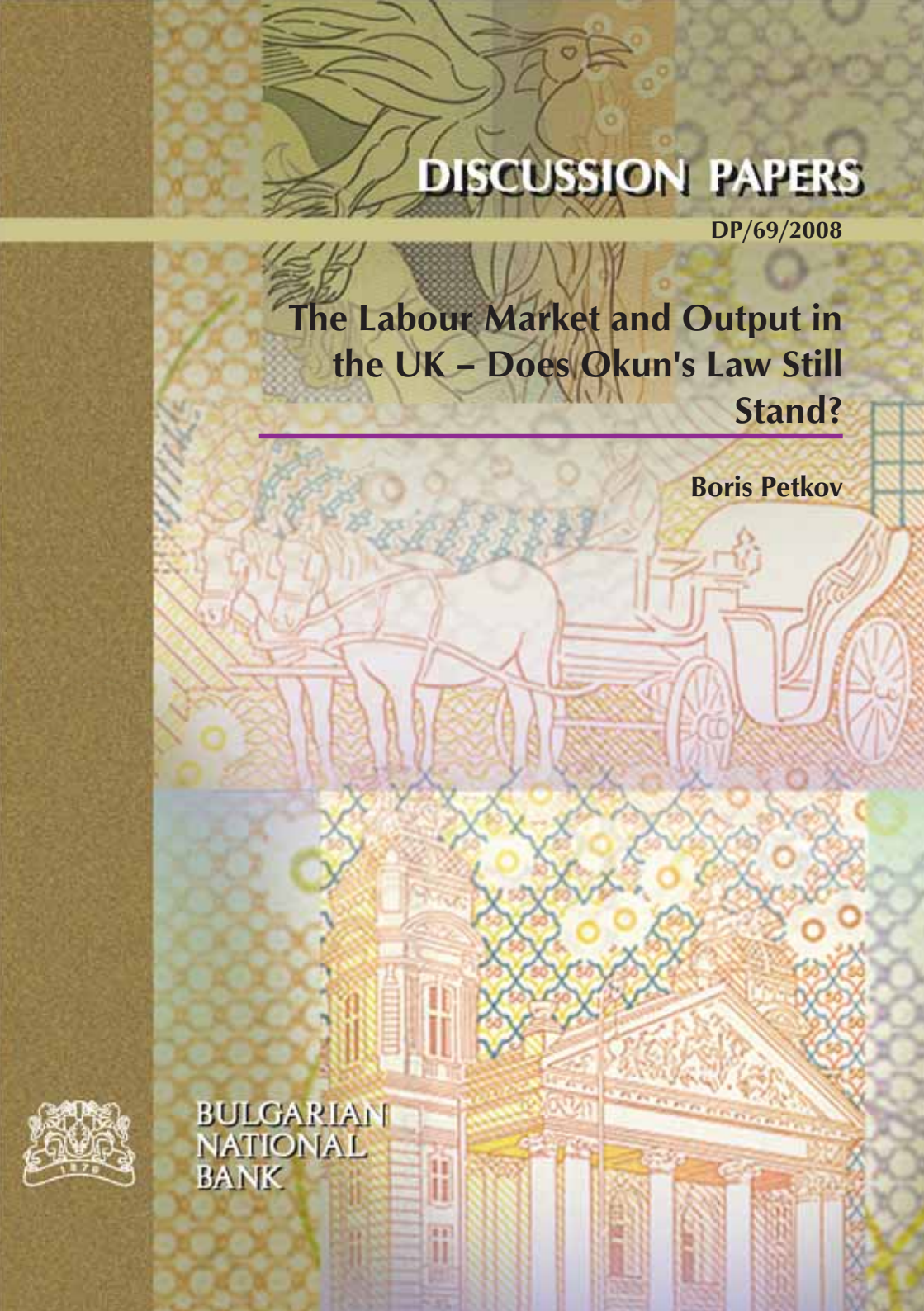

DISCUSSION PAPERS

DP/69/2008

The Labour Market and Output in the UK – Does Okun's Law Still Stand?

Boris Petkov

BULGARIAN NATIONAL BANK

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Contents

SUMMARY. This paper estimates Okun's law for the UK. The results indicate that Okun's law is a valid empirical approximation. The long-run relation is reasonably stable to sample periods and different estimation techniques, notwithstanding the existence of persistent local trends – within certain bounds of variation – Okun's coefficient is of potential usefulness for forecasting and policy analysis. We take account of recent advances in the econometric analysis of time series – fractional cointegration – by extending the empirical literature through exploring the possibility that the rates of unemployment or / and the output gap series are characterised by long memory.

JEL Classification Numbers: C29, E24, E32, E6

Key words: Okun's Law, Output Gap, Potential Output, Cyclical Unemployment, NAIRU, Employment, Verdoorn's Law, Fractional Cointegration.

Introduction

The inverse relationship between the unemployment rate and output has been of long-standing interest. For most countries a clear relationship has been observed between the change in unemployment rate and GDP growth. The relationship is such that high growth is typically associated with a lower unemployment rate and conversely low rates of growth or even negative growth is associated with a high unemployment rate. This is expected because economic theory suggests that at higher levels of output growth, due to an increase in the level of aggregate demand for example, firms will be required to hire more workers to meet that demand and hence unemployment falls.

One of the most influential papers on the relationship between the labour market and output growth is by Arthur M. Okun. While at Yale University and serving on the staff of the Council of Economic Advisers in 1962, Okun published a paper titled "Potential GNP: Its Measurement and Significance". This paper looked at the relationship between output and the change in the unemployment rate and found that there was a reliable empirical relationship between the two, which became dubbed Okun's Law.

The importance and value of Okun's law is not only for the interest of economists. Knowledge of whether this empirical relationship still holds is important for both structural policies and macroeconomic stabilisation as it is a reasonable 'rule of thumb' for estimating the likely impact of changes in output on the labour market. It is also for similar reasons a valid approach for economic forecasting. As a consequence this empirical relationship has had a great deal of attention in the academic world and has been found to hold in the UK among other countries as well as the US. However, macroeconomic forecasting is a continuous process and the current stage of the model building should not be taken as its final version.

In recent years, there have been some major changes in the mechanics of the UK labour market with the reforms on trade unions in the 1980s and the more recent New Deal policies amongst others. The effect of these policies has been to increase the flexibility of the labour force through greater ease to hire and fire and through increased participation of the labour force. There has also been much greater macroeconomic stability arguably through better economic management not only in the UK but also across most developed countries. This gives rise to the question as to whether Okun's law has changed or even still holds in this new economic environment of increased macroeconomic stability and changed employer and employee dynamics.

The results found in this article indicate that Okun's law is a valid empirical approximation. The long-run relation is reasonably stable to sample periods

and different estimation techniques, notwithstanding the existence of persistent local trends – within certain bounds of variation – Okun's coefficient is of potential usefulness for forecasting or policy analysis.

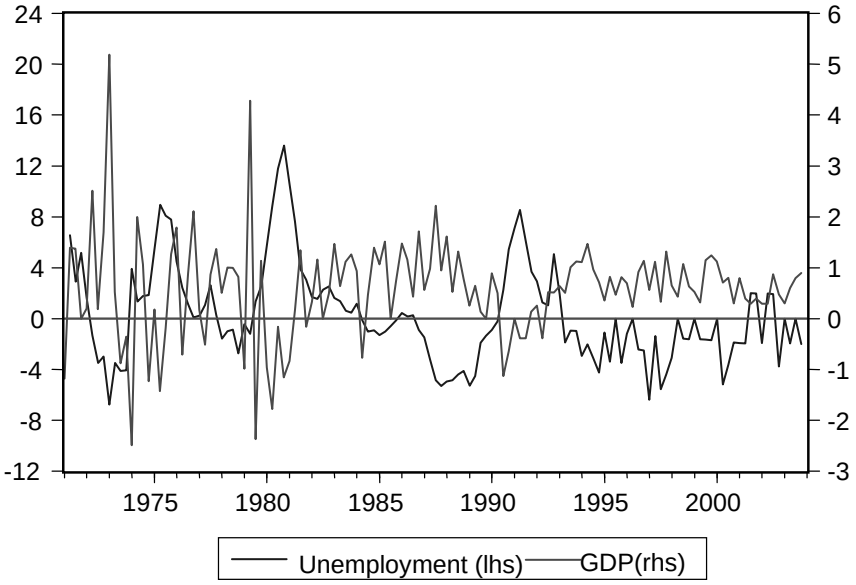
This paper is organised as follows: In Section II a look at the economic background regarding output and employment is taken for the UK. In section III a brief summary of Okun's paper is made to help explain the theory and method of analysis. In section IV the associated problems with Okun's econometric methodology are discussed. In section V some analysis is done using an advanced method of modelling with the most up-to-date data available. The results are then shown and discussed in section VI. Section VII then concludes.

GDP and the Labour Market – Background

Figure 1 shows UK GDP and the LFS historical time series for unemployment.[1] The cyclical changes over time can be seen and there is a clear inverse relationship between GDP growth and the unemployment rate.

Figure 1

UNEMPLOYMENT AND GDP 1971 – 2004, UK, QUARTERLY PER CENTAGE CHANGE



[1] http://www.statistics.gov.uk/CCI/article.asp?ID=418

Of course economies differ and therefore the exact relationship may differ, but this inverse relationship is observed across most other countries. When looking at GDP and the unemployment rate for the US over the last decade for example, GDP increases whilst the unemployment rate falls between 1994 and 2000. In 2000 GDP flattens off, as does the unemployment rate. 2001 brings a recession with an increase in the unemployment rate. GDP slowly starts to increase again in 2002 whilst the fall in the unemployment is lagged and starts mid 2003. So it seems the relationship still holds in the UK and abroad.

Theoretical Background and Brief Description of Okun's Findings

The economic world that we live in is one where productivity is constantly improving. It is this improving productivity that has enabled us to raise our standards of living so dramatically. It also means that to have a constant level of unemployment, even in an economy whose population is stable, the output level would have to increase. At the same time if the unemployment level falls, the wage bargaining power of workers increases because there is less of a labour pool from which employers can search from, which raises the wage rate. Due to this and the fact that there is a natural degree of turnover (i.e. frictional unemployment), it is almost impossible to eradicate unemployment. It can therefore be seen that unemployment below a certain level may lead to inflationary pressures, which adversely affect the economy's output - the level of unemployment at which this occurs is known as the non accelerating inflation rate of unemployment (from now on NAIRU). At the NAIRU, unemployment is such that there are no inflationary pressures on wages and therefore prices are stable in the economy.

This links into output as the NAIRU is the unemployment rate that corresponds to an economy producing its sustainable level of output. If unemployment is above the NAIRU, this means that the economy is not producing as much as it could (the economy's potential output) and so output is growing below trend. By comparison, if unemployment is below the NAIRU, then growth will be above trend and unsustainable.

When actual output is lower than potential output this has important implications for many aspects of the economy, individuals, firms and the future. With actual output lower than potential output there are resources in the economy sitting idle instead of working towards improving our standard of living. Firms will be producing at levels less than the optimal level. Also having actual output less than potential output in an economy will effect

future investment and the growth of potential GDP will be impeded - "today's actual output influences tomorrow's productive capacity"(Okun, A 1962 pg.3). Unemployment also has social effects over and above the extra burden of benefits, such as the effects on the individual, for example depression and financial instability. Unemployment is also often linked with crime. All of the above are important issues for policy-makers as the economy will be stronger and citizens will have a better standard of living the closer actual output is to potential output.

What Okun found was the level of unemployment that balanced the social goals of maximised output, minimised unemployment and stable prices and the relationship between unemployment and growth when say unemployment fell below its NAIRU. It can therefore be seen that the full employment goal of any government should be one that achieves "maximum production without inflationary pressure" (Okun, A 1962 pg.1)

Okun's Assumptions

In the paper "Potential GNP: Its Measurement and Significance" Okun observes the fact that when looking at the relationship between the labour market and output one needs to consider what components of the labour market would affect output. Areas of the labour market Okun discussed were the level of labour participation, hours worked per worker and productivity.

Looking at labour market participation, post-war literature supports the belief that an economy in a period of weak growth leads to a depression in the size in the labour force (those willing and able to work), but the magnitude and timing of such changes are unclear. Trying to assess the size of the labour force is further complicated by the inactive; who represent a significant proportion of the working age population. Technically, the inactive are not part of the labour force. However, in reality their attitudes to work vary and some may be close to the market. For example, some people may be content not to work and aren't actively seeking work but would take a job if one were offered; others may like a job but are discouraged and as a result do not think it is worth looking. Other factors affecting the propensity to move into the labour force may depend on changing family situations. All of these possible inflows and outflows to the labour force are unclear and make quantifying the size of the labour force a difficult issue.

Productivity is a major factor determining the level of output. Similarly to labour force participation (activity) rates, workers during expansionary times are more willing to work longer hours, hence labour supply increases in the number of hours willing and able to work per worker as well as the number of workers willing to work. Another reason is that labour is less flexible due to contractual commitments, specialisation of workers, the transaction costs of

hiring and firing and morale factors, which makes labour akin to a fixed cost. Therefore labour, if output is above (below) trend, will first require greater (fewer) hours from existing workers before hiring (firing) more workers. As a result, if business cycle dips or tips were mild, productivity would take more of the brunt than unemployment – average hours will increase and decrease with the business cycle.

This does mean one must be cautious when assessing if the economy is at stable full employment, as this will not necessarily be when average hours are at their peak. Average hours may be greater in times of expansion than they are in times of stable and full employment. This is due to the fact that extra over-time is worked as a short-term response to a pick-up in demand. However, if the higher level of demand is sustained, then more employees will be taken on and average hours will decrease.

Having identified these factors, instead of looking at all of them separately Okun takes one leap from unemployment to potential output. This is carried out on the assumption that when all the influences are summed together they produce the effect seen in the unemployment rate. "With this assumption, the unemployment rate can be seen as a proxy variable for all the ways in which output is affected by idle resources" (Okun, A 1962 pg.2). In his modelling, Okun found and used the 4 per cent unemployment rate as the 'price stable' position for the economy - what is now referred to as the NAIRU. The measurement is therefore simplified into an estimate of how output is depressed by unemployment in excess of 4 per cent.

Okun's Results

Okun used three different ways of calculating the relationship between output and unemployment. This section will concentrate on the 'First differences' method, which is the most widely quoted and used. It should be noted that all three of the methods he used achieved similar results for the USA data used and therefore for descriptive purposes the choice of method has no real significance. Okun performed first differences by relating quarterly per centage changes in the unemployment rate (U) to quarterly per centage changes in GNP (Y). This fitted to 55 quarterly observations from 1947 Q2 – 1960 Q4 and gave him the following relationship:

$$U = 0.3 - 0.3Y \quad (r=0.79) \qquad (1)$$

He found that the unemployment rate would rise by 0.3 points from one quarter to the next if real GNP was unchanged, as gains in productivity and growth in the labour force pushed up the unemployment rate. For each extra

1-percentage point of GNP, unemployment was 0.3 per cent lower. Conversely, for every 1 per cent increase in the rate of unemployment growth, the rate of GNP growth declined by 3.3 per centage points. See table 1 below:

Table 1

OKUN'S RESULTS - EMPIRICAL RELATIONSHIP BETWEEN OUTPUT AND UNEMPLOYMENT

Quarterly per centage change in unemployment (U)	Quarterly per centage change in GNP (Y)
0	1
1	-2.3
2	-5.6
3	-8.9

The uniformity that emerged from the three techniques was an approximate 3 to 1 link between output and the unemployment rate. Okun's subjectively weighted average of the relevant coefficients is 3.2. Yielding the following estimate of potential output:

$$Y_p = Y_a [1 + 0.032 (U - 4)] \quad (2)$$

When the unemployment rate (U) is 4 per cent potential GNP (Yp) is estimated as equal to actual GNP (Ya); at a 5 per cent rate of unemployment, the estimated gap between potential and actual GNP is 3.2 per cent of GNP. Or alternatively, if actual output is 3.2 per cent below potential (or sustainable trend) output, the unemployment rate will rise 1 per cent above its sustainable level. (This relationship was obtained from a period where unemployment ranged from 3 – 7.5 per cent; there is no reason to expect this relationship to occur when unemployment is outside this range).

Problems and Developments

Since Okun's paper was originally published many economists have delved further into this subject, updating it, carrying out comparisons across countries and also using modern and often more sophisticated econometric techniques in order to model Okun's law more effectively.

Time Period: Altig, Fitzgerald and Rupert looked at Okun's Law and updated it for the period 1960-96. They suggest that a 1– per cent decline in the unemployment rate is now generally accepted to relate to a 2 per cent increase in output rather than a 3 per cent increase. What this example shows is that Okun's law should be seen more as a rule of thumb that can change over time. This is because there are a number of factors that can change the relationship between output and employment such as breaks in

the historical magnitude between the unemployment rate and population growth rate, labour force participation or average hours. It is therefore preferable to check the rule still holds every now and again.

Hours Worked: There is empirical evidence that generally shows that hours worked per worker are not constant and that they vary positively with output. A corollary of this behaviour is that unemployment response to changes in output may be delayed. If this were found to be the case then a dynamic model would be preferred over a static model so as to capture these possible delayed responses.

Stationarity, non-stationarity, cointegration and fractional cointegration: Okun's original calculations didn't consider the possibility that unemployment or the output gap were non-stationary. More recent theory suggests for example that output (among other macroeconomic variables) exhibits non-negligible amounts of persistence. This is because there is significant empirical evidence that macroeconomic fluctuations are dominated by shocks with permanent effects. Theory tells us that aggregate demand shocks do not have permanent effects, therefore these permanent effects must originate from the aggregate supply-side. A corollary of this is that changes in technology, a major factor in changes to aggregate supply, could have major influences on output levels often having persistent effects. Persistence and hence non-stationarity mean series do not follow a linear trend and therefore performing regressions that assume linearity will give results that could well be 'spurious'.

A series is stationary if it is I(0) (Integrated to order zero). A test for non-stationarity is often called a test for a unit root, as it is the existence of unitary value in the 1st lag of the lag operator that leads to a deterministic trend. Finding a unit root has generally meant in econometrics that the series has been found to be I(1), i.e the series is 1st difference stationary - it becomes stationary when the 1st difference is taken. Taking 1st differences in order to solve the issue of non-stationarity is generally of little use in macroeconomics however, as this then means only the short run dynamics are considered and it is the long run relations that we are interested in. An econometric answer to this problem of estimation is to find a variable that over time moves with output, possibly unemployment which in-turn if found to be 'cointegrated' with output could then be used to estimate a relationship.

Not everyone accepts the idea of non-stationarity in macroeconomic series. Some believe that there are occasional episodes of large, permanent shocks to the economic system that cause a break in trend, but in-between these episodes the series is trend deterministic. In this case a linear trend is still assumed and major shocks such as the oil crisis of 1973 are assumed as trend shifting events.

More recently however, the idea of fractional integration has come into the fray. Traditionally, economic time series have been described based on deterministic I(0) or unit root models I(1). This approach has the advantage of conceptual and computational straightforwardness, but is too narrow and restrictive, ruling out a wide range of dynamic behaviour if the integration order (d) is limited to integer values. There is no reason why a series could not be integrated to a non integer value.

In this more general case though, there is a complication. The problem is in defining a cointegrating relationship between series that do not have the same order of integration, or even defining a cointegrating relationship when the order of integration is undetermined. Recent work by Pesaran and Shin has shown that using the Autoregressive Distributed Lag Approach allows the test for cointegration (existence of a long run relation) to be performed on series' that are I(0), I(1), or even I(d) (where d is a non-integer). Therefore, the concept of cointegration replicates the concept of long run equilibrium, where the former is statistical construct, whilst the latter is structural/ economic interpretation. Furthermore, this novel approach could be seen as a possible remedy when the empirical applications contain violation of theoretical assumptions. Fractional cointegration is currently one of the most active research areas in econometrics, greatly enhancing the existing methods of dynamic modelling and reaching innovative conclusions.

Asymmetry: The original Okun paper assumed the relationship between output and unemployment was symmetrical. That is, the direction of the change in output didn't matter to the magnitude of the change in unemployment. Research, especially in the area of business cycle theory has since argued that a change in output away from trend may affect unemployment to a different extent, dependent on whether output is moving above or below trend. H.G Courtney (1991) was the first to suggest asymmetry in Okun's Law and claimed that imposing symmetry in the Okun's Law regression leads to serious underestimates of unemployment rate increases in contractions and overestimates of decreased in the unemployment rate during expansions. Harris and Silverstone (2001) have also looked into this issue asserting that if there is asymmetry and if it is ignored Okun's Law could lead to forecasting errors, and wrong policies being enacted. They examined the relationship between output and unemployment in seven OECD countries and found that if asymmetry is not taken into account then Okun's Law would not fit certain countries' long-run relationship between unemployment and output. By using an asymmetric approach they established a co-integration for all countries (except Canada) in the short-run, giving the expected movement in the business cycle. Harris and Silverstone suggest that using an asymmetric approach should become

the standard approach to estimating the well-established link between labour market and output in the economy. However, J. Dopke (2001) also tests the possibility of asymmetric relation and his findings provide evidence against such interaction. Testing for possible asymmetry among eighteen selected OECD countries for the 1971 to 1999 period he concludes that: "asymmetry of the relation seems not to be a solid empirical ground for policy advice".[2] Particularly in the case of the UK the coefficient associated with the positive rate of growth of real GDP is of almost exactly the same magnitude (in absolute terms) as the parameter associated with the decline in real output growth rate. Furthermore, the former coefficient turns out to be insignificant. Consequently one needs to be very cautious when considering possible supporting and denouncing arguments in trying to assess the nature - asymmetric or symmetric – of the unemployment-growth relationship.

Price Stability: Price stability is an important policy objective and is closely linked with Okun's Law. When unemployment is at the NAIRU, actual output equals potential output. Therefore when the economy is producing at its potential level of output this is achieved without inflationary pressure. Apel and Jansson propose a system for estimating potential output and the NAIRU. This involves a Phillips type equation, which defines the NAIRU as the long-run unemployment rate consistent with steady inflation and a standard version of Okun's Law that states that deviations of unemployment from the NAIRU induce deviations of the level of output from its potential level.

Labour demand and supply and an implied Okun coefficient: Another development would be to look into the effects of changes in GDP on employment and the activity rate of the labour force, rather than unemployment, in a bid to see how demand for labour and supply of labour respond. Thus an 'implied' estimate of Okun's coefficient can be derived by relating the cyclical fluctuations of GDP to changes in employment which, in turn, affect the labour force and therefore finally unemployment. The implied Okun coefficient is derived from the following labour market identity:

$$\frac{P}{P} = \frac{E}{P} + \frac{U}{P} + \frac{I}{P} = 1 \qquad (3)$$

Where: P = the population of working age; E = the employment level; U = the unemployment level; and I = the inactive labour force level. The active labour force rate (a) is the employment rate (e) plus the unemployment rate (u).

[2] Dopke (2001), p. 20.

Hence,

$$P/P = E/P + U/P + I/P, \quad (4)$$

so it follows that the employment rate (e)

$$e = 1 - U/P - I/P, \quad (5)$$

The following identities hold:

u = unemployment rate (Defined as a proportion of the active labour force, unlike employment and inactivity which are defined as proportions of the population of working age) (u = U/(E+U) = U/(P-I)); i = inactivity rate (i=I/P)

The employment rate can be further decomposed:

$$e = 1 - u - i - ui \quad (6)$$

taking logs and rearranging yields:

$$Ln(e) + Ln(i) = -u \quad (7)$$

or

$$Ln(ei) = -u$$

substituting (1-a) for i we have

$$Ln(e(1-a)) = -u \quad (8)$$

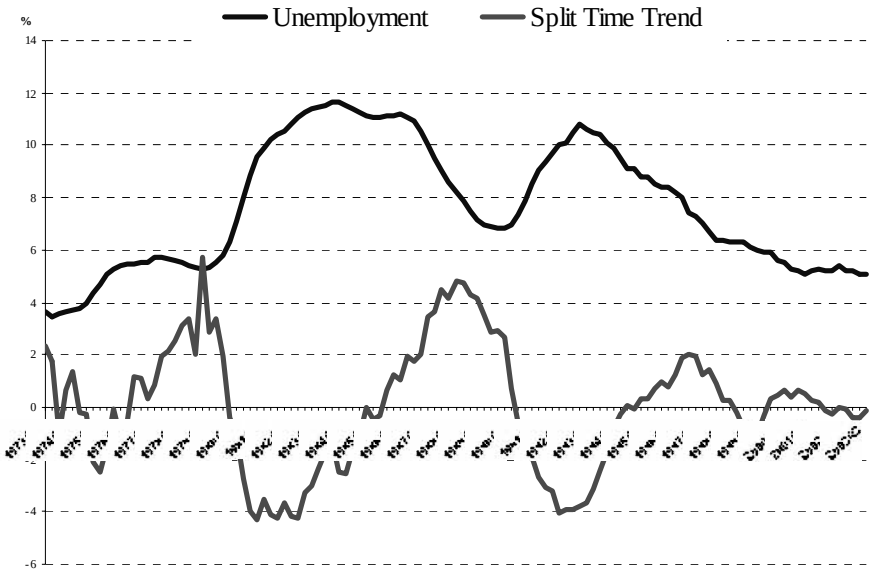
The left-hand side is one and the same thing with (μ) the Okun's coefficient. This is to say that unemployment reaction to changes in output growth can be "decomposed" to the sum of the change in employment rates and the change in activity rates.

Re-estimating Okun's Law

Having set out the background to Okun's work, this article now re-estimates the relationship between unemployment and GDP to see if Okun's Law still applies. The method used here is known as the trial gaps method where unemployment is regressed upon the output gap. The data used for quarterly unemployment rate is from the Labour Force Survey available from the National Statistics and runs from 1972. This data set uses the recently released modelled quarterly LFS pre 1992 data with quarterly survey data from 1992 onwards giving a large set of consistent data. Potential output and the output gap are not observed directly and therefore have to be estimated drawing on information from other observable economic aggregates. A variety of methods can be used to estimate potential output and the output gap. Here we employ the split time trends estimation method of potential output (A discussion on various trend estimation methods and their advantages and disadvantages is presented in Annex 1). The output gap is then the difference between actual and potential output. The output gap is shown with unemployment in *figure 2* (below) illustrating the inverse relationship between the deviation of the actual output from potential and the unemployment rate:

Figure 2

THE OUTPUT GAP AND UNEMPLOYMENT, 1973Q3 – 2003Q3



Stationarity of variables is a major concern in time series analysis since non-stationary variables are not mean preserving leading to invalid standard errors and related problems with hypothesis testing and other standard inferential techniques. The purpose of a unit root test is to statistically test the data generating process for trend stationarity against difference stationarity.

The test for stationarity used was the Augmented Dickey Fuller test (ADF), which when performed as follows is a simple t-test but with different critical values from the standard normal distribution:

$$\Delta Y_t = \alpha + Y_{t-1} + \sum_{i=1}^{k} \Delta Y_{t-k} + u_{1t} \qquad (9)$$

The lagged first difference terms are added so as to remove any serial correlation in the error term. First we test unemployment. The test cannot reject the null hypothesis of a unit root. The ADF statistic is in absolute value below its 95 per cent critical values of -2.8853 for up to the fifth order of augmentation. The values reported in Annex B for the various model selection criteria (AIC, SBC, and HQC) suggest that the correct order of the ADF regression is around two, with the maximum log-likelihood (LL) selecting

a higher order. Next we test for a unit root in the same time series again, but this time transformed by differencing (differencing a non-stationary variable generally results in a stationary variable). However, almost all values of the ADF statistics are above the 95 per cent critical value, the ADF (1) statistics is below its asymptotic critical value, at the same level of significance. The model selection criteria suggest that the proper order of the regression is between one and three. Based on the outcome of the test, we cannot reject safely the hypothesis that the growth rate of unemployment has a unit root. Simultaneously the ADF test seems to suggest that uneployment is neither level nor first difference stationary, in other words, the order of integration is not an integer, demonstrating that the standard choice between unit root I(1) and level stationary I(0) process is overly restrictive in this case. This result may be compared to those obtained by Gil-Alana (2001) who finds the fractionally differencing parameter (d) for logarithm of the UK unemployment to oscillate between 1.62 and 2.01 and by Davidson (2003), who reveals in the "best ARFIMA model" that d for the UK unemployment rate equals around 1.2. Hence, our findings are not inconsistent with the conclusions reached by other studies of the behaviour of unemployment rate.

Second we test for unit root in the output gap. The null hypothesis that this variable is difference stationary (unit root) against the alternative that it is trend stationary is not rejected for the first and second order of augmentation. This is not true when higher orders (up to five) are considered. All model selection criteria are suggesting that the suitable order of augmentation is three. Further we test for unit root in the growth of the output gap. In this case for all orders of augmentation (five) the absolute values of the ADF statistics are well above the 95 per cent critical value of the test and thus the hypothesis is apparently steadily rejected. However, it is well known in the literature on long-memory processes, that standard unit root tests have low power against values of d in the range of $0.5 < d < 1$. The model selection criteria are suggesting that the order of augmentation of the output gap could be around two.

The following section discusses the theoretical basis of our modelling approach. In economics we can discern two main propositions relating unemployment and the business cycle. The first relates to the NAIRU concept and characterises unemployment dynamics as a mean reverting, stationary process where shocks and cyclical movements do not have strong permanent effect. Consequently the unemployment rate tends to revert to its long run equilibrium level rather quickly. The second is associated with the notion of "hysteresis", asserting that cyclical fluctuations have rather permanent effects on the rate of unemployment and, therefore unemployment could appropriately be characterized as a non-stationary, long

memory, non mean reverting process.

It should be born in mind that it can be problematic to distinguish small trends from "spurious" local trends as a stationary time series under strong dependence can easily look a lot like the former but be essentially the latter and vice versa. As a result the discussion concerning the subtleties of distinguishing between a mean reverting and hysteric process is difficult to be brought to a close in any definite and plain way. Importantly, decisions on the order of integration of the series imply certain behaviour about the variable of interest. If stationarity were accepted it would imply an equilibrium that remains constant despite short-term shocks and government policy. On the other hand, if nonstationarity is assumed, no point of equilibrium will exist. One possible way out of this conceptual maze, although not without its problems, can be to assume that NAIRU is time varying (TV-NAIRU). This would suggest that the series under consideration may be non-stationary but also mean reverting, i.e., possibly fractionally integrated of the order I(d).

To accommodate the characteristics of the series in statistical terms and investigate whether a relationship exists between them we need to leave the linear stationary framework and test for cointegration. Essentially the evidence strongly suggests that at least one of the variables is mean reverting, nonstationary, i.e., its order of integration is not an integer. To examine the nature of the relationship between the output gap and unemployment, therefore, we need to address the general problem of defining a cointegrating relationship between series that do not have the same order of integration.

The standard cointegration tests (e.g., Johansen's ML) are inappropriate as the ADF tests for stationarity indicate that the variables are characterised by different orders of integration. We therefore turn towards the autoregressive distributed lag (ARDL) testing and estimating procedure developed recently in Pesaran and Shin (1995) and Pesaran, Shin and Smith (2001). This approach allows the regressors to be I(1), I(0), or even fractionally integrated, testing in fact for the existence of a long-run relation between the variables under investigation irrespective of the order of their integration. The null hypothesis of non-cointegration is tested against the existence of a long-run relationship by computing the F-statistics for the joint significance of the lagged levels of the variables in the ARDL model. The asymptotic distribution of this F-statistics is non-standard, but the critical value bounds are tabulated by Pesaran *et al*. If the estimated F-statistic exceeds the upper bound of the critical value band, we can reject the null hypothesis of no long run relationship between unemployment and the output gap.

A legitimate test of the cointegration hypothesis entails elimination of the trend from the unemployment data. In general, as this series (unemployment)

grows, the other (output gap) declines, so they appear to share long-run equilibrium. Nonetheless, it is known that many series grow over time, and due to this, they share a common trend. Such series that share a common trend but no underlying relationship will generate still a statistically significant correlation. Therefore, we need to remove the trend before testing for a reliable relationship. The series are filtered using the Hodrick-Prescott filter in an attempt to capture the (time varying) NAIRU. Then the so obtained "equilibrium unemployment rate" is subtracted from the original data, providing us with the de-trended series we use in our test.

The test for a long-run relationship between cyclical unemployment and the output gap is performed using the following version of the ARDL model:

$$\Delta U_{1t} = \theta_1 + \chi \Delta U_{\{1-3\}} + \phi \Delta \left(\frac{Y_{1t} - \overline{Y_t}}{\overline{Y}_t} \right)_{\{1-3\}} + a_1 \left(\frac{Y_{1t} - \overline{Y_t}}{\overline{Y}_t} \right)_{-1} + b_1 U_{1t-1} + u_{1t} \quad (10)$$

The null hypothesis of "non-existence of long-run relationship" is defined by $H_0 : a_1 = b_1 = 0$ against, $H_1 : a_1 \neq 0, b_1 \neq 0$, where the relevant statistics is the F-statistics for the joint significance of a_1 and b_1.

We estimate (10) by OLS and then calculate the F-statistic for the joint null hypothesis that the coefficients on the level variables are jointly equal to zero. The results are reported in Tables C.1 and C.2, Annex C. Following Pesaran et al. bounds test approach, and given that our sample test statistic exceeds the associated upper critical value (at the 99 per cent level the values are 7.057 and 7.815 respectively) we reject the null in favour of the alternative that there exists a long-run relationship between unemployment and output gap. Further, the data set is split into two sub-samples (1973Q3 to 1988Q3 and 1988Q4 to 2003Q3) and they are tested for cointegration using the same approach (see tables C.4 to C.9). The null of no cointegration is rejected at the 95% confidence interval for the former sub sample and at the 90% confidence interval for the latter sub sample.

The results have shown that these variables are cointegrated. Theory tells us that the least square estimator of a cointegrating regression is "super" consistent, i.e., converging faster to the true parameter than the least square estimator converges in the common case where the variables are not cointegrated.

Methods of Analysis

In what follows two different methods are used in our estimation of Okun's coefficient in a bid to obtain a reliable estimate of this empirical regularity for the UK. Every method is applied to the 1973Q3 to 2003Q3 (full sample) period and to two sub periods, 1973Q3-1988Q3, and 1988Q4-2003Q3.

The first method is based on the ARDL approach as presented by equation (10) above. The long-run coefficients and error correction model (ECM) are estimated by the ARDL approach, where the ECM is estimated using OLS and the lag structure for the ARDL specification of the short-run dynamics is determined by the Akaike information criteria. We begin by choosing the maximum order of lags present in the ARDL model to be three, allowing for standard lags between output and employment.

Second: This model is aimed at decomposing the changes in employment, or labour demand (equation (11) below) and changes in labour force or labour supply (equation (12) below) to changes in output.

First, employment is regressed on GDP applying the following specification:

$$e = \alpha + \beta y + \pi e_{-1} \tag{11}$$

Where: e = Growth in employment rate; y = Growth in output

Then labour force is regressed on employment using the following specification:

$$a = \gamma + \delta e + \kappa a_{-1} \tag{12}$$

Where: α = Growth in active labour force (unemployment + employment);
e = Growth in employment rate

In passing it is worth mentioning that the coefficient β denotes another key empirical regularity: Verdoorn's / Kaldor's coefficient capturing the positive association of growth rates of productivity and output.

From equations (11) and (12) we write $\beta(1 - \delta) = \mu$ – which is our implied Okun coefficient.

Results

Table 2

THE RESULTS OBTAINED FOR THE EQUATIONS 10, 11AND 12 ARE REPORTED IN TABLE 2, BELOW.

Estimates of Okun's Coefficient: 1973Q3 to 2003Q4									
Estimation method and period	*Constant*	*Okun Coeff*	*a(gap)*	*b(unemp-1)*	*c(unemp-2)*	*F-stat.*	$\overline{R^2}$	*AIC*	*LM Test*
ARDL Procedure									
Full Sample		**-0.2538**	--	--	--	981.10	0.9712	79.30	2.04
*t-ratio**		*[-5.8010]*							
1973:3 - 1988:3		**-0.2771**	--	--	--	800.05	0.9884	65.62	1.66
*t-ratio**		*[-2.3985]*							
1988:4 - 2003:3		**-0.4053**	--	--	--	897.76	0.9681	35.13	1.51
*t-ratio**		*[-11.1892]*							
Employment / GDP	**α**	**β**							
Full Sample	-0.0002	**0.4324**	--	--	--	179.39	0.7483	573.52	-2.0468**
t-ratio	*[-1.1284]*	*[3.1118]*							
1973:3 - 1988:3	-0.0001	**0.5240**	--	--	--	142.67	0.8252	297.49	1.7706**
t-ratio	*[-0.6411]*	*[1.9610]*							
1988:4 - 2003:3	-0.0008	**0.6729**	--	--	--	63.70	0.6800	278.26	-3.454**
t-ratio	*[-1.8410]*	*[3.0968]*							
Labor Force / Employment	**γ**	**δ**							
Full Sample	0.0003	**0.4591**	--	--	--	94.86	0.6100	618.29	2.5635**
t-ratio	*[2.6569]*	*[8.2632]*							
1973:3 - 1988:3	0.0005	**0.4796**	--	--	--	61.56	0.6656	314.31	4.5306**
t-ratio	*[2.5765]*	*[4.8866]*							
1988:4 - 2003:3	0.00008	**0.4375**	--	--	--	52.87	0.6374	312.24	1.4870**
t-ratio	*[0.4664]*	*[9.3486]*							
Implied Okun Coefficient		**μ**							
Full Sample	--	**-0.2338**	--	--	--	--	--	--	--
1973:3 - 1988:3	--	**-0.2727**	--	--	--	--	--	--	--
1988:4 - 2003:3	--	**-0.3785**	--	--	--	--	--	--	--

** Based on Newey-West adjusted S.E.'s, Parzen weights*

***D's h-statistic*

The t statistics for the implied Okun's coefficient models are shown for descriptive purposes only. Naturally their distribution is non-standard and they cannot be used for purposes of inference.

As shown in Table 2 the estimated Okun's coefficient by the ARDL approach displays relatively small variability - though exhibiting apparent upward trend with time. The coefficients of mutual determination are very high suggesting that the regressor explains most of the variation in the dependent variable. The Lagrange Multiplier (LM) test of residual serial correlation rejects the hypothesis that disturbances are serially correlated. Further to obtain an approximation of the speed of convergence to equilibrium we estimate the error correction model associated with the long-run estimate. The error correction coefficient, estimated at -0.1458 is highly statistically significant and suggests that the economy's return to equilibrium would take around seven quarters. This is to say that around 15% of the

opening between the long-run values of the variables is closed every quarter. Some other methods are explained and compared in annex D with some additional analysis looking at the response of the dynamic model to a 1 time shock in period 0 in annex E.

The implied Okun coefficients here are practically identical to the figures obtained by the ARDL approach and of the same magnitude as that found using the original Okun method of estimation. The coefficients of mutual determination are explaining from more than 60% to up to 82% of the total variation in the relevant variables. Serial correlation of the residuals does not appear to be a serious problem for this model. Okun's coefficient shows, as well, increase in value of parameter estimates over the later sub sample period. On inspection it is obvious that the regression coefficient characterising the interrelation between labour force and employment ( ) is broadly constant, hence higher responsiveness of employment to output during the 1988Q4-2003Q3 period accounts for the almost entire increase in magnitude of the Okun's coefficient. In other words, these estimates suggest stronger employment covariance with output during the last decade or so, which is equivalent to weaker pro-cyclicality of productivity per worker for the same period.

It is apparent that overall the Okun coefficient does vary somewhat depending on model specification and on different time periods but exhibits similar patterns of evolution through time (see annex F for a comparison of articles using varied methods and time periods).

Conclusion

This paper has estimated Okun's law for the UK. Our method exploit the ARDL approach, which is capable of dealing with fractionally integrated variables and also looks at the relationship between labour demand and supply with changes in output.

There have been some changes over time in the values of the Okun's coefficient. Some implications of the Okun's law were explored, e.g., labour market flexibility. The reported evidence seems to confirm that, based on the small statistically significant increase in magnitude in parameter estimates, the UK labour market is becoming rather more flexible. Some of the factors possibly playing a major role in these developments are: supply of labour; demand for labour; alterations in labour productivity such as efficiency in the use of workers, characteristics of the added workers, variability of average hours worked, as well as institutional factor modifications.

Whilst there are some differences in the Okun's coefficient over time and in-between alternative specifications it seems clear that the Okun's Law continues to be a reasonably robust relationship. Whilst, Okun's law is not alleged to hold exactly over any particular time period, and there is degree of uncertainty involved in forecasting, it is nonetheless useful predictive relation.

ANNEXES

Annex A

Potential/Trend output estimation discussion

The Linear Time Trend: This is the most common approach where trend growth rate is estimated using a linear regression of the Log of real GDP on a constant and a time trend. The residuals from the regression equation make available a measure of the output gap. This specification entails a constant potential output growth rate – a problematic assumption in the light of the variation in employment and capital.

Split Time Trend: This method is based as well on time trends to estimate potential output, but allows the trend growth of output to change between cycles. This requires a wide range of information and judgement to be used for determining the on-trend points (dating the business cycle). It does allow for changes in the potential level of output thus making it a more plausible estimation method of output trend.

Hodrick-Prescott Filter (HP): Linear filter aimed at removing low frequency variation from a series. This is accomplished by finding such a trend output that minimises a weighted average of the difference between output and trend output at whichever point in time, and at the same time minimises the rate of change in trend output over the sample period. However, there are a number of difficulties with the HP filter application. The selection of the value for the smoothing parameter (weighting factor,) determines the variance of the trend output estimate. As well estimates for the last data points are always preliminary (end-point problem) necessitating a final decision about an on-trend point to be taken with a lag of perhaps about 2-3 years.

Approximate calculations of the output gap

1. Simple Time Trend

This method entails a liner regression of the Log of real GDP on a constant and a time trend, i. e., decomposing GDP into trend and a cyclical component. The residuals from the regression equation make available a measure of the output gap. These results a re reported in Table 1A and Figure 1A (below).

Table A.1

ORDINARY LEAST SQUARES ESTIMATION

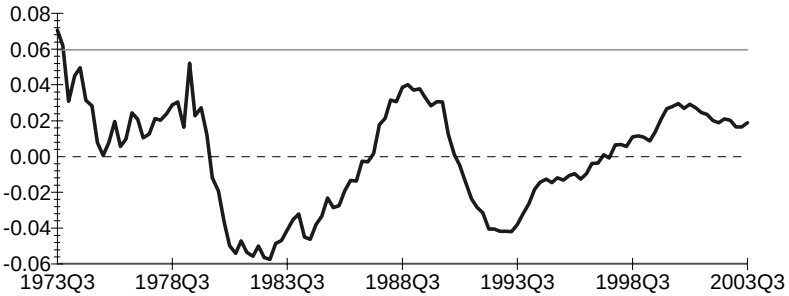
Dependent variable Log(RGDP)

121 Observation used for estimation

Regressor	Coefficient	Standard Error	T-ratio
Constant	11.3121	.010842	1043.4
Time Trend	.0056	.0000	73.2
R Bar Square	.9769		
F statistics	5295.3		
LM Test (CHSQ)	114.58		

Figure A. 1

SIMPLE TIME TREND OUTPUT GAP ESTIMATE, 1973Q3 – 2003Q3



2. Split Time Trend

This method estimates the output gap again on the basis of time trends, but allows the trend growth rate to change between cycles - between points when the economy is judged to have been on-trend. The regression equation is specified as with a linear time trend with the addition of dummies for chosen on trend points. For this exercise we identify the following on-trend points: 1978Q1, 1986Q2, 1991Q1, 1997Q2, and 1999Q3. In choosing the dates of business cycle on trend points we are broadly in line with the HM Treasury procedures.[3]

[3] For more details see " Trend Growth: Recent Developments and Prospects", April 2002, HM Treasury, and "Trend Growth: Prospects and Implications for Policy", 1999, HM Treasury.

Table 2A

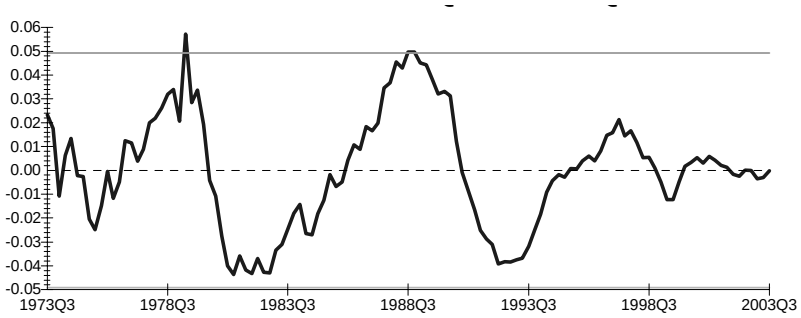
ORDINARY LEAST SQUARES ESTIMATION

Dependent variable Log(RGDP)
126 Observation used for estimation

Regressor	Coefficient	Standard Error	T-ratio
Constant	11.5621	.0467	247.06
Time Trend	.0029	.0005	5.4255
T2	.0020	.0007	2.5950
T3	.0021	.0007	2.7051
T4	-.0024	.0009	-2.5673
T5	.0061	.0018	3.3967
T6	-.0055	.0023	-2.4282
	R Bar Square	.9858	
	F statistics	1450.7	
	LM Test (CHSQ)	105.00	

Figure A.2

SIMPLE TIME TREND OUTPUT GAP ESTIMATE, 1973Q3 – 2003Q3



3. Hodrick-Prescott Filter

This approach is based on a linear filter aimed at removing low frequency variation from a series. is a weight parameter which rules the smoothness of the resulting trend line. This, again, is subjective like the choice of on trend points but two estimations using the HP filter with different values of are shown below (figures 3A and 4A) illustrating this method.

Figure A. 3

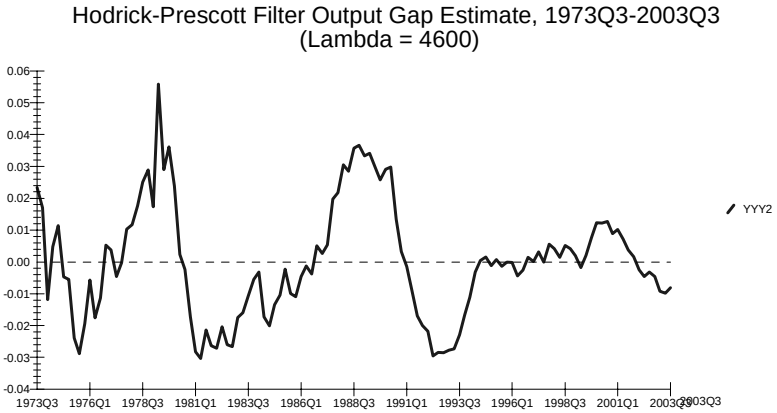


Figure A. 4

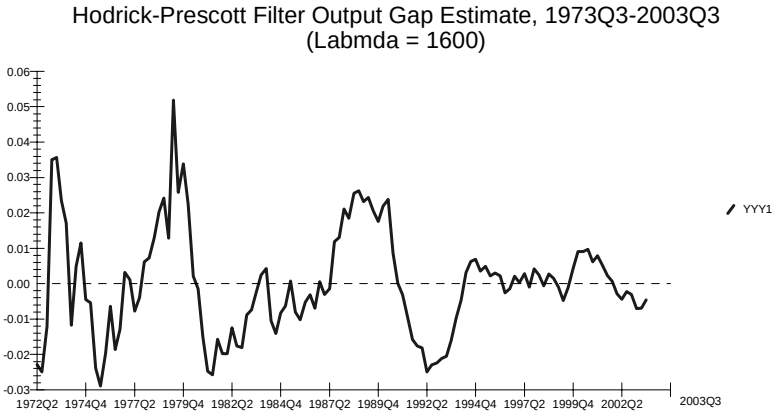
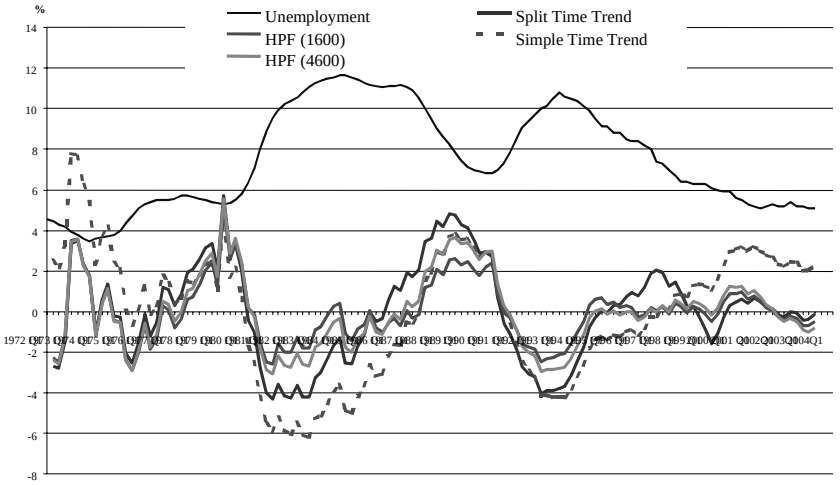


Figure A. 5

THE OUTPUT GAP (VARIOUS ESTIMATES) AND UNEMPLOYMENT



Comparing the results shows broad correspondence among the simple time trend, the split time trend, and the HP filter estimate in terms of the profiles of the output gap. On the other hand the output gap is greater when the growth rate of trend output is kept constant (simple time trend estimate) and the sign sometime is different. Over the whole period since 1998 to present (2003) the output gap is strongly positive using the simple time trend approach, whereas applying the other two methods produces similar but more complex patterns showing the output gap moving from slightly positive to moderately negative over recent past. In what follows we utilise the seemingly most realistic[4] split time trend estimate of the output gap.

[4]Consistent with the levels and changes of other macroeconomic aggregates, e.g., inflationary pressures, behaviour of average hours worked, etc.

Annex B

Unit root tests for variable (U) Unemployment

The Dickey-Fuller regressions include an intercept but not a trend

115 observations used in the estimation of all ADF regressions.
Sample period from 1975Q1 to 2003Q3

Test Statistic		LL	AIC	SBC	HQC
DF	-1.2989	-18.0132	-20.0132	-22.7581	-21.1274
ADF(1)	-2.3750	53.2136	50.2136	46.0962	48.5424
ADF(2)	-2.7960	55.9963	51.9963	46.5064	49.7680
ADF(3)	-2.4536	56.7878	51.7878	44.9255	49.0024
ADF(4)	-2.2278	57.4950	51.4950	43.2602	48.1525
ADF(5)	-2.2254	57.5282	50.5282	40.9210	46.6287

95 per cent critical value for the augmented Dickey-Fuller statistic = -2.8865

Unit root tests for variable (DU) First differences of Unemployment

The Dickey-Fuller regressions include an intercept but not a trend

115 observations used in the estimation of all ADF regressions.
Sample period from 1975Q1 to 2003Q3

Test Statistic		LL	AIC	SBC	HQC
DF	-3.1725	50.3884	48.3884	45.6435	47.2742
ADF(1)	-2.5475	52.0828	49.0828	44.9654	47.4116
ADF(2)	-2.9204	53.7241	49.7241	44.2342	47.4958
ADF(3)	-3.2407	54.9348	49.9348	43.0724	47.1494
ADF(4)	-3.1326	54.9501	48.9501	40.7153	45.6077
ADF(5)	-3.1879	55.1936	48.1936	38.5864	44.2941

95 per cent critical value for the augmented Dickey-Fuller statistic = -2.8865

LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable (GAP) Output Gap

The Dickey-Fuller regressions include an intercept but not a trend

115 observations used in the estimation of all ADF regressions.
Sample period from 1975Q1 to 2003Q3

Test Statistic		LL	AIC	SBC	HQC
DF	-1.8705	-140.6967	-142.6967	-145.4417	-143.8109
ADF(1)	-1.9459	-140.4946	-143.4946	-147.6120	-145.1658
ADF(2)	-2.5107	-136.1723	-140.1723	-145.6621	-142.4006
ADF(3)	-3.2297	-131.4670	-136.4670	-143.3293	-139.2523
ADF(4)	-3.4850	-130.5556	-136.5556	-144.7904	-139.8981
ADF(5)	-3.6845	-129.8208	-136.8208	-146.4281	-140.7203

95 per cent critical value for the augmented Dickey-Fuller statistic = -2.8865

Unit root tests for variable (DGAP) First Differences of Output Gap

The Dickey-Fuller regressions include an intercept but not a trend

114 observations used in the estimation of all ADF regressions.
Sample period from 1975Q2 to 2003Q3

Test Statistic		LL	AIC	SBC	HQC
DF	-10.2906	-141.6656	-143.6656	-146.4018	-144.7761
ADF(1)	-5.8863	-138.6164	-141.6164	-145.7207	-143.2821
ADF(2)	-4.0965	-135.7149	-139.7149	-145.1873	-141.9359
ADF(3)	-3.7606	-135.7088	-140.7088	-147.5493	-143.4850
ADF(4)	-3.5439	-135.7078	-141.7078	-149.9164	-145.0392
ADF(5)	-3.2584	-135.6528	-142.6528	-152.2295	-146.5395

95 per cent critical value for the augmented Dickey-Fuller statistic = -2.8868

LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Annex C

Table C.1

VARIABLE ADDITION TEST

Added variables $\left(\frac{Y_{1t}-\overline{Y_t}}{\overline{Y}_t}\right)_{-1}$, U_{1t-1}

117 Observations used for estimation (Full sample)

Regressor	Coefficient	Standard Error	T-ratio
$\left(\frac{Y_{1t}-\overline{Y_t}}{\overline{Y}_t}\right)_{-1}$	-.0354	.0101	-3.4778
U_{1t-1}	-.1558	.0388	-4.0159

Table C.2

JOINT SIGNIFICANCE TEST

Lagrange Multiplier Statistics	CHSQ (2) = 15.4333 [.000]
Likelihood Ratio Statistics	CHSQ (2) = 16.5506 [.000]
F Statistics	F (2, 108) = 8.2054 [.000]

Table C.3

ESTIMATED LONG-RUN COEFFICIENT USING ARDL APPROACH

ARDL (3,0) selected based on Akaike Information Criterion

Dependent variable U_{1t}

117 Observations used for estimation (full sample)

Regressor	Coefficient	Standard Error	T-ratio
$\left(\frac{Y_{2t}-\overline{Y_t}}{\overline{Y}_t}\right)$	**-0.2538**	.0423	-5.8010

R Bar Squared	.9712
Akaike Information Criterion	79.3004
Schwarz Bayesian Criterion	72.3949
LM Test (CHSQ)	2.0488 [.727]
DW Statistics	1.9785

Table C.4

VARIABLE ADDITION TEST

Added variables $\left(\frac{Y_{1t}-\overline{Y_t}}{\overline{Y}_t}\right)_{-1}, U_{1t-1}$

58 Observations used for estimation from 1974Q3 to 1988Q4

Regressor	Coefficient	Standard Error	T-ratio
$\left(\frac{Y_{1t}-\overline{Y_t}}{\overline{Y}_t}\right)_{-1}$	-.0207	.0007	-2.9533
U_{1t-1}	-.1121	.0319	-3.5148

Table C.5

JOINT SIGNIFICANCE TEST

Lagrange Multiplier Statistics	CHSQ (2) = 12.1554 [.002]
Likelihood Ratio Statistics	CHSQ (2) = 13.6408 [.001]
F Statistics	F (2, 49) = 6.4960 [.003]

Table C.6

ESTIMATED LONG-RUN COEFFICIENT USING ARDL APPROACH

ARDL (3,1) selected based on Akaike Information Criterion

Dependent variable U_{1t}

58Observations used for estimation from 1974Q3 to 1988Q4

Regressor	Coefficient	Standard Error	T-ratio
$\left(\frac{Y_{2t}-\overline{Y_t}}{\overline{Y}_t}\right)$	**-0.2771**	.1155	-2.3985

R Bar Squared	.9991
Akaike Information Criterion	60.9517
Schwarz Bayesian Criterion	54.7703
LM Test (CHSQ)	2.6101 [.625]
DW Statistics	2.2172

Table C.7

VARIABLE ADDITION TEST

Added variables $\left(\frac{Y_{1t}-\overline{Y_t}}{\overline{Y}_t}\right)_{-1}$, U_{1t-1}

60 Observations used for estimation from 1988Q4 to 2003Q3

Regressor	Coefficient	Standard Error	T-ratio
$\left(\frac{Y_{1t}-\overline{Y_t}}{\overline{Y}_t}\right)_{-1}$	-.0794	.0251	-3.1610
U_{1t-1}	-.2369	.0251	2.8810

Table C.8

JOINT SIGNIFICANCE TEST

Lagrange Multiplier Statistics	CHSQ (2) = 9.8478 [.007]
Likelihood Ratio Statistics	CHSQ (2) = 10.7569 [.005]
F Statistics	F (2, 51) = 5.0071 [.010]

Table C.9

ESTIMATED LONG-RUN COEFFICIENT USING ARDL APPROACH

ARDL (1,0) selected based on Akaike Information Criterion

Dependent variable U_{1t}

60Observations used for estimation from 1988Q4 to 2003Q3

Regressor	Coefficient	Standard Error	T-ratio
$\left(\frac{Y_{2t}-\overline{Y_t}}{\overline{Y}_t}\right)$	**-0.4053**	.0362	-11.1892

R Bar Squared	.9681
Akaike Information Criterion	5.1313
Schwarz Bayesian Criterion	31.9898
LM Test (CHSQ)	1.5176 [.824]
DW Statistics	1.8347

Annex D

Two other specifications applied in many previous articles are described and run for comparison.

The Static OLS method, as originally used by Okun, is applied:

$$U_{1t} = \theta_1 + a_1\left(\frac{Y_{1t} - \overline{Y_t}}{\overline{Y}_t}\right) + u_{1t} \qquad (1D)$$

Where: U = Unemployment rate; α = Okun's coefficient; Y = Real GDP; $\overline{Y}$ = Potential GDP; and θ = Constant (the NAIRU).

An auto-regressive form of the Okun's coefficient is estimated as to allow for a delayed reaction and to compare the long-run response to the stochastic form results. The model is of the following form:

$$U_{2t} = \theta_2 + a_2\left(\frac{Y_{2t} - \overline{Y_t}}{\overline{Y}_t}\right) + \sum_{i=1}^{k} b_{2k} U_{2t-k} + u_{2t} \qquad (2D)$$

The Okun coefficient is then found by:

$$Okuncoefficient = \left(\frac{a_2}{1 - \sum_{i=1}^{k} b_{2k}}\right) \qquad (3D)$$

RESULTS:

Estimates of Okun's Coefficient: 1973Q3 to 2003Q4

Estimation method and period	*Constant*	*Okun Coeff*	*a(gap)*	*b(unemp-1)*	*c(unemp-2)*	*F-stat.*	$\overline{R^2}$	*AIC*	*LM Test*
Static OLS									
Full Sample	7.6908	**-0.4196**	-0.4196	--	--	24.0825	0.1613	-269.66	115.9
*t-ratio**	*[18.2856]*	*[-2.9767]*	*[-2.9767]*						
1973:3 - 1988:3	7.937	**-0.4158**	-0.4158	--	--	9.8618	0.1286	-148.08	57.80
*t-ratio**	*[10.9770]*	*[-2.2125]*	*[-2.2125]*						
1988:4 - 2003:3	7.4401	**-0.4251**	-0.4251	--	--	18.5175	0.2289	-113.39	55.68
*t-ratio**	*[17.939]*	*[-2.4080]*	*[-2.4080]*						
Dynamic OLS									
Full Sample	0.15358	**-0.9260**	-0.0181	1.7151	-0.7346	10461.5	0.9961	55.71	15.2
*t-ratio**	*[3.0696]*	*[-2.3651]*	*[-2.1333]*	*[24.6356]*	*[-10.8814]*				
1973:3 - 1988:3	0.1410	**-0.7908**	-0.0133	1.8222	-0.8391	15471.6	0.9987	48.94	18.11
*t-ratio**	*[3.7400]*	*[-1.9880]*	*[-1.4285]*	*[15.0996]*	*[-7.0137]*				
1988:4 - 2003:3	0.1476	**-1.1027**	-0.0244	1.5547	-0.5768	1867.2	0.9895	14.75	16.23
*t-ratio**	*[3.3014]*	*[-1.3967]*	*[-1.3600]*	*[7.4584]*	*[-2.8043]*				

** Based on Newey-West adjusted S.E.'s, Parzen weights*

***D's h-statistic*

For the static OLS specification the results show overall very similar value to that obtained by the ARDL approach. This value is robust by sub periods. However, one should note that these values are contemporaneous ones, therefore not rendering themselves easily to comparison with our ARDL derived coefficients. The coefficients of mutual determination values are within the range of 0.13 to 0.23, i.e., explaining from 13% up to 23 % of the total variation in unemployment. There is however, as would be expected from a static model using time series data, a very high value for the LM test statistic showing high serial correlation up to the fourth order.

The Dynamic OLS model reports apparently fairly different figure for Okun's coefficient over the full sample period and by sub-periods. This is not at all surprising given that the model under consideration is a dynamic one, capturing all transitional short-run dynamics. In such a case the initial shock to output will set off aggregate unemployment fluctuations and if we are to make a valid comparison (with the other long-run coefficients) we need to provide an answer to the question: how long is it going to take for the shock to propagate through the economic system before converging to equilibrium? This is investigated in annex E. The coefficients of mutual determination values are very high and the f-statistic is exceedingly high, meaning that the null of all coefficients being equal to zero is rejected and the coefficients are found to be very highly jointly significant.

Annex E

Impulse Response Function Analysis

DYNAMIC OLS REGRESSIONS

	Estimation Period	1973-2003	1973-1988	1988-2003
	Coefficients			
	GAP	-0.0181	-0.0133	-0.0244
	UNEMP(-1)	1.7151	1.8222	1.5547
	UNEMP(-2)	-0.7346	-0.8391	-0.5768
SHOCK				
Period	GAP	UNEMP	UNEMP	UNEMP
-1	0	0	0	0
0	0	0	0	0
1	1	-0.018	-0.013	-0.024
2	1	-0.049	-0.038	-0.062
3	1	-0.089	-0.071	-0.107
4	1	-0.135	-0.110	-0.155
5	1	-0.184	-0.155	-0.204
6	1	**-0.234**	**-0.203**	**-0.252**
7	1	**-0.285**	**-0.254**	**-0.298**
8	1	-0.335	-0.305	-0.343
9	1	-0.383	-0.356	-0.385
10	1	-0.429	-0.407	-0.426
11	1	-0.472	-0.455	-0.464
12	1	-0.513	-0.501	-0.500
13	1	-0.551	-0.545	-0.535
14	1	-0.587	-0.586	-0.567
15	1	-0.619	-0.624	-0.597
16	1	-0.649	-0.658	-0.626
17	1	-0.677	-0.689	-0.653
18	1	-0.702	-0.717	-0.679
19	1	-0.725	-0.741	-0.703
20	1	-0.745	-0.762	-0.726
21	1	-0.764	-0.780	-0.748
22	1	-0.781	-0.796	-0.768
23	1	-0.797	-0.809	-0.787
24	1	-0.810	-0.819	-0.805
25	1	-0.823	-0.827	-0.822
26	1	-0.834	-0.833	-0.838
27	1	-0.844	-0.838	-0.853
28	1	-0.853	-0.841	-0.867
29	1	-0.861	-0.842	-0.881
30	1	-0.869	-0.842	-0.894
31	1	-0.875	-0.842	-0.906
32	1	-0.881	-0.840	-0.917
33	1	-0.886	-0.838	-0.928
34	1	-0.891	-0.835	-0.938
35	1	-0.895	-0.832	-0.947
36	1	-0.899	-0.829	-0.956
37	1	-0.902	-0.825	-0.964
38	1	-0.905	-0.822	-0.972
39	1	-0.907	-0.818	-0.980
40	1	-0.910	-0.815	-0.987

Using the impulse response function (IRF) analysis, the general path followed by the Okun Coefficient in response to a onetime change (shock) to output gap is presented above. The response is very slow and takes more than forty quarters to start approaching equilibrium. However, observing the effect of the shock after seven quarters displays values of almost equal magnitudes to the level of the long-run coefficients obtained by the ARDL method. This helps to better understand the dynamics and interactions characterising output gap and unemployment rate, providing evidence that the dynamic results by and large do not reject certain parameter regularity of Okun's coefficient.

Annex F

Table F.1

Comparison of Okun's Coefficient Estimates for the UK*

Moosa (1997)	**-0.37**	1960-1995
Sogner L. and A. Stiassny (2000)	**-0.58**	1960-1999
Lee (2000)	**-0.72**	1955-1996
Candelon B. and A. W. Hecq (1998)	**-0.26**	1960-1994
Perman R. and Ch. Tavera (2004)	**-0.64**	1970-2002
Perman R. and Ch. Tavera (2004)	**-0.24**	1970-2002
Schnabel (2002)	**-0.50**	1963-2000
Schnabel (2002)	**-0.75**	1991-2000

**Various methodologies and data frequencies.*

Table F.2

Comparison of Okun's (Implied) Coefficient Estimates for the UK:

	Employment on GDP	Labour Force on Employment	Okun's Coefficient
European Commission (2002)			
1969-1989	***0.55***	***0.36***	**-0.35**
1989-2001	***1.06***	***0.47***	**-0.56**
Petkov B., G. Heckley, et. al. (2005)			
1973Q3-1988Q3	***0.52***	***0.47***	**-0.27**
1988Q4-2003Q3	***0.67***	***0.44***	**-0.38**

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