FACTFILE:
GCE ECONOMICS

AS2 INDEX NUMBERS & INDICES

Rewarding Learning

Index numbers and indices

Learning outcomes

Students should be able to:
- calculate and interpret index numbers in relation to inflation and other areas
- calculate retail prices indices and understand the significance of weights

Students should be able to:
- calculate and interpret a basic trade-weighted exchange rate index

How will the topic be tested?

Questions involving understanding, illustration and interpretation of indexation may take the following forms.

Section A or B
- Calculations of (or based on) an index
- Questions on the interpretation of specified indices.

Section C
You may need to:
- explain aspects of a price index or
- (at A2 2) explain aspects of an exchange rate index, or
- make judgements about how useful a particular index may be or
- decide which of a choice of indices is better suited for different purposes.

Index numbers are values expressed in percentage terms

An **index number** is a simplified presentation of data so that it's easier to make comparisons over a period of time. It is based on calculations in terms of percentages. At the simplest level, compare the sets of information below.

The United Kingdom's estimated output of carbon dioxide (CO_2) in 2013 was 467.5 million tonnes. For 2014 the provisional estimate for CO_2 output was 422 million tonnes.

Recent estimates suggest that the United Kingdom's carbon dioxide output fell by 9.73% - almost a tenth - between 2013 and 2014.

A lot depends on what you are investigating, and to whom you are reporting.

A figure of 467,500,000 tonnes of carbon dioxide seems an enormous amount, but it may be quite creditably low in comparison to relative outputs of other countries. Without expertise in the science of climate change or environmental monitoring, the raw figures are not very useful. If what is important

is whether and how quickly emissions are changing the second set of information is more immediately relevant and understandable. If we were to add data about CO_2 output in other countries, the picture with tonnages alone could become even more blurred.

However, although comparisons in percentage terms may be more direct, simplification creates a big problem in interpretation.

Question: a pause for thought ...

In what way may the following table fail to deliver important information?

Country	change in CO_2 emissions since last year
R	-7.241%
S	-0.895%

The table seems to show much more environmental responsibility on the part of Country R than Country S. However, it gives us no idea how much carbon dioxide either country had been producing, nor how big their relative contribution has been to atmospheric pollution. Country S may have a long and distinguished record of reducing emissions, and so find it increasingly difficult to achieve further significant reductions. If Country R has been a long-time polluter, under pressure because of new treaty commitments, its improvement might not be quite as impressive as unqualified percentages suggest.

Comparisons in percentage terms make more sense the more we know about what's being compared.

A basic index

Once we've established that UK CO_2 emissions are down in 2014 in comparison with 2013, we can express that change in a different way. The United Kingdom's level of CO_2 output in 2014 is, to two decimal places, 90.27% of what it was in 2013.

That's what an index number is. It's a percentage of a total in some other period, written without the "%" sign. Specifying when that other period is or was is very important. Using the information so far we can construct a single-row index table:

Year (Base 2013 = 100)	CO_2 index value
2014	90.27

For every period afterwards - or before, if we need to make comparisons further back - the percentage change is calculated **in terms of the base year value.**

Extracting data from an index

If you are told that the value of our UK carbon dioxide emissions index for 2012 is 101.41, you should say that the value was 1.41 index points higher than in the base year. Be careful to get into the habit of using this vocabulary; don't worry if you find the explanation why (later) too difficult. In this case we know that 2012 CO_2 output was a little more than a hundred and one hundredths (101.41/100) of the 2013 value.

$$\text{UK } CO_2 \text{ emissions in 2012} = \frac{\text{UK } CO_2 \text{ emissions in 2013}}{100} \times 101.41$$

Now calculate, to one decimal place, how many million tonnes of CO_2 were produced in the UK in 2012.

As long as you don't allow panic in exam conditions to put you off, you should realise that you already do have a rough idea of how the answer should look before you put any figures into a calculator. Let's convert everything into easier numbers.

- 2013 output isn't all that much more than 450 million tonnes
- 2012 output was almost exactly between 1% and 2% higher than that
- the figure we're looking for must be 4½ to 9 million tonnes more than in 2013
- expect the answer to be more than 470 million tonnes
- understand that an answer more than 477 million tonnes must be wrong.

UK CO_2 emissions in 2012 = (467.5m tonnes × 101.41) ÷ 100 ≈ 474.1 million tonnes

Optional: why we can't express next year's change simply in percentage terms?

These notes are being written near the end of 2015, so we don't and won't for a while have accurate information on the quantity of carbon dioxide produced in the UK during the year. That leaves us free to pick a convenient number. So, suppose that the rate of decrease slows, but is still respectable at exactly five per cent.

That is 5% of what it was in 2014, but remember that we are measuring change in terms of what the value was in 2013. We'd calculate change in tonnage for 2015 as:

Reduction in CO_2 = (422 million tonnes × 5) ÷ 100 = 21.1million tonnes

UK CO_2 output in 2015 = (422 -21.1) million tonnes = 400.9 million tonnes

A 5% change from one year to the next is not the same as a 5% change in the index. In fact, a reduction to 400.9 million tonnes will reduce the index by 4.52 points.

How to we convert between raw data and index numbers?

On our index, we now have to show what the 2015 output (400.9 million tonnes) is as a percentage of the base period. That is (400.9 million × 100) ÷ 467.5 million. Do this calculation and complete the table below:

Index of CO_2 output (base year 2013 = 100)	
Year	**Index value**
2012	101.41
2013	
2014	
2015	

From time to time, **indices** - (the word "indexes" **isn't** incorrect, but in most textbooks and exams 'indices' is the plural form of 'index') - need to be updated, but there's no reason why the base year can't be part of a series.

Summing up

To convert a raw value for year 'y' into an index number,
(value in year 'y' × 100) ÷ value in base year

for example;
CO_2 index value for 2014 = (422m × 100) ÷ 467.5 = 90.27

To find actual figures for year 'y' from index values,
(Base year actual figure × index value for year 'y') ÷ index value for base year

for example,
CO_2 output in 2014 = (467.5 million× 90.27) ÷100 ≈ 422.0 million

The missing values in the table are 100, 90.27 and 85.75

There's more to it than that, though

The main indices you will be using in the GCE Economics don't refer to anything as simple as a change in a single figure for production of something, whether desirable, like a consumer good, or undesirable, like air pollution. It's all very well to talk in vague terms of an 'average level of prices', but whatever that might be as a quantity is almost certainly meaningless to nearly everyone. The statement, "The average level of prices in the UK has risen by two per cent in the last twelve months" is understandable. No-one needs training in Economics to get the idea. However, no economist could answer a question such as "What is the average price in the UK?" Yet unless we measure prices and price changes, we can never get a clear understanding of whether they are changing too fast for the health of the economy.

One last theoretical idea, (but it's a lot of questions and no answers yet)

A vital point about the illustration you have been working through so far is that figures on carbon dioxide alone don't give a full picture about air pollution.

The UK government signed up to the Kyoto Protocol, agreeing to reduce output of various 'greenhouse' gases. A reduction of nearly 10% in carbon dioxide last year sounds good, but what if there has been more methane or nitrous oxide released into the atmosphere? Wouldn't a proper pollution index need to include changes in other emissions ? How do we work out the relative importance of different emissions? Article – COP 21: UN climate change conference | Paris

Measuring inflation in the United Kingdom

The Office for National Statistics (ONS - www.ons.gov.uk) describes itself: "We are the UK's national statistical institute and the largest producer of official statistics in the UK. We are also the only government department with the production of statistics as its main role. We are independent of ministers and instead report through the UK Statistics Authority to Parliament and the devolved administrations of Scotland, Wales and Northern Ireland."

ONS statistics for the Consumer Prices Index and the Retail Prices Index.

The Consumer Prices Index (CPI) is the main official instrument for measuring inflation in the UK. In agreement with authorities in the European Union, the UK adopted this measure in 2003. Since it is the standard way of measuring inflation throughout the EU, it makes comparison with other member states more accurate. You should be able to calculate the rate of inflation as measured by the CPI after reading page 3, even without knowing how the Index is constructed.

The table below is extracted from the ONS's 'Statistical Bulletin' of 15 October 2013. Calculate the rate of inflation for the period September 2012 to September 2013.

CPI index values (UK, 2005 = 100)	
Period	**Index**
September 2012	123.5
September 2013	126.8

In the period running up to late 2015, inflation has been consistently very low, as can be judged from the fact that the value for September 2015 was only 128.2.

The Retail Prices Index (RPI) is an older system, still calculated even though the ONS 'de-designated' it in August 2015 - (the measure as originally calculated is no longer fully trusted): Office for National Statistics - Consumer Price Inflation: August 2015. Reasons for this involve complex maths will be briefly outlined later.

A great deal of historical data is in the RPI format, and the government has made commitments to refer to it in certain circumstances. The way it is compiled is easier to explain as a starting point for understanding the CPI (see below). RPIJ still is a national statistic; it measures basically the same forms of consumption, for the same groups of consumers, as RPI, but uses the more statistically-respectable techniques that the CPI does (The 'J' is just the initial of the name of the mathematician whose formula for 'weighting' price changes CPI and RPIJ use.)

The rate of inflation in the year from September 2012 to September 2013 was 2.67%

How is a Retail Prices Index calculated?

ONS employs researchers who conduct interviews in "average" households. They do not investigate the budgets of the highest- and lowest-earning households. From results of these surveys, statisticians construct a "basket" of goods and services which are consumed by this sample of UK households. Items include things that might be found in a real shopping basket, such as tea and washing powder, but also furniture and laptops, pub snacks and holiday costs and such services as home insurance, car repairs, and Internet service provision. As well as finding out what people consume, it is very important to find out how much of people's budgets are taken up with each category of consumption. The prices of the items in the "basket" are regularly monitored - in a variety of locations and from a variety of providers nationwide. Changes in these prices are averaged to produce an estimate of the rate of change in prices throughout the whole economy each month.

Weight

The ONS uses an example of petrol and tea. For most households, a 10% increase in the price of tea will not have nearly as much impact as a 10% increase in the price of petrol. Most people spend much more money each month on petrol. In the official classification for the RPI, there are fourteen groups of items in the basket, each of which is given a weight which reflects the proportion of the average household's spending allocated to that type of consumption.

For our purposes now, it is simpler to combine some groups.

Note, however, that this simplification cuts down on detail - for example, in the first combined category there is no mention that it includes expenditure on tobacco, which still accounts for almost 3% of the average household budget.

What this column contains: an unofficial, simplified version of the groups into which the ONS classifies goods and services bought by consumers in the United Kingdom	**What this column contains:** the approximate percentage of its spending the average household is expected to allocate to each consumption category during 2015
Consumption category	**Weight**
food and drink	24
housing, heating, furnishing	43
clothing and footwear	4
transport	14
leisure and personal spending	15
total	100

Because inflation has been running at such a low level since 2013, it is easier to illustrate 'weighting' using invented figures rather than real data. In an economy, weights of various categories of consumption are as shown in the table. During the year 2018, prices in various categories of consumption change as follows:

Consumption category	**Percentage price change 31/12/2017 – 31/12/2018**	
A	food and drink	+9%
B	housing, heating, furnishing	+6%
C	clothing and footwear	-12%
D	transport	-1%
E	leisure and personal spending	+6%

Another pause ...

Before you read on ... are you able to explain why the increase in prices of leisure and housing expenditure will not be cancelled out by the decrease in prices of clothing and footwear?

How weights are applied

As with tea and petrol, it should be clear that the 6% rise in housing prices will hurt nearly everybody more than the same increase in prices of leisure. This different impact is accounted for by expressing each price change in a slightly different form.

- Food and drink prices at the end of 2018 are 109% of what they were at the end of 2017.
- People allocate nearly a quarter of their spending to food and drink, so nearly a quarter of what they consume goes up in price by 9%.
- A simple way to account for this is to multiply each new price burden by its respective weight.
- By working out a weighted average of the changes in price, we make a more accurate assessment of their effect.

The first five values in the right hand column of the table have been calculated by multiplying figures for modified prices by 100, so their total must be divided by 100 to calculate the overall effect. Prices generally at the end of 2018 are 105.02% of what they were at the end of 2017.

This RPI method has measured inflation in that economy during 2018 at 5.02%

Consumption category	Weight	2018 price as a percentage of 2017 price	Column 2 × Column 3
A	24	109	2616
B	43	106	4558
C	4	88	352
D	14	99	1386
E	15	106	1590
total	**100**		**10502**

Differences between Consumer Prices Index and Retail Prices Index

- Spending patterns surveys for the CPI are much more inclusive
  – the whole population is sampled, not just the middle income ranges.
- The "baskets" for the two indices differ. Only RPI includes mortgage repayment costs, house insurance premiums, local rates (council taxes) and 'road tax'. Included in CPI and not RPI are fees charged for management of people's personal investments and various fees associated with university education.
- Weights in the RPI are reviewed annually; CPI weighting is adjusted automatically, because price changes themselves cause changes in consumption.
- The indices use different ways of calculating the mean. RPI uses an arithmetic mean. This is less suitable when comparing dissimilar items and trends than the geometric mean used in the CPI but less difficult for a non-expert to calculate.

Arithmetic means are derived from the sum of a series of figures, divided by the total number of figures in the calculation... so, the arithmetic mean of 2, 4 and 8 = (2 + 4 + 8) ÷ 3 = 4.666

Geometric means multiply together a series of figures and then compute the appropriate root of that product. With two figures it is a square root, with three a cube root, and for a series of twenty numbers, it would be the twentieth root ... so, the geometric mean of 2, 4 and 8 = $\sqrt[3]{(2 \times 4 \times 8)} = \sqrt[3]{64}$ = 4 ... [4 × 4 × 4 = 64]

- Because of the last two points a CPI calculation of the same raw data would result in a lower figure than an RPI calculation: (weights may be revised downwards as soon as prices increase and CPI geometric mean values tend to be lower.)
- You may check all this at:

Consumer Price Indices – A brief guide

Summary

- An index simplifies comparisons into terms of percentages
- The Consumer Prices Index measures inflation in the UK
- CPI is a measure which conforms to international standards
- The UK Government still needs RPI for some purposes
- All price indices involve "weighting" because all the price changes they take account of are not equally important
- Changes from one year to another aren't in 'percentage' terms
- In an exam you may be asked to construct a simple index
- As further reading you should research some of the limitations of price indices as measures of inflation

Exchange rates: a context

The exchange rate for a country's currency may fluctuate for a number of reasons. These include but are not confined to

- that country's balance of payments situation
- its rate of inflation relative to other countries
- the prevailing rates of interest in the country's financial markets and
- the expectations of international speculators as to what is most likely to happen in that country next.

In a complicated world, not all these variables are necessarily moving in the same direction at the same time, so it is possible for the UK pound (£) to be growing stronger against the euro (€) the same time as it is weakening against the dollar ($).

Reminder

A strong £ means UK holiday-makers - (this is the classic illustration!) - would find sun loungers and excursions relatively cheaper, but British exporters might be adversely affected as their customers find goods produced in the UK relatively more expensive.

A trade-weighted exchange rate index

Suppose you're looking at a text page on television (for example, page 240 on BBC) with a long list of currencies and the rate at which they exchange for the £ that day.

Now imagine how difficult it would be to assess whether the £ was in a stronger or weaker position than the day before from that information alone. That, of course is where an index once more proves useful. As we have already established, it will be very important that the measure takes account of how important each currency is in terms of the impact of a change in its value on the UK economy.

The actual UK index is based on the effective exchange rate of sterling in January 2005. Thus the base of the index is stated as "January 2005 = 100". The Bank of England records trade flows of money in and out of the UK. There are about 50 individual countries which each account for a significant enough percentage of Britain's trade to have their currencies weighted. Obviously, when we leave some of these out to simplify calculations, we distort the true weights of those more important trading partners left.

For that reason, although the weights in the illustration which follows are based on the most recently updated weights and are relatively proportional to each other, these are not the real weights used to calculate the sterling exchange rate index.

Also, Switzerland and Japan are not the fourth and fifth most important nations in terms of UK trade. Fellow-members of the EU - Belgium/Luxembourg, France, Ireland, Italy and the Netherlands - are all higher up the list, and Germany, in fact, is the UK's second most important single trading partner after the United States.

However, these six European states are grouped together in the weightings as the most important element in the United Kingdom's trade in late 2015 – Eurozone.

Trading patterns change over time; the ERI weight for Japan in 1995 was 8.0. China's weighting was only 1.6. in 1995. This information was compiled from Article – Annual reweighting of the sterling ERI using the table "Sterling ERI weights (published 11 March 2015)".

trading partner	China	Eurozone	Japan	Switzerland	USA
notional weight	11	60	4	5	20
currency	yuan renminbi (CNY)	euro (€)	yen (JPY or ¥)	Swiss franc (CHF)	dollar (US$)

Questions set in 'A' level examinations are likely to feature similarly distorted or perhaps totally fictional weightings.

The table below shows the value of the pound sterling (UK£) in terms of each of the currencies above at a 12 month interval.

Value of UK£ in terms of:	as of 1 Nov 2014	as of 1 Nov 2015
CNY	9.78	9.76
euro (€)	1.27	1.40
JPY (¥)	179.66	186.05
CHF	1.54	1.53
US$	1.60	1.54

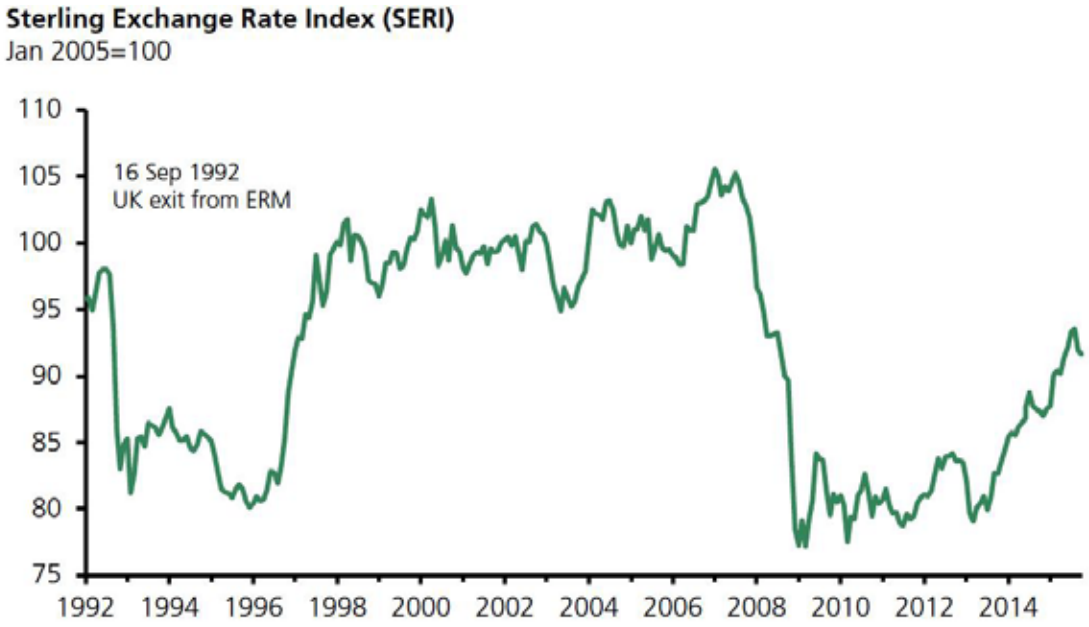
Over the period of twelve months, the pound gained in value against the euro and the yen, and fell in value against the other three currencies. To compare the change in its value in percentage terms against any of these currencies we would need to divide the second number by the first and multiply by 100.

Currency	Exchange rate for £ as a percentage of value one year earlier	Weight	column 2 × column 3
CNY	99.80	11	1097.80
euro (€)	110.24	60	6614.40
JPY (¥)	103.56	4	414.24
CHF	99.36	5	496.80
US$	96.25	20	1925.00
change in effective exchange rate of UK£	([total in column 4] ÷ 100) - 100		+5.48%

The official Exchange Rate Index for Sterling is compiled and published by the Bank of England. At the time of writing these notes, the index value was 93.7, found at Article – Published Material on Foreign Exchange Markets

Finally, parts of a House of Commons Library publication of 3 November 2015 Exchange rates: Key Economic Indicators are reprinted below:

The Sterling Exchange Rate Index (SERI) measures sterling's value against a 'basket' of currencies, 'trade-weighted' (based on currencies' relative importance in UK trade). The SERI fell by 0.3% in October 2015. Compared with the same period a year ago, it is 4.9% higher. It is currently 18.6% above its March 2009 level, when it was at its lowest point since the series began in 1980. It is 13.2% below its pre-recession peak in July 2007.



Note that the value illustrated at the right edge of the chart is close to the figure of 93.7 quoted at the foot of page 8, and that the year-on-year change figure (+4.9%) quoted in the text is very close to the approximation calculated in our illustration.

The external purchasing power of the UK£ is about 6% lower than at the base date (2005) of the index, but is about 20% stronger than during the financial crisis years.

Revision Questions

If you are asked to construct a price index from data supplied, you will not be required to calculate geometric means, and the weights supplied will be assumed not to change. Questions involving construction of a price index may not necessarily use real data and will follow the pattern of the Retail Prices Index on pages 5 and 6. ERI calculations will be no more intricate than those illustrated on page 8.

1 The table shows Gross Disposable Household Income (GDHI) per head, 2013. The average of the four income totals for each member country of the United Kingdom is £16160.

Explain why £17559, and not £16160, is the average UK GDHI.

Region	GDHI per head (£)
England	17842
Northern Ireland	14347
Scotland	17039
Wales	15413
United Kingdom	17559

2 The numbers of people aged 16 and over unemployed in the United Kingdom during the same quarter in recent years are shown in the table below. The table shows approximately 2,510,000 people unemployed in 2012.

Construct an Index of UK Unemployment (base period Jul-Sep 2012 = 100)

time period	unemployment (millions)
July - September 2010	2.45
July - September 2011	2.62
July - September 2012	2.51
July - September 2013	2.47
July - September 2014	1.96
July - September 2015	1.75

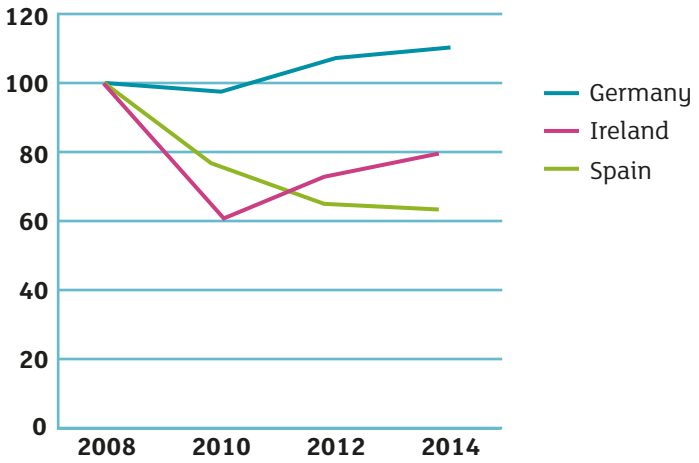
3 Rates for the type of unemployment illustrated above are calculated by dividing the number of people in the 16 to 64 age-group by the economically active population in that same age-group and multiplying by 100. The unemployment rate for the base period, (July to September 2012) was 7.9%.

Explain why it is not possible to use the data above to make accurate comparisons of unemployment rates.

Revision Questions

4 The diagram below shows changes in gross investment expenditure in three member countries of the European Union between 2008 and 2014.

Compare the trends in investment expenditure in Germany, Ireland and Spain during the period shown in the diagram below.



© Data from European Union 1995-today. / Graph © CCEA

5 Statisticians in a particular country have identified five broad categories of consumer expenditure. The table below shows weights of these categories, based on the percentage of each household's spending allocated to each category and the percentage by which average prices in each category have changed in the past twelve months. Twelve months ago the country's Index of Retail Prices stood at 150.00 (Base year, 1996 = 100)

(a) Using the data below, calculate the rate of inflation during the past year.
(b) Adjust the price index to show its current value.

consumption category	weight	change in price since this time last year
food and drink	20	+2%
housing, heating, furnishing	30	+5%
clothing and footwear	10	-7%
transport	25	-2%
leisure and personal spending	15	+6%

Revision Questions

6 The following table shows an exchange rate index for a country's currency, the couronne, based on a basket of currencies of countries with which the country trades, and weighted according to volumes of trade.

(a) Calculate the change in the external purchasing power of the couronne,
   (i) between 2012 and 2013, and
   (ii) between 2014 and 2015

(b) Briefly explain the effect the change between 2014 and 2015 may have on customers of this country's exports.

couronne exchange rate indes, 2001 = 100	
Year	Index value
2012	95.00
2013	85.50
2014	84.00
2015	88.20