Real-time output gaps in the estimation of Taylor rules: A red herring?

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Abstract
Real-time, quasi-real, 'nearly real' and full sample output gaps for the UK, generated by linear and quadratic, Hodrick-Prescott filter and unobserved components (UC-ARIMA) techniques, are presented and analysed. Particular attention is paid to the behaviour of the different series during the large fluctuations of the late 1980s and early 1990s, and the implied underlying trends of potential output are identified. In that period the rolling-time estimation of the real-time and quasi-real gaps involves systematic distortion. After 1994, by contrast, the various measures are closer together, and the choice between them is less important. None of these measures corresponds precisely to what researchers would like – the output gap as understood at the time by policymakers – which it seems nearly impossible to identify with (non-spurious) precision but, given the nature and purpose of Taylor rule estimations, imperfect measures are acceptable. For periods with large swings researchers should settle for the nearly real series, while for more stable periods the choice of measure makes little difference.

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Keywords: output gap, real-time, quasi-real, nearly real, Taylor rule

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I Introduction

Over the last decade empirically estimated monetary policy reaction functions in the form of Taylor rules have come to be widely used as ways of characterising the behaviour of the monetary authorities in different countries and different time periods (eg Clarida, Galí and Gertler, 1998, 2000; Nelson, 2000; Adam, Cobham and Girardin, 2004). An interesting development in this literature has been the use of output gap measures based on the latest data available to the monetary authorities at the time (only) by authors such as Orphanides (2003) for the US and Nelson and Nikolov (2003) for the UK. At first glance it seems clearly desirable, in modelling the authorities' decisions, to use the data which they themselves had available at the time when they made their decisions: the use of different data may lead to incorrect estimates of the authorities' behaviour. The biases involved are potentially large. Some general concerns about the unreliability of real-time measures of the output gap have already been voiced by Orphanides and van Norden (2002) in the context of the US economy. In this paper we take the argument a step further to suggest that the use of real-time output gap measures in *ex post* policy analysis – for example in the use of Taylor Rules – may result in a seriously misleading representation of the actual policymaking process, especially at times when the economy is subject to large variations in actual output.

Two preliminary points should be noted. First, we follow the bulk of the literature in this area in concentrating on output gaps derived as the difference between actual output and a 'mechanically' estimated trend series, where it is assumed that at each point in time the authorities re-estimate trend output from the latest data and derive the output gap as the difference between actual output and that trend. There are three main alternatives to this procedure. One is to construct a larger structural model which embeds an explicit model of the supply-side of the economy, as in Muellbauer and Nunziata (2001); however, the model-specific nature of such exercises appears to have deterred economists from using their predictions in Taylor rules, and we do not pursue this here. A second alternative is to study what the authorities believed at each point in time about the trend in output and, using real-time data on actual output, construct a series for the real-time output gap on that basis, as is done by Nelson and Nikolov (2003). A third, related, alternative is to make a detailed reading of the historical record of what the authorities believed at each moment in time (of the kind exemplified by Cobham, 2002), focused on the output gap itself. We discuss both of these latter two in our concluding section.

Secondly, we analyse series for the output gap derived on the basis of three popular techniques – the linear and quadratic trend (LQ), the Hodrick-Prescott filter (HP) and the Unobserved Components–ARIMA procedure as discussed in Harvey and Jaeger (1993) (UC)[1] – in order to be sure that our results are not dependent on a specific technique, but our concern is with the choice between measures rather than the choice between techniques. Thirdly, we use data from 1974 only, so that the issue of a break in the trend at the end of the Bretton Woods/'long boom' period of the 1950s-1960s can be ignored.

The next section of the paper starts by presenting full sample and real-time output gaps. It then focuses on the largest cyclical fluctuations in the period, that is the Lawson boom of 1988-89 and the subsequent recession of 1991-92, and discusses the large differences between the real-time and full sample series over those episodes with reference to both the 'quasi-real' measure introduced by Orphanides and van Norden (2002) and a new, 'nearly real' measure. Section III focuses on the more recent period, from 1993 to 2004, where the cyclical fluctuations have been smaller and the various measures of the output gap are closer together. It examines the correlations between different measures and the implied differences between them in the timing of peaks and troughs. Section IV returns to the basic underlying concept to argue that while none of the possible real-time measures of the output gap are entirely satisfactory in the context of estimating Taylor rules, there is little to choose between alternative measures in relatively stable periods, but when the economy is subject to significant movements in actual output, our proposed 'nearly-real' measure of the output gap may offer the best characterisation of policy-makers' behaviour.

II Full sample, real-time, quasi-real and nearly real gaps

The real-time output gap at any point in time is computed as the deviation of actual output from an estimated trend where both are based exclusively on the data available to policymakers at that time. There are two differences between this series and one computed on the basis of a 'full' sample of data extending beyond this point. The first is that the real-time series is constructed from contemporary unrevised data on output rather than the revised data which become available later and are used in the full sample series, and the second is that the estimated trend in output is estimated on a rolling basis on data only up to the date of each observation, whereas the full sample series uses the whole range of the data to compute the trend. Between the real-time and full-sample measures we can define two alternative measures. The first is the 'quasi-real' output gap, proposed by Orphanides and van Norden (2002), which is computed using the final (full-sample) revised data but only for the period up to each observation. The second, which we will term the 'nearly real' gap, uses contemporary unrevised data on actual output but takes the trend from the full sample data. Thus, while the quasi-real series eliminates the effect of data revisions (but not the effect of estimating the trend in 'real time'), the nearly-real series eliminates the effect of real-time estimation of the trend but keeps the original real-time data. The way these four measures of the output gap relate to each other is as follows:

Alternative measures of the output gap

		data	
		contemporary	revised
estimation of trend	rolling	real-time	quasi-real
	full sample	nearly real	full sample

Figures 1 and 2 show the full sample and real-time output gaps estimated using the linear and quadratic (LQ), Hodrick-Prescott filter (HP) and unobserved components (UC) techniques from 1984.[2] In Figure 1 it is noticeable that the LQ series fluctuates more widely than the HP series which in turn fluctuates more widely than the UC series, particularly in the Lawson boom and the subsequent recession. This is also broadly true for the real-time series in Figure 2. Here it is noticeable that the UC series is highly erratic in the short term, while there is a prolonged period, from 1993 Q3 to 1996 Q3, when the HP gap is positive and the LQ gap negative.

Figures 3, 4 and 5 show the full sample and real-time series for the LQ, HP and UC techniques respectively. Here it is noticeable that in each case the real-time series turns down in 1987-89 well before the full sample series, and (allowing for the rather erratic nature of the UC series) falls in 1991-92 well below the full sample series. The implication is that policymakers using the real-time series would have underestimated the size and duration of the boom (as shown by the full sample series), but then would have exaggerated the depth and the extent of the subsequent recession.

The same figures also show the series for the 'quasi-real' output gap. In the LQ and HP cases the quasi-real series is nearly always closer to the real-time series than to the full sample series. In particular, both the quasi-real series start to fall in late 1987 or early 1988 around the same time as the real-time series, and both fall well below the corresponding full sample series in the early 1990s. For the UC series the relationships are less clear-cut.

Table 1 gives basic statistics on the various gap measures over the whole period and divided between 1984-93 and 1994-2004. Table 2 shows the correlation between the gaps over the first period, and together with Table 1 confirms the evidence of the figures that the real time and quasi-real series are relatively close, with correlations of 0.99 for the LQ, 0.97 for the HP series and 0.73 for the UC series. The implication is that only a small part of the difference between full sample and real time gaps is the result of the subsequent revisions to the data themselves. Rather, the bulk of the difference reflects the basis on which the underlying trend in output is estimated. The use of rolling-time estimation of the trend introduces a systematic distortion: this is what Orphanides and van Norden (2002, p582) refer to as the 'pervasive unreliability of end-of-sample estimates of the output trend'.

One way to elucidate this phenomenon is to examine the implied trends in output which lie behind each of the gap series. Figures 6, 7 and 8 show the trends for the full sample, real-time and quasi-real series as estimated by the LG and HP techniques respectively. In Figure 6, while the full sample trend output grows at a roughly constant rate, the real-time and quasi-real trend outputs grow rapidly in the late 1980s but stagnate or even, for a few quarters of the real-time trend, fall in the early 1990s. The same feature can be seen in Figure 7. While the full sample HP trend fluctuates a little more than the full sample LQ trend in Figure 6, the real-time and quasi-real HP trends actually turn down significantly in the early 1990s, reaching levels in early 1993 which are well below the peaks of 1990. And in Figure 8, the full sample UC trend fluctuates a little more than the full sample HP trend, while the real-time and quasi-real UC trends turn down even more in the early 1990s (although the quasi-real UC trend is highly erratic).

These variations feed directly into the gaps: the higher growth rate of the late 1980s makes the positive output gap at that time smaller, and then insofar as it continues to influence the estimate of trend output (which remains well above the full sample trend for several years) makes the negative gap in the recession of the early 1990s larger. It seems highly unlikely a priori that policymakers would have believed such variations in trend growth rates. Even if some policymakers were persuaded in the initial stages of the Lawson boom that the whole UK supply side had improved and underlying economic growth with it, there can have been no doubt by late 1988 that the economy was overheating,[3] and the policy interest rate was raised from 8% in the second quarter of 1988 (briefly 7.5% in late May) to 13% in November 1988, and 15% in October 1989 (Cobham, 2002). In addition, policymakers would have been aware of the preceding boom when considering the depth of the recession in 1991-2 and the following recovery. In fact, interest rates were raised pre-emptively in late 1994 because policymakers believed the economy was close to overheating – although the LQ (but not the HP) real-time gap was still negative.[4] Policymakers, in other words, would seem to have interpreted as cyclical fluctuations some of what the real-time and quasi-real series (particularly in the HP and UC cases) are depicting as fluctuations in the trend. And the policymakers were right, insofar as in subsequent years output returned broadly to its previous trend. More succinctly, *policymakers would have known the economy was in a boom in the late 1980s and they would have had a good idea of the depth of the recession in the 1990s*.

Our proposed 'nearly-real' measure of the output gap may, therefore, be a better representation of this reality. Figures 3, 4 and 5 also show the relevant nearly real series, and Table 1 includes the basic statistics on these too. It turns out that the nearly real gaps are typically closer to the full sample gaps than to the real-time gaps. In particular, both the LQ and HP nearly real gaps are a bit above the corresponding full sample gaps in 1989-90, both fall more or less in line with the full sample gaps during 1991-92 and both remain just above the full sample gaps. The correlations between these two series in Table 2 – 0.92 for the LQ, 0.85 for the HP, and 0.73 for the UC – confirm their closeness. The implication is that if policymakers could exercise foresight about the long run trend in output, but had access only to contemporary, unrevised, data on actual output – i.e. they were able to compute the 'nearly-real' output gap – they would not make large mistakes about the output gap. They would, for example, have been encouraged to take strong action to restrain the boom at the end of the 1980s, as indeed they did.

III Smaller cyclical fluctuations from 1994

While 1984-93 includes the major fluctuations of the Lawson boom and the subsequent recession, those between 1993 and 2004 are much smaller, and all the various measures of the output gap are closer together. Tables 1 and 3 provide basic statistics and correlations. In nearly all cases the means and standard deviations of the gaps are smaller than in 1984-93. The correlations between all the various LQ series are now high, and it is no longer the case that the real-time and quasi-real gaps, on the one hand, and the full sample and nearly real gaps, on the other, are the closest to each other. The correlations between the HP series are mostly but not all higher than for the earlier period, and the previous relationships between the series no longer hold; the same holds true for the UC series. A large part of the reason for the change between this and the previous period is that, particularly in the LQ case, the underlying trends are not moving around relative to each other as much in this period as in the previous one (Figures 6-8).

Table 4 reports the principal turning points using the Bry-Boschan (1971) business-cycle dating algorithm. The Bry-Boschan algorithm first identifies peaks and troughs in the output gaps as the locally highest and lowest values of real output. Then it eliminates two types of 'false' cycles, those where a peak and trough are separated by less than three quarters, and those where the amplitude from peak to trough, or trough to peak is less than 0.5% of GDP. The results in the table illustrate the significant differences in the dating, duration and amplitude of the various measures of the Lawson boom and subsequent recession. But they also suggest that in the period from 1994, where there is greater stability in the level and growth of GDP, the various measures of the output gap are closer together, particularly the LQ measures. Although though some differences exist, the turning points are generally close, as confirmed visually by Figure 9, which shows the number of series (out of the total of 12 described in Table 4) for which there is a peak or trough identified in each quarter. In contrast to the earlier period, it seems a priori unlikely that it would matter which measure is used in Taylor rule regressions for the post-1994 period, and in earlier work we have found little difference between the full-sample and real-time gaps for the period May 1997-July 2002 (Adam, Cobham and Girardin, 2004).

IV Concluding reflections

We have argued that for periods with large fluctuations rolling-time estimation introduces serious distortions, so that both the real-time and the quasi-real measures are suspect. For more stable periods, the differences seem to be of much less importance. However, none of the measures of the output gap used here really corresponds to what policymakers look at and act upon. The full sample measures assume the policymakers have remarkably good foresight about both data revisions and the trend. The real-time measures use contemporary data as it was available to the policymakers, but, to the extent that these estimates are based on standard univariate techniques to de-trend the data on output, they imply what might be called remarkably poor foresight about the trend. The quasi-real measures keep the poor foresight on the trend but assume perfect foresight about the data. And the nearly real measures keep the contemporary data but assume a remarkable foresight about the trend.

Actual policymakers, in contrast to all of these, use contemporary data but also have some ability to use other information in thinking about the output gap, for example, direct evidence on capacity utilisation and skills shortages and indirect evidence from current inflation rates; they have what might be termed imperfect but intelligent foresight.[5] Nelson and Nikolov (2003) try to make use of part of that information by identifying official beliefs about the underlying trends in the productive potential of the economy. Their exercise is of great intrinsic interest, but the need for a precise measure of the gap which can be used in estimation inevitably leads to an element of over-simplification. Nelson and Nikolov in effect consider variations in trend growth rates in minimum units of 0.25% or 0.5%, and they assume that official views are changed abruptly, rather than changing more gradually over time. For example, according to their Table B between 1986 Q1 and 1988 Q4 the official view on potential output growth since 1981 Q4 was that it had been 2.5% per year; one quarter later, in 1989 Q1, this changed to 2.75%.

What Nelson and Nikolov do is essentially to identify official announcements about the trend of potential output. But policymakers, who have discretion, are at any time trying to gauge where the economy is and where its potential is, using a wide set of information and with their own views able to evolve more or less gradually at any point. Moreover, as the Bank of England has been keen to emphasise in recent years, what matters is not just the point estimate of the output gap but also its probability distribution, and the latter (as well as the former) varies over time. An alternative procedure is to make a detailed reading of the historical record of the making of monetary policy with a view to gauging the monetary policymakers' direct beliefs about the output gap at each point in time. But such a procedure is even less likely to produce a measure of the output gap as perceived by the policymakers at each moment in time which is sufficiently precise and convincing to be accepted for use in Taylor rule regressions.[6]

However, while Taylor rule reaction functions are useful ways of characterising the behaviour of the monetary authorities in different countries and periods, they cannot claim to provide a complete description of that behaviour. In that case, researchers may reasonably use an admittedly imperfect measure of the output gap. Given the strong evidence provided by Nelson and Nikolov (2003) of the stability over considerable periods of the official view of the growth of productive potential, we suggest that for periods with wide fluctuations, such as the earlier period considered here, researchers should settle for the nearly real series, while for more stable periods it probably makes little difference.

NOTES

[1] The UC-ARIMA trend assumes that actual output can be described as

$$y_t = \mu_t + z_t + \varepsilon_t$$

where μ_t denotes a stochastic trend, z_t is the cycle (characterized by an ARMA (0,2) process and ε_t is an idiosyncratic shock. The stochastic trend is defined as

$$\mu_t = \beta_t + \mu_{t-1} + u_t$$

$$\beta_t = \beta_{t-1} + v_t$$

and $u_t \sim niid(0, \sigma_u^2)$, $v_t \sim niid(0, \sigma_v^2)$.

The stochastic trend is thus represented as an I(2) process (see Harvey and Jaeger, 1993) and is estimated using STAMP and assuming smoothing is carried out using a Kalman Filter.

[2] The real-time output series is that in Eggington et al (2002), updated from *Economic Trends* and *Economic Trends Annual Supplement*. A similar database, which covers components of GDP as well as the aggregate, can be found on the Bank of England's website (see Castle and Ellis, 2002).

[3] See chapter 4.2 of Cobham (2002) for an account of macro policy decisions over the period, and chapter 8 for an analysis of the official concerns mentioned in relation to each interest rate change: according to the latter the interest rate rises in June 1988 reflected in part official concerns about the sterling exchange rate, but those from July onwards were dominated by concerns about domestic growth or inflation and domestic monetary growth.

[4] The LQ full sample gap moved from negative to positive in 1994 Q4. On policy in these years see chapters 4 and 5 of Cobham (2002).

[5] Lomax (2004) provides a useful discussion of the sources of information currently used by the MPC.

[6] Even in the MPC period from 1997, for which there is much more information about policymakers' thinking in the published minutes of the MPC meetings as well as the *Inflation Reports*, there is very little quantitative discussion of the size of the gap.

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Table 1: Basic statistics, 1984 Q2-1993 Q4

	Linear quadratic					Hodrick-Prescott					Unobserved components			
	Full sample	Real-time	Quasi-real	Nearly real		Full sample	Real-time	Quasi-real	Nearly real		Full sample	Real-time	Quasi-real	Nearly real
1984:2 to 2004:2														
Mean	0.003	-0.012	-0.007	0.015		0.000	-0.001	0.001	0.013		0.000	0.003	0.013	0.012
s.d.	0.021	0.026	0.023	0.029		0.011	0.015	0.013	0.021		0.007	0.015	0.025	0.018
Skewness	0.602	-0.556	-0.486	0.863		0.192	-0.740	-0.600	0.625		0.305	0.152	0.812	0.627
Kurtosis	-0.147	-0.287	-0.413	-0.126		-0.138	0.437	-0.140	-0.763		-0.862	-0.163	0.022	-0.691
1984:2 to 1993:4														
Mean	0.006	-0.011	-0.007	0.032		-0.001	-0.005	-0.001	0.025		-0.002	0.004	0.027	0.024
s.d.	0.028	0.036	0.031	0.033		0.015	0.018	0.016	0.023		0.008	0.018	0.028	0.018
Skewness	0.255	-0.470	-0.375	-0.044		0.334	-0.566	-0.516	-0.469		0.418	0.121	-0.046	-0.183
Kurtosis	-1.418	-1.484	-1.605	-1.239		-1.247	-0.778	-1.108	-0.997		-0.996	-0.476	-0.603	-1.074
1994:1 to 2004:2														
Mean	0.000	-0.012	-0.007	0.000		0.001	0.002	0.003	0.001		0.001	0.002	-0.001	0.000
s.d.	0.011	0.011	0.009	0.012		0.005	0.010	0.010	0.008		0.006	0.012	0.012	0.009
Skewness	-0.208	-0.138	-0.299	-0.613		0.070	0.506	0.346	0.146		0.432	-0.013	0.524	0.510
Kurtosis	-0.698	-0.764	-0.937	-0.531		-0.364	-0.644	-0.023	-0.875		-0.746	-0.559	-0.576	-0.319

Table 2: Correlations between gap measures, 1984:2 to 1993:4

		LQ				HP				UC			
		FS	RT	QR	NR	FS	RT	QR	NR	FS	RT	QR	NR
LQ	Full sample	1.00											
	Real-time	0.32	1.00										
	Quasi-real	0.30	0.99	1.00									
	Nearly real	0.92	0.60	0.54	1.00								
HP	Full sample	0.95	0.51	0.3	0.96	1.00							
	Real-time	0	0.85	0.99	0.23	0.21	1.00						
	Quasi-real	-0.02	0.81	0.86	0.16	0.17	0.97	1.00					
	Nearly real	0.72	0.79	0.72	0.93	0.85	0.47	0.36	1.00				
UC	Full sample	0.66	0.38	0.32	0.71	0.82	0.2	0.11	0.74	1.00			
	Real-time	0.08	0.82	0.83	0.32	0.25	0.73	0.73	0.52	0.17	1.00		
	Quasi-real	0.04	0.85	0.83	0.36	0.24	0.69	0.64	0.62	0.24	0.73	1.00	
	Nearly real	0.44	0.78	0.69	0.73	0.64	0.52	0.38	0.93	0.73	0.55	0.72	1.00

Table 3: Correlations between gap measures, 1994:1 to 2004:2

		LQ				HP				UC			
		FS	RT	QR	NR	FS	RT	QR	NR	FS	RT	QR	NR
LQ	Full sample	1.00											
	Real-time	0.70	1.00										
	Quasi-real	0.95	0.84	1.00									
	Nearly real	0.81	0.88	0.85	1.00								
HP	Full sample	0.74	0.49	0.72	0.60	1.00							
	Real-time	-0.06	0.24	0.07	0.37	0.28	1.00						
	Quasi-real	0.12	0.23	0.26	0.4	0.45	0.92	1.00					
	Nearly real	0.35	0.68	0.46	0.78	0.53	0.78	0.69	1.00				
UC	Full sample	0.42	0.04	0.31	0.35	0.81	0.49	0.60	0.46	1.00			
	Real-time	0.54	0.87	0.69	0.69	0.33	0.14	0.13	0.51	0.54	1.00		
	Quasi-real	0.23	0.42	0.29	0.56	0.36	0.65	0.58	0.74	0.44	0.32	1.00	
	Nearly real	0.19	0.38	0.24	0.62	0.47	0.88	0.78	0.92	0.63	0.23	0.77	1.00

Table 4: Output gap cycle characteristics

Gap	Peak	Trough	Dur. [2]	Ampl. [1]	Trough	Peak	Dur. [2]	Ampl. [1]	Dur. [3]
LQFS	88:4	93:2	18	-7.8%	93:2	94:4	6	2.8%	24
	94:4	96:2	6	-0.8%	96:2	00:3	17	2.4%	23
	00:3	03:2	11	-3.9%	03:2				
LQRT	87:3	92:1	18	-9.5%	92:1	97:3	22	7.6%	40
	97:3	99:1	6	-2.4%	99:1	00:2	5	1.3%	11
	00:2	03:2	12	-2.6%	03:2				
LQQR	85:2	92:2	28	-8.7%	92:2	94:4	10	5.0%	38
	94:4	96:2	6	-0.5%	96:2	00:1	15	1.7%	21
	00:1	03:2	13	-3.2%	03:2				
LQNR	90:2	93:2	12	-10.2%	93:2	95:1	7	3.2%	19
	95:1	96:2	5	-1.2%	96:2	97:3	5	2.1%	10
	97:3	99:1	6	-2.1%	99:1	00:2	5	1.4%	11
	00:2	03:3	13	-3.7%					
HPFS	88:4	92:3	15	-4.6%	92:3	94:4	9	3.0%	24
	94:4	97:3	11	-1.1%	97:3	00:3	12	1.3%	23
	00:3	03:2	11	-2.1%	03:2				
HPRT	87:3	91:2	15	-6.0%	91:2	94:4	14	6.5%	29
	94:4	96:2	6	-1.7%	96:2	97:3	5	0.4%	11
	97:3	99:1	6	-2.2%	99:1	00:2	5	1.1%	11
	00:2	02:1	7	-1.4%	02:1				
HPQR	85:2	91:2	24	-5.5%	91:2	94:3	13	5.5%	37
	94:3	99:2	19	-2.7%	99:2	00:1	3	0.8%	22
	00:1	02:2	9	-1.8%	02:2				
HPNR	90:2	93:1	11	-7.5%	93:1	95:1	8	3.2%	19
	95:1	96:2	5	-1.6%	96:2	97:3	5	1.6%	10
	97:3	99:1	6	-2.5%	99:1	00:3	6	1.4%	12
	00:3	03:3	12	-1.7%	03:3				
UCFS	90:2	92:2	8	-2.6%	92:2	94:4	10	2.6%	18
	94:4	97:3	11	-2.1%	97:3	00:3	12	1.6%	23
	00:3	03:2	11	-1.9%	03:2				
UCRT	86:3	92:1	22	-4.8%	92:1	97:4	23	4.4%	45
	97:4	98:4	4	-3.2%	98:4	00:2	6	2.1%	10
	00:2	02:4	10	-2.6%	02:4				
UCQR	85:1	92:3	30	-10.4%	92:3	95:2	11	5.0%	41
	95:2	96:4	6	-3.3%	96:4	98:2	6	2.5%	12
	98:2	00:1	7	-3.0%	00:1	00:4	3	1.8%	10
	00:4	00:3	7	-2.4%	00:3				
UCNR	90:2	92:3	9	-5.8%	92:3	95:1	10	2.6%	19
	95:1	99:1	16	-3.4%	99:1	00:3	6	1.6%	22
	00:3	03:3	12	-1.6%	03:3				

Notes: Peaks and troughs identified by Bry-Boschan (1971) technique. [1] Amplitude is percentage points around trend from peak-to-trough and trough-to-peak; [2] duration in quarters, peak-to-trough/trough-to-peak; [3] duration in quarters, peak-to-peak.

Figure 1: Full sample output gaps
1984:2 to 2004:2

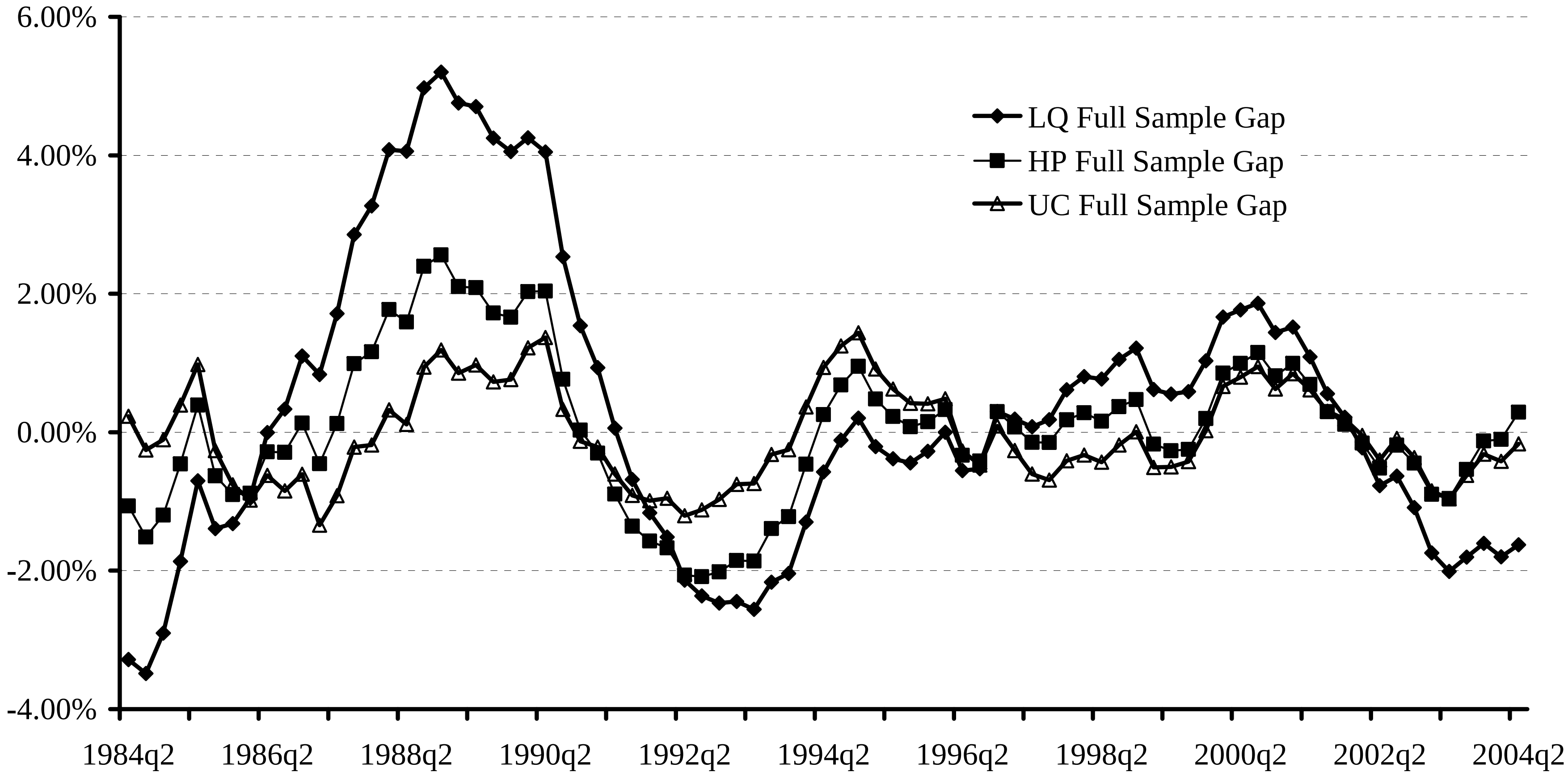

Figure 2: Real-time output gaps
1984:2 to 2004:2

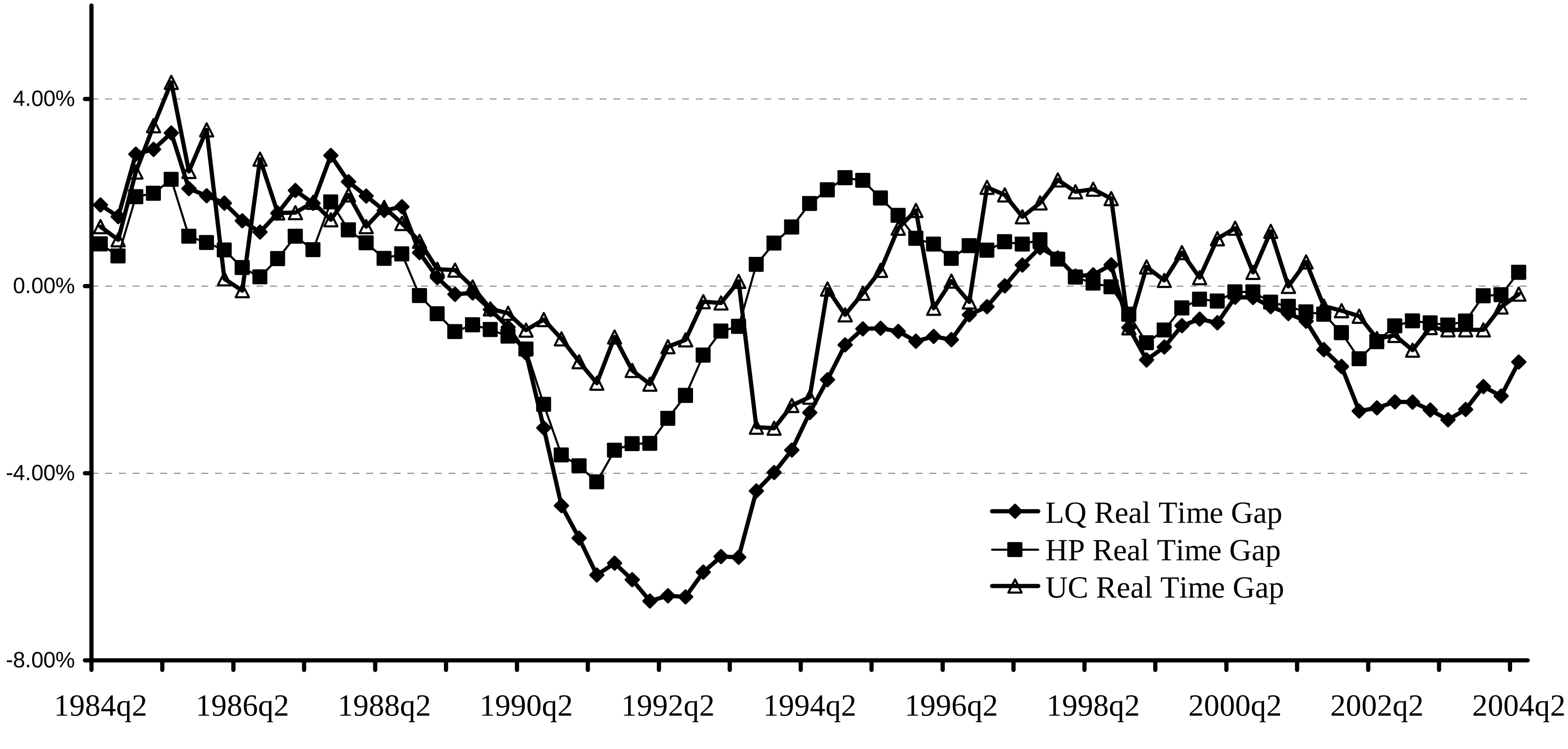

Figure 3: Linear quadratic output gaps
1984:2 to 2004:2

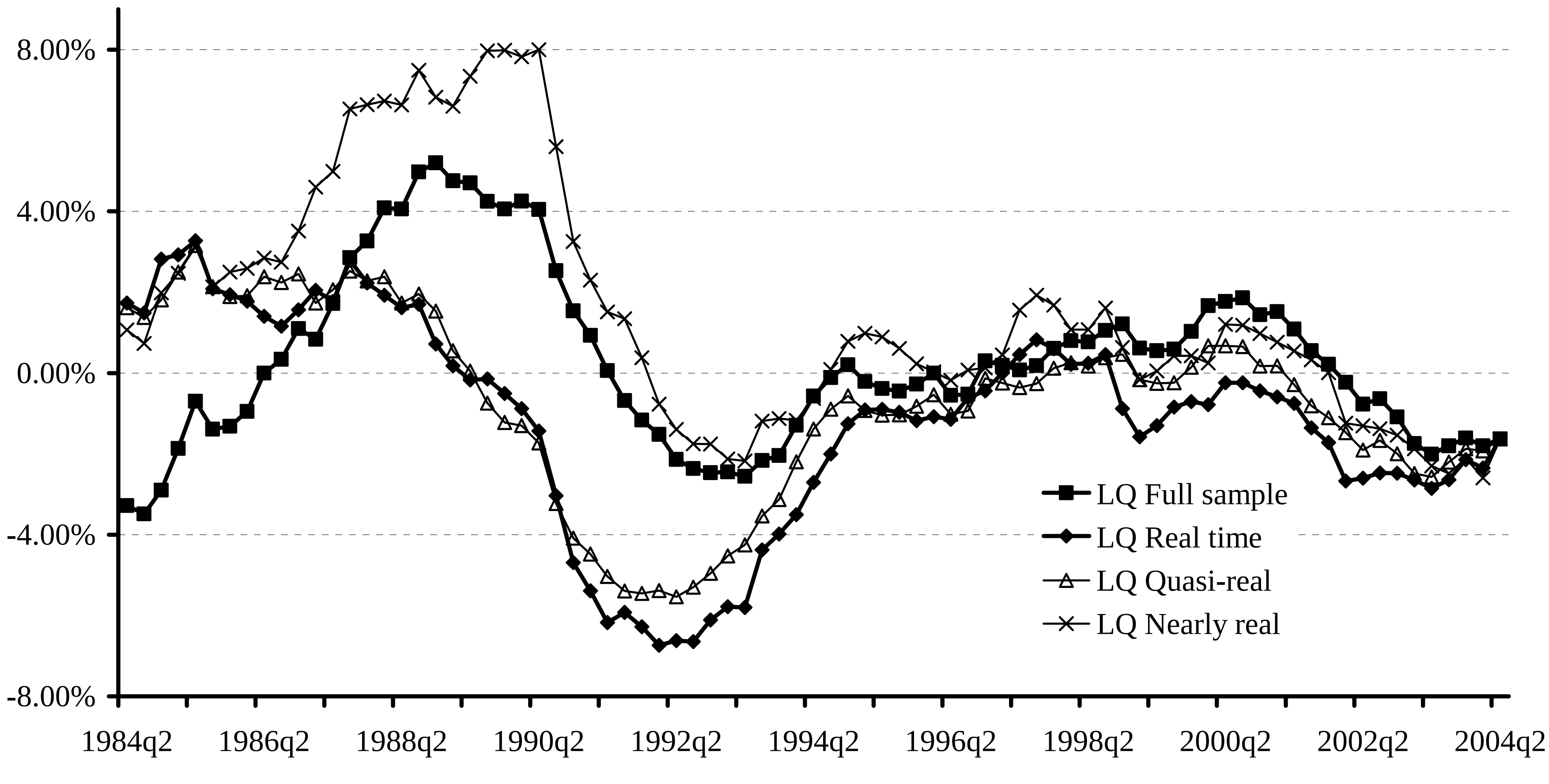

Figure 4: Hodrick-Prescott output gaps
1984:2 to 2004:2

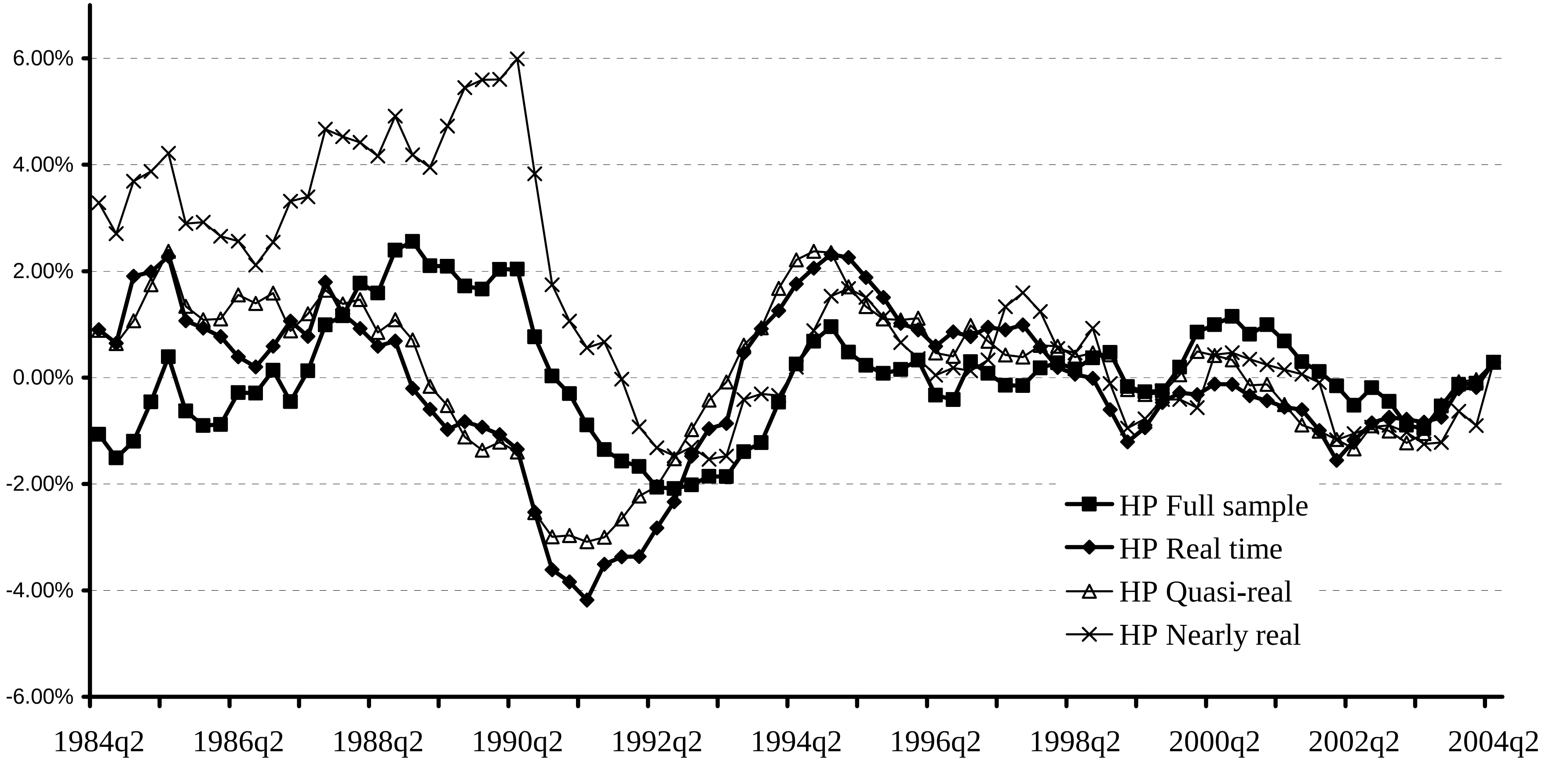

Figure 5: Unobserved components output gaps
1984:2 to 2004:2

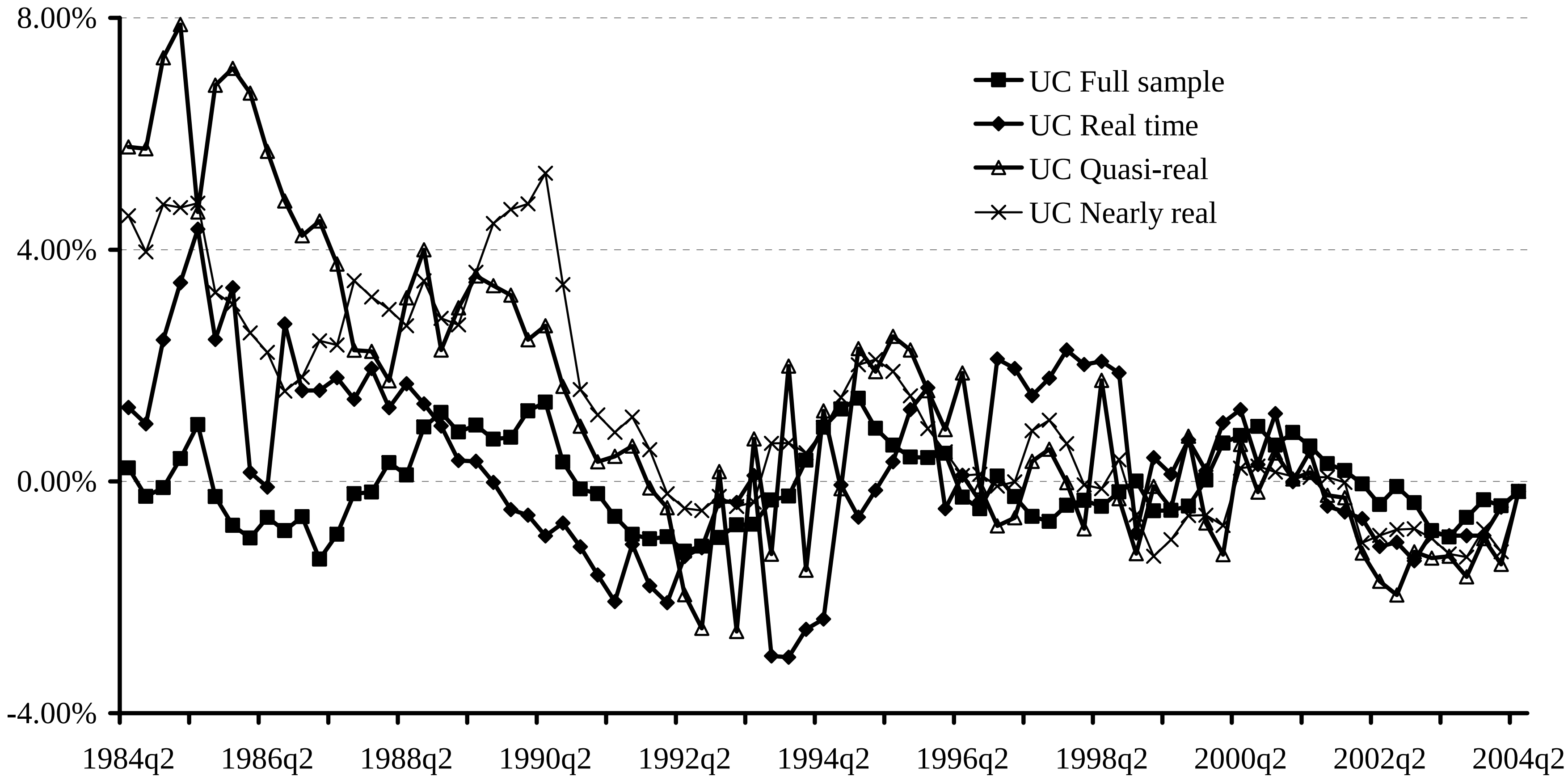

Figure 6:Linear quadratic trend output estimates

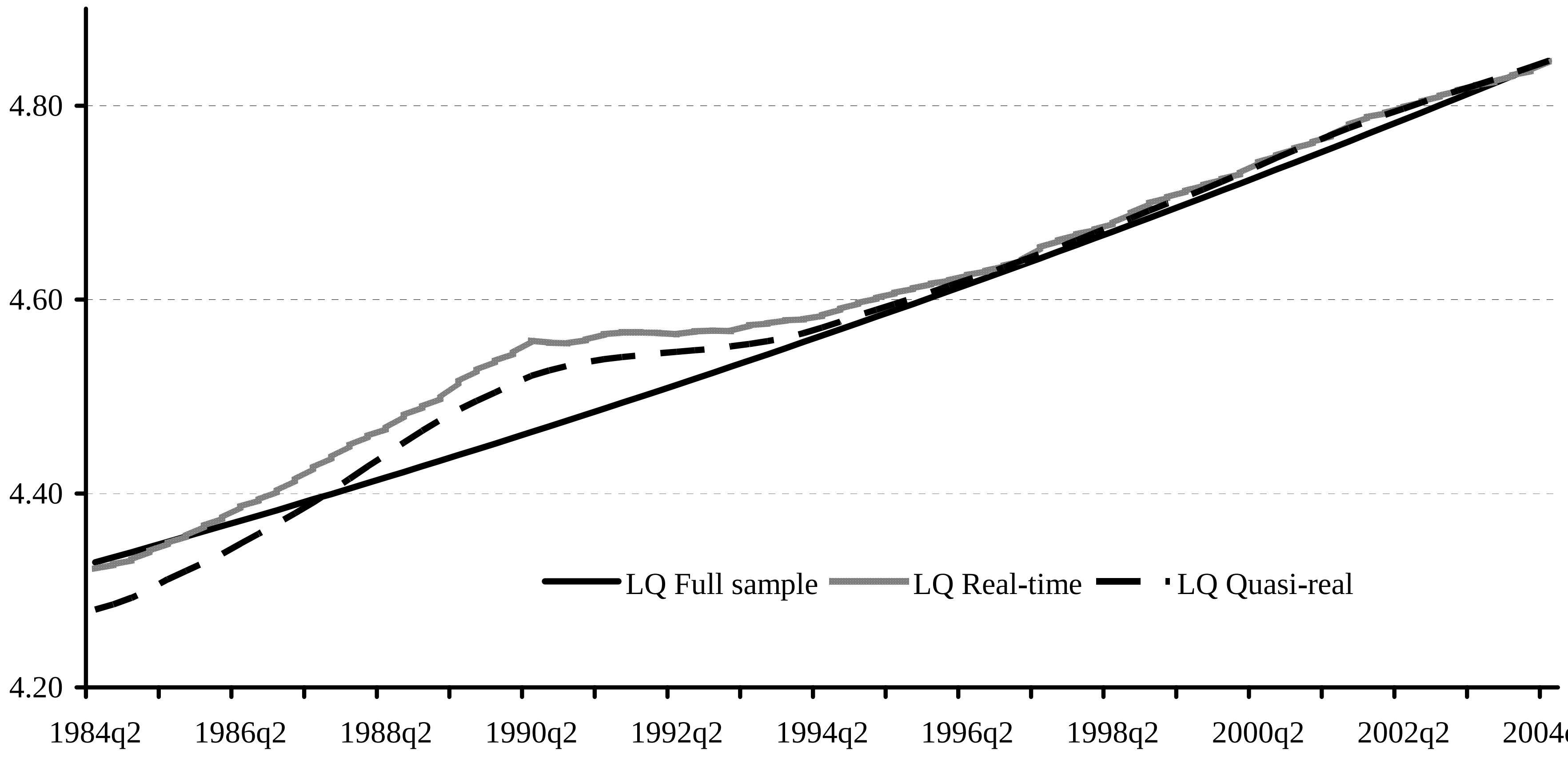

Figure 7: Hodrick Prescott trend output estimates

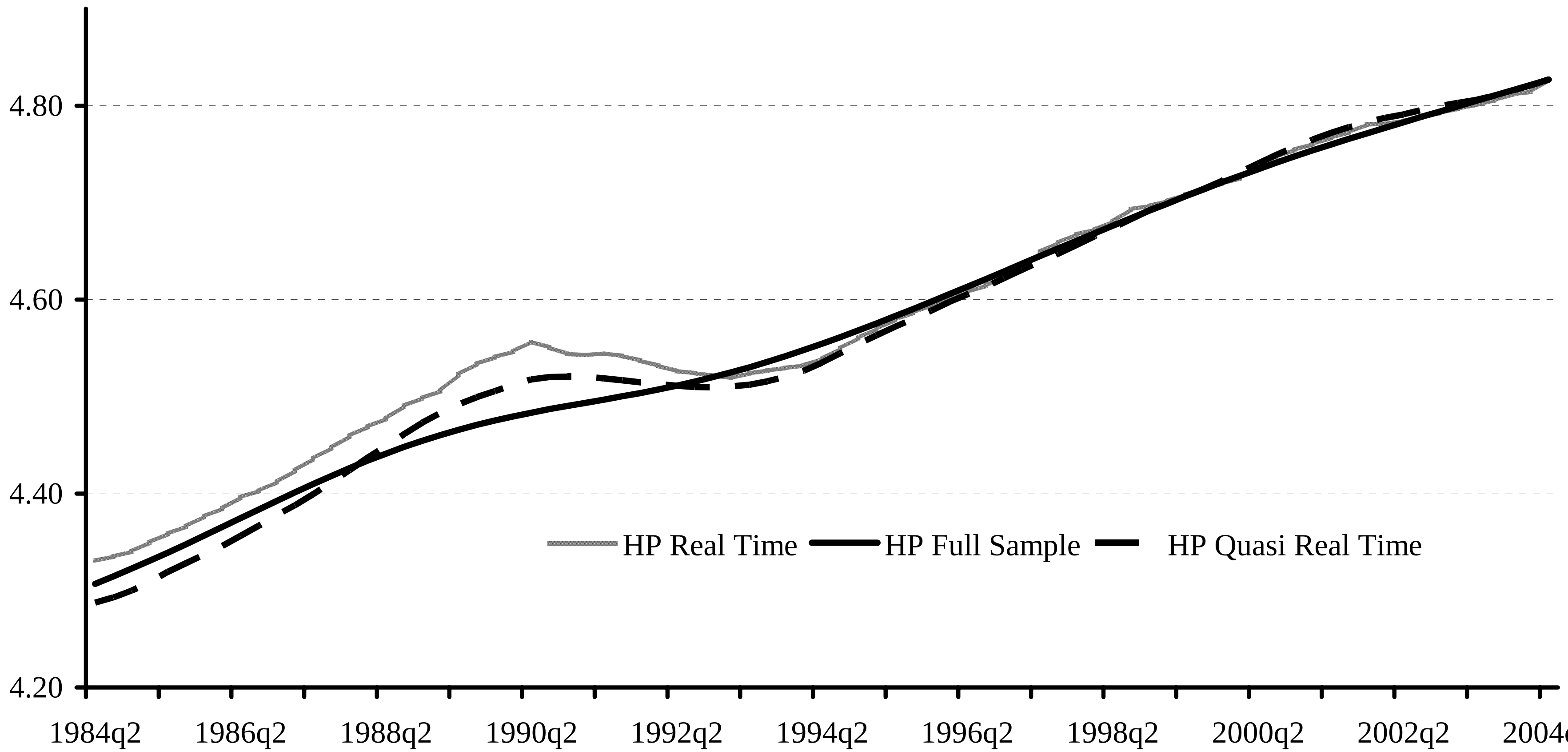

Figure 8: Unobserved component trend output estimates

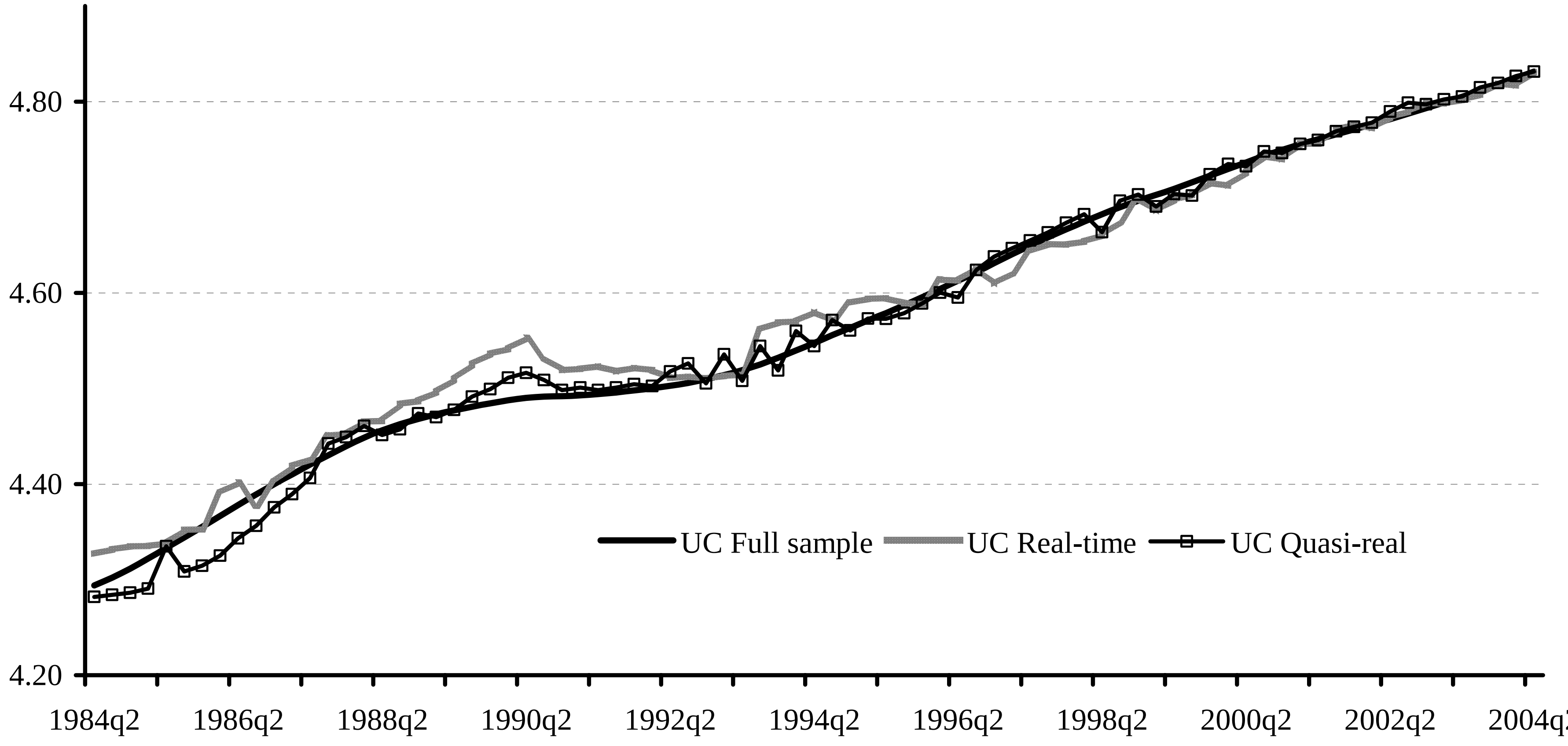

Figure 9: Number of output gap series identifying peaks and troughs