

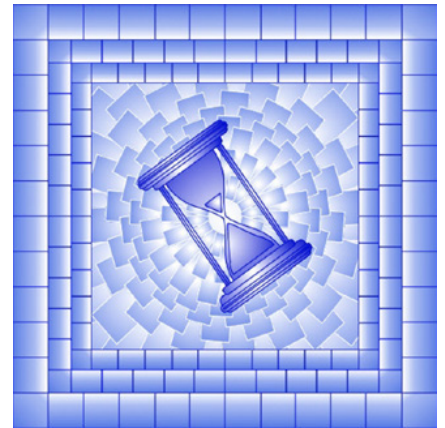
Catalogue no. 62F0014M
ISSN 1706-7723
ISBN 978-0-660-72860-5

Prices Analytical Series

Updated Methodology for the Compilation of the Cellular Services Price Index

by Joseph Waihenya, Maria Rosario Reyes and Clément Yélou

Release date: August 20, 2024



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Overview

The Consumer Price Index (CPI) measures price change by comparing the cost of a fixed basket of consumer goods and services through time. To produce a CPI that accurately reflects the experience of Canadians, Statistics Canada regularly updates the methodologies of various components of the CPI. The method used to calculate the CPI follows accepted [international standards](#). It is also regularly reviewed internally and by experts outside the agency, and adjusted as needed to ensure it meets best practices.

The Cellular services price index (CSPI) is part of the Household operations, furnishings and equipment index, one of the eight major components of the CPI. It represents 1.22% of the most recent CPI basket based on 2023 expenditures.¹

Statistics Canada prioritizes the accuracy and timeliness elements of quality in measuring price change. As part of its modernization initiative, the agency has been working with major Canadian wireless services providers (WSPs) to obtain transaction data for wireless plans. This initiative is aimed at improving the quality of the CSPI by expanding the sample and incorporating hedonic quality adjustment methods and plan level weights.

Thanks to this collaboration, Statistics Canada now receives monthly transaction data containing plan level information from WSPs with several retail brands across Canada.² Since not all WSPs in the market provide the agency with transaction data, the CSPI will continue to use web-collected data, which will be combined with transaction data.

This document details the methodology used to incorporate transaction data in the CSPI. The result is a “hybrid” index that combines the transaction data from participating WSPs with the web collected data from the other sampled WSPs.

Scope of the CSPI

The CSPI measures the monthly change in the prices of services associated with a cellular device. These include local and long-distance voice calls, text messaging, and internet access.³ Miscellaneous fees, such as activation fees, overage charges, and roaming charges are excluded.⁴ The cost of the cellular device is also excluded.⁵ It is important to note that the services included in the CSPI have evolved with the consumption patterns of Canadians over the years.

Outlets

In each province or territory, prices are collected from all major WSPs, which collectively account for over 90% of the total provincial or territorial revenue. Within each province or territory, WSPs are weighted by their provincial or territorial market share, calculated in terms of revenue. Weighting the WSPs by their market share aims at ensuring the representativeness of the index. Revenue data are obtained from the Annual Survey of Telecommunications (AST), conducted jointly by Statistics Canada and the Canadian Radio-Television and Telecommunications Commission (CRTC).⁶ The WSPs’ weights at the provincial and territorial levels are updated annually to reflect their current market shares.

1. CSPI weight at basket link month prices. See Statistics Canada: [Table 18-10-0007-01 Basket weights of the Consumer Price Index, Canada, provinces, Whitehorse, Yellowknife and Iqaluit](#).
2. WSPs will often have several retail brands to serve different consumer segments, e.g., a primary brand and several secondary (or flanker) brands.
3. Add-ons like international long-distance voice calls are typically excluded from collection unless they are already included with the plan at no extra cost.
4. These miscellaneous fees either make up a small portion of total mobile consumer spending or there isn’t sufficient information to weigh them (as is the case with activation fees).
5. The cost of cellular devices is included in the multipurpose digital devices index, a sub-index of the digital computing equipment and devices index. See [Measuring the price of digital computing equipment and devices in the Consumer Price Index](#) for more information.
6. See [Annual Survey of Telecommunications](#) for more information.

Data

Web collected data

Canadian consumers have few WSPs to select from, and each retail brand within a WSP offers a limited number of cellular service plans on its website. Given the dynamic nature of the market, the consumer profile method is used, where prices for several consumer profiles, or representative bundles of cellular services, are tracked over time.⁷ The method of pricing the same consumer profile over time ensures constant quantity and quality of services, and that the index reflects pure price change. The set of consumer profiles in use are designed to best reflect cellular services usage patterns of Canadian households and are regularly updated to ensure that they remain relevant. New profiles can be added, or old ones removed based on market share shifts or technological changes in the telecommunication industry. Table 1 includes two examples of representative consumer profiles.

Table 1
Fictional examples of two representative consumer profiles

Service	Profile A	Profile B
Nationwide calling minutes	Unlimited	Unlimited
Nationwide text messaging (SMS)	Unlimited	Unlimited
Data, number of gigabytes (GB)	From 1 to less than 15 GB	From 50 to less than 100 GB
Network type	4G	5G
Canada-US calling	No	Yes

For each retail brand in each province and territory, one plan is matched to each consumer profile. The plan must meet the consumer profile's minimum specifications. While it may exceed the specifications, it must never fail to meet them. Out of all the plans that meet the specifications of a profile, the price of the least expensive plan is used. For the purposes of the CSPI, a (web-collected) plan is defined by brand, number of minutes and texts, data allowance, network type, international calling, and price status (regular or on special). Plan prices and features are collected each month from the websites of the WSPs' retail brands. The following are excluded from collection due to low market share or measurement complexities: bundled plans, family plans, and prepaid plans.⁸

Transaction data

Each month, Statistics Canada receives a file from participating WSPs that contains information on wireless plans from each of their retail brands across Canada. All in-market (postpaid and prepaid) wireless plans, and the most popular legacy plans are included.⁹ Statistics Canada's objective is to achieve full market coverage with transaction data for each WSP. However, given that some WSPs can only provide a subset of their data, a minimum of 70% coverage of a WSP's total market is acceptable.

For each plan, the following features are provided:

7. This approach is in line with international standards as per the [Consumer Price Index Manual: Concepts and Methods](#), published by the International Monetary Fund. In addition, the consumer profile method is one of the recommended methods to measure price change for telecommunications services by [Member States of Eurostat](#).

8. As per the [2022 Annual Survey of Telecommunications](#), 94% of retail mobile revenues is generated from postpaid plans.

9. An in-market plan is a plan that is available for purchase by consumers, while a legacy plan is a plan that has been phased out of the market and is no longer offered to subscribers. Note that in-market plans are not limited only to those advertised on a WSP's website. Unadvertised plans, such as "winback" plans offered to former subscribers who have switched to a different WSP, are also in-market plans. A prepaid plan, often referred to as a "pay-as-you-go" plan, lets the consumer purchase a plan with a finite amount of service features (e.g., calling minutes, SMS messages or data allowance) upfront. In contrast, subscribers on postpaid plans pay for a plan with a bundled set of service features after use.

Table 2.
Feature names and descriptions of plans included in the transaction data

Feature name ¹	Description
1. Ranking Number	A plan's rank based on its subscriber count in a province or territory
2. Geography	The province or territory where a plan is offered
3. Plan ID	An internal WSP-generated alphanumeric code used to identify plans
4. Plan Name	The name of the plan—will sometimes include a description of the plan's characteristics (like data allowance in GB, etc.)
5. Retail Brand	The name of the retail brand offering the cellular service plan
6. Plan Type	Indicator for prepaid or postpaid plans
7. Plan Availability	Indicator for in-market or legacy plans
8. Monthly Recurring Charge (MRC)	Monthly price of a plan, before tax and other fees
9. Voice	Voice allowance, in number of minutes per month
10. Short Message Service (SMS)	SMS allowance, in number of texts per month
11. Data	Data allowance, expressed in Gigabytes (GB) per month
12. Subscriber Count	Count of subscribers on the plan

1. The agency is interacting with WSPs to obtain data on additional price determining characteristics (such as network type, upload/download speeds, etc.) to better reflect changing market trends and consumer behaviour over time.

All plan features (except for Plan Availability and Subscriber Count) for a given plan remain constant over time. A plan's availability status could change from 'in-market' to 'legacy' when the retail brand stops advertising it on its website and offering it to new subscribers. Any modification by the retail brand to an existing plan is introduced in the dataset as a new observation with a new Plan ID.¹⁰

Data processing

Web collected data

Once a plan has been selected for a consumer profile, it will be priced every month until the retail brand either stops advertising it or makes significant modifications to its features (e.g., adding bonus data). In both situations, a quality adjustment is done before proceeding.

Transaction data

Tracking plans to manage churn

To track plans over time, a "unique plan ID" is created for each observation in the dataset by concatenating the Plan ID, Geography, Retail Brand, and Plan Type features.¹¹ Note that the 'Plan Availability' feature is not included in this derived unique plan ID, because retail brands routinely stop offering certain plans to new subscribers but will continue to provide services to active subscribers on these "legacy" plans.

Given that the inclusion of any legacy plan in the file is contingent on its popularity, legacy plans that fail to reach a certain threshold of subscribers in each month will naturally drop out of the data file for that month. At the same time, in-market plans that become legacy plans in the current month may not appear in the list of the most popular legacy plans in the following month. This dynamic over time results in plan-level churn. It is important to note that the disappearance of a legacy plan from the monthly file does not mean that the plan no longer has any subscribers.

10. For example, if a retailer offers a promotion on its website for a 10 GB plan by reducing the price from \$80 to \$70, the cheaper promotional plan will appear as a separate plan or row in the dataset. This price decline is reflected in the index by assigning the two separate plans in the dataset as a single observation, referred to as a service package. See the Assigning comparable plans to service packages section.

11. The Plan ID is not unique for every plan (or row) in the dataset, which is why this step is necessary.

To reduce the impact of churn on the index, the following actions are taken during data processing, grounded on information provided by WSPs that plan features do not change once a plan is launched in the market and has active subscribers.

1. **Carry forward:**

- b. **Legacy plan:** A legacy plan that is in the previous month (T_0) but not in the current month (T_1) gets its feature information (e.g., data allowance, MRC, etc.) carried forward to T_1 . The plan’s disappearance in T_1 is likely due to the plan losing subscribers between the two periods. The missing legacy plan’s T_0 subscriber counts are carried forward to T_1 if they are less than the subscriber counts of the least popular legacy plan in T_1 . Otherwise, the subscriber counts of the least popular legacy plan in T_1 is used.¹²
- c. **In-market plan:** In-market plans missing in T_1 but present in T_0 have their feature information carried forward to T_1 . These missing plans likely had their Availability switched to “legacy”, and thus, continue to exist in the market but were not popular enough to be included in the the list of most popular legacy plans in T_1 .

- 2. **Carry backward:** If a legacy plan is in T_1 but not T_0 , its feature information is carried backward to create a record in T_0 . This situation is likely due to the plan not having enough subscribers to place it among the most popular legacy plans in T_0 . The presence of the plan in the T_1 file is likely because the subscriber counts of other legacy plans dropped in T_1 .

Table 3 summarizes the actions for the cases described above:

Table 3
Processing steps to reduce churn of legacy and in-market plans in the transaction data

Plan	T_0	T_1	Action
Legacy plan A	In sample	Missing	Carry forward plan A’s feature information to T_1
Legacy plan B	Missing	In sample	Carry backward plan B’s feature information to T_0
In-market Plan C	In sample	Missing	Carry forward plan C’s feature information to T_1

Assigning comparable plans to service packages

Sample analysis of plans has revealed that retail brands often launch promotional plans with the same features as existing plans, but at different prices. A secondary processing step of assigning these types of plans into a “**service package**” (SP) is necessary in the compilation of the index. A service package is comprised of one or more plans which have the same values for the following features:

Table 4.
Features used to assign plans into service packages

Feature name	Description	Provided by WSP?
Geography	The province or territory where a plan is offered	Yes
Retail Brand	The name of the retail brand offering the cellular service plan	Yes
Plan Type	Indicator for prepaid or postpaid plans	Yes
Data	Data allowance, expressed in Gigabytes (GB) per month	Yes
IsMinUnlimited	Binary variable that indicates if the service package includes unlimited calling minutes	No--derived from Voice feature
IsSMSUnlimited	Binary variable that indicates if the service package includes unlimited SMS (text) messages	No--Derived from SMS feature
IsDataUnlimited	Binary variable that indicates if the service package includes unlimited data ¹	No--Derived from Plan Name feature
IsDataShareable	Binary variable that indicates if the service package includes data that can be shared among the members in a family plan.	No--Derived from Plan Name feature
IncludesCANUS	Binary variable that indicates if the service package includes Canada-US calling	No--Derived from Plan Name feature
Is5G	Binary variable that indicates if the service package uses the 5G network	No--Derived from Plan Name feature

1. All plans have a fixed numerical value for the “Data” feature. This value is the amount of data that a consumer can use in a month before incurring overage fees, or before experiencing reduced network service quality. A plan offering ‘Unlimited data’ means that for any use beyond the monthly data allowance, the provider will reduce the network quality (e.g., data transmission speed) in lieu of charging overage fees. For example, a 10 GB plan with no unlimited data (a value of 0) will incur overage charges if the consumer uses more than 10 GB in a month.

12. This imputation procedure for subscriber counts is applied whenever plans are carried forward or backward.

Note that a service package can contain both in-market and legacy plans, since the Availability feature is not used to assign plans into service packages. Each service package's price is calculated as the weighted arithmetic average of all its plans' MRCs. Individual plans' subscriber counts are used as weights.

An example of a service package is given in Table 5 below. Service package "A" contains all 5G postpaid plans offered by Retail Brand 1 in Province A, having a data allowance of 50 GB, unlimited nationwide talk and text, and unlimited and shareable data. There are two plans in the service package (Plan X and Plan Y) and the weighted average price is \$89.00.

Table 5
Assigning plan X and plan Y to Service package A

	Service package A	
Plan Name	Plan X	Plan Y
Geography	Province A	Province A
Retail Brand	Retail Brand 1	Retail Brand 1
Plan Type	Postpaid	Postpaid
Data	50 GB	50 GB
IsMinUnlimited	1	1
IsSMSUnlimited	1	1
IsDataUnlimited	1	1
IsDataShareable	1	1
IncludesCANUS	0	0
Is5G	1	1
MRC (price)	\$95.00	\$85.00
Subscribers	40,000	60,000

Service packages are the fundamental building blocks on which pure price change of transaction data is measured. They also serve to classify the data into two distinct observation types:¹³

1. **Continuing:** service packages which are available in both T_0 and T_1 .
2. **Entering:** service packages which are available in T_1 but not in T_0 .

Entering service packages are not carried backward to T_0 since they are composed of new (in-market) plans. Thus, T_0 prices for entering service packages are imputed via hedonic regression.

The monthly file is comprised mostly of continuing service packages given that a small number of service packages enter the sample every month. In addition, most entering or new service packages do not attract sufficiently large numbers of subscribers to be significant in terms of market share. However, some service packages gain larger numbers of new subscribers during certain months (in particular, during select statutory holidays or back to school events) when retailers usually offer new plans at promotional prices or with updated features (e.g., data allowances).

13. Note that there are no exiting service packages due to the carry-forward procedure done to missing in-market and legacy plans.

Quality adjustment for new plans and service packages

According to the Wireless Code¹⁴, WSPs cannot change the terms and conditions of postpaid wireless plans while subscribers are still under contract. Therefore, their retail brands will frequently replace existing plans with new plans, instead of modifying them. When they introduce new plans that offer larger data allowances or additional features (e.g., such as international calling, faster transmission speeds, etc.), some of the new plans can quickly become popular with consumers looking to switch from their current cellular plans. In this context, there is a need to apply quality adjustment methods to predict missing T_0 prices and thus, account for price change that would otherwise be missed if the index were based on a matched model approach only.¹⁵

Web collected data

When a retail brand stops advertising a plan that was being priced for a consumer profile, the least expensive plan that fits the profile is selected. While Canadians might not always choose the cheapest plan that meets their needs, it is more reasonable to assume this behavior than to assume that consumers make no effort to minimize their costs. Quality adjustment using the option cost approach is then used to estimate the price of the replacement plan in T_0 . This adjustment is based on price per GB and is controlled within the WSP's retail brand and geography. If the replacement plan existed in T_0 , then no imputation is performed and the actual T_0 price is used instead.

Transaction data

Hedonic regression can be used to impute T_0 prices of new service packages in T_1 by estimating the statistical relationship between prices and product characteristics. The regression model uses the multivariate adaptive regression splines (MARS) algorithm to predict prices.¹⁶ The MARS algorithm was chosen because it produced more accurate predictions, with the lowest Root Squared Mean Error (RMSE) for out-of-sample predictions compared to the other algorithms that were reviewed.¹⁷

The general hedonic regression model is:

$$(1) \ln(MRC_i) = f(X_i) + \varepsilon_i$$

where:

X_i consists of the following explanatory features used to explain the (log-transformed) MRC for service package i : Retail Brand, Plan Type, Data, IsMinUnlimited, IsSMSUnlimited, IsDataUnlimited, IsDataShareable, IncludesCANUS, and Is5G.¹⁸

Service packages in the T_0 file, composed of in-market plans only, are used to estimate a hedonic regression model in every province or territory. The estimated regression model is used to predict T_0 prices of new service packages entering the provincial or territorial market in T_1 . Legacy plans in the T_0 file are not used to estimate the model because they were not offered in the market in T_0 and thus reflect prices from a period prior to T_0 .¹⁹ Between 30 to 80 services packages are used to estimate the provincial and territorial models each month.

14. See [The Wireless Code, simplified | CRTC](#) for more information.

15. Triplett, J. (2004), "[Handbook on Hedonic Indexes and Quality Adjustments in Price Indexes: Special Application to Information Technology Products](#)", OECD Science, Technology and Industry Working Papers, No. 2004/09, OECD Publishing, Paris.

16. Friedman, J. (1991) "[Multivariate Adaptive Regression Splines](#)" Ann. Statist. 19 (1) 1 - 67.

17. Other algorithms that were considered include ordinary least squares, random forest, and extreme gradient boosting.

18. Other features such as cellular data transmission speeds (download and upload), geographic coverage, jitter, or latency are not included as explanatory features primarily because of lack of data. Furthermore, most of these excluded features generally apply to all available plans and they remain unchanged over many months.

19. For example, a typical postpaid plan that had unlimited talk & text and 4 GB cost around \$55 prior to the [government-mandated 25% reduction in wireless prices](#). Given the dynamic nature of the cellular services market, it makes sense to leave out these old plans for the model estimation. As of May 2024, one can obtain a 20 GB plan for as low as \$34.

Index aggregation

After the missing prices have been estimated, current period prices are directly compared with the preceding period's prices to construct price relatives.²⁰ The price relatives are then aggregated in several stages:

Stage 1: Retail brand level

Web collected data

The price relatives for each consumer profile are aggregated using an unweighted geometric mean to produce a price relative for a retail brand in a province or territory. The profiles are not weighted at this level due to lack of appropriate weight information for WSPs not providing transaction data. The equation below shows the calculation of month-to-month price change for retail brand A:

$$(2) I_A^{t-1:t} = \left(\prod_{i=1}^n \frac{P_{i,t}}{P_{i,t-1}} \right)^{1/n}$$

where:

$I_A^{t-1:t}$ is the Jevons price index for retail brand A between period $t-1$ and t ²¹

$P_{i,t}$ is the price of consumer profile i in period t

n is the number of consumer profiles priced for retail brand A

Transaction data

Given the availability of quantity information in the form of subscriber counts, the price relatives for each service package are aggregated using a weighted geometric mean to produce a price relative for a retail brand in a province or territory. Each service package's price relative is weighted by its average revenue share over T_0 and T_1 . A plan's monthly revenue is the product of the plan's subscriber counts and its MRC. Thus, the monthly revenue of a service package is the sum of all monthly revenues for all plans in that service package. The equation below shows the calculation of month-to-month price change for retail brand B:

$$(3) I_B^{t-1:t} = \prod_{i=1}^n \left(\frac{P_{i,t}}{P_{i,t-1}} \right)^{\frac{1}{2} \left[\frac{P_{i,t-1}q_{i,t-1}}{\sum_{j=1}^n (P_{j,t-1}q_{j,t-1})} + \frac{P_{i,t}q_{i,t}}{\sum_{j=1}^n (P_{j,t}q_{j,t})} \right]}$$

where:

$I_B^{t-1:t}$ is the Törnqvist – Theil price index for retail brand B between period $t-1$ and t ²²

$P_{i,t}$ is the price of service package i in period t

$q_{i,t}$ is the number of subscribers of service package i in period t

n is the number of service packages priced for Retail brand B

20. Prices include 911 fees and applicable taxes.

21. The Jevons price index is a geometric mean of the price relatives. See section 6.13 of [The Canadian Consumer Price Index Reference Paper](#) for more information.

22. The Törnqvist-Theil index is a weighted geometric mean of the price relatives using the arithmetic means of the shares in the two periods as weights. See the appendix of [The Canadian Consumer Price Index Reference Paper](#) for more information.

Stage 2: Provincial/territorial level

The transaction data price relatives are then combined with the web collected data price relatives from the other retail brands in the same province or territory using a weighted geometric mean to produce a hybrid provincial or territorial price relative. The resulting provincial or territorial index is a hybrid index because it is compiled using transaction data for some WSP’s retail brands and manually web collected data for other WSPs’ retail brands in the same market. Provincial or territorial retail brand weights are based on the latest revenue data from the AST. The equation below shows the calculation of price change for province X:

$$(4) I_X^{t-1:t} = \prod_{k=1}^m (I_k^{t-1:t})^{w_k}$$

where:

$I_X^{t-1:t}$ is the Geometric Young price index for province X between period t-1 and t²³

$I_k^{t-1:t}$ is the price change of retail brand k in province X

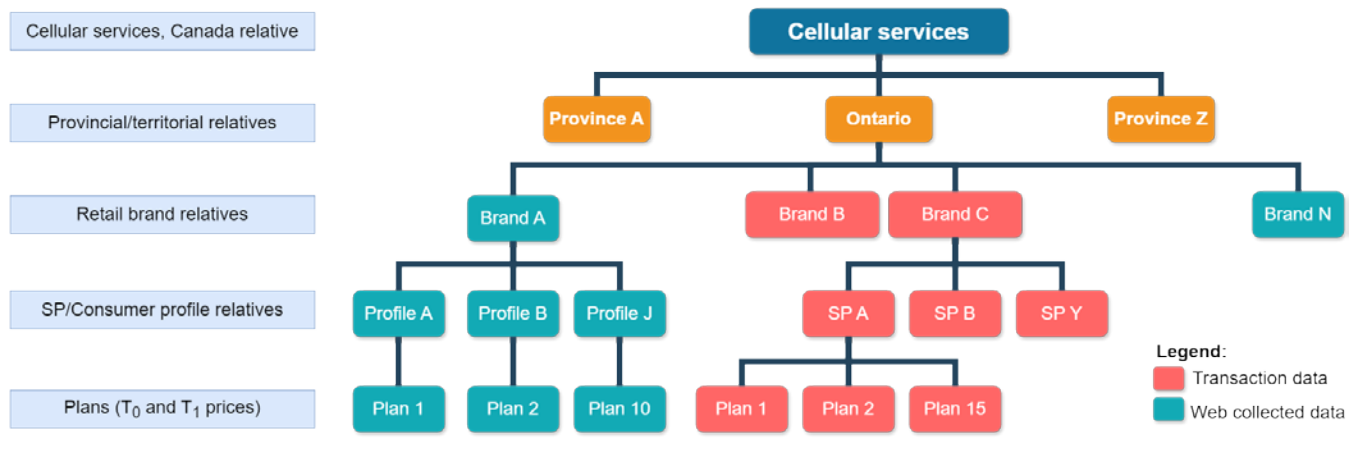
w_k is the revenue share of retail brand k in province X

m is the number of retail brands in province X

Stage 3: Canada level

The Canada level price relative is obtained by computing the weighted arithmetic mean of all provincial and territorial relatives. Weights for this aggregation are sourced from the National Household Final Consumption Expenditure (HFCE) dataset.²⁴ Figure 1 below shows the aggregation scheme for the CSPI.

Figure 1
Aggregation plan of the hybrid Cellular services price index



Source: Statistics Canada, Consumer Prices program.

23. The Geometric Young index is a weighted geometric mean of the price relatives. See [Consumer Price Index Manual: Concepts and Methods](#) for more information.
 24. See [Surveys and statistical programs - National Gross Domestic Product \(GDP\) by Income and by Expenditure Accounts \(statcan.gc.ca\)](#) for more information.

In summary

This methodology for a hybrid index will be used for incorporating transaction data in the CSPI. Transaction data from WSPs are a comprehensive source of information that can be used to enhance the index. They include a larger volume and type of plans each month and thus, represent a more complete picture of the market. The subscriber counts are used to calculate more accurate measures of price change. Finally, the larger sample size allows the implementation of a hedonic imputation model using the MARS algorithm for quality adjustment. Given that not all WSPs in the market have agreed to provide the agency with transaction data, the hybrid CSPI will continue to use web-collected data alongside the transaction data. The incorporation of transaction data into the currently published CSPI will lead to an improvement in the quality of the index.

Note to users

As part of Statistics Canada's rigorous and ongoing efforts to maintain the quality and relevance of the CPI, this technical paper explains the data and methodology for including transaction data in the CPI's cellular services price index.

This enhancement improves the quality of the data, while ensuring the representativeness of prices paid by Canadian consumers. Users should exercise caution when interpreting the year-over-year change for the first 12 months following the implementation of a new methodology and data source.

Users are also advised to exercise caution when making provincial/territorial comparisons. The market shares of the sampled wireless service providers vary across provinces and territories, and price changes derived from transaction data may differ from price changes derived from web-collected data as transaction data includes monthly charges for in-market and legacy plans, while web-collected data only contains monthly charges for advertised plans. The hybrid cellular services price index in each province or territory is affected by the market shares of the wireless service providers from which Statistics Canada is receiving transaction data.

Statistics Canada continues to work with price experts, national statistical organizations, and other partners to ensure data and methods used in the calculation of the CPI are aligned with international standards and best practices. To maintain the accuracy and relevance of the CPI, the agency will continue to monitor prices for cellular services and to acquire transaction data from additional wireless service providers.

For additional information or to provide comments on the proposed enhancement, users may contact the Consumer Prices Division at statcan.cpddisseminatunite-dpcunitedediffusion.statcan@statcan.gc.ca.