8

The UK macroeconomy

In this part of the book, we provide a description of the construction of a quarterly long-run structural macroeconometric model for the UK using the framework and the techniques set out in Chapters 3–7. The econometric methods employed are relatively straightforward to implement and our intention is to give a detailed account of the different steps involved in the modelling process, covering the specification, estimation and evaluation stages.

The model will be estimated over the period 1965q1–1999q4. This is a sample of data which is relatively reliable in the sense that it is now unlikely to be revised. We also consider some results obtained over a longer sample of data covering the period 1965q1–2001q1. This provides a useful means of investigating the robustness of the model to changes in the sample period and enables us to produce forecasts, in Chapter 11, which are relevant to policy-makers at the time of going to print. A postscript evaluation of point and event forecasts is also provided in Section 11.3. Before undertaking this analysis, however, in the remainder of this chapter, we provide an overview of the time series properties of the macrovariables included in the model.

The theory outlined in Chapter 4 motivates our choice of the variables to be included in the core model and suggests the appropriate measurements to be used. Hence, y_t is measured as the natural logarithm of UK real per capita GDP; p_t is the logarithm of domestic producer prices; $\tilde{p}_t$ is the logarithm of domestic retail prices; p_t^* is the logarithm of the producer prices of the OECD countries; e_t is the logarithm of the UK effective nominal exchange rate (defined as the domestic price of a unit of foreign currency, so that an increase in e_t represents a depreciation of the home currency); r_t is the domestic nominal interest rate, computed as $r_t = 0.25 \ln(1+R_t/100)$, where R_t is the 90 day Treasury Bill average discount rate per annum; r_t^* is

the foreign nominal interest rate, computed as $r_t^* = 0.25\ln(1 + R_t^*/100)$, where R_t^* is a weighted average of 90 day interest rates per annum in the US, Germany, Japan and France and weights are provided by the International Monetary Fund Special Drawing Right (SDR); y_t^* is the logarithm of real per capita GDP of the OECD countries; h_t is the logarithm of (end-of-period) real per capita money stock ($M0$); and p_t^o is the logarithm of oil prices, measured by the average crude oil price published by the IMF. Details of the construction and sources of the data are provided in Appendix C.

Considerable care has been exercised in choosing the appropriate measure for the macroeconomic variables of interest described above, ensuring that the various measures correspond as closely as possible to the theoretical concepts discussed in Chapter 4. For example, to ensure a more satisfactory match between theoretical and empirical concepts, producer price indices are used to construct deviations between the domestic and foreign price levels in the *PPP* relationship, while the retail price index is used to measure domestic inflation in the *FIP* relationship.[1] To check on the robustness of our results, we also considered various alternative measures of y_t^*, p_t^* and r_t^*, but we found that these have relatively little impact on the estimation results.[2] For example, the use of a weighted average of the logarithm of the price indices of UK's 42 largest trading partners, where the weights are given by the share of UK imports from these countries and the use of an export-weighted average of foreign output, including countries both inside and outside of the OECD, appears to have only marginal effects on the results. Similarly, the results were hardly affected when we used the US nominal interest rate as an alternative to the SDR-weighted rate.

The data used in the applied work are quarterly, seasonally adjusted series covering the period 1964q1–1999q4. To ensure that all regressions are comparable (irrespective of the order chosen for the underlying VAR model, for example), all estimation results reported in the book are carried out over the period 1965q1–1999q4 (140 observations) or the slightly extended period 1965q1–2001q1 (145 observations). Plots of the core macroeconomic series are provided in Figures 8.1–8.7. In what follows, we summarise the main statistical characteristics of the series and provide

[1] There is considerable evidence, both on the basis of our own analysis and elsewhere, that the various alternative measures of inflation that are available are pairwise cointegrated with a cointegrating vector of $(1, -1)$ and a zero constant. The use of two measures of prices, p_t and $\widetilde{p}_t$, in the analysis has no impact on the long-run properties of the model, therefore, but is likely to capture the short-run dynamics more accurately.

[2] Other approaches to the construction of foreign variables are discussed in Pesaran, Schuermann and Weiner (2004).

a brief account of their history, considering, in turn, the series of outputs, prices, exchange rates, interest rates and money.

8.1 Domestic and foreign output

Figures 8.1a and 8.1b show the level and first differences of the logarithm of domestic output y_t over our sample period, and Figures 8.1c and 8.1d show the corresponding plots for foreign (OECD) output y_t^*.

Both variables show clear upward trends and appear stationary in first differences. Over the whole of the sample period 1965q1–1999q4, y_t and y_t^* grew at similar rates, at 1.97% and 2.10% per annum, respectively. But this obscures quite different experiences over different sub-periods, with foreign output growing very rapidly at the beginning of the sample before slowing at the end while the UK achieved relatively stable rates of growth over these horizons. So, for example, the UK achieved a growth rate of 1.86% per annum during the second half of the 1960s, 1965q1–1969q4, rising to 2.15% over the 1970s, before falling slightly to 1.91% per annum over the period 1980q1–1999q4. Foreign output, by way of contrast, achieved very high levels of growth, of 3.9% per annum, during

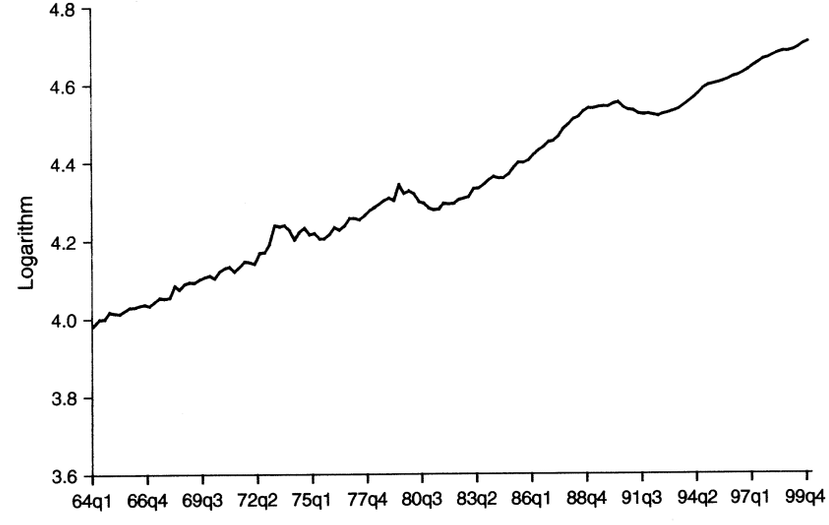

Figure 8.1a UK output, y_t.

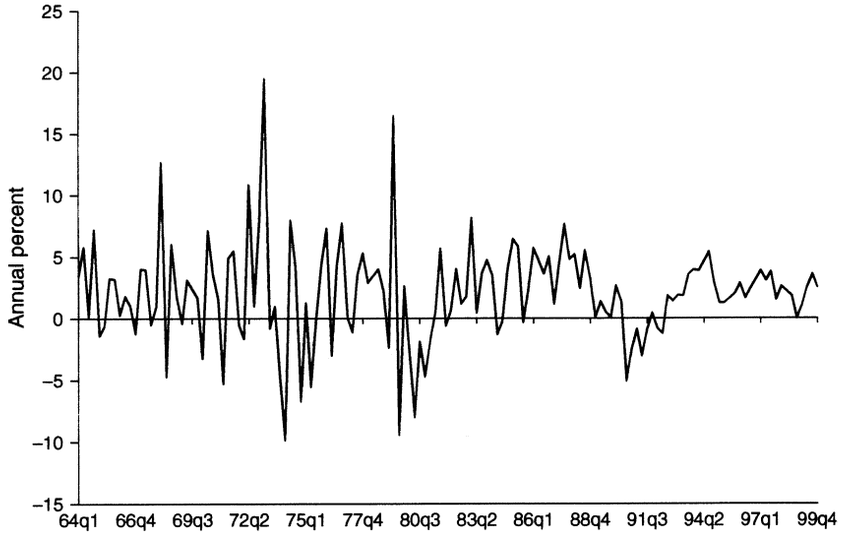

Figure 8.1b First difference of UK output, Δy_t.

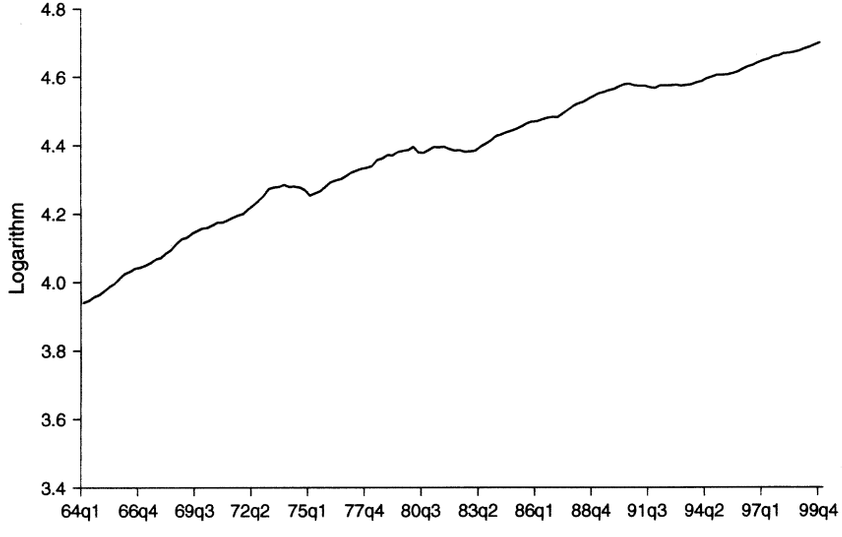

Figure 8.1c Foreign output, y_t^*.

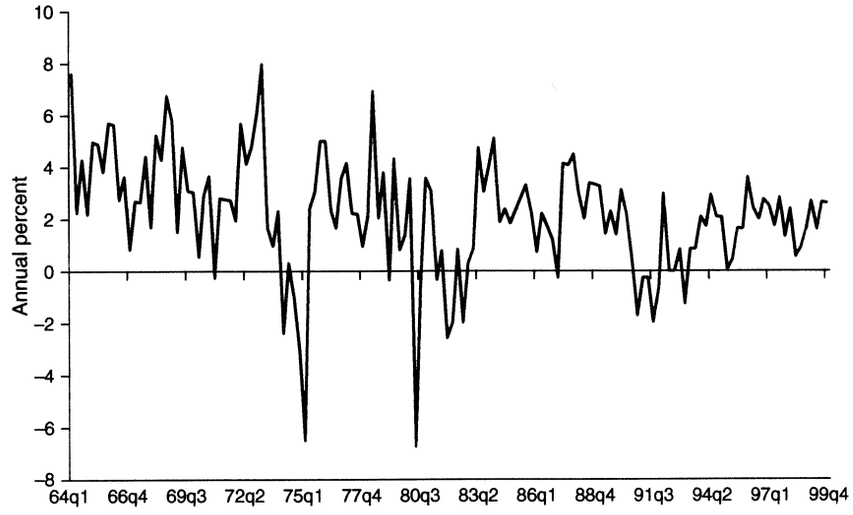

Figure 8.1d First difference of foreign output, Δy_t^*.

1965q1–1969q4, compared to an average growth rate of 2.29% per annum over the period 1970q1–1979q4, and an average rate of 1.56% per annum for the period 1980q1–1999q4.

These differences in growth rates across extended periods are demonstrated in Figures 8.1e and 8.1f, which show clearly the UK's relative decline over the first half of the sample period and relative recovery over the second half of the sample.

Of course, the growth rates achieved over the decades were influenced by some particular, and remarkable, episodes of output change in the UK. For example, y_t fell by around 2.47% in 1974q1 and this was followed by a period of low growth that persisted throughout the mid-1970s. A similar, although less pronounced, slowdown in growth was observed in y_t^* also, and the timing of the slowdown provides some support for the view discussed in Chapter 3 that the oil price shock could be an important factor in bringing about such sharp declines. In the early 1980s, domestic output fell for five consecutive quarters between the periods 1980q1–1981q1, including a fall of 2.00% in 1980q2. There was an associated rise in unemployment from 1.37 million to 2.37 million and this contributed to a growth rate in y_t of just 0.85% per annum over the period 1980q1–1984q4 (compared to 1.1% per annum in y_t^*). However, in terms of international

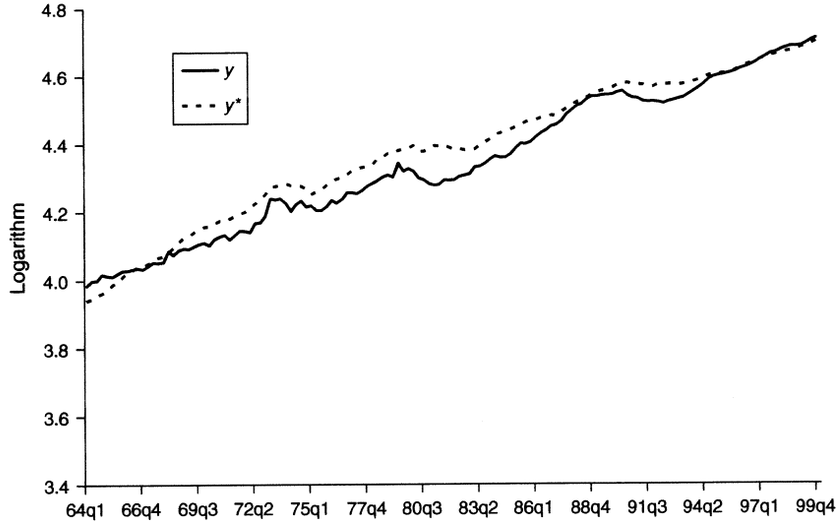

Figure 8.1e UK and foreign output, y_t and y_t^*.

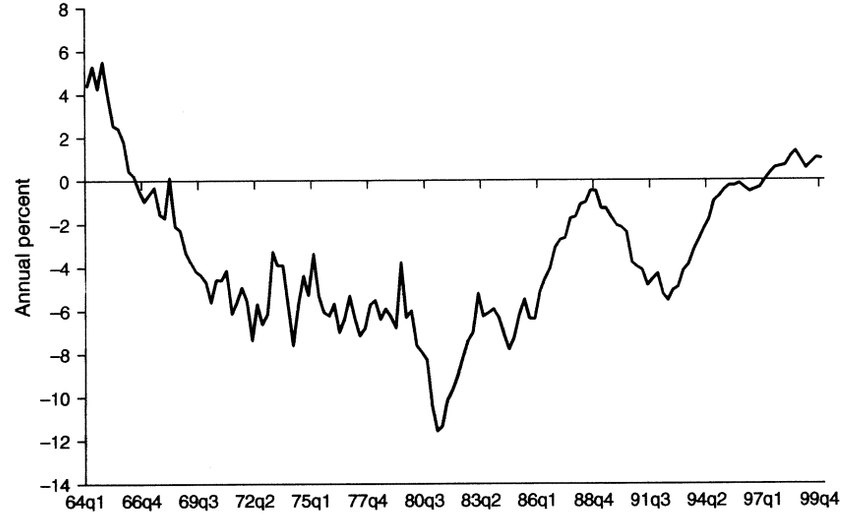

Figure 8.1f Difference of UK and foreign output, $y_t - y_t^*$.

comparisons, this was more than offset during 1985q1–1989q4 by the rapid growth associated with the 'Lawson boom': unemployment fell from 3.34 million to 1.64 million, and output growth reached 3.49% per annum in the UK (compared to 2.45% per annum abroad).

These episodes, among others, have contributed to a relatively volatile output growth series for the UK considered quarter-on-quarter, with the UK output growth series having a standard deviation of 4.1% compared to 2.3% for foreign output growth over the whole sample. However, an additional feature, which is readily apparent in Figures 8.1b in particular, is the large time-variation in the volatility of output growth. For the period 1965q1–1979q4, the standard deviation of Δy_t was 5.33% per annum (compared to 2.51% per annum for Δy_t^*), but these fell dramatically during the second half of the sample to 2.84% per annum for the UK during 1980q1–1999q4 (and to 1.90% per annum for foreign output growth). Output growth in the UK was at its most volatile during the 1970s, during which time there were industrial disputes in the Mining and Energy sectors in 1972 and 1974,[3] and the effects of the oil price rises of the early 1970s were apparent. But the reduction in volatility is not just associated with these particular episodes and it is worth noting here that a decline in the volatility of domestic and foreign prices and interest rates has also been apparent since the mid-1980s, as we shall discuss below.[4]

Finally, an alternative and complementary way of considering the variation in output growth is provided in Table 8.1. This table gives information for the four-quarter moving average of output growth showing the proportion of observations in which this average has fallen below various thresholds during the extended sample 1965q1–2001q1 and during three sub-periods 1970q1–1979q4, 1980q1–1989q4 and 1990q1–2001q1.

For example, we might be interested in the occurrence of a 'recession', which we define as an event where the four-quarter moving average of output growth falls below zero. Table 8.1 shows that the proportion of times in which according to this definition recession occurred over the whole sample was 13.1%, but that this proportion was higher through the

[3] The miners' strike of January–February 1971 resulted in the government declaring a state of emergency, power cuts and fuel rationing, and much of British industry went on a three-day working week. Industrial action by the miners and power engineers in the final months of 1973 resulted in the declaration of a further state of emergency, the imposition of prohibitions on space heating in industrial and commercial premises and the imposition of a reduced working week in January–February 1974.

[4] The decline in the volatility is not thought to be sufficiently large that it will have much effect on the unit root tests. See, for example, Busetti and Taylor (2005) and, for the testing of cointegrating rank in the presence of GARCH error terms, see Garratt, Lee and Pesaran (2005b).

Table 8.1 Historical unconditional probabilities for output growth (4-quarter moving average).

Sample period	Thresholds (per cent)									
	−2.0	−1.0	−0.5	0	1	2	2.5	3	4	5
1970q1–1979q4	5.00	10.00	12.50	15.00	17.50	37.50	57.50	70.00	80.00	90.00
1980q1–1989q4	10.00	12.50	12.50	12.50	17.50	35.00	40.00	47.50	72.50	95.00
1990q1–2001q1	2.22	6.67	13.33	17.78	22.22	42.22	60.00	77.79	93.33	100.00
1965q1–2001q1	4.83	8.28	11.03	13.10	17.93	40.00	55.86	67.59	83.45	95.86

Note: Output growth here is computed as: $(\Delta y_t \times 400) + 0.22236$ where y_t is the logarithm of real per capita output and 0.22236 is the annualised population growth rate.

period 1990q1–2001q1 at 17.8%. Of course, this information is already implicitly provided in Figures 8.1a and 8.1c. But these proportions convey the information on the mean values and the volatility of the series during the sub-samples in a particularly useful and meaningful way and in much the same way as the probability forecasts convey information on expected future events compared to the more usual point forecasts (as discussed in Chapter 7). Certainly the values in Table 8.1 provide useful reference points, showing the unconditional probability of the various events occurring based on the various sub-samples, and can be readily used in the interpretation of the probability forecasts that we shall describe in Chapter 11.

8.2 Domestic and foreign prices

Figures 8.2, 8.3 and 8.4 plot the time paths of the levels and first differences of the various price series considered in our model $p_t, \widetilde{p}_t, p_t^*, p_t - p_t^*, p_t^o$ (plus the second difference of p_t and $\widetilde{p}_t$) over the sample period 1964q1–1999q4. We focus mostly on the price changes, but make the observation that the levels of the price series are clearly non-stationary and upward trended.

Domestic price inflation, measured either by producer price inflation Δp_t or retail price inflation $\Delta \widetilde{p}_t$, was relatively low through the early part of the sample, averaging 4.46% per annum and 5.22% per annum, respectively, over the period 1965q1–1972q2. But it rose to very high levels through the mid-1970s, averaging in excess of 15% per annum during 1972q3–1976q4 and peaking at 25.95% per annum for Δp_t and 33.03% per annum for $\Delta \widetilde{p}_t$ in 1974q1 and 1975q2, respectively.

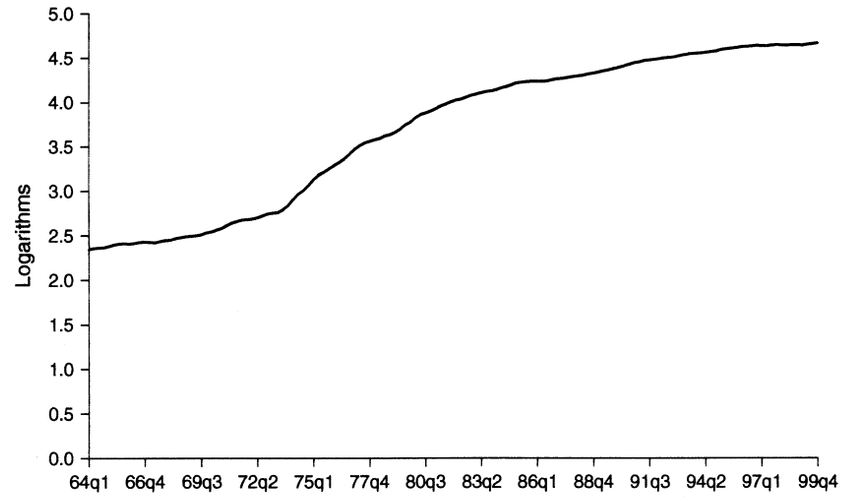

Figure 8.2a UK producer prices, p_t.

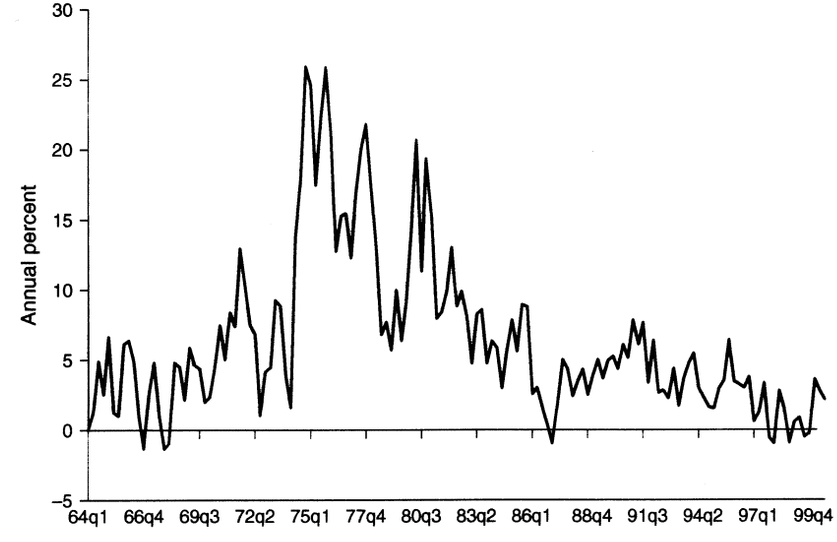

Figure 8.2b First difference of UK producer prices, Δp_t.

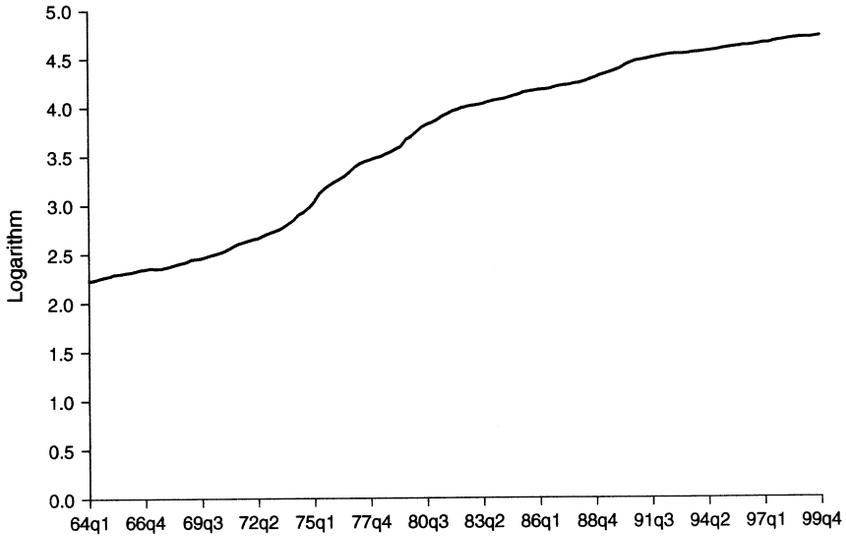

Figure 8.2c UK retail prices, $\widetilde{p}_t$.

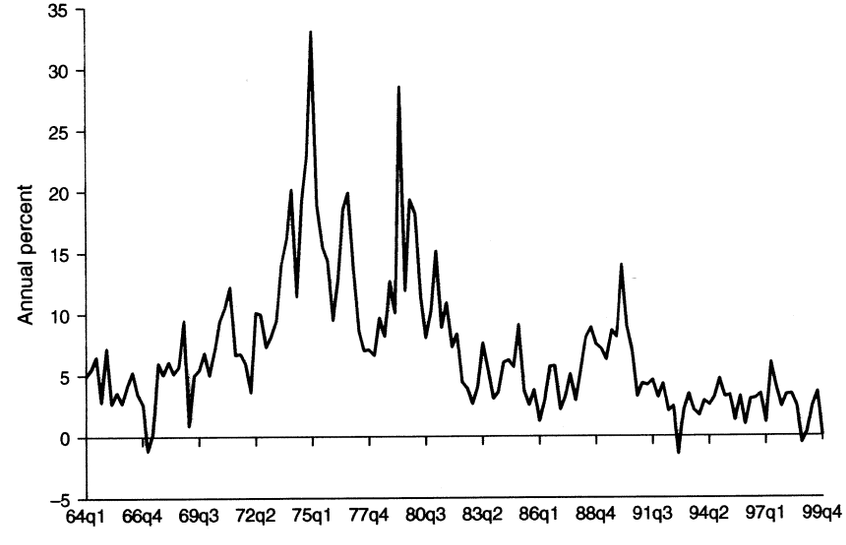

Figure 8.2d First difference of UK retail prices, $\Delta\widetilde{p}_t$.

Focusing on Δp_t, a significant part of these price movements are associated with rapidly rising oil prices and exchange rate depreciations. However, other domestic factors were also associated with the high inflation of this period. The implementation of various forms of incomes policy in this period can also help explain the volatility of the Δp_t series: sharp reductions in the series are observed in 1967q1, 1967q2 and 1973q2, following the statutory period of zero wage increases during the 'Wage Freeze' and 'Severe Restraint' of the Wilson administration (covering two six-month periods beginning June 1966) and the wage and price 'Standstill' of the Heath administration (lasting from November 1972 to March 1993); and the effects of the statutory ceilings on pay increases imposed during 1968q2–1969q2 and 1973q2–1974q3 help account for falls in Δp_t observed at the end of these two sub-periods. The Callaghan government's 'Social Contract' with the Trade Unions, beginning in July 1976, saw a reduction in wage inflation from 27% per annum in 1975 to 9% per annum in 1977, and there was a corresponding reduction in price inflation. But the breakdown of this policy in the 'Winter of Discontent' of 1978/79, the oil price rises of 1978 and 1979 and the increase in VAT from 8% to 15% in June 1979 generated upward pressure on prices, so that producer price inflation averaged 12.07% per annum over the period 1977q1–1981q1. Since that time, Δp_t and $\Delta\widetilde{p}_t$ have achieved relatively low levels once more, averaging 3.97% and 4.53% per annum over the period 1981q2–1998q2. Particularly low levels of inflation, of 2.24% and 2.54% per annum, were observed during the later period 1992q4–1999q4, which largely coincides with the period over which the British government adopted an explicit policy of inflation targeting (a strategy followed in the aftermath of the UK's exit from the ERM in 1992 and implemented both before and after central bank independence was announced in 1997).[5]

In view of the various policy stances taken on inflation over the sample, it is interesting to consider the proportion of times that the (four-quarter moving average of) domestic inflation, as measured by the Retail Price Index has fallen below various thresholds, as shown in Table 8.2.

[5] Inflation targets relating to the Retail Price Index (excluding mortgage payments) were first set explicitly in the UK in October 1992, specifying that inflation should be in the lower half of the range 1–4% per annum by Spring 1997. The policy was formalised further in May 1997 when the Bank of England was given operational independence with the remit to aim for an average annual inflation rate of 2.5%, with the rate falling in the target range 1.5–3.5%. The current target is consumer price inflation of 2.0%, with bands of 1% either side. If these bands are exceeded then a letter is required to be sent to the Chancellor explaining why this has occurred.

These show that realisations of the annual rate of inflation below 6% were rare in the 1970s, but occurred quite frequently during in the 1980s and were experienced in almost 90% of cases in the 1990s. The proportion of occasions on which inflation has been within the acceptable range of [1.5%, 3.5%] over the sample 1965q1–2001q1 is just 24.14%. However, over the low inflation period after 1990q1, inflation was within this band 60% of the time.

The apparently distinct episodes of high and low inflation influence the statistical characterisation of the data since the persistence of shocks in the inflation series suggests that inflation might not be stationary. In contrast,

Table 8.2 Historical unconditional probabilities for inflation (4-quarter moving average).

Sample period	Thresholds (per cent)										
	1.5	2.5	3.5	5.0	6.0	7.0	8.0	9.0	10.0	15.0	20.0
1970q1–1979q4	0.00	0.00	0.00	2.50	7.50	12.50	30.00	37.50	52.50	72.50	90.00
1980q1–1989q4	0.00	0.00	10.00	40.00	55.50	62.50	75.00	77.50	77.50	92.50	100.00
1990q1–2001q1	8.89	28.89	68.89	86.67	88.89	88.89	91.11	93.33	100.00	100.00	100.00
1965q1–2001q1	3.45	10.35	27.59	48.28	57.93	62.01	71.03	74.48	80.69	90.35	97.24

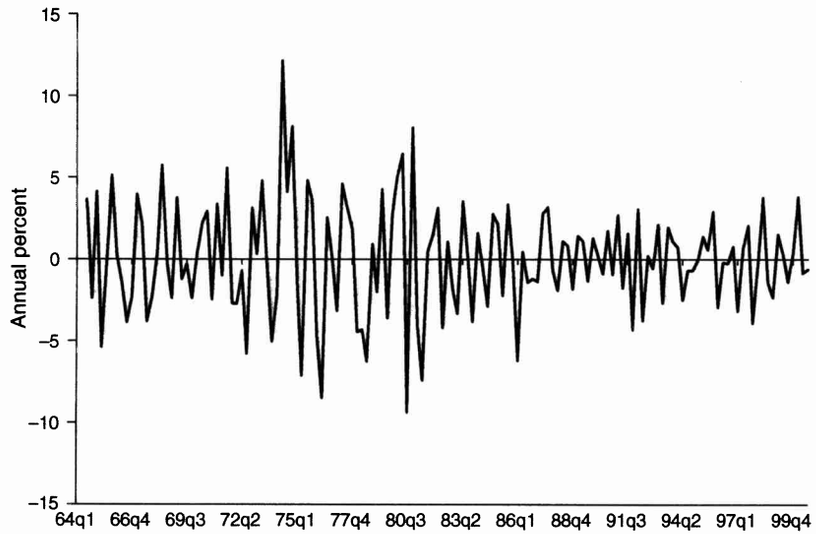

Figure 8.2e Second difference of UK producer prices, $\Delta^2 p_t$.

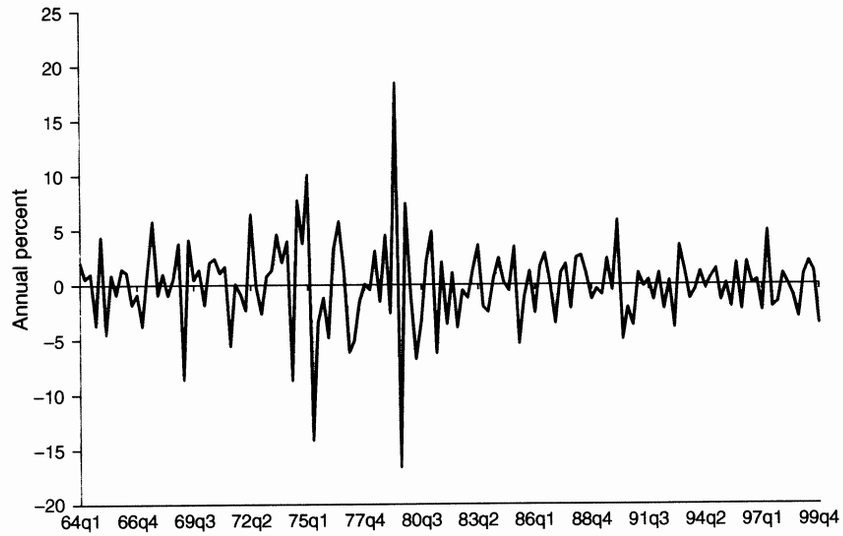

Figure 8.2f Second difference of UK retail prices, $\Delta^2 \widetilde{p}_t$.

changes in the rate of inflation (illustrated in Figures 8.2e–f) appear clearly stationary. We discuss this feature of the data more formally in Section 9.2.

The effects of the oil price hikes can also be seen in the Δp_t^* series, with high inflation observed worldwide during the 1970s. There are, however, clear periods during which UK and world inflation diverge.

For example, Figure 8.3c shows the UK price index rose very rapidly relative to world prices around the mid- to late-1970s. In particular, we see that during the period 1972q3 to 1976q4, $(p_t - p_t^*)$ rose at an average rate of 5.05% per annum, and this compares to average growth of 0.55% per annum over the sample period up to 1972q3, and of 0.13% per annum during the sample period after 1976q4.

Finally, to be quite clear on the timing and size of the effects of oil prices on domestic and foreign price inflation, Figures 8.4a and 8.4b plot the level and first difference of oil prices themselves. These are obviously dominated by the effects of the various large oil price shocks.

Over the period 1965q1–1973q4, the price of oil was essentially flat, but quadrupled in 1974q1 as a result of the Yom Kippur War and its aftermath. Oil prices remained relatively stable until the second increase in the price of oil in 1979q2, which was brought about largely due to the Iranian Revolution in February 1979. In 1986q1, the oil price fell sharply, largely

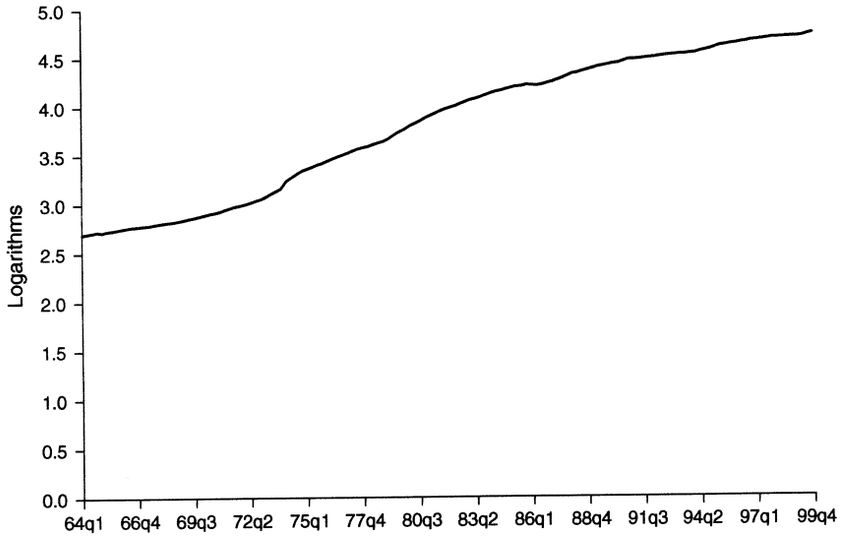

Figure 8.3a Foreign producer prices, p_t^*.

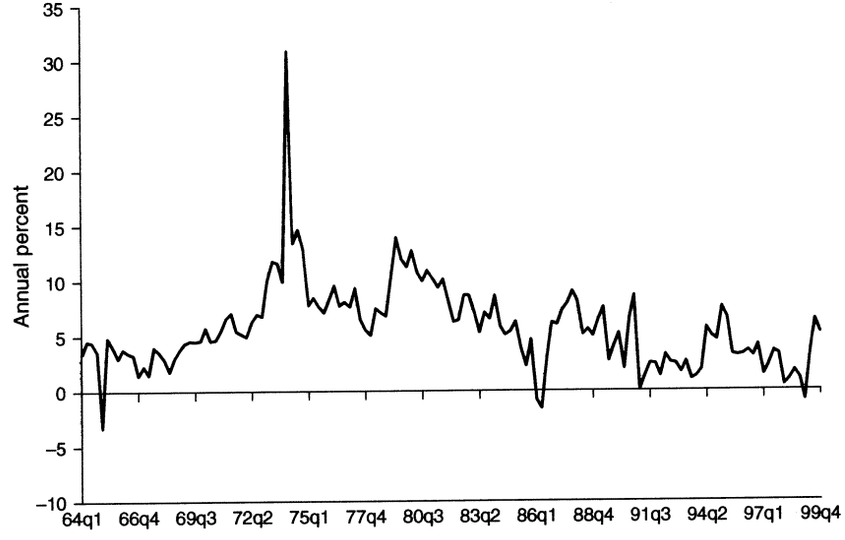

Figure 8.3b First difference of foreign producer prices, Δp_t^*.

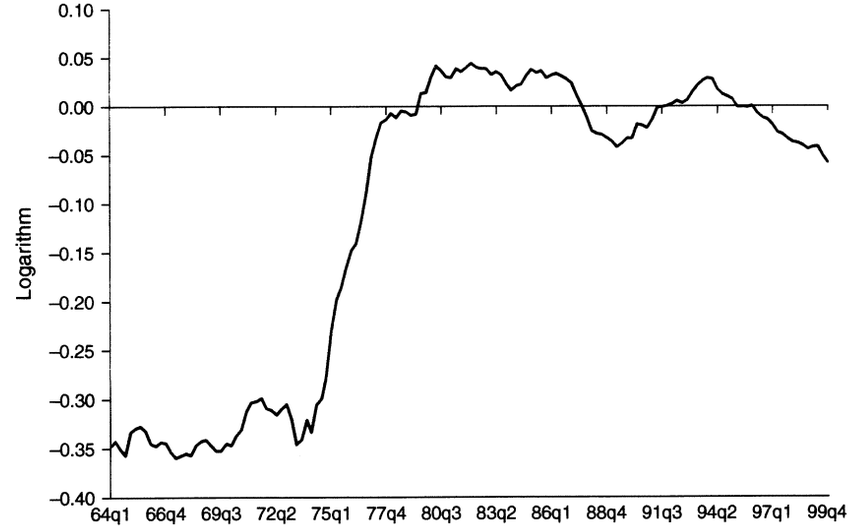

Figure 8.3c Relative prices, $p_t - p_t^*$.

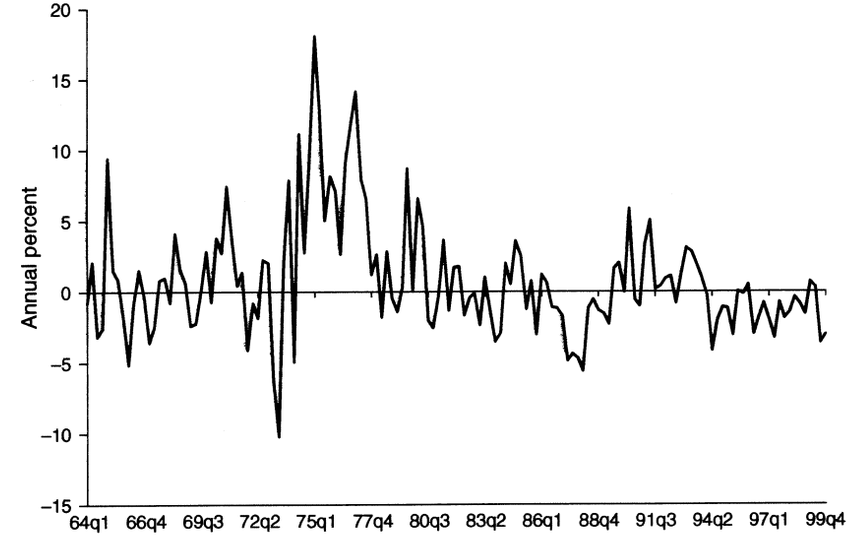

Figure 8.3d First difference of relative prices, $\Delta(p_t - p_t^*)$.

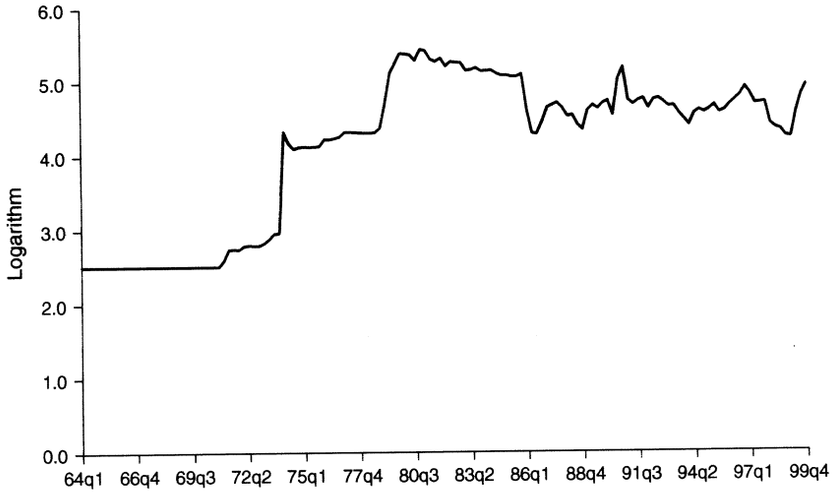

Figure 8.4a Oil price, p_t^o.

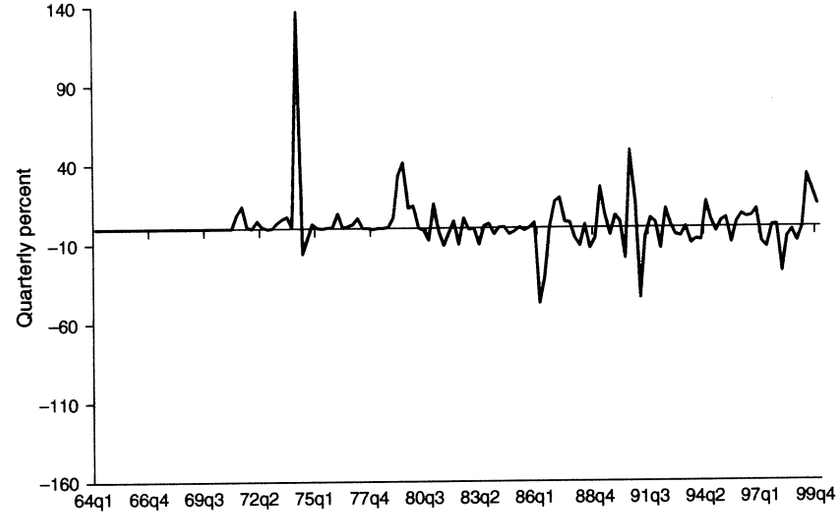

Figure 8.4b First difference of the oil price, Δp_t^o.

instigated by Saudi Arabia, and there followed a period where the level was considerably lower than previously, but where the volatility was high. Large increases in the price of oil were experienced in 1990q3 and 1990q4 during the Persian Gulf War in the aftermath of the invasion of Kuwait by Iraq, but these were reversed in 1991q1. Over the remaining part of our sample, 1991q2–1999q4, real oil prices fell slightly relative to domestic as well as foreign prices.

8.3 Exchange rates

Figures 8.5a and 8.5b plot the level and first differences of the UK effective exchange rate, e_t. When considering exchange rate movements, the sample can conveniently be split into four main episodes, namely: (i) the period of fixed exchange rate upto June 1972; (ii) the high inflation period of 1972q3–1976q4; (iii) the period between 1977q1 and 1981q1; and (iv) 1981q2–1999q4.

During the first of these episodes, e_t depreciated by 2.08% per annum, although this depreciation came about almost entirely through the 14% devaluation of November 1967. The flotation of sterling in June 1972 was

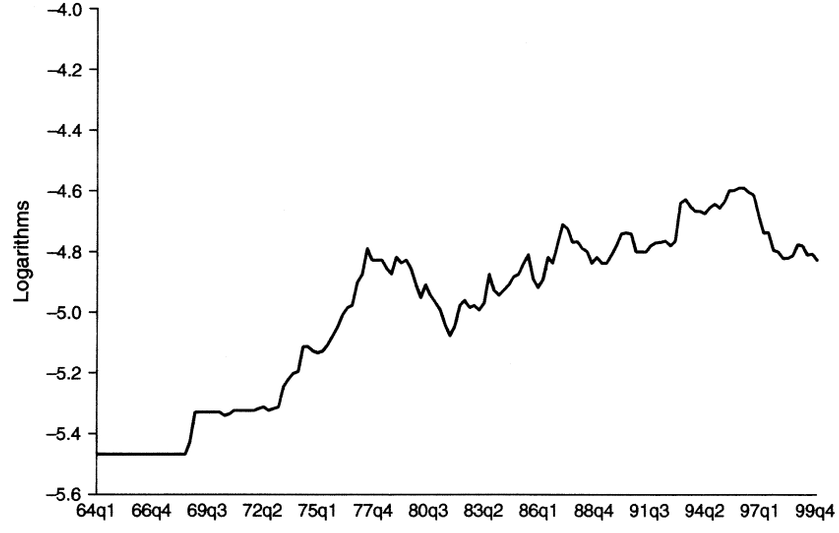

Figure 8.5a Effective exchange rate, e_t.

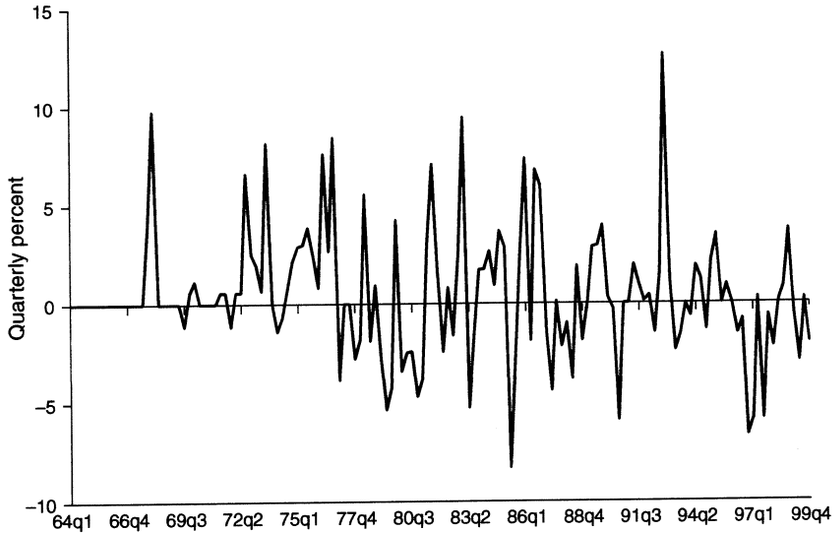

Figure 8.5b First difference of effective exchange rate, Δe_t.

accompanied by a sharp depreciation. And the worsening of the UK's trade balance, associated with its accession to the EC in January 1973 and with the oil price shock of 1973q4, was followed by a sequence of further depreciations. Hence, the average rate of increase in e_t over the second episode, covering 1972q3–1976q4, was 11.61% per annum (substantially outstripping the rise in $(p_t - p_t^*)$ over the same period). The third period, covering 1977q1–1981q1, saw the UK become a net exporter of oil at a time when oil prices rose once more and when the Thatcher administration started to implement its Medium Term Financial Strategy (both in 1979). Over this period, e_t appreciated at a rate of 6.77% per annum, reversing (and overshooting) the trend reduction in the terms of trade that had occurred over the first two periods. Finally, the fourth period is characterised once more by moderate depreciation, averaging 1.33% per annum over 1981q2–1999q4, although this has been subject to a certain degree of exchange rate volatility and there have been a number of episodes during the period which particularly stand out. For example, the rise in e_t of 18.2% during 1986, associated with the fall in oil prices of that year; the period of exchange rate appreciation observed during the pound's shadowing of the Deutschemark during 1987–88; the sharp appreciation of sterling following entry into the ERM in October 1990; the sharp depreciation of

sterling in the aftermath of the pound's exit from the ERM in September 1992; and the almost continuous appreciation of sterling from 1996q1 to the end of the sample in 1999q4.

8.4 Domestic and foreign interest rates

Figures 8.6a–8.6d display the time series for r_t, r_t^* and their first differences. Again the series can be considered in four broad episodes, defined according to the movements in r_t^*.

Episode 1 is defined over the period 1965q1–1970q1, during which time r_t^* gradually rose, largely reflecting the rising budget deficit in the US emerging as a result of financing the Vietnam War, rising US inflation and the contractionary monetary policy of the Nixon administration through 1969.[6] The second episode, over the 1970q2–1974q3 period, sees r_t^* first falling and then rising as the US Federal Reserve pursued

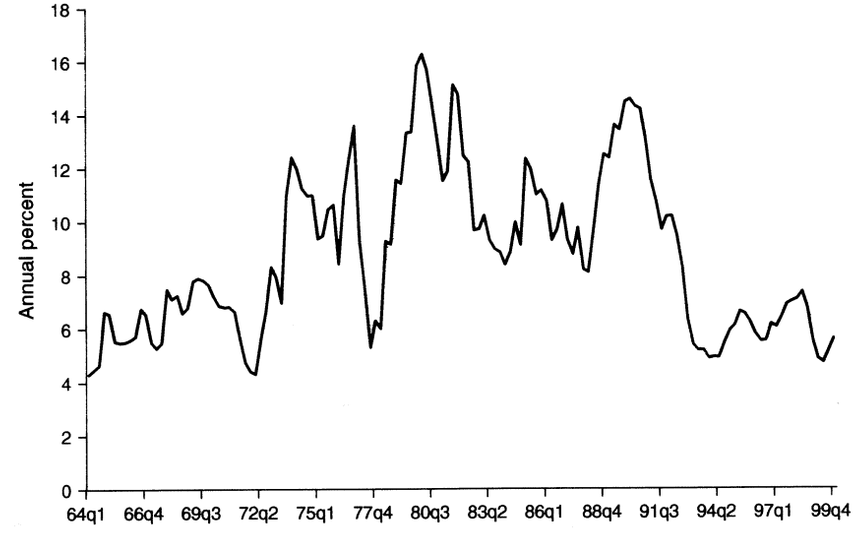

Figure 8.6a UK interest rates, r_t.

[6] This discussion is based on the assumption that the primary driving force in r_t^* is the US short-term interest rate whose weight when computing r_t^* is 0.4382, compared with the next largest weight of 0.2360 for Germany.

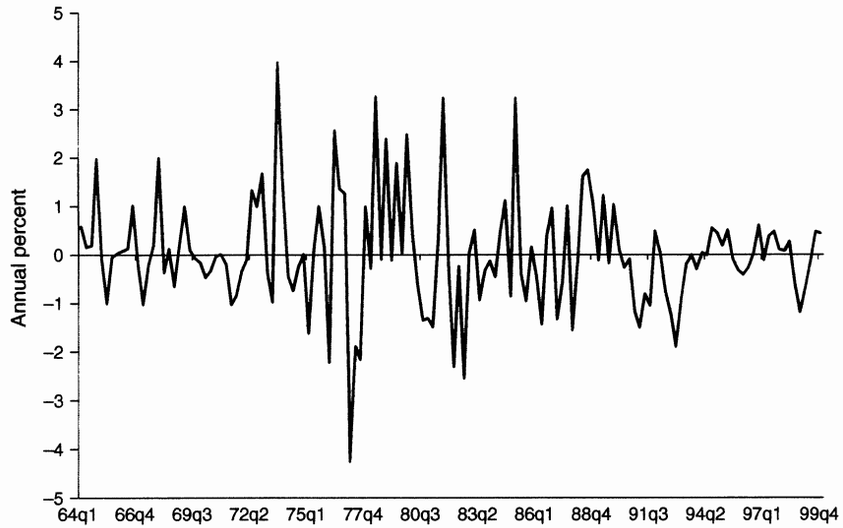

Figure 8.6b First difference of UK interest rates, Δr_t.

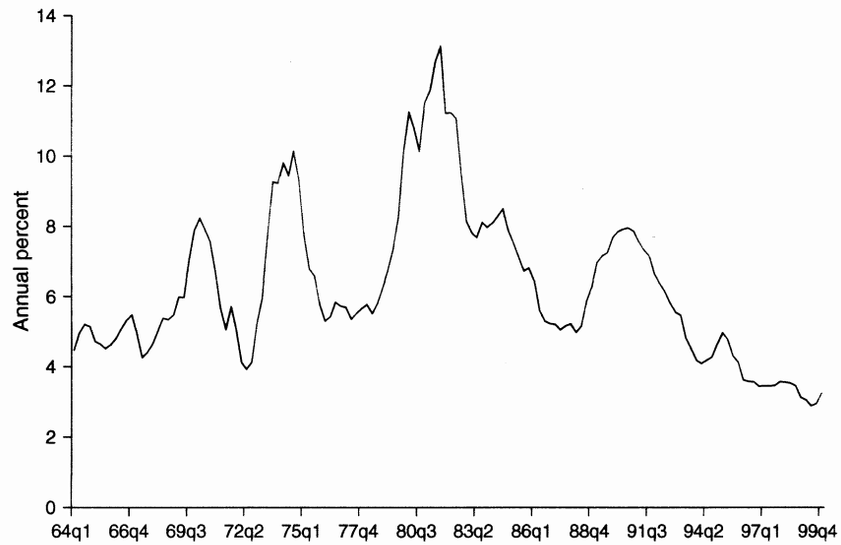

Figure 8.6c Foreign interest rates, r_t^*.

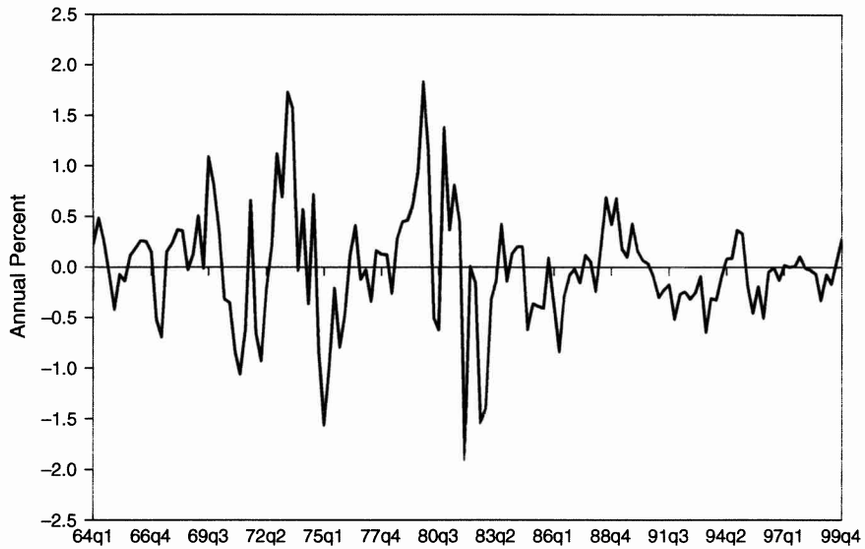

Figure 8.6d First difference of foreign interest rates, Δr_t^*.

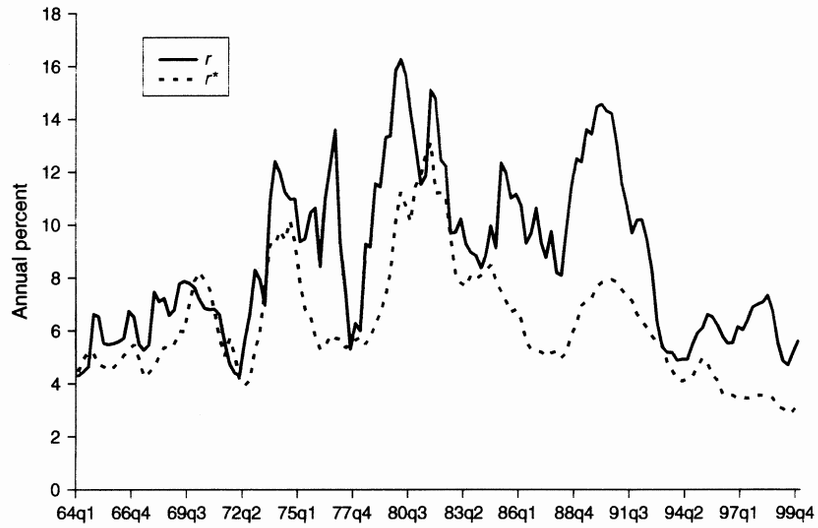

Figure 8.6e UK and foreign interest rates, r_t and r_t^*.

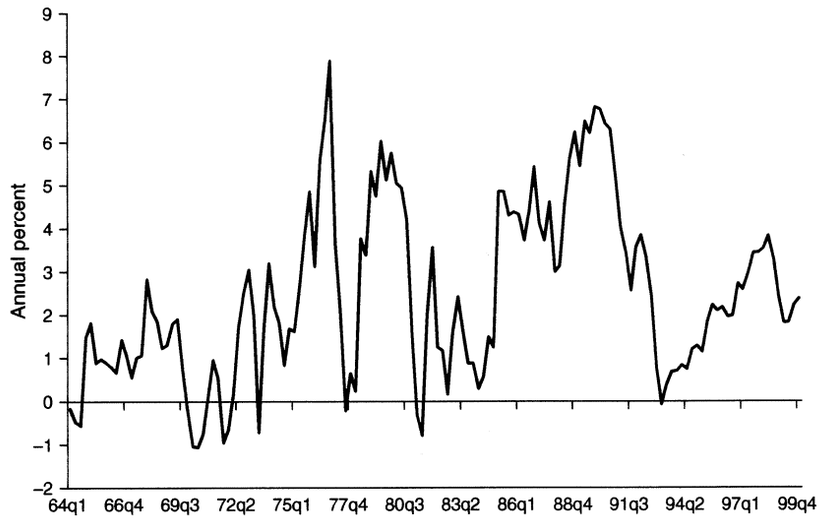

Figure 8.6f Difference of UK and foreign interest rates, $r_t - r_t^*$.

a non-accommodating monetary policy following the OPEC oil price shock. The third episode, 1974q4–1981q3, ends with US rates achieving unprecedentedly high levels following the Reagan administration's anti-inflationary policy and the US monetary authorities' pursuit of tight money through 1980/81, and the fourth episode, lasting to the end of the sample, is characterised by generally falling foreign nominal rates. Rates reached their lowest levels since 1972 at the end of 1987 when the monetary authorities loosened policy following the Wall Street Crash of October 1987, but rose through 1990 in response to the effects of monetary unification of Germany in July 1990.

Over the first of these episodes, r_t corresponds quite closely to movements in r_t^*, although r_t appears relatively high in 1967q4 (at which time Harold Wilson's government in the UK was implementing deflationary measures to support the devaluation of the exchange rate) and r_t fell relatively rapidly through 1971 in reaction to the changes in monetary control outlined in the Bank of England's publication on 'Competition and Credit Control'. In the second episode, the UK and worldwide experience of inflation through the early and mid-1970s coincided

with high nominal interest rates at home and abroad. Although r_t rose substantially higher than r_t^* during this period, UK nominal rates did not keep pace with the very high inflation of the time and real rates of interest in the UK were negative for most of the 1970s. During the third episode, while r_t^* fell through 1974q4–1976q2 and then remained low until 1978q2, r_t rose sharply during 1976 following the implementation of monetary targets by the Callaghan administration from mid-1975 and the administration's loan negotiations with the IMF at the end of 1976. UK rates rose throughout 1978/79, preceding the rises abroad, and remained high until international rates began to fall at the end of 1981. Finally, during the fourth episode, UK rates fell through to the end of 1987, although even during this period they remained high by international standards. The UK policy of shadowing the Deutschemark through 1988 and sterling's membership of the ERM between October 1990 and September 1992 saw r_t high relative to r_t^* although, by the end of the sample, r_t was at a level comparable with those of the early 1960s.

8.5 Real money balances relative to income

Figures 8.7a and 8.7b show the time series for $h_t - y_t$ and their first difference. The variable $h_t - y_t$ measures the inverse of the per capita real narrow money velocity and what is very clear is the almost uninterrupted downward trend since the beginning of our period (a trend which goes back as far as the late 1940s; see Janssen, 1996).

This trend is usually explained by progress in payments technology. The increased use of alternative means of payments has caused the proportion of expenditure financed by cash to fall almost continuously. However, since 1990, the trend has flattened out. Explanations given for this are that the payments technology growth has slowed down to a point of no longer having an effect and that a shift to a low inflation environment has led agents to voluntarily hold a larger proportion of their portfolios in cash. Evidence on these hypothesis are presented in Janssen (1996).

This concludes our overview of the UK macroeconomic experiences as reflected in the variables to be included in the core UK macroeconomic

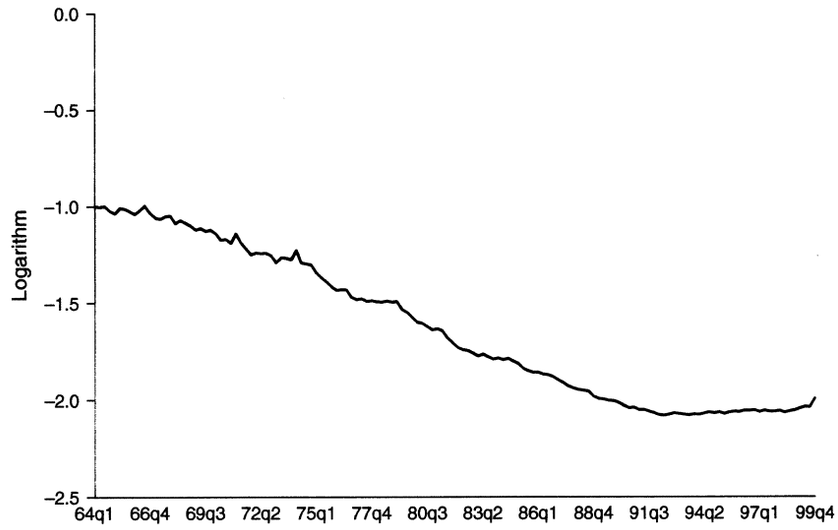

Figure 8.7a Money income ratio, $h_t - y_t$.

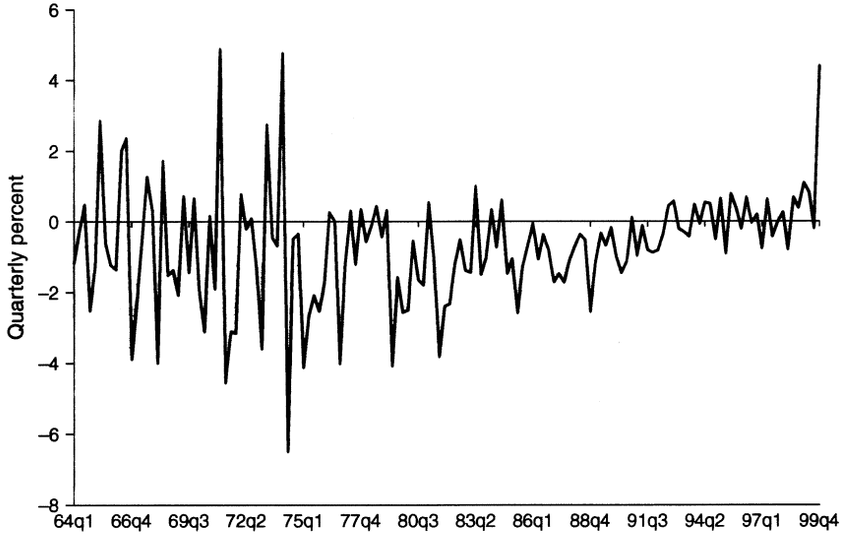

Figure 8.7b First difference of the money income ratio, $\Delta(h_t - y_t)$.

model. The overview is not intended to provide a comprehensive economic history of the UK economy over the last three decades, but provides a useful statement of some of the major events that lie behind the data presented to place the econometric analysis in context. This formal econometric analysis follows in the next chapter.