(MCh)} = P_{L(MCh),t-1} * \Sigma p_t q_{t-1} / \Sigma p_{t-1} q_{t-1}$				106.7
Monthly Chained Paasche Price Index	when $t = 0,\ P_{P(MCh)} = 100$ when $t > 0,\ P_{P(MCh)} = P_{P(MCh),t-1} * \Sigma p_t q_t / \Sigma p_{t-1} q_t$				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

Note that in time period 1, the result P for the Laspeyres—either the fixed-base or monthly chained—is higher than the Paasche. The Laspeyres uses the earlier period quantities to weight the prices, whereas the Paasche uses the current period's quantities after consumers have substituted some beef for pork, and so the Laspeyres is higher. This occurs in markets where consumers respond to price change by shifting quantities consumed in the opposite direction.

The Fisher is the geometric average of the Laspeyres and the Paasche price indexes, either fixed-base or monthly-chained, and its level will always bisect the Laspeyres and Paasche. The Fisher is in the class of "superlative" price indexes which make equal use of weights from both periods whose prices are being compared. Superlative indexes remove the effects of substitution, and can be used to measure its effects when compared to the Laspeyres or Paasche price indexes.

Note also that in time period 2 in the example, the prices and quantities consumed have returned to time period 0 levels, but the monthly-chained Laspeyres price index does not return to their period 0 level, and the monthly-chained Laspeyres price index diverges from the fixed-base Laspeyres price index.

This can be explained using the following:

$$P_{L(Ch),1:2} = \Sigma_n^N p_{n,2}q_{n,1} / \Sigma_n^N p_{n,1}q_{n,1} = \Sigma_n^N (p_{n,1}q_{n,1} / \Sigma_n^N p_{n,1}q_{n,1} * p_{n,2} / p_{n,1})$$

$$P_{L(F),1:2} = \Sigma_n^N p_{n,2}q_{n,0} / \Sigma_n^N p_{n,1}q_{n,0} = \Sigma_n^N (p_{n,1}q_{n,0} / \Sigma_n^N p_{n,1}q_{n,0} * p_{n,2} / p_{n,1})$$

$$P_{L(Ch),1:2} - P_{L(F),1:2} = \Sigma_n^N (p_{n,1}q_{n,1} / \Sigma_n^N p_{n,1}q_{n,1} * p_{n,2} / p_{n,1}) - \Sigma_n^N (p_{n,1}q_{n,0} / \Sigma_n^N p_{n,1}q_{n,0} * p_{n,2} / p_{n,1})$$

where

n is an elementary product

N is the total number of elementary products

0, 1 and 2 are periods

$p_{n,t}$ is the price for elementary product n in period t

$p_{n,u}q_{n,v}$ is the expenditure on elementary product n with period u prices and period v quantities

The monthly-chained Laspeyres uses period 1 quantities to aggregate period 1 to period 2 price change, whereas the fixed-base Laspeyres uses period 0 quantities.

In our example, consumers have reduced quantities of pork from period 0 to period 1 as the price increased. The relative importance of pork in period 1 used in the monthly-chained Laspeyres $\left(p_{n,1}q_{n,1} / \Sigma_n^N p_{n,1}q_{n,1} = 25 / 45 = 56\%\right)$ is less than the period 0 weight of pork used in the fixed-base Laspeyres $(p_{n,1}q_{n,0} / \Sigma_n^N p_{n,1}q_{n,0} = 40 / 50 = 80\%)$. As a result, in period 2, the price drop for pork from period 1 to period 2 will have less impact in the monthly-chained Laspeyres index than in the fixed-base Laspeyres index.

When prices and quantities interact in this way, the monthly-chained Laspeyres price index will exceed the fixed-base Laspeyres price index. This divergence is often referred to as chain drift.

Appendix 2: The Similarity-linked Fisher using predicted share measure of relative price dissimilarity and predicted share measure of relative quantity dissimilarity, 202105 to 202109

The following method was used to derive the Similarity-linked Fisher price index used in the Adjusted price index. Starting with period 1, for each value of t, and for all prior periods r = 0:t-1, compute a Predicted Share measure of relative price dissimilarity:

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

and a Predicted Share measure of relative quantity dissimilarity:

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

where

$\Delta_{SP}\left(p^r,p^t,q^r,q^t\right)$ is the Predicted Share measure of relative price dissimilarity

$\Delta_{SQ}\left(p^r,p^t,q^r,q^t\right)$ is the Predicted Share measure of relative quantity dissimilarity

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.

Find the minimum of $\Delta_{SP}\left(p^r,p^t,q^r,q^t\right)$ and $\Delta_{SQ}\left(p^r,p^t,q^r,q^t\right)$, denoted as min $(\Delta_{SP}\left(p^r,p^t,q^r,q^t\right),\Delta_{SQ}\left(p^r,p^t,q^r,q^t\right))$. Then find the period r with the lowest min $(\Delta_{SP}\left(p^r,p^t,q^r,q^t\right),\Delta_{SQ}\left(p^r,p^t,q^r,q^t\right))$. Finally, calculate the Fisher price index between r and t using:

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

where

$P_{F(SPQ),r:t}$ is the Similarity-linked Fisher price index between periods r and t using the Predicted Share measure of relative price dissimilarity and the Predicted Share measure of relative quantity dissimilarity

n is an elementary product

N is the total number of elementary products

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

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

$p_{n,r}q_{n,r}$ is the expenditure on elementary product n in period r

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

Table A2 illustrates the similarity in prices and quantities between each period from May 2021 to September 2021. Table A2 also presents the resulting Fisher price index between each period from May 2021 to September 2021. The symbol † indicates the period r which satisfies the minimum of $\Delta_{SP}\left(p^r,p^t,q^r,q^t\right),\Delta_{SQ}\left(p^r,p^t,q^r,q^t\right)$ for each period t.

Table A2
Predicted share measure of relative price and quantity dissimilarity and Fisher price index between each period from May 2021 and September 2021

			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†

.. not available for a specific reference period

† This period r satisfies the minimum of $\Delta_{SP}\left(p^r,p^t,q^r,q^t\right),\Delta_{SQ}\left(p^r,p^t,q^r,q^t\right)$ for each period t.