THE RELATIONSHIP BETWEEN OUTPUT GROWTH AND UNEMPLOYMENT: A RE-EXAMINATION OF OKUN’S LAW IN AUSTRALIA

D.T. Nguyen and A.M. Siriwardana

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SUMMARY

How fast must the level of economic activity grow to prevent the unemployment rate from rising? How much faster than this would it need to grow in order to reduce the unemployment rate by, say, 1 percentage point? In analysing these, and other related issues, it is probably useful to consider a number of rules-of-thumb derived from Okun's law, the reduced-form relationship between unemployment and output growth. In this paper, we investigate the question of whether some form of Okun's law holds for Australia, and if so whether it has been stable.

Our results indicate that the various alternative formulations of Okun's law do not give rise to numerically similar parameter estimates. We identify one of these formulations as being the closest to the postulated relationship and yielding the most plausible estimates. We show that the other formulations involve approximation errors, which may help to explain why some of their results appear rather unrealistic.

Results based on the preferred formulation suggest that in Australia Okun's relationship underwent a structural change around the third quarter of 1974. After this break, it would appear, the unemployment rate became more responsive to variations in the rate of growth in output. The results also suggest that, currently, actual (non-farm) output must grow at a rate of approximately 0.8 per cent per quarter to keep the unemployment rate from rising. Each additional 0.3 per cent increase in output (per quarter) over and above this threshold rate can be expected to reduce the unemployment rate, after some lag, by about 0.1 percentage points.
1. INTRODUCTION

A basic problem in macro-economic policy-making is the fact that, at any given time, there are generally several objectives which may conflict with one another. This problem was clearly illustrated by the debate early in 1986 over the growth rate of the economy. Many commentators were concerned that, if the Australian economy continued to grow more rapidly than the rest of the world, it would encounter considerable exchange rate and/or balance-of-payments difficulties. Yet few would deny, per se, the desirability of the Government’s objective of maintaining economic growth at sufficiently high rates to reduce unemployment. The real question, then, was how to design and combine policies so as to meet the unemployment reduction objective without endangering the fulfillment of other objectives, such as a ‘healthy’ current account, a relatively low inflation rate, or the preservation of real wages and standards of living.

In this context, it would seem useful to be able to determine some of the parameters governing such a policy choice. In particular, one would presumably like to know (a) what the economy’s growth rate must be to prevent the unemployment rate from rising; and (b) how far must the actual growth rate exceed the above ‘threshold’ rate in order for the unemployment rate to fall by, say, 1 percentage point.

One way to obtain answers to these questions would be to simulate macro-econometric models of the economy. This, however, presumes that one has ready access to such a model, and that one’s conception of how the economy works is accurately reflected in the model’s various structural equations. As an alternative, one might consider using rules-of-thumb derived from a reduced-form relationship known as Okun’s Law. This approach is simple, and allows us to bypass the thorny question of what is the true specification of each of the relationships which make up the model.

Okun (1962) postulated a simple relationship between unemployment and output growth. His results, based on data for the U.S. economy during the period 1954 to 1960, indicate that there was a 1-to-3 relationship between these variables: on average, a 1-percentage-point rise in the unemployment rate was associated with a fall of about 3 percentage points in the growth rate of real G.N.P. This relationship proved quite robust during the 1960s, and became a popular inclusion in
macro-economic textbooks -- to the extent where it came to be known as a 'law'. It has been used not only to provide answers to questions such as (a) and (b) above, but also to generate estimates of potential output and of the economic cost (in terms of output foregone) of unemployment.

During the 1970s, as unemployment rates in most countries rose significantly, confidence in Okun's law began to wane. It has been suggested, for example, that the 'law' suffered its demise during this period because it was no longer a stable relationship; see, for example, Thurow (1983, p.9) and Okun (1980, p.168). Despite this, intellectual interest in Okun's law and its various applications has continued. In a recent study, Woodham (1983) found that, although Okun's relationship in the U.S. underwent some structural changes in 1974 and 1979, some of its central features remained remarkably stable throughout the sample period (1960 to 1982). Gordon (1984) regarded the relationship as sufficiently stable and reliable to warrant its use in analysing recent changes in U.S. output, potential output and unemployment. Interest in Okun's law has not been restricted to the U.S. context. Hamada and Kurosaka (1984), for example, investigated the question of whether the relationship (in some form) holds for Japan. Their reference list alluded to other Japanese studies of similar purposes.

The first attempt, to our knowledge, to examine Okun's law in Australia was made by Kennedy (1970). The period of analysis covered the years 1950 to 1968. As Kalisch (1982) pointed out, this period was characterised by a relatively low rate of unemployment and by little variation in that rate. Focussing on a later sample period (1960 to 1980), during which unemployment became significantly higher, Kalisch established an output-unemployment relationship for Australia which is much more similar to Okun's own results than Kennedy's findings had been. Kalisch's principal use of the estimated relationship was to derive a set of estimates for the output loss attributable to unemployment being higher than its 'full employment' level. These estimates were updated by Chapman and Graen (1984). More recently, Furnell (1985) compared one version of Okun's relationship with the corresponding unemployment equation in the 1981 version of the NIF-10 model, and found that the former performed slightly better in out-of-sample forecasting.
In all of these Australian studies, stability was not a central issue, although Furnell did briefly consider the question. In view of Woodham’s work, and of the major changes which the Australian economy underwent during the past fifteen years or so, it would seem worthwhile to re-examine Okun’s law in the Australian context, paying special attention to the (in)stability of any relationships observed. In addition, it would be useful to consider the various alternative formulations of Okun’s law and to compare their implications, as previous studies have tended to concentrate on single individual formulations. We propose to address these issues in this paper.

In Section 2, we outline the alternative methods for estimating Okun’s relationship. Section 3 contains a description of the data used and their sources. Section 4 deals with estimation and model selection, including work related to the stability issue, and Section 5 draws out the implications of the results. Some concluding remarks are contained in Section 6.

2. ALTERNATIVE FORMULATIONS

Okun (1962) postulated the following relationship:

\[ P = A[1 + 0.032(U - 4)], \]  

(1)

where \( P \) denotes potential output, \( A \) actual output, and \( U \) the unemployment rate. Note that, in the literature, “potential output” generally does not indicate the maximum level of production which the economy is capable of, but the “optimum or best practice which it is believed the economy is capable of sustaining on the average, year after year, without running into serious instability of employment, output, or prices” (Knowles, 1960, p.6).

Equation (1) reflects the judgement that the “full employment” rate of unemployment (FEU), which corresponds to potential output, was 4 per cent for the U.S. More generally, if we let \( \alpha \) denote this rate, equation (1) can be rewritten as:

\[ (P - A)/A = \beta (U - \alpha). \]  

(2)
This shows clearly that Okun's law is a way of relating the proportional gap between actual and potential output to the gap between actual and potential unemployment. Thus if actual output A is equal to potential output P, the unemployment rate U will be equal to α, theFERU. However, if A falls short of P, U will rise above α.

Okun did not arrive at the value of 0.032 for β in (1) through direct estimation. Rather, he put it forward as a subjectively weighted average of coefficients obtained from three econometrically estimated equations. These were of the following forms:

\[ \Delta U_t = a_1 - b_1(\Delta A_t/A_{t-1}) \]  \hspace{2cm} (A)
\[ U_t = a_2 + b_2(\Pi_t - A_t)/A_t \]  \hspace{2cm} (B)

and
\[ \ln N_t = a_3 + b_3 \ln A_t - c_3 t \]  \hspace{2cm} (C)

where \( N = 1 - U \) is the employment rate.

Re-arranging equation (2) one obtains:
\[ U = \alpha + \left( \frac{1}{\beta} \right) \left( \frac{P - A}{A} \right) \]  \hspace{2cm} (3)

which is of the form (B). Thus, if one believes that the true relationship is of the form expressed in equation (2), one can fit equation (B) directly to the available data. The problem with this approach is that it depends critically on the specification of the variable P, which is unobservable. Okun experimented with various alternative series of potential output, and selected the one which essentially gave him the best fit for equation (B). While this allowed him to get around the problem of unobservable data, some degree of arbitrariness still remained.

As for the other two forms, it is relatively simple to show that, subject to certain conditions, they can be regarded as approximations of form (B). Noting that \( x = \ln(1 + x) \), where \( x \) is a small fractional number, we can approximate (3) by:
\[ U = \alpha + b \ln(1 + (P - A)/A) \]
\[ = \alpha + b \ln(P/A) \]  \hspace{2cm} (4)
where \( b = 1/\beta \). Differentiating with respect to time both sides of equation (4) we obtain:

\[
\dot{U} = b(\dot{P}/P) - b(A/A). 
\]  

(5)

If one assumes that the growth rate in potential output \( \dot{P}/P \) is constant, one can approximate (5) in discrete time as:

\[ \Delta U = \alpha \cdot b(A/A_{t-1}) \]

which is of the form (A).

Similarly, we can approximate -U by \( \ln(1-U) = \ln(N) \). Using this, and equation (4), we can derive:

\[ \ln N = -\alpha \cdot b \ln(P/A). \]  

(6)

If, as before, we assume that \( P \) grows exponentially at a constant rate, i.e. \( P_t = P_0e^{\beta t} \), equation (6) can be rewritten as:

\[ \ln N = (-\alpha \cdot b \ln P_0) + b \ln A - (bt) \]

(7)

which is of the form (C).

Thus, both equations (A) and (C) can be seen as ways of indirectly estimating (B) — ways which allow us to bypass the problem of measuring \( P \). However, it should be kept in mind that, of course, they are only approximations. The larger are the output gap, \( (P-A)/A \), and the unemployment rate, \( U \), the less accurate are the approximations, assuming that (B) is the true underlying relationship. In addition, it should be emphasised that both formulations (A) and (C) embody the restrictive assumption that \( P \) grows at a constant rate, an assumption which is not required under (B).

Although Okun used all of the three formulations presented above, subsequent studies typically concentrated on one of them at a time. For example, both Woodham and Farnell focussed exclusively on form (A). While Kalisch experimented with all three forms, he quickly discarded forms (A) and (C). In this paper, we shall examine how the data fit each of these forms in turn.
3. DATA

Most of the data which are used in this study are available from publications of the Australian Bureau of Statistics (ABS). The key data series are those which measure the unemployment rate and real non-farm gross domestic product (GDP). We have chosen to use non-farm GDP instead of total GDP because the farm component of GDP is strongly influenced by various exogenous factors which may mask the underlying relationship between output and unemployment. Seasonally adjusted data on the unemployment rate (NUR) and real non-farm GDP (GNM) are available from the quarterly database compiled by the ABS for the NIF-10 model. The data cover the period 1959 Q3 through 1985 Q3, a total of 105 observations.

Movements in these two variables during the past 25 years are illustrated in Figures 1 and 2. After having been relatively stable around the 1.8 - 2.0 per cent level for much of the 1960s, NUR began to rise sharply in 1974, reaching 6 per cent by the end of 1977. It then remained near this level until 1982, when another series of sharp rises took it to a peak of 10.3 per cent in mid-1983. Since then, there has been a noticeable decrease in the unemployment rate. To some extent, these movements have reflected fluctuations in GNM. For example, Figure 2 shows clearly that output growth slowed down significantly in 1974 and again in 1982-83.

From equation (B), it is clear that we require data for at least another variable, namely P. We have adopted Kalisch’s basic approach in constructing a potential output series. First, the years 1966 through 1971 were chosen as representing a "golden era" when full employment generally prevailed, in the sense that the only unemployment which existed could be regarded as frictional unemployment. This choice was motivated partly by the fact that, during much of the period, the number of persons unemployed was fairly close to the number of vacancies. We then fit a linear trend through observed values of GNM during this golden era. The resultant equation is:

\[
\text{FEOUT}_t = 7068.8 + 289.98 t \\
(70.68) \quad (44.05) \\
R^2 = 0.995 \quad DW = 1.75
\]

Sample: 1966 Q1 to 1971 Q4

where \( t = 1 \) for 1966 Q1. In Figure 2 the derived values of FEOUT are shown as the dotted line.
Another approach which we could have employed to derive the potential output series is the "linked-peaks" method. This involves the selection of a number of peaks in the historical actual output series, and some interpolation between these peaks. We did not follow this method, because of the inherently arbitrary nature of the peak selection process, and because the peaks selected may not necessarily coincide with full employment.

Yet another approach would have been to generate estimates of potential output with the use of a "structural" model, which incorporates both an aggregate production function and some relationships governing the supply of labour over time. While this would have provided a more satisfactory theoretical basis for the constructed series, the exercise would have been a fairly major one, and is therefore outside the scope of the present study. Nevertheless, it is interesting to note that Peters and Petridis (1977) have developed such a model, and to compare their estimates of potential output with the extrapolated values of FEOUT. Figure 3 illustrates the movements of the two series (both expressed as indices with base period 1971 Q4 = 1000) over the period 1971 Q4 to 1976 Q2. As can be seen from the figure, the two series moved very closely together. This can be interpreted as providing some support from an independent source for the use of FEOUT as an approximation of P.

In equation (1), Okun treated $\alpha$ as a constant. By contrast, Kalisch argued that it varies over time due to changes in the demographic composition of the labour force. He constructed a series of $\alpha_L$ for Australia as follows. First, from labour force survey data for August in each "golden era" year, he calculated the unemployment rates applicable to various demographic groups (classified by age and sex). Second, for each group, he averaged the unemployment rates prevailing in these golden years, to derive what he regarded as the group's frictional unemployment rate (a constant). Third, from survey data for August in each year of interest (including post-1971 years), he calculated the proportion of the total labour force represented by each demographic group. Finally, these proportions were used as weights to combine the various group rates of frictional unemployment into an aggregate rate of frictional unemployment. More concisely,

$$ AFUR_t = \sum_1^T (L_t/L_T) GFUR_t, $$

(9)
ESTIMATES OF POTENTIAL OUTPUT

FIGURE 3
where GFUR\textsubscript{1} and AFUR\textsubscript{1} are group and aggregate rates of frictional unemployment, respectively; and L\textsubscript{g1} and L\textsubscript{1} represent group and total labour forces, respectively.

We experimented with a constructed series of $\alpha_\text{L}$ based on equation (9). However, it turned out to be not very useful for our purposes. First, the various GFUR\textsubscript{1} values are based on August (Q3) data. As unemployment tends to be seasonally low in the third quarter of each year, these values probably understate the true level of frictional unemployment in each group. Second, the weights (L\textsubscript{g1}/L\textsubscript{1}) are calculated only for the third quarter of each year. Thus one has to make an arbitrary decision as to how quarterly movements in $\alpha_\text{L} = \text{AFUR}_\text{1}$ are imputed. Third, such movements tend to be quite small, and are typically dominated by movements in $U_\text{L}$ that is NUR\textsubscript{1}. From equation (2), it can be seen that what is important is not $\alpha$ but ($U - \alpha$). For practical purposes, therefore, it is quite reasonable to regard $\alpha$ as a constant, and this is what we shall do in the remainder of the paper.

4. **ESTIMATION**

We applied a uniform approach to the estimation of equations (A)-(C) discussed in Section 2. Initially, a very simple version of each equation was fitted, using ordinary least squares (OLS). Results from a range of econometric tests were then analysed to provide a guide for choosing superior and more complex versions of the fitted equation.

4.1 **Form (A)**

Let $\text{UD}_\text{1}$ denote the first difference in NUR, and $\text{YD}_\text{1}$ the proportional rate of change in GNM. A simple OLS version of form (A), which Okun called the "First Differences" method, is

\[ \text{UD}_\text{1} = 0.18 - 0.11 \text{YD}_\text{1} \]  
\[ (4.32) \quad (4.72) \]

\[ R^2 = 0.1715 \quad DW = 1.49 \]

Sample 1959 Q4 to 1985 Q3

The coefficients in equation (A.1) are significantly different from zero and have the expected signs. However, $R^2$ is rather low, and the Durbin-Watson statistic indicates the presence of autocorrelation. Correcting for first-order autocorrelation using the Cochrane-Orcutt adjustment,
we obtained:

$$UD_t = 0.13 \cdot 0.07 \text{ YD}_t$$

$$\hat{\rho} = 0.36 \quad \text{SSE} = 10.56$$

(A.2)

Sample 1960 Q2 to 1985 Q3

Following Woodham (1983), we considered equation (A.2) as a restricted version of a more general equation, namely:

$$UD_t = 0.20 - 0.09 \text{ YD}_t - 0.05 \text{ YD}_{t-1} + 0.27 \text{ UD}_{t-1}.$$ (4.12)

$$\hat{\rho} = 0.3220 \quad \text{LM}(4) = 2.18 \quad \text{SSE} = 9.35$$ (A.3)

Sample 1960 Q2 to 1985 Q3.

That (A.2) represents a restricted version of the model in (A.3) can be seen as follows. The latter equation is of the form:

$$UD_t = a + b \text{ YD}_t + c \text{ YD}_{t-1} + d \text{ UD}_{t-1} + \nu_t$$

(10)

whereas (A.2) is of the form:

$$UD_t = a_0 + b_0 \text{ YD}_t + u_t$$

$$u_t = \rho u_{t-1} + \epsilon_t.$$ (11)

Simple manipulations of (11) yield:

$$UD_t = a_0(1-\rho) + b_0 \text{ YD}_t - \rho b_0 \text{ YD}_{t-1} + \rho UD_{t-1} + \epsilon_t.$$ (12)

Comparing (10) with (12), it is clear that the latter embodies the restriction that \(c\), the coefficient on \(\text{YD}_{t-1}\), must equal \(-bd\), where \(b\) and \(d\) are the coefficients on \(\text{YD}_t\) and \(\text{UD}_{t-1}\), respectively. Whether this restriction is supported by the data or not can be tested using a likelihood-ratio statistic based on the sums of squared errors of the restricted and unrestricted equations; see Woodham (1983, p.8). The test results indicated that the restriction implied by equation (A.2) can be rejected at the 1 per cent significance level. Thus, equation (A.3) is preferred over (A.2).

We applied the LM test for autocorrelation to (A.3); for a description of the test see McAleer and Deistler (1986). The results suggested that there was no first-, second- or third-order
autocorrelation. However, the presence of fourth-order autocorrelation was indicated (under the null hypothesis of no autocorrelation, the LM statistic is distributed as a standard normal deviate). To allow for longer lag structures, we considered lags of up to eight quarters. The following equation was obtained.

$$UD_t = 0.1499 - 0.0764 YD_t + 0.2930 UD_{t-1} - 0.2372 UD_{t-4} - 0.1880 UD_{t-8} \quad (A.4)$$

$$R^2 = 0.2864 \quad LM(2) = 2.09$$

Sample 1961 Q4 to 1985 Q3.

Clearly this equation is not problem-free, as the LM statistic for second-order autocorrelation is quite significant. However, attempts to find an alternative equation which is superior to (A.4) without using dummy variables were unsuccessful, at this stage (when re-estimated for the same sample as that of equation (A.4), equation (A.3) gives an unambiguously poorer fit).

We next turned to the stability of the preferred equation. The cumulative sum (CUSUM) and cumulative sum of squared (CUSUMSQ) tests suggested by Brown, Durbin and Evans (1975) were applied at the 5 per cent level. The results suggested that the coefficients may have undergone structural changes in late-1974 and late-1982. This is consistent with the results obtained from two Chow tests (at 5 per cent) performed on split samples, with the breaks occurring in 1974 Q2 and 1982 Q3. The identification of these two quarters as periods of structural change was based partly on an inspection of time plots of the coefficients obtained from a set of moving regressions of an equation similar to (A.4). For a discussion of the use of moving regressions to pinpoint structural breaks, see Woodham (1983, p.14ff). Additional evidence of structural breaks around these quarters was obtained from an inspection of time plots of recursive estimates of the coefficients of (A.4).

In an attempt to identify the particular coefficients which shifted at these points of time, and to measure the extent of the change, we introduced appropriate slope and intercept dummy variables into equation (A.4). First, two dummy variables were created to capture the effects on the intercept term: D74 (unity for 1974 Q2 through 1983 Q3, zero elsewhere) and D82 (unity for 1982 Q3 through 1985 Q3, zero elsewhere). We also set up D74*YD, D82*YD to account for shifts in the
coefficient on \( YD \), and similar dummy variables to measure changes in the coefficients on \( UD_{t} \), \( UD_{t-1} \), etc. The data appear to support the inclusion of only two of these dummy variables. The resultant equation, (A.5), was subjected to a number of further diagnostic tests. The equation and the test statistics are reported in Table 1.

As may be seen from the table, all the coefficients except the one on D82 are significant at 5% level. Note that the coefficient on D82 is significant at the 10% level. The results of the diagnostic tests attached to Table 1 provide some additional information on the overall fit of this equation. The LM-statistics show some evidence of second-order autocorrelation. The RESET test suggests that the equation has no specification bias. However, the results of the Jarque-Bera test indicate that the assumption of normality for the residual errors does not hold. In general, while (A.5) represents a distinct improvement over the other equations considered above, it is itself subject to a number of problems.

4.2 Form (B)

Okun called form (B) the "Trial Gap" method of deriving his "law". In following this method, we must address the issue of how to measure \( P \), potential output, and \( \alpha \), the full-employment rate of unemployment. As indicated in section 3, we have adopted Kalisch's approach to construct a series, \( \text{FEOUT} \), to approximate the true but unobservable \( P \). As for \( \alpha \), we found that Kalisch's approach resulted in a near-constant series. If \( \alpha \) is treated as a constant, there are basically two ways of estimating it. First, we might simply postulate that it is equal to the average value of NUR during the 1966-1971 era, which is 1.82 per cent. (Kalisch's estimates are slightly lower than this, because they are based on seasonally low Q3 statistics). Second, we can estimate \( \alpha \) as an unrestricted parameter in an equation such as equation (3). We have adopted the latter approach in order to allow for the possibility of structural changes in its value over time.

In Table 2 we present a summary of our regressions based on form (B). These proceeded along similar lines to those described in the previous subsection. The variables in the table are defined as follows. \( U \) is simply the NUR series from the NIF data-base, and \( UL1 \) and \( UL2 \) are its
one- and two-quarter lagged series. YGAP is calculated as \((FEOUT - GNM)*100/GNM\). D74 has the value of unity from 1974 Q3 onwards, and zero before that.

It can be seen from the table that the simplest version of form (B), namely equation (B.1), suffers from the problem of autocorrelation, even though its \(R^2\) is fairly high and both its coefficients are strongly significant. Equation (B.2), which exhibits no evidence of autocorrelation, turns out to be fairly stable. It easily passes the CUSUM test at the 5% significance level, and just fails the CUSUMSQ test during the 1972-1975 period. Results from Chow tests at the same level of significance, however, suggest that there was no structural break in 1974 Q3, although a break in 1982 Q4 is indicated. Note that, as before, the dates chosen for the Chow tests are obtained from inspection of time plots of moving regression coefficients for an equation very similar to (B.2). In view of the conflicting results, dummy variables are introduced to cover both possible breaks. The data appear to support the CUSUMSQ test: equation (B.3) represents the best overall equation found under form (B).

4.2 Form (C)

Table 3 is a summary of regressions based on form (C), which Okun called the "Fitted Trend and Elasticity" method for obtaining his relationship. The variables in the table are derived as follows. LnY is the (natural) logarithm of GNM, and LnYL2 is simply its two-quarter lagged value. LnN is calculated as the logarithm of (100-NUR), and LnNL1 and LnNL2 are its lagged series. T represents the time trend, where \(T = 1\) for 1959 Q3, D74 is unity from 1974 Q3 onwards, and zero before 1974 Q3. Another dummy variable was used, namely D80 (unity from 1980 Q4 onwards, zero elsewhere), but it was not selected in the preferred equation.

As before, we began with the simplest version of the relevant formulation. The result is equation C.1, which shows evidence of severe autocorrelation. Experimentation with various lag patterns led us to equation C.2, which still exhibits some evidence of fourth-order autocorrelation (the null hypothesis of no autocorrelation is rejected at 10 per cent probability of type 1 error). Stability tests (at 5 per cent) using CUSUM and CUSUMSQ indicate that a structural break may have occurred around 1974. Chow tests applied on samples split in 1974 Q3 and 1980 Q4 indicate
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<td>D74*LnNL2</td>
<td></td>
<td></td>
<td>-0.0006 (2.18)</td>
</tr>
</tbody>
</table>

<table>
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<td>R^2</td>
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<td>0.9878</td>
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<td>LM (autocorrelation)</td>
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<td></td>
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<td>8.60</td>
<td>1.19</td>
<td>1.13</td>
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<td>2</td>
<td>6.74</td>
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</tr>
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<td>3</td>
<td>4.55</td>
<td>0.15</td>
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<td>4</td>
<td>2.56</td>
<td>1.72</td>
<td>1.42</td>
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<td>5</td>
<td>1.05</td>
<td>0.27</td>
<td>0.53</td>
</tr>
<tr>
<td>6</td>
<td>0.16</td>
<td>0.23</td>
<td>0.37</td>
</tr>
<tr>
<td>7</td>
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<td>0.19</td>
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<tr>
<td>8</td>
<td>0.51</td>
<td>1.46</td>
<td>1.76</td>
</tr>
<tr>
<td>RESET3</td>
<td>(Critical value* = 5.99)</td>
<td>0.19</td>
<td>5.33</td>
</tr>
<tr>
<td>Jarque-Bera</td>
<td>(Critical value* = 5.99)</td>
<td>37.45</td>
<td>47.95</td>
</tr>
</tbody>
</table>

*At the 5 per cent level of significance.
no break if the significance level is 5 per cent. However, at 10 per cent significance, the null hypothesis of model stability is rejected for both dates, suggesting that two breaks may have occurred.

Equation C.3, which incorporates the dummy variable D74*LnNL2 to capture some of the effects of the first break, is our preferred equation under formulation (C), despite the fact that it exhibits some evidence of eighth-order autocorrelation.

5. ECONOMIC IMPLICATIONS

5.1 General Issues

We noted in Section 2 above that Okun’s relationship can be expressed in the following form:

\[ U = \alpha + \left[ \left( 1/\beta \right) \left( P - A \right) / A \right]. \] (3)-(13)

Now suppose that actual output, \( A \), grows at the same rate as potential output, \( P \). Then \( P/A \) will be constant, implying, in turn, a constant output gap, \( (P-A)/A \). From (13) we can see that, if Okun’s law holds, the unemployment rate \( U \) will also be unchanged in that case.\(^1\) Thus, Okun’s law can be used to answer one of the basic questions which were raised in the introductory section and which motivated this study, namely how fast must output grow to prevent the unemployment rate from rising. The answer provided by Okun’s approach is that it must grow at the same rate as potential output. In other words, the rate of growth in potential output, \( r = \dot{P}/P \), represents a “threshold” level for \( A/A \), the rate of growth in actual output: \( A/A \) must be at least equal to \( r \) before \( U \) can be reduced.

We now turn to another basic question raised in Section 1. Okun’s rule of thumb that there is a 1-to-3 relationship between unemployment and output growth might tempt one into expecting a

\(^1\) In the short run, \( \alpha \) (the full-employment unemployment rate) is likely to vary little, if at all, and can be regarded as a constant.
fall of 0.33 percentage points in \( U \) for a 1 per cent rise in \( A \). (Note that \( \beta \) should replace 3 and \( b = 1/\beta \) should replace 0.33 in a more general version of the above discussion). Such an interpretation is, of course, incorrect. The reason is that the rule of thumb applies only to output growth in excess of the threshold rate, \( r \). To see this, rewrite (13) as:

\[
U = (\alpha - b) + b(P/A).
\]

Differentiating both sides of the equation with respect to time, we obtain:

\[
\dot{U} = b(\dot{P}/A) - (P\dot{A}/A^2).
\] (14)

For the present purposes, it is reasonable to use the approximation \( P = A \) to derive

\[
\dot{U} \approx b[(\dot{P}/P) - (\dot{A}/A)] = -b(\ddot{A}/A) - r.
\] (15)

Note that \( \beta = 1/b \) is generally referred to as "Okun's coefficient". It indicates the extent to which \( \dot{A}/A \) must exceed \( r \) in order to reduce \( U \) by 1 percentage point.

From equation (13) it is clear that when \( A = P, U = \alpha \). The implication of this is that, for a given value of \( \beta \), potential output and FERU are defined not independently, but rather in a closely related way. If one specifies a certain level of output to be the "potential" level, then it follows immediately from Okun's relationship that some level of the unemployment rate will be the FERU consistent with that definition of potential output. Similarly, if one selects a rate of unemployment as representing the best available measure of FERU, the level of potential output can be derived using a relationship of the form (13), but cannot be specified independently. The above implications of equation (13) are summarised in Table 4.

Another use to which estimated versions of Okun's law have been put is the estimation of the prevailing output gap. In the literature, this (proportional) difference between potential and actual output is often interpreted as a measure of the macroeconomic cost of unemployment, the output which must be forgone because unemployment exceeds its potential level. If one estimates (13) directly with the use of some constructed data series \( \dot{P} \) as a proxy for \( P \), this gap can simply be calculated as \( \ddot{P}/A \). Where, as in Okun's own case, the estimated version of (13) does not rely on any single \( \dot{P} \), \( \dot{P} \) itself can be derived from the estimated relationship:
<table>
<thead>
<tr>
<th>Actual Output A</th>
<th>Output Gap (P-A)/A</th>
<th>Unemployment Rate U</th>
</tr>
</thead>
<tbody>
<tr>
<td>grows at g &lt; r</td>
<td>increases</td>
<td>increases</td>
</tr>
<tr>
<td>grows at g = r</td>
<td>constant</td>
<td>constant</td>
</tr>
<tr>
<td>grows at g &gt; r</td>
<td>decreases</td>
<td>decreases</td>
</tr>
<tr>
<td>equals P</td>
<td>equals zero</td>
<td>equals α</td>
</tr>
</tbody>
</table>

Notes:
\[ P = \text{potential output} \]
\[ r = \frac{\dot{y}}{P} \]
\[ g = \frac{\dot{A}}{A} \]
\[ α = \text{full-employment rate of unemployment} \]
\[ \hat{\beta} = A(1 + \hat{\beta} (U - \hat{\alpha})) \]  

(16)

where \( \hat{\beta} \) is the estimated Okun's coefficient, and \( \hat{\alpha} \) the estimated (or postulated) FERU.

5.2 Form (B)

Since equation (13) is of form (B), it seems natural to proceed next to an analysis of the implications of the equations estimated under this form. The equations presented in Table 2 can be represented generally by:

\[ U_t = a + b \text{Ygap}_t + c \text{U}_{t-1} + d \text{U}_{t-2}. \]  

(17)

For equation (B.1), \( c = d = 0. \) For equation (B.3), \( c = 0.7327 \) before 1974 Q3, and \( 1.1945 \) after this quarter. It is simple to derive \( \alpha \), the FERU, from (17). Suppose full employment has prevailed for some time, so that \( \text{Ygap} = 0 \) and \( U_t - U_{t-1} = U_{t-2} = \alpha. \) Then (17) can be rewritten as:

\[ \alpha (1-c-d) = a, \]

so that

\[ \alpha = a/(1-c-d). \]  

(18)

Application of (18) to parameter estimates from equation (B.1) and (B.2) yields \( \alpha = 1.88 \) per cent, and \( \alpha = 1.99 \) per cent, respectively. These are of the same order of magnitude as the average value (1.82 per cent) of NUR during the period 1966-1971. Calculations based on equation (B.3) suggest that \( \alpha \) underwent a shift from 1.96 per cent before 1974 to 2.39 per cent after this date.

As regards equation (B.1), Okun's coefficient, \( \beta, \) can be derived simply as the inverse of \( b. \) This yields \( \beta = 2.75. \) For the other equations, the presence of lagged variables makes the derivation a little more complicated. We have derived the \( \beta \) coefficients by simulating the appropriate equation for the effects of a once-only, 1 per cent fall in \( \text{A}/\text{A}_{t-1}, \) occurring in time 0. Prior to that, the economy is assumed to be in full employment, with \( A = P \) continuously and \( U = \)
α. Figure 4 illustrates, for equation (B.2), the effects of this shock on U. Before $t = 0$, $U = \alpha = 1.99$ per cent. The drop in $(\Delta A_{1}/A_{1})$ in period 0 immediately creates an output gap of 1.00 per cent causing, in turn, a rise in U to 2.08 per cent. After 4 quarters, the cumulative increase in U will have reached 0.34 percentage points, implying $\beta = 2.9$ within a year. The long-run counterpart (after 4 years) of this is $\beta = 2.7$. More interestingly, the simulation results for equation (B.3) indicate that $\beta$ (for one year) shifted from 4.5 during the pre-1974 period, to 3.0 in the post-1974 period. This movement implies a shift toward greater responsiveness of unemployment with respect to variations in output growth.

The estimation of these equations is based on the assumption that PEOUT, as given in equation (8) and depicted in Figure 2, is a reasonable approximation of potential output. Given that assumption, the “threshold” growth rate of output is simply the rate of growth in PEOUT, which has been around 0.8 per cent per quarter during the last several years. This implies that actual output must grow at an annual rate of around 3.2 per cent to keep the unemployment rate constant. Further, the assumption leads to an estimate of around 14 per cent for the output gap, $(P-A)/A$, in 1985; see Figure 2.

5.3 Form (A)

We shall analyse the implications of three equations estimated under form (A), namely (A.1), (A.4) and (A.5). These all have the following form:

$$\Delta U_t = a - b(\Delta A_{t}/A_{t-1})*100 + c\Delta U_{t-1} + d\Delta U_{t-4} + e\Delta U_{t-8}.$$  \hspace{1cm} (19)

Using a similar line of reasoning to that in the previous subsection, we conclude that for the unemployment rate to be constant, A must grow at the rate given by:

$$(\Delta A_{t}/A_{t-1})*100 = a/b.$$  \hspace{1cm} (20)

As no P is involved in the estimation of an equation such as (19), the expression given in (20) can
also be used as an estimate of \( r \), the rate of growth in \( P \).

Applying the formula (20) to parameter estimates from equation (A.1) gives \( r = 1.59 \) per cent. Equation (A.4) implies an even greater growth rate, \( r = 1.96 \) per cent. Equation (A.5) implies \( r = 1.71 \) per cent in the pre-1982 period, and 4.05 per cent in the post-1982 period. In subsection 5.5 we shall compare these estimates with those obtained from other equations and from other studies.

To derive Okun’s coefficient for equations other than (A.1) we subjected the relevant equation to a simulation exercise similar to that outlined in subsection 5.2. For equation (A.1), \( \beta \) is simply \( 1/b = 8.8 \). Simulations of (A.4) indicate that \( \beta = 11.1 \) (henceforth all references to values of \( \beta \) obtained from simulations are for a time horizon of 4 quarters). The corresponding values for equation (A.5) are \( \beta = 20.8 \) for the pre-1974 period and \( \beta = 11.1 \) after 1974.

5.4 Form (C)

The equations presented in Table 3 are of the form:

\[
\ln N_t = a + b \ln A_t - c \ln A_{t-1} + d \ln A_{t-2} + e \ln N_{t-1} + f \ln N_{t-2}.
\]  

(21)

Differentiating (21) with respect to time, and approximating the result in discrete time, yields:

\[
\frac{\Delta N_t}{N_{t-1}} = b \frac{\Delta A_t}{A_{t-1}} - c + d \frac{\Delta A_{t-2}}{A_{t-3}} + e \frac{\Delta N_{t-1}}{N_{t-2}} + f \frac{\Delta N_{t-2}}{N_{t-3}}
\]  

(22)

For \( U \) to be constant, \( N \) has to be constant also. Under this circumstance, and recalling our earlier result that \( \dot{A}/A \) must equal \( r \) for \( U \) to be constant, we can derive from equation (22) the following expression for \( r \):

\[
r = \frac{\Delta A_t}{A_{t-1}} = c/(b+d).
\]  

(23)

This gives \( r = 1.4, 1.5 \) and 1.4 per cent for equations (C.1), (C.2) and (C.3), respectively.
To simulate these equations, some minor calibrations must be carried out first. Details concerning these calibrations are available from the authors upon request. The simulations indicate that $\beta \approx 5.3, 4.7, 5.3$ and $5.4$ for equations (C.1), (C.2), (C.3) before 1974 and (C.3) after 1974, respectively.

5.5. Comparison

Rate of growth in potential output. Equations (C.1) to (C.3) suggest that $r$ is around 1.4 - 1.5 per cent. Equations (A.1), (A.4) and (A.5) indicate a higher rate, one of around 1.7 - 2.0 per cent. A similar range was indicated by Furnell’s results. However, she tended to discount this aspect of the results, arguing that these estimated rates of growth are unrealistically high, in view of the historical performance of the Australian economy. For the same reason, we would treat the estimates of $r$ generated by forms (A) and (C) with caution. Form (B), however, suggests that $r$ is around 0.8 per cent for Australia currently, compared with Woodham’s estimate of 0.9 per cent and Okun’s estimates of 0.9 to 1.1 per cent for the U.S. When translated to an annual rate of 3.2 per cent, it is also broadly in line with what the authorities apparently regard as the minimum rate of growth in real GDP to prevent unemployment from increasing (Keating, 1986).

Okun’s coefficient. Equations (C.1) to (C.3) imply a value of around 5 for $\beta$. This is similar to Kennedy’s estimate, but much higher than Kalisch’s, which is 2.7. Even higher estimates are indicated by equations (A.1), (A.4) and (A.5): these range from 9 to 21. While this is comparable to Hamada and Kurosaka’s results (13 to 32), the range does seem rather high. In view of our previous lack of confidence in forms (A) and (C) regarding their estimates of $r$, we tend to discount these estimates of $\beta$ also. Form (B) indicates that $\beta$ was around 4.5 before 1974 and 3 after this date. These values are consistent with both Kennedy’s and Kalisch’s results for Australia. They suggest that, over time, the unemployment rate has become more responsive to changes in output growth. They are also comparable to Okun’s own estimate of $\beta$ for the U.S.

Potential output and PERU. Equations estimated under forms (A) and (C) yield no estimate for $\alpha$. Further, we do not have sufficient confidence in their parameter estimates to use them for generating an estimated series of $\hat{p}$. Equations (B.1) to (B.3) suggest that the PERU was
around 2.0 per cent before 1974, but has since risen to about 2.4 per cent. As noted before, our series of \( \hat{P} \), that is FEOUT, was calculated independently and all estimation under form (B) is predicated on the assumption that it is a reasonable proxy for \( P \). Given this assumption, it is estimated that, as at the third quarter of 1985, the gap between potential and actual output was approximately 14 per cent of actual output.

Our decision to rely only on equations (B.1) to (B.3) and to discount results generated by equations of forms (A) and (C) was prompted not only by the fact that the latter did not conform to prior expectations and previous results. Equation (B.3), while still not entirely problem-free, gives the best overall performance in diagnostic tests. Further, as noted in Section 2, formulations (A) and (C) are regarded as approximations of (B), approximations that become less accurate the more the output gap grows.

5.6 The Attainability of Potential Output and FERU

It might be argued that the estimates which we obtained above for \( \alpha \) are too low. Sloan (1985), for example, raised the question of whether the Australian labour market had in fact approached full employment even though the recorded unemployment rate remained around 8 per cent. In this connection, it is interesting to note the results obtained by Trivedi and Baker (1985), who found that most of the observed increase in unemployment since 1969 can be attributed to cyclical rather than frictional or structural factors. This would tend to support a relatively low estimate of an equilibrium unemployment concept which is based largely on frictional/structural factors, as is our FERU.

Nevertheless, one must be careful in interpreting the estimates obtained for \( P \) and \( \alpha \). For example, it would be obviously unrealistic to expect that the FERU can be re-attained in a short time. To lower the unemployment rate to 2.4 per cent would require the elimination of the 14 per cent output gap. In all likelihood, a change of this magnitude could only be achieved over a long period, if at all. It may require, for example, 14 consecutive years during which growth in actual output consistently exceeds growth in potential output by 1 percentage point per year.
Why must the catching-up process be so long and gradual? The answer lies partly in the "hysteresis" phenomenon, which has received considerable attention in recent analyses; see, for example, Hargreaves Heap (1980). Suppose that the economy is operating at a level far below full employment, and that this situation has persisted for some time. The system will have become fully adapted to this environment. Parts of the capital stock which lay idle will have been scrapped. Some of the long-term unemployed workers will have become discouraged or experienced a significant depreciation in their human capital. Some form of external constraint will have developed and will have been operative. The overall effect would be to produce bottlenecks, shortages and other forms of constraint in the event of a sudden, large movement in actual output toward the potential level -- thus ensuring that such a movement could not be sustained. In short, as Chapman and Gruen (1984) argued, estimates of potential output and FERU should not be regarded as "short-term attainable targets, but rather as longer term indications of what might have been if circumstances had been more favourable" (p.12).

6. CONCLUDING REMARKS

The present study has been motivated by two main factors. First, we were interested in finding out whether some form of Okun's law holds for Australia, and if so whether it has been stable. Second, we would like to see if such a relationship can be used to provide rule-of-thumb answers to a number of policy questions concerning output growth and unemployment.

Our results indicate that the three alternative formulations of Okun's law do not give rise to numerically similar parameter estimates. Our interpretation of this is that equations estimated under forms (A) and (C) yield invalid parameter estimates, because these formulations involve approximation errors. By contrast, direct estimation of form (B) generated parameter estimates which are both plausible and consistent with results from earlier analyses.

The estimated equations (B), in particular (B.3), suggest that in Australia Okun's relationship underwent a structural change around the third quarter of 1974. After this break, it would appear, the unemployment rate became more responsive to variations in the rate of growth in
output. We can only speculate as to what caused this shift. Perhaps there may have been a general change in attitude among Australian employers concerning labour hoarding. In the aftermath of the 1974-75 recession, and in view of the lower growth expectations in most countries after this episode, employers may have become more ready to accept that any given slowdown in economic activity may be more than temporary. As a result, they may have become more willing to shed labour when confronted with a slackening in demand -- and, conversely, to rehire former workers and train new ones when the demand picks up again.

Equations (B) also imply that, currently, actual (non-farm) output must grow at about 0.8 per cent per quarter to prevent the unemployment rate from rising. Each additional 0.3 per cent rise in output over and above this threshold rate can be expected to reduce the unemployment rate by about 0.1 percentage points within a year -- giving an Okun's coefficient of 3 as at present, compared with a value of 4.5 for the pre-1974 period.

These results can be regarded as some rules-of-thumb which may be useful in discussing the broad consequences of policy actions in the output-employment area. They may also be of use in providing a set of simple, intuitive benchmarks for comparison with results from simulations of large and complex macro-ecometric models.

In the body of this paper, we have repeatedly highlighted the critical role played in the entire estimation process by the series constructed to approximate potential output. Given the results of the present study, it would appear that further research into this concept, perhaps to update the work of Peters and Petridis (1977), would be a very useful contribution.
REFERENCES


Furnell, P. (1985), "The Dynamic Effects of a Change in the Growth of Real Output on the Unemployment Rate", Australian National University, unpublished manuscript.


## APPENDIX

**GLOSSARY OF KEY SYMBOLS AND ABBREVIATIONS**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Actual output</td>
</tr>
<tr>
<td>AFUR</td>
<td>Derived series: Aggregate frictional unemployment rate, a measure of $\alpha$ (see below)</td>
</tr>
<tr>
<td>b</td>
<td>Inverse of $\beta$ (see below)</td>
</tr>
<tr>
<td>FEOUT</td>
<td>Derived series: Full employment output, a measure of $P$ (see below)</td>
</tr>
<tr>
<td>FERU</td>
<td>Full employment rate of unemployment, also denoted by $\alpha$</td>
</tr>
<tr>
<td>GFUR</td>
<td>Derived series: Group frictional unemployment rate</td>
</tr>
<tr>
<td>GNM</td>
<td>Series from NIF-10 Database: real gross non-farm product, a measure of $A$</td>
</tr>
<tr>
<td>N</td>
<td>Employment rate, i.e. $1 - U$ (see below)</td>
</tr>
<tr>
<td>NUR</td>
<td>Series from NIF-10 Database: rate of unemployment, a measure of $U$ (see below)</td>
</tr>
<tr>
<td>P</td>
<td>Potential output</td>
</tr>
<tr>
<td>r</td>
<td>Rate of growth in potential output</td>
</tr>
<tr>
<td>U</td>
<td>Rate of unemployment</td>
</tr>
<tr>
<td>UD</td>
<td>Derived series: First different in NUR</td>
</tr>
<tr>
<td>YD</td>
<td>Derived series: proportional rate of change in GNM</td>
</tr>
<tr>
<td>YEAP</td>
<td>Derived series: $(FEOUT - GNM) * 100/GNM$, a measure of the proportional gap between potential and actual output</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>Notation for the full employment rate of unemployment</td>
</tr>
<tr>
<td>$\beta$</td>
<td>Okun's coefficient</td>
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