1

Introduction

1.1 What is an index number?

The simplest description of an index number is that it is a measure of change. Consider the data in Table 1.1, which shows the total value of retail sales[1] for Great Britain between 2005 and 2008 presented in two ways, firstly, as values in billion pounds, and secondly, scaled so that the value in 2005 is set to be 100.

The idea behind representing the time series of the values of sales in a scaled form is to make the degree of change readily apparent. The process of creating values in the third column is a simple one. Firstly, we choose a time period as the reference time period with which we want to compare the change; in this case, we have chosen 2005 as the reference (or base) time period. The index number series is then scaled to be equal to 100 for this reference period; the same scaling factor is then applied to the values of sales for other years. We explain how to do this in detail in Chapter 2.

The values for the scaled series are set to be around 100, as this is judged to make the degree of change clearest; the scaled values are called index numbers. Representing the time series in this way makes comparison easy. For example, the percentage change in retail sales between 2007 and 2005 can just be read from the index number for 2007 – it is 7.88%. Note that although the scaling process changes the numbers, it does not alter the percentage differences. Chapter 2 shows how to convert the percentage change from an index series back to values; for example, if we want to calculate how much money the change of 7.88% in this series represents.

By creating an index number representation of the time series of retail sales values, we have gained a more direct representation of change. In doing so, we have lost the actual monetary values; however, frequently the focus is primarily on the change in the level of the series rather than on the actual amount sold in billion pounds.

[1] As the name suggests, this is the total estimated value of sales across retailers in Great Britain in any given year. More information on this series can be found at http://www.ons.gov.uk/ons/rel/rsi/retail-sales/index.html

A Practical Introduction to Index Numbers, First Edition. Jeff Ralph, Rob O'Neill and Joe Winton.

Companion Website: http://www.wiley.com/go/ralph/index_numbers

Table 1.1 Value of retail sales 2005–2008 for Great Britain.

	Value of retail sales (£bn)	Value relative to sales in 2005 (2005 = 100)
2005	281.450	100.00
2006	292.110	103.79
2007	303.621	107.88
2008	321.178	114.12

Source: Office for National Statistics (Time series of retail sales data are available from the ONS website http://www.ons.gov.uk/ons/rel/rsi/retail-sales/july-2013/rft-rsi-poundsdata-july-2013.xls; series ValNSAT).

1.2 Example – the Consumer Prices Index

A different example of an index number series is provided by the Consumer Prices Index (CPI). This is a measure that tracks the movement in the general level of prices of consumer goods and services.

Table 1.2, taken from the CPI Statistical Bulletin for September 2013, shows index numbers representing the general level of prices for each month from September 2012 to September 2013,[2] where the index value has been set to be 100 in 2005. The index number represents the general level of prices in any given month. The change between the level of prices in any given month and the level of prices in 2005 is easily found by referring to the index number. For example, in September 2012, we can see that prices had increased by 23.5% from 2005.

Table 1.2 also contains the percentage rate of change in the general price level for each month compared with the previous month ('1-month rate') and compared with the same month in the previous year ('12-month rate'). The two rates of change figures are very important as the rate of change of the general price level is also known as the rate of inflation.

The monthly figure for the 12-month rate is the headline inflation figure produced by the UK Office for National Statistics and is arguably the most important of all economic statistics. When it is released each month, it is often the lead item in news bulletins and is reported widely in the national press. Its prominence is a consequence of its widespread use as a key input to important economic decisions such as setting interest rates and its use in adjusting benefits and allowances.

Producing the CPI every month is a considerable task, which is the responsibility of the Prices Division within the UK Office for National Statistics. Ideally, every transaction for every good and service in the UK would be captured over the month and an average of the price paid across all these transactions would be taken. This is, however, clearly not possible, and hence a sample of prices of goods and services is taken instead. The UK Office for National Statistics constructs a representative

[2] See http://www.ons.gov.uk/ons/rel/cpi/consumer-price-indices/september-2013/stb---consumer-price-indices---september-2013.html

Table 1.2 CPI values, 1- and 12-month inflation rates: September 2012–2013, United Kingdom.

		Index (UK, 2005 = 100)	1-Month rate	12-Month rate
2012	Sep	123.5	0.4	2.2
	Oct	124.2	0.5	2.7
	Nov	124.4	0.2	2.7
	Dec	125.0	0.5	2.7
2013	Jan	124.4	−0.5	2.7
	Feb	125.2	0.7	2.8
	Mar	125.6	0.3	2.8
	Apr	125.9	0.2	2.4
	May	126.1	0.2	2.7
	Jun	125.9	−0.2	2.9
	Jul	125.8	0.0	2.8
	Aug	126.4	0.4	2.7
	Sep	126.8	0.4	2.7

Source: Office for National Statistics.

'basket' of goods and services and records the prices of these items from a sample of geographical locations and from a sample of shops within these locations. The sample is constructed to represent the range of shops and locations in a 'fair' way. The basket consists of about 700 representative goods and services and about 180 000 prices of these items are captured every month. More information on how the CPI is calculated is given in Chapter 8.

It is interesting to note here that the value of the general level of prices is not a particularly useful statistic and is not published; it is the rate of change that is the statistic which is important. Of course, we could look at the price level of the basket and how it changes over time; however, it contains such a variety of goods and services that it would be difficult to interpret.

Regarding the CPI, it is not just the headline figure of the rate of inflation for the UK for all goods and services that is of interest. The inflation figure is made up of changes in the costs of different types of goods and services and their price movements are different. The following graph shows the index numbers for four types of goods and services for a 2-year period, where the index numbers have been scaled to be 100 in September 2011.

Figure 1.1 shows that the variations in prices of different types of goods and services are different. For example, there has been a greater rise in prices for 'Alcoholic Beverages and Tobacco' than for 'Transport' for most time periods. The solid black line shows the all-items index series, which is a combination of index series covering 12 types of goods and services (only four types are shown in Figure 1.1), and so the movement of the overall index series is an 'average' of the variations in the 12 index series for more specific categories of goods and services. Note that it is not just the

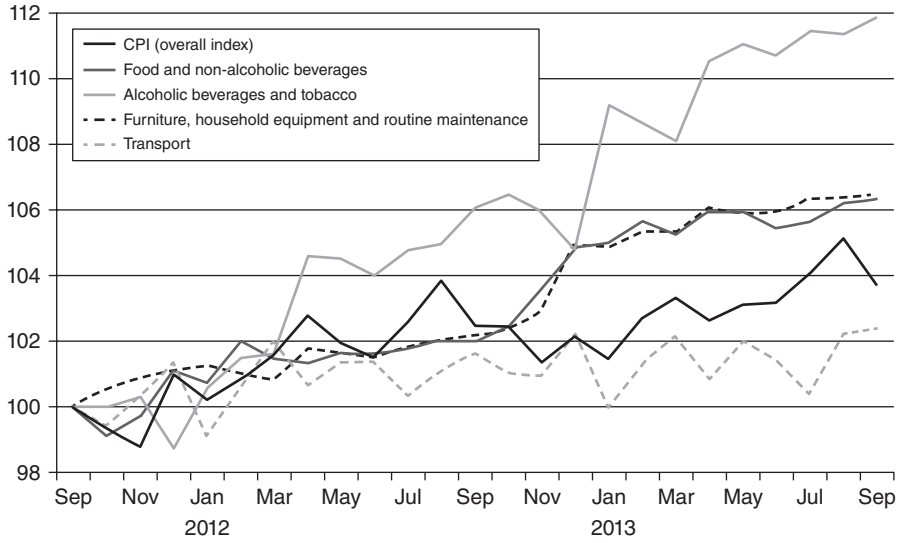

Figure 1.1 UK Consumer Prices Index and selected sectors, September 2011–2013. Source: Office for National Statistics (http://www.ons.gov.uk/ons/rel/rsi/retail-sales/july-2013/tsd-retail-sales--july-2013.html).

overall, or the 'all-items' CPI index number series, that is useful; each of the component index number series is also valuable. In addition, depicting the component series as index numbers makes comparison of their movements clearer; if the figure had shown the price levels, they would be much more difficult to compare.

The index numbers in the all-items CPI are not a simple average of the index numbers of the 12 sub-categories; they are combined using the proportion of consumer expenditure on each type of commodity to give a 'weight' to each sub-category. Table 1.3 shows the 12 categories and the weights assigned for the year 2013; these weights are revised every year in line with other information collected by the UK Office for National Statistics, which looks at the spending patterns of UK households. Weights are applied so that the variations in the component series are combined in a 'fair' way to produce an overall variation in the level of prices.

Having seen some examples, we are now ready to consider a definition of an index number. One of the most famous definitions was given by the economist Irving Fisher (1867–1947), who was highly influential in the development of index numbers as a subject and in economics in general. He established his own index number institute as a business that sold economic data in index number form, long before governments became the main suppliers of index numbers [1]. He stated that:

> The fundamental purpose of an index number is that it shall fairly represent, so far as one figure can, the general trend of the many diverging ratios of which it is composed.
>
> (Fisher [2])

Table 1.3 Weights for categories of goods and services in the CPI 2013, UK.

	Parts per 1000
01 Food and non-alcoholic beverages	95
02 Alcoholic beverages and tobacco	38
03 Clothing and footwear	60
04 Housing, water, electricity, gas and other fuels	244
05 Furniture, household equipment and maintenance	52
06 Health	23
07 Transport	128
08 Communication	26
09 Recreation and culture	123
10 Education	18
11 Restaurants and hotels	103
12 Miscellaneous goods and services	90
	1000

Source: Office for National Statistics (www.ons.gov.uk/guide-method/user-guidance/prices/cpi-and-rpi--updating-weights/2013.pdf).

How well does this definition apply to the CPI example? Firstly, the CPI price index numbers summarise the differing movements of the prices of constituent goods and services into one overall index series. Secondly, it is a fair measure in the sense that the price movements are weighted by the expenditure shares of each type of good and service.

1.3 Example – FTSE 100

The FTSE 100[3] is one of a wide range of stock market indices produced by the FTSE Group. It is an index of the share prices of the top 100 UK companies as measured by market capitalisation. It was first produced in 1984 when the index value was set to 1000 and since then, it has not been re-scaled; its current value is more than 6700.[4] The index is updated every 15 seconds during trading hours. The share price for each company is weighted by a factor involving the size of the company as measured by the market capitalisation (the total value of shares).

How does this index fit in with Irving Fisher's definition? The index certainly summarises a great deal of share information, where the movement of each share is different. It is fair in the sense that each individual share price movement is weighted by a factor that includes the market capitalisation of the company. The index was not initially set to 100; instead it was set to 1000. However, there is no strict need to take an initial value of 100; it is just a convenient value. In a similar way, the index value has reached above 6000, a significantly larger number than the initial value.

[3] See http://www.londonstockexchange.com/exchange/prices-and-markets/stocks/indices/summary/summary-indices.html?index=UKX

[4] At the end of July 2014.

Table 1.4 Multidimensional Poverty Index dimensions, indicators and weights.

Dimension	Indicator	Weight
Health	Child mortality	1/6
	Health	1/6
Education	Years of schooling	1/6
	Child school attendance	1/6
Standard of living	Electricity	1/18
	Drinking water	1/18
	Sanitation	1/18
	Flooring	1/18
	Cooking fuels	1/18
	Assets	1/18

1.4 Example – Multidimensional Poverty Index

For an indicator such as inflation, we are combining together quantities of the same type, which are price changes for goods and services. This process is called aggregation and provides an overall, summary measure of the change in the general level of prices. This index number concept of summarising changes has been applied to wider uses where a single summary measure is created from different quantities having different units to give what is known as a 'composite indicator'.

To illustrate the concept of an index number as a composite, we consider a measure of poverty. The Multidimensional Poverty Index is a measure of acute poverty produced by the Oxford Poverty and Human Development Initiative (OPHI, Oxford [3]). It combines a number of deprivations that an individual may experience at any one time to provide a comprehensive measure of extreme deprivation.

The measure is composed of dimensions, indicators and weights, which are summarised in Table 1.4.

To produce a numerical score, criteria are applied to each indicator; the resulting scores are then combined into an overall poverty measure.[5] This facilitates the comparison of poverty scores across countries and regions and also across time.

1.5 Example – Gender Inequality Index

A second example of an index number, as a composite measure, is provided by the Gender Inequality Index, produced by the United Nations as part of the United Nations Development Programme.[6] It is a measure of the inequality in achievement by men and women and is calculated every year; in 2013, it covered 187 countries.

[5] See http://www.ophi.org.uk/

[6] United Nations Development Programme, Gender Inequality Index, http://hdr.undp.org/en/content/gender-inequality-index-gii

Table 1.5 Gender Inequality Index, dimensions and indicators.

Dimension	Indicator
Health	Maternal mortality ratio
	Adolescent birth rate
Empowerment	Parliamentary representation
	Attainment at secondary and higher education
Labour market	Labour market participation

Of course, 'gender inequality' is not a quantity that can be measured directly. A numerical score for this concept is constructed by specifying and measuring attributes of gender inequality, which experts consider to be relevant and which have a resonance with the general public. The Gender Inequality Index has three dimensions and five indicators (Table 1.5).

For each country, a numerical value is assigned to each indicator and the values are combined into a single overall score.[7] The scores for each country can be ranked to identify which countries display the most and which display the least gender inequality. The figures for 2013 show that European countries tend to display small values of gender inequality while African countries mostly show the highest values.

1.6 Representing the world with index numbers

Although the methodologies behind all aggregates and composite indicators are disputed to a degree, those in the social, political and medical domains attract greater attention to the judgements made in order to construct index numbers. As a result, commentators have expressed concern about their validity and have suggested that we should treat them with a degree of scepticism. As the number of indicators has increased along with the experience of using them, there has been much academic work to identify the best practice in the design and construction of such indicators [4]. For example, it is important that the theoretical background to a measure is based on solid scientific research and evidence; this will result in a robust mathematical model to link the aspect of the world being examined to the factors that influence it. In addition, the data used in the indicators need to be measured in an accurate manner.

The construction of indicators, whether social, medical, political or economic, follows the same overall structure: an indicator is constructed from raw or processed data combined in accordance with a model of the aspect of the world being considered. It might be thought that a measure such as CPI does not require a theoretical framework; however, as Chapter 8 will show, there is much discussion over the theoretical basis of a measure of inflation.

[7] United Nations Development Programme, Table 1.4. http://hdr.undp.org/en/content/table-4-gender-inequality-index

For composite indicators constructed to measure subtle, abstract quantities, there are both positive and negative aspects. On the positive side, they can summarise complex phenomena in a single index number to support communication and policy making. With a time series of such measures, an assessment of the progress (or the lack of it) can be made. On the negative side, they can lead to a simplistic representation of complex phenomena, which can then lead to inappropriate policy decisions. A poor model and/or poor data will result in a poor indicator. The weighing of different components is a particularly difficult topic.

1.7 Chapter summary

Although many important phenomena are difficult to measure, the advantages of a numerical representation are significant. Policy makers frequently want to allocate limited resources to achieve the highest impact and they want a means to assess the impact of policy decisions. This need for quantification of an ever wider range of aspects of the world has led to an increasing number of indicators being devised and this trend will surely only continue. An optimistic view of the future would suggest that as our experience with using such indicators grows, so will our ability to develop better quality measures.

References

1. See Vogt, A., Fisher, I., and Barta, J. (1997) *The Making of Tests for Index Numbers: Mathematical Methods of Descriptive Statistics: Published in Honour of the 50th Anniversary of the Death of Irving Fisher*, Physica-Verlag, Heidelberg.
2. Quote from Fisher, I. (1922) *The Making of Index Numbers: A Study of their Varieties, Tests, and Reliability*, Mifflin, Boston, MA. Californian Digital Library, https://archive.org/details/makingofindexnum00fishrich (accessed 16 January 2015), p. 10.
3. See University of Oxford (2014) Oxford Poverty and Human Development Initiative, http://www.ophi.org.uk/research/multidimensional-poverty/ (accessed 13 January 2014).
4. See OECD, JRC, European Commission, OECD, Joint Research Centre, European Union, and Source OECD (Online service) (2008) *Handbook on Constructing Composite Indicators: Methodology and User Guide*, Organisation for Economic Cooperation and Development (OECD), Paris. http://www.oecd.org/std/42495745.pdf