(ii) Deriving constant price estimates of GDP: An illustration of chain-linking

1. Introduction

The Office for National Statistics[1] estimates that for 2006 the total expenditure on goods and services produced by firms within the United Kingdom was approximately £1,290 billion which is £1.29 trillion. We better know this expenditure as Gross Domestic product or GDP. It involves expenditure by households, firms and government in both the UK and overseas. In 2005 the UK's GDP is estimated at approximately £1,226 billion or £1.23 trillion. This means that GDP increased between 2005 and 2006 by approximately £64 billion. This is an increase of 5.2%[2].

The increase of 5.2% in the total *value* of expenditure on goods and services produced within the UK does not mean that the *volume* of goods and services consumed increased by 5.2%. Yet, as economists we often want to comment on whether we are producing and consuming ever greater quantities of goods.

Amongst the ways in which it is possible to measure our standard of living is to look at the production or consumption of goods per person. But, total expenditure depends not only on the quantities of goods and services purchased, but also the prices charged. So if we want to compare the volume of demand for a country's goods and services over time then we have to control for price changes. Looking across the whole range of goods and services we produce, this means controlling for rising prices.

In this case study we look at how by using a technique called *chain-linking* economists are able to make inferences about the volume of goods and services consumed.

The need for a technique to make meaningful comparisons about the volume of output is apparent when one bares in mind the sheer variety of what is produced. Chain-linking involves fixing the prices of different categories of goods and services at a moment in time. To undertake chain-linking requires information about the *expenditure* on groups of commodities and their *price* levels. This is used to produce a constant price series for items of expenditure before being aggregated to produce a constant price series of GDP. This series is also referred to as real GDP.

2. Illustrating chain-linking

The approach adopted to generate a volume series for an item of expenditure is called chain-linking. To illustrate annual chain-linking we will consider how constant price series for two items of household consumption are compiled.

In practice, this process has to be repeated for the remaining consumption by households, the consumption by firms and government, and for the consumption of British goods and services by foreigners. Finally, a constant price series is created for imports consumed by British households and firms and by the UK government. Import expenditures are then subtracted in order to derive the constant price estimate for GDP.

Table 1 displays information relating to expenditure by households in the UK on fruit and vegetables. In 2003 the expenditure by households in the UK on fruit was £4,752 million (£4.752 billion), while that on vegetables was £8,595 (£8.595 billion).

[1] National Statistics Online can be accessed at http://www.statistics.gov.uk/

[2] =64,000/1,226,000 *100

Table 1: Expenditure, £m, and price relatives, fruit and vegetables

Year	Exp on fruit	Price relative for fruit	Exp on vegetables	Price relative for vegetables
2001	4,242	1.0847	8,418	1.0901
2002	4,489	1.0106	8,473	0.9836
2003	4,752	1.0154	8,595	1.0238
2004	5,109	0.9652	8,739	0.9871

Source: Consumer Trends, Office for National Statistics and Author's Calculations

Adjacent to the expenditure figure for fruit and for vegetables is a figure known as the *price relative*. The price relative measures the price level this year relative to the price level last year, P_t/P_{t-1}. If it exceeds 1 then the price level this year is greater than last year. A price relative of less than 1 indicates that the price level has fallen. A price relative of 1 indicates that the price level has not changed.

From Table 1, we observe that in 2003 the price of fruit was 1.0154 times that in 2002, so that the annual rate of price inflation for fruit was 1.54%. In 2003 the price of vegetable was 1.0238 times that in 2002, so that the annual rate of price inflation for vegetables was 2.38%.

For each year we can re-calculate the expenditure on vegetables and on fruit based on the prices levels of the previous year. For instance, we can calculate 2002 expenditures at 2001 prices and 2003 expenditures at 2002 prices.

To do this we simply divide the most recent expenditure, E_t, by the price relative. We can write this as

(1) $$\frac{E_t}{P_t / P_{t-1}}$$

Consider again 2003. To re-calculate the expenditure on fruit and on vegetables at 2002 prices we divide the expenditure totals for 2003 by the price relatives. Hence, the expenditure on fruit in 2003 at 2002 prices is calculated as £4,752m/1.0154, which is £4,680m. The expenditure on vegetables in 2003 at 2002 prices is calculated as £8,595/1.0238, which is £8,395m.

By holding prices at their 2002 levels we can calculate the percentage change between 2002 and 2003 in the *real expenditure* on fruit and on vegetables. This percentage change in constant price expenditure is our measure of the percentage change in volumes consumed. Since expenditure at constant 2002 prices for fruit increased by 4.26%[3] while falling by 0.92%[4] for vegetables, we can refer to the volume of food consumption having increased by 4.26% and the volume of fruit expenditure having fallen by 0.92%.

Table 2 overleaf completes the exercise of estimating constant and current price expenditures for both commodity groups. The figures in bold are current prices, while the figures to the left of these are expenditures at the previous year's prices.

[3] =((4,680-4489)/4489)*100
[4] =(8,395-8,473)/8,473)*100

Table 2: Expenditures at current and previous year's prices, £m

	2000 prices		2001 prices		2002 prices		2003 prices		2004 prices	
	Fruit	**Veg**	**Fruit**	**Veg**	**Fruit**	**Veg**	**Fruit**	**Veg**	**Fruit**	**Veg**
2001	3,911	7,723	**4,242**	**8,418**						
2002			4,442	8,615	**4,489**	**8,473**				
2003					4,680	8,395	**4,752**	**8,595**		
2004							5,293	8,853	**5,109**	**8,739**

Source: Consumer Trends, Office for National Statistics and Author's Calculations

We can now complete the exercise of comparing expenditures in the current year when price levels are held at those of the previous year with expenditure in the previous year. The results are shown in Table 3. These figures act as our estimates of the change in the volume of consumption.

Table 3: % change in constant price expenditures

	Fruit	Vegetables
2002	4.71	2.34
2003	4.26	-0.92
2004	11.38	3.00

The final step in chain linking is to generate a constant price series based on a single year's prices. This particular year is known as the *base year*. To do this we use the expenditure numbers for the base year and then apply the percentage changes in constant price expenditures.

Consider the case of generating a constant price series for fruit consumption at constant 2003 prices. Fruit expenditure in 2003 was £4,752m. We now wish to apply the percentage growth rates in Table 3. To see how we do this we need to recall the general formula for a percentage change. Let g_t be the percentage change in variable X from the last period, t-1, to the current period, t.

(2) $$g_t = \left[\frac{X_t - X_{t-1}}{X_{t-1}}\right]100$$

To apply percentage changes going *backwards* from the base year we need to rearrange the formula so that the subject is X_{t-1}

(3) $$X_{t-1} = \frac{X_t}{\left(1 + g_t/100\right)}$$

To apply percentages going *forwards* from the base year we need to rearrange the formula so that its subject is X_t

(4) $$X_t = X_{t-1}\left(1 + g_t/100\right)$$

Using (3) we can show that the expenditure on fruit in 2002 at constant 2003 prices is £4,558m

(5) $$\frac{£4{,}752\ m}{\left(1 + 4.26/100\right)} = £4{,}558\ m$$

Using (4) we can show that the expenditure on fruit in 2004 at constant 2003 prices is £5,293m

(6) $$£4{,}752\ m\left(1 + 11.38/100\right) = £5{,}293\ m$$

Table 4 completes this exercise for both fruit and vegetables.

Table 4: Fruit and vegetable expenditure, £m, constant 2003 prices

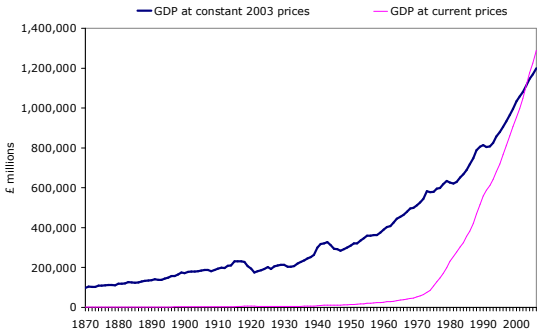
	Fruit	Veg	Fruit and Veg
2001	4,353	8,477	12,830
2002	4,558	8,675	13,233
2003	4,752	8,595	13,347
2004	5,293	8,853	14,146

3. UK GDP at current and constant prices

Constant price series are aggregated to derive constant prices series for household consumption, private and public investment, government final consumption, exports and imports. These in turn are aggregated to generate a constant price GDP series.

Chart 1 shows GDP at current and constant 2003 prices for the United Kingdom since 1870. The two series are equal in 2003 because the underlying price levels are those in 2003. The constant price series for GDP is therefore an estimate of what the value of GDP would have been if the prices of goods and services were those in 2003.

Chart 1: UK GDP, 1870-2006



Sources: (i) Feinstein, C.H., 1972. National Income, Expenditure and Output of the UK 1855-1965. Cambridge: Cambridge University Press (figures from 1870-1955); (ii) National Statistics (figures from 1955)
Note: Figures up to 1920 include Republic of Ireland.

The significance of the constant price GDP price series is that it shows that the volume of goods and services produced by British firms has increased over time. The value of GDP in 1870 at constant 2003 prices was £97.3 billion. By 2006, this had risen to £1,199.2 billion or almost £1.2 trillion.

We can measure the long-run growth of real GDP by calculating an annual compound growth rate.[5] This is the year-on-year rate of growth which accounts for the growth in output from the first year to the last year. It is calculated by subtracting 1 from the result of taking the nth root of the relative value in the final year, V, to that in the first year, A, where n is the number of years in the period being considered.

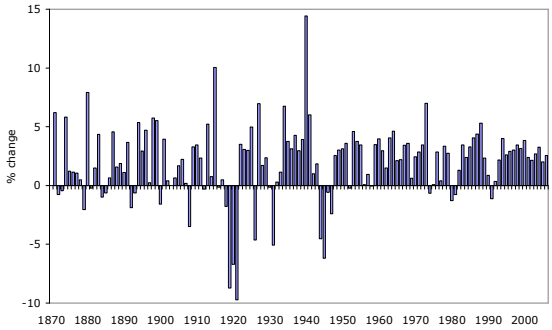
(7) $$g = \left(V \big/ A\right)^{1/n} - 1$$

By inserting the appropriate values into (7) we find that between 1870 and 2006 the volume of GDP in the United Kingdom grew at an annual rate of 1.86%.

(8) $$g = \left(£1{,}199.2b \big/ £97.3b\right)^{1/136} - 1 = 0.0186$$

However, the rate of output growth is not smooth. Chart 2 shows the percentage change in real GDP from year-to-year.[6] Despite the volatility over the period as a whole, we do observe a relative robustness and stability of growth after the early 1990s. Contrast this, for instance, with the period following World War I when the UK economy contracts sharply with annual falls in output approaching 10%.

Chart 2: Annual growth in real GDP, %



Source: Author's calculations using data from Chart 1

Tasks

The following is information from *Consumer Trends*. It details UK household expenditure on rail transport and its price relative, i.e. the ratio of the current price level relative to the previous year.

	Expenditure on rail services, £m	Price relative, P_t/P_{t-1}
2003	4,501	1.0121
2004	4,748	1.0431
2005	5,051	1.0468
2006	5,441	1.0449

Use this information to calculate

(i) Rail expenditure at constant 2003 prices

[5] In the case study '*Economic growth: What factors matter?*' some of the possible influences on long-run economic growth are considered.

[6] With annual data, the annual percentage change in real GDP is calculated as $\left(\frac{RGDP_t - RGDP_{t-1}}{RGDP_{t-1}}\right)*100$

(ii) Rail expenditure at constant 2005 prices
(iii) The annual growth rates for nominal and real rail expenditure