



MONASH University

Information Technology

FIT1006

Business Information Analysis

Lecture 13

Index Numbers

# Topics covered:

- Simple indices – and the problem with these
- Aggregate indices – Laspeyres, Paasche and Fisher
- Changing the base of an index
- Chaining indices
- The Consumer Price Index (CPI)

# Motivating Problem

- Petrol cost, on average, 130 cents per litre in Melbourne in 2007.
- What should the average price of petrol be now to maintain parity with the 2007 price?

# Costs Over Time

- We are often interested in monitoring the changes in costs over time. For example, the cost of day-to-day living, or how various costs have changed relative to each other.
- It is usual to express the costs over time relative to those in a base year, and create a price index.
- We are often interested in the overall change in a group of items, such as those that contribute to everyday family spending. For this purpose we use an aggregate index, the Consumer Price Index.

# Housing affordability Australia's average house price hits record high as buyers flood market post-COVID

Marius Beck a guided tour through their corner

In 1955, \$7000 bought a house. Now, it's not even a deposit on a dream



By Stuart Marsh • Senior Producer | 5:03pm Jan 28, 2021

## Domain House Price Report: December Quarter 2020

Capital city:	Average house price:	Year-on-year growth:
Sydney	\$1,211,488	+ 6.7 per cent
Melbourne	\$936,073	+ 3.9 per cent
Brisbane	\$616,387	+ 5.6 per cent
Adelaide	\$574,264	+ 6.1 per cent
Canberra	\$855,530	+ 9.1 per cent
Perth	\$563,214	+ 6.3 per cent
Hobart	\$564,091	+ 12.4 per cent
Darwin	\$533,845	+ 3.6 per cent
National	\$852,940	+ 5.8 per cent

- Source: The Sunday Age, April 18 20

# Prices/Wages over time...

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# 40 years of change: 1975 to 2015

## Earning more, costing more

Australians are also earning a lot more now than we were back then; the average full time earnings in 1975 was \$7,600 per year, today the annual average earnings exceed \$72,000 per annum.

And while we are earning more, costs are a lot more today than they were back then. The cost of a loaf of bread today is more than 10 times the price it was in 1975, while a litre of milk today is 3 times the cost it was 4 decades ago.

	1975	2015
Full time earnings	\$7,618	\$72,000
Everyday costs	1975	2015
Loaf of bread	\$0.24	\$2.84
1 litre of milk	\$0.30	\$1.45
Newspaper	\$0.12	\$2.50
Petrol	\$0.57 / litre	\$1.20 / litre

Four decades ago Sydney had the highest house cost, averaging \$28,000 while today it exceeds \$850,000. So while earnings have gone up, by almost tenfold, house prices have gone up by more than thirtyfold in that same period of time.

Source:

<https://mccrindle.com.au/insights/blog/40-years-of-change-1975-to-today/>



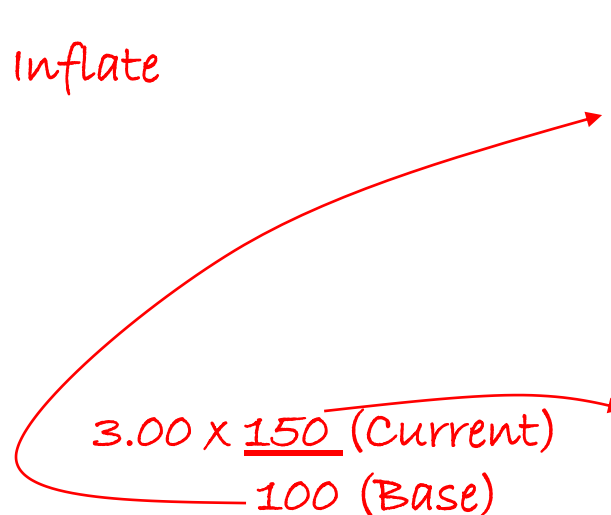
<https://flux.qa> (Feed code: SJ6KGV)

## Question 1

What should a hamburger costing \$3.00 in Year 0 cost in Year 5?

- A. \$3.00
- B. \$3.50
- ✓ C. \$4.50
- D. \$5.00

*Inflate*



Year	Index
0	100
1	110
2	120
3	130
4	140
5	150
6	160
7	170
8	180
9	190
10	200



# A Simple Price Index

- Consider the cost of a hamburger over time.

Year	1970	1975	1980	1985	1990
Price	\$0.19	\$0.35	\$0.95	\$1.80	\$2.40

- Let  $p_t$  be the cost of hamburger at time  $t$ .
- Using  $P_i = 100p_i/p_0$ , we can construct a price index for hamburgers over time.

$$100 \times \frac{0.35}{0.19}$$

Year	1970	1975	1980	1985	1990
Price	\$0.19	\$0.35	\$0.95	\$1.80	\$2.40
Index	100	184	500	947	1263

- In 1975, the price of a hamburger was 184% of the price in 1970.

<https://flux.qa> (Feed code: SJ6KGV)

## Question 2

What should a hamburger costing \$3.40 in Year 7 have cost in Year 1?

- A. \$1.70
- ✓ B. \$2.20
- C. \$2.30
- D. \$2.80

Deflate

$3.40 \times \frac{110}{170}$  (Base)

170 (current)

Year	Index
0	100
1	110
2	120
3	130
4	140
5	150
6	160
7	170
8	180
9	190
10	200

# Changing the Base of an Index

- We frequently want to re-scale an index relative to a period later than the original base period. We achieve this by dividing each index by that of the new base period and multiplying by 100. For example:

Year	1970	1975	1980	1985	1990
Index	100	184	500	947	1263
To set 1980 as the base period divide by 500, multiply by 100					
Index	20	36.8	100	189.4	252.6

$$\frac{947}{500} \times 100$$

<https://flux.qa> (Feed code: SJ6KGV)

## Question 3

What should a hamburger costing \$2.00 in Year 0 cost in Year 10?

A. \$4.00

✓ B. \$4.50

C. \$5.00

D. \$6.00

Inflate =  $\frac{\text{Current}}{\text{Base}}$

Step 2:  
 $2.00 \times \frac{225}{100}$  (Current)  
= 4.50

Step 1:  
 $\frac{150}{100} \times 150 = 225$

Year	Index 1	Index 2
0	100	
1	110	
2	120	
3	130	
4	140	
5	150	100
6		110
7		120
8		130
9		140
10		150

# Chaining Indices

- We frequently need to extend indices backwards or forwards by joining two separate indices. For example, this is necessary when the range of components forming a composite index changes.

This process is called chaining.  
We obtain the chained index by multiplying the second index by the terminal value of the first index and dividing by 100.

*Eg.  $102 * 132 / 100 = 134.6$*

Period	Index 1	Index 2	Chained Index
1	100		100.0
2	101		101.0
3	110		110.0
4	113		113.0
5	125		125.0
6	132	100	132.0
7		102	134.6
8		109	143.9
9		110	145.2
10		124	163.7

# Aggregate Indices

- In order to overcome the weaknesses simple average or relative indices (see pre-reading) it is more usual to use weighted indices, where the proportion consumed or money spent on an item over a certain period of time determines its relative contribution to the index.
- We will consider three indices: the Laspeyres, the Paasche and the Fisher.

# Sample Data

- Consider the following data:

Item	1970 Price	Quantity	Value	1980 Price	Quantity	Value	Unit
Petrol	0.20	200	40.00	0.35	230	80.50	<i>l</i>
Electricity	0.10	350	35.00	0.18	450	81.00	<i>KWh</i>
Steak	2.80	15	42.00	3.50	25	87.50	<i>Kg</i>
Potatoes	0.60	20	12.00	0.55	40	22.00	<i>Kg</i>
Milk	0.35	26	9.10	0.62	86	53.32	<i>l</i>
Newspapers	0.10	34	3.40	0.25	34	8.50	
<b>Total</b>			<b>141.50</b>			<b>332.82</b>	

- Over the 10 years between surveys, costs and consumption patterns have changed.
- Total spending has increased by  
 $100(332.82/141.50)=235.2\%$ .



# Laspeyres Index

- The Laspeyres index uses the base period values to provide weightings for each product in subsequent periods.

$p_i$  be the price per unit of item  $i$  in period  $t$

$q_i$  be the quantity purchased of a particular item  $i$  in some period

$$I_{0,t}^{LP} = \frac{\sum q_0 p_t}{\sum q_0 p_0} 100$$

...

- Laspeyres: use 1970 (*base period*) weights.

Item	$P_0$ 1970 Price	$q_0$ Quantity	Value	$P_t$ 1980 Price	Quantity	Value	Unit
Petrol	0.20	200	40.00	0.35	230	80.50	l
Electricity	0.10	350	35.00	0.18	450	81.00	KWh
Steak	2.80	15	42.00	3.50	25	87.50	Kg
Potatoes	0.60	20	12.00	0.55	40	22.00	Kg
Milk	0.35	26	9.10	0.62	86	53.32	l
Newspapers	0.10	34	3.40	0.25	34	8.50	
<b>Total</b>			<b>141.50</b>			<b>332.82</b>	

$$\begin{aligned}
 I_{0,t}^{LP} &= \frac{\sum q_0 p_t}{\sum q_0 p_0} 100 \\
 &= \frac{200(0.35) + 350(0.18) + 15(3.50) + 20(0.55) + 26(0.62) + 34(0.25)}{200(0.20) + 350(0.10) + 15(2.80) + 20(0.60) + 26(0.35) + 34(0.10)} 100 \\
 &= \frac{221.12}{141.50} 100 = 156.26
 \end{aligned}$$

# Paasche Index

- The paasche index uses the current time period to provide weightings for each product in the index.

$p_i$  be the price per unit of item  $i$  in period  $t$

$q_i$  be the quantity purchased of a particular item  $i$  in some period

$$I_{0,t}^{PP} = \frac{\sum q_t p_t}{\sum q_t p_0} 100$$

...

- paasche: use 1980 (*end period*) weights.

	$P_0$			$P_t$	$q_t$		
Item	1970 Price	Quantity	Value	1980 Price	Quantity	Value	Unit
Petrol	0.20	200	40.00	0.35	230	80.50	l
Electricity	0.10	350	35.00	0.18	450	81.00	KWh
Steak	2.80	15	42.00	3.50	25	87.50	Kg
Potatoes	0.60	20	12.00	0.55	40	22.00	Kg
Milk	0.35	26	9.10	0.62	86	53.32	l
Newspapers	0.10	34	3.40	0.25	34	8.50	
<b>Total</b>			<b>141.50</b>			<b>332.82</b>	

$$\begin{aligned}
 I_{0,t}^{PP} &= \frac{230(0.35) + 450(0.18) + 25(3.50) + 40(0.55) + 86(0.62) + 34(0.25)}{230(0.20) + 450(0.10) + 25(2.80) + 40(0.60) + 86(0.35) + 34(0.10)} 100 \\
 &= \frac{332.82}{218.5} 100 \\
 &= 152.32
 \end{aligned}$$

$$I_{0,t}^{PP} = \frac{\sum q_t p_t}{\sum q_t p_0} 100$$

# Laspeyres vs Paasche

- The Laspeyres Index uses base period quantities as weights and makes no allowance for changes in consumption patterns over time. It tends to *overestimate* price rises.
- The Paasche Index uses current period quantities as weights. It tends to *underestimate* prices rises.
- The Laspeyres Index is generally preferred because it avoids the costs of surveying consumption patterns for each period of interest.
- The Laspeyres Index provides a better comparison of price movements in the intermediate periods, since all periods use the same base quantity consumption patterns.

# Fisher Price Index

- As a compromise between the assumptions of the Laspeyres and Paasche Indices, the Fisher Price Index is proposed as the geometric mean of the Laspeyres and Paasche.

$$I_{0,t}^{FP} = \sqrt{I_{0,t}^{LP} \times I_{0,t}^{PP}}$$

- For the data in the previous problem:

$$I_{0,t}^{FP} = \sqrt{152.32 \times 156.26} = 154.28$$

Do this as homework and we will continue next lecture.

## Class exercise

The prices of certain commodities and the quantities consumed per month are given for 1992 and 2010. Calculate the Fisher Price Index.

Item	Quantity 1992	Quantity 2010	Cost 1992	Cost 2010
A	3	4	4.00	5.00
B	2	1	20.00	40.00

$$I_{0,t}^{LP} = \frac{\sum q_0 p_t}{\sum q_0 p_0} 100$$

$$I_{0,t}^{PP} = \frac{\sum q_t p_t}{\sum q_t p_0} 100$$

$$I_{0,t}^{FP} = \sqrt{I_{0,t}^{LP} \times I_{0,t}^{PP}}$$



## More Information ...

- Visit the Australian Bureau of Statistics web site:
  - <http://www.abs.gov.au/>
  - Access to most ABS publications is free!
- Further Reading:
  - 6401.0 - Consumer Price Index (most recent)
  - 6440.0 - A Guide to the Consumer Price Index: 16<sup>th</sup> Series, 2011
  - 6461.0 - Consumer Price Index: Concepts, Sources and Methods, 2011
  - 6470.0 - Introduction of the 16<sup>th</sup> Series Australian Consumer Price Index

# Necessary Skills

- Know how to:
  - Calculate Laspeyres, paasche and Fisher indices;
  - Change the base of an index;
  - Chain indices;
- Have a general idea of how the CPI is constructed and used.

# Reading/Questions (Selvanathan)

- Reading:
  - 7<sup>th</sup> Ed. Chapter 18.
- Questions:
  - 7<sup>th</sup> Ed. Questions: 18.1, 18.3, 18.4, 18.9, 18.14, 18.17.