

Example 2: Consumer Price Index and weighted mean

Key Stage: 3

Strand: Number and Algebra, Data Handling

Learning Unit: (1) Using percentages
(2) Measures of central tendency

Objective: (1) Understand that statistics are closely related to our lives and understand the application of statistics in daily life
(2) Using official data and the Consumer Price Index as an example to solve application problems involving weighted mean

Prerequisite knowledge: (1) Understand the concept of percentage changes and solve related real-life problems
(2) Recognise the concept of weighted mean

Activity 1 (Budget of Expenditure):

(i) Teachers may compile personal expenditure records with students in their daily life, and record the expenditure records of each item in the spreadsheet, as shown in the following table:

Item	Expenditure (last week)
transport	\$80
lunch	\$300
snacks	\$120
sporting goods	\$110
entertainment	\$450
extracurricular activity	\$300

(Note: The expenditure patterns of individual students are different. The items spent are also different. The above table is for reference only, and the expenditure items can be changed).

(ii) Teachers may use the above table as an example to discuss with students whether Student A can achieve his goal last week if he has \$1500 in pocket money last week and he wants to save at least \$100 a week.

Student A's total spending expenditures for last week = $80 + 300 + 120 + 110 + 450 + 300 = \1360

He could save last week $1500 - 1360 = \$140$

Student A can achieve the goal last week.

- (iii) Teachers assume that the expenditure of Student A on each item this week has changed compared to last week, as shown in the table below:

Item	Expenditure (this week)
transport	\$ 100
lunch	\$ 350
snacks	\$ 100
sporting goods	\$ 100
entertainment	\$ 500
extracurricular activity	\$ 400

Student A calculates the week-on-week (%) change of each expenditure, as shown in the following table:

Item	Expenditures week-on-week (%) change
transport	$\frac{100 - 80}{80} = 0.25 \times 100\% = 25\%$
lunch	$\frac{350 - 300}{300} = 0.167 \times 100\% = 16.7\%$
snacks	$\frac{100 - 120}{120} = -0.167 \times 100\% = -16.7\%$
sporting goods	$\frac{100 - 110}{110} = -0.0909 \times 100\% = -9.1\%$
entertainment	$\frac{500 - 450}{450} = 0.111 \times 100\% = 11.1\%$
extracurricular activity	$\frac{400 - 300}{300} = 0.333 \times 100\% = 33.3\%$

- (iv) Teachers discuss with students the following two ways to calculate Student A's total expenditure week-on-week(%) change:

Method 1: $\frac{1}{6}(25\% + 16.7\% - 16.7\% - 9.1\% + 11.1\% + 33.3\%) = 10.05\%$

Method 2: Student A's total Expenditure last week: 1360

Student A's total Expenditure this week: $100 \times 3 + 350 + 500 + 400 = 1550$

Student A's total Expenditure percentage changes per week:

$$\frac{1550-1360}{1360} \times 100\% = 14.0\%$$

Teachers guide students to discuss which is correct method and ask them to explain.

(**Suggested solution:** Method 2 is correct, as the share of each item in the total expenditure is different, it is unreasonable to directly take the mean of the percentage changes for each item).

- (v) Teachers guide the students to discuss how to find the weights of each expenditure week-on-week (%) change and use the weighted mean to calculate Student A's total expenditure week-on-week(%) change.

Item	Expenditure (last week)	Expenditure (last week) weights	Expenditure (this week)	Expenditure week-on-week (%) change	Weights of each expenditure week-on-week (%) change
transport	80	$\frac{80}{1360} = 0.0588$	100	25.0%	$0.0588 \times 25.0\% = 1.47\%$
lunch	300	$\frac{300}{1360} = 0.2206$	350	16.7%	3.68%
snacks	120	$\frac{120}{1360} = 0.0882$	100	-16.7%	-1.47%
sporting goods	110	$\frac{110}{1360} = 0.0809$	100	-9.1%	-0.74%
entertainment	450	$\frac{450}{1360} = 0.3309$	500	11.1%	3.68%
extracurricular activity	300	$\frac{300}{1360} = 0.2206$	400	33.3%	7.35%
Total	1360	1	1550		14.0%

Activity 2 (Statistics on Price Changes):

- (i) Teachers collect some press releases about inflation and ask the students if they know what inflation is and what deflation is.

(Suggested solution: Inflation refers to the phenomenon of a continuous rise in the general price level, and deflation refers to the phenomenon of a continuous decline in the general price level.)

Teachers may introduce students “**Introduction to the Consumer Price Index (CPI)**” compiled by the Census and Statistics Department, which is widely used as an indicator of inflation faced by consumers. The base period value of the index is set at 100, and subsequent values may be greater or less than 100, depending on the price level at the time. The booklet can be downloaded from the website: https://www.censtatd.gov.hk/en/data/stat_report/product/B8XX0021/att/B8XX0021.pdf

Refer to Question 2 in worksheet 2, its calculation is summarised as follows:

Comparing the share of expenditures of Student A in the group (transport, snacks, entertainment) this week with last week (base period) and calculate the index of the group in this week.

Student A's transport expenditure in this week is \$100 and the expenditure in last week (base period) is \$80, so its transport expenditure relative = $\frac{100}{80} = 1.25$. The item index of transport in this week = $1.25 \times 100 = 125$. By similar computation, the item index of snacks and entertainment can be calculated. We get the table below:

Item	Expenditure Weight	Index
transport	0.0588	125
snacks	0.0882	83.33
entertainment	0.3309	111.11

Weighted expenditure index for the group (transport, snacks, entertainment)

$$\begin{aligned} &= \frac{0.0588 \times 125 + 0.0882 \times 83.33 + 0.3309 \times 111.11}{(0.0588 + 0.0882 + 0.3309)} \\ &= 107.7 \end{aligned}$$

Main points on the CPI are as follows:

- ◆ Reflects the price changes of the total value of the specified consumer goods and services in a basket over a specified period of time;
- ◆ Different items will account for different weights of the index, that is, each item has different weights (or weighting);
- ◆ When the CPI rises, it means that citizens need to pay more money for their goods and services;

- ◆ Students should understand that households in different expenditure ranges have varying expenditure patterns. For example, households in lower expenditure range spend relatively more on food, electricity, gas and water. Households in higher expenditure range spend relatively more on clothing and footwear, durable goods, transport and miscellaneous services. Therefore, the Census and Statistics Department compiles different series of CPI for analysis by households with different expenditure ranges.

For a more in-depth understanding of the Consumer Price Index, students may refer to **“Introduction to the Consumer Price Index(CPI)”** compiled by the Census and Statistics Department.

Students may use the following example to understand how the Census and Statistics Department compiles the CPI. Suppose that the CPI includes only three commodities, namely clothing and footwear, transport and food, and their respective weights (i.e. weighting) and indices are shown in the following table:

Commodity	Weights	Base period index	Index for 2021	Index for 2022
clothing and footwear	30%	100	110	120
transport	20%	100	105	115
food	50%	100	130	180

$$\text{Consumer Price Index for 2021} = 30\% \times 110 + 20\% \times 105 + 50\% \times 130 = 119$$

$$\text{Consumer Price Index for 2022} = 30\% \times 120 + 20\% \times 115 + 50\% \times 180 = 149$$

$$\text{Consumer Price Index year-on-year (\% change } (R) = \frac{149-119}{119}$$

$$= 0.2521 \times 100\% = 25.2\%$$

Namely

$$R = \frac{(30\% \times 120 + 20\% \times 115 + 50\% \times 180) - (30\% \times 110 + 20\% \times 105 + 50\% \times 130)}{(30\% \times 110 + 20\% \times 105 + 50\% \times 130)} \times 100\%$$

$$R = \left(\frac{30\% \times (120 - 110)}{119} + \frac{20\% \times (115 - 105)}{119} + \frac{50\% \times (180 - 130)}{119} \right) \times 100\%$$

$$R = 2.52\% + 1.68\% + 21\% (=25.2\%)$$

In percentage terms, among the 25.2% increase in the CPI, 2.52% come from clothing and footwear, 1.68% from transport and 21% from food.

- (ii) According to Census and Statistics Department, please fill in the table below Hong Kong's Composite CPI year-on-year (%) change in the period from 2012 to 2021.

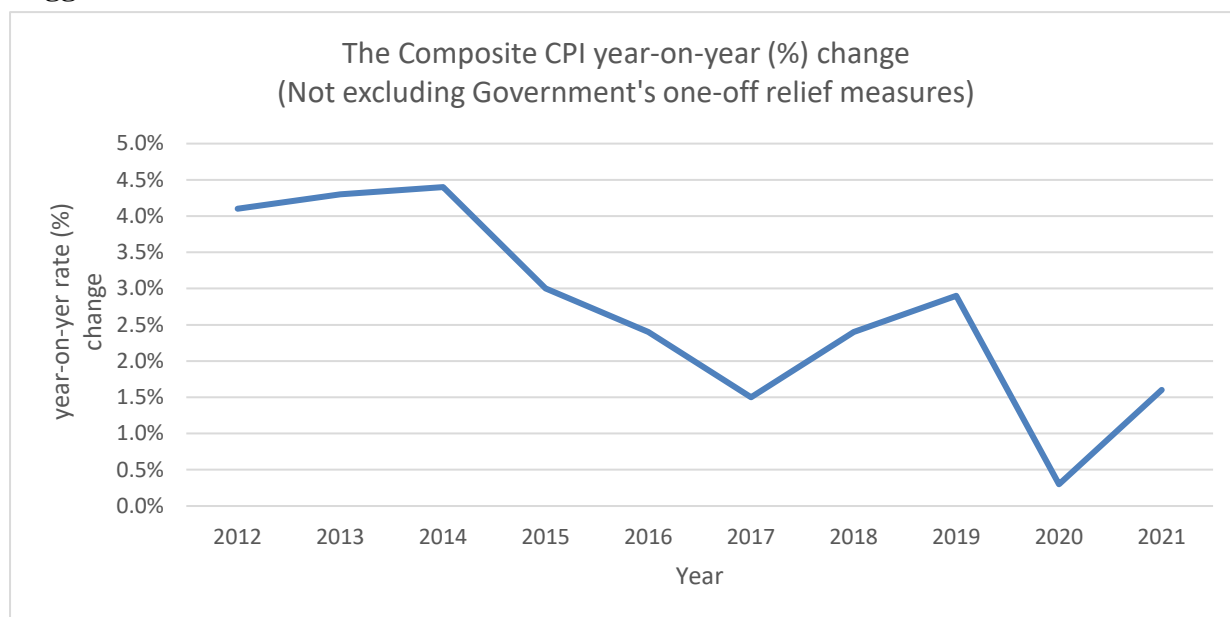
Suggested Solution:

Year	The Composite CPI year-on-year change (%) (Not excluding Government's one-off relief measures)
2012	+4.1
2013	+4.3
2014	+4.4
2015	+3.0
2016	+2.4
2017	+1.5
2018	+2.4
2019	+2.9
2020	+0.3
2021	+1.6

Source: Census and Statistics Department (2021)

- (vi) Based on the above data, draw a statistical graph about the Composite CPI year-on-year (%) change from 2012 to 2021. Describe the changes of the Composite CPI in this period.

Suggested Solution:



In terms of year-on-year (%) change, the increase in the Composite CPI remained about 4.3% between 2012 and 2014, and the rate of increase in the composite CPI narrowed during 2014 to 2017, fell from about 4.4% to 1.5%, and its changes increased from 1.5% to 3.0% between 2017 and 2019. Due to the impact of the COVID-19 epidemic, household expenditure on certain goods or services should deviate significantly from normal expenditures, resulting in a significant narrowing of the composite CPI changes between 2019 and 2020, and only gradually increased in 2021.

Extended Question:

- ◆ Why is the perceived price increase different from the official CPI?

(Suggested solution: The CPI is to reflect the price changes of the goods and services generally purchased by consumers. Everyone's consumption habits and preferences are different, so if you compare the price changes you feel when purchasing goods and services with the overall price changes, you will form a personal feeling of price increases that are different from the increase in the CPI. If a household spends more on goods and services whose prices are rising sharply, the impact of inflation will be greater.)

Reference:

1. Hong Kong in Figures (2023 Edition)
http://www.censtatd.gov.hk/hkstat/hkif/index_tc.jsp
2. Monthly Report on Consumer Price Index (August 2023)
<https://www.censtatd.gov.hk/en/wbr.html?ecode=B10600012023MM08&scode=270>
3. Introduction to the Consumer Price Index
https://www.censtatd.gov.hk/en/data/stat_report/product/B8XX0021/att/B8XX0021.pdf