LONG-RUN SHIFTS OF THE BEVERIDGE CURVE AND THE 
FRICTIONAL UNEMPLOYMENT RATE IN AUSTRALIA

by

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1. Introduction

The Beveridge Curve, the relationship between the unemployment and vacancy rates, has been described as the “neglected stepsister” of the Phillips Curve, the relationship between the unemployment and inflation rates (Yellen, 1989, p. 65) although Blanchard and Diamond argue that this ought not to be the case. Indeed, they claim that, compared to the Phillips relation, “the Beveridge relation comes conceptually first and contains essential information about the functioning of the labour market and the shocks that affect it” (Blanchard and Diamond, 1989, p. 1). The relative neglect of the Beveridge Curve is also a feature of the Australian literature. This is somewhat surprising since the relationship between unemployment and vacancies in Australia appears to have been considerably more stable than that in the UK, for example. Thus Jackman, Layard and Pissarides (1989) observe that in the UK the vacancy rate was remarkably stable over the business cycles in the 1960s to the 1980s whereas there was a great deal of variation in the unemployment rate, thus suggesting significant shifts in the unemployment-vacancy relation – either cycles around a stable Beveridge Curve or shifts of the curve itself (or both). In contrast the Australian relation looks to have been relatively stable over the period as indicated in Figure 1 which graphs the unemployment rate, u, against the vacancy rate, v.

[Insert Figure 1 near here]

While there seems to have been some shift in the early part of the sample period, associated with the steep increases in the unemployment rate in the second half of the 1970s, it is rather modest when compared to those for many other OECD countries shown in Chapter 8 of Layard, Nickell and Jackman (1991).

Existing Australian work on the Beveridge Curve includes that by Harper (1980), Fahrer Pease (1993) and Webster (1999). Harper (1980) uses data for the period 1952-1978 to estimate a Beveridge Curve. He finds it necessary to use a dynamic form of the Beveridge Curve to capture the interaction between u and v over the period. He also experiments with two variables which shift the Beveridge Curve through time, viz., real unemployment benefits and immigration but finds that neither satisfactorily explains the relationship between the unemployment and vacancy rates.

Fahrer and Pease (1993) estimate a Beveridge Curve similar in form to Harper’s in that it is linear and dynamic and includes unemployment benefits (in the form of the replacement ratio) as a shift variable. In addition, they use a variable measuring the gap between actual and potential output as part of the dynamic
adjustment process. They use data for the period 1966-1992. Fahrer and Pease argue that a proper distinction between the short-run and long-run influences requires a more disaggregated approach and they proceed to analyse the underlying labour-market flows which they use to define equilibrium in the labour market and hence the Beveridge Curve.

Webster (1999) also estimates an aggregate linear dynamic Beveridge Curve for Australia. Her focus, however, is not on the Beveridge Curve as such but on its use as a framework for the evaluation of Australian labour-market programmes. In addition to explanatory variables measuring expenditure on labour-market programmes, she uses the replacement ratio, a measure of labour-force skills, the level of immigration, a measure of long-term unemployment and an activity index as variables which shift the Beveridge Curve. She finds limited evidence that labour-market programmes generate favourable shifts in the Beveridge Curve.

The analysis of the Beveridge Curve which is reported in this paper is similar to all three existing studies in that it estimates an aggregate Beveridge Curve using quarterly Australian data. It extends existing work in several ways, however. In the first place, we extend the data to the end of the 1990s.

Secondly, like Fahrer and Pease we wish to analyse the long-run movements of the unemployment-vacancy relationship although, in contrast to their disaggregated approach, we use a cointegration framework for this purpose. None of the Australian studies cited above takes serious account of the possibility that the variables being analysed are non-stationary. Indeed, in the broader international literature, the paper by Jones and Manning (1990) appears one of the few empirical studies of the Beveridge Curve which explicitly takes advantage of the cointegration framework to analyse the long-run nature of the relationship. We, therefore, analyse the long-run relationship between the unemployment and vacancy rates in terms of a cointegrating regression. We find that (the logs of) the vacancy and unemployment rates are not stationary and not cointegrated so that a long-run relationship involving just these two variables does not exist over our sample period. Alternatively, at least one of the variables which shift the relationship must be non-stationary. We find this to be the case and find a cointegrating relation to exist involving, in addition to the logs of u and v, the real wage, the replacement ratio, the long-term unemployment ratio and the proportion of females in the labour force. We are also able to specify a parsimonious cointegrating regression involving just unemployment, vacancies and the real wage.
We use the cointegrating regression to analyse the long-run relationship between the Beveridge Curve and the shift variables, including a decomposition of the sources of changes in the unemployment rate over the sample period. We find, in contrast to our casual inference from Figure 1, that most of the increase in unemployment since the late 1970s has been associated with shifts of the Beveridge Curve rather than movements along it. This suggests that demand shocks have been unimportant relative to structural shifts.

A second application of our long-run u-v relationship is to derive a series for the frictional unemployment rate which we define as the unemployment rate when the vacancy rate corresponds to capacity output. We derive and graph a series which, in its general shape, is similar to but lies everywhere below existing estimates of the natural rate/NAIRU for Australia.¹

The structure of the paper is as follows. In section 2 we set out the standard model of the labour market underlying the Beveridge Curve and briefly discuss the variables which other studies have used in empirical analyses of the Beveridge Curve. The data are discussed in section 3, and the results in section 4, with conclusions being drawn in the final section.

2. The Beveridge Curve

The Beveridge Curve is usually derived as the outcome of equilibrium between labour-market flows. There are various similar expositions of the basic model and we follow that in Jones and Manning (1990).² Assume that inflows into unemployment are driven by a constant separation rate, τ, so that:

\[ \text{inflows} = \tau E_{t-1} \]

where \( E \) represents employment. Outflows are determined by the efficiency with which the unemployed are matched to vacant jobs which, in turn, is determined by the total number unemployed, \( U \), the total number of vacancies, \( V \), combined in a Cobb-Douglas form:

\[ \text{outflows} = \pi_0 \pi_1 U^{1/2} V^{1/2} \]

¹ See, e.g. the series recently reported in Groeneveld and Hagger (2000) and Gruen, Pagan and Thompson (1999).
² Other more or less equivalent developments may be found in Harper (1980), Budd, Levine and Smith (1988), Blanchard and Diamond (1989), Jackman, Layard and Pissarides (1989), Layard, Nickell and Jackman (1991), Jones and Manning (1992) and Fahrer and Pease (1993).
where $\pi_0$ is the probability that an unemployed worker locates a vacant job and $\pi_t$ the probability that a given job offer will be accepted. Then $\pi_0, \pi_t$ may be re-written as $\lambda$, which is used as a measure of labour-market efficiency.

The Beveridge Curve is defined by labour-market equilibrium where inflows and outflows are equal which requires that:

$$\lambda U^a V^b = \tau E$$

or,

$$\gamma U^a V^b = E$$

where $\gamma = \lambda/\tau$. It is then supposed that $\gamma$ is function of a set of exogenous variables, $Z_i$ ($i = 1, 2, \ldots, N$). Assuming the relationship between $\gamma$ and the $Z_i$ is also of the Cobb-Douglas form, we have:

$$\left( \prod_{i=1}^{N} Z_i^y \right) U^a V^b = E$$

Following empirical work by Blanchard and Diamond (1989), we assume that the matching function is homogeneous of degree 1 in $U$ and $V$ so that we can write:

$$\left( \prod_{i=1}^{N} Z_i^y \right) U^a V^{1-a} = 1$$

where $u = U/E = \text{the unemployment rate}$ and $v = V/E = \text{the vacancy rate}$. Log-linearising, we have

$$\ln(u) = (-1/\alpha)(1-\alpha)\ln(v) - (1/\alpha)\Sigma y_i \ln(Z_i)$$

which forms the basis of the estimated Beveridge Curve.

In the empirical literature on the Beveridge Curve a variety of variables has been used to represent $Z$ in equation (3). Jones and Manning (1990) used five $Z$ variables, viz., the real wage, the replacement ratio, the relative export price, the proportion of young workers in the labour force and the proportion of old workers in the labour force. Another variable which has been widely used and which was initially explored by Budd, Levine and Smith (1988) is the importance of long-term unemployed in total unemployment. The argument is that the long-term unemployed lose employment and job-search skills so that overall search efficiency falls the larger is average unemployment duration. Similar variables to the ones used by Jones and Manning were also used by Borsch-Supan (1991) who, in addition, used a variable measuring the average educational achievements of the unemployed as well as
cyclical variables such as GDP, the CPI and the interest rate. Samson (1994), in a
study of the Canadian Beveridge Curve, also introduced a variable measuring the
dispersion of economic activity across industries in the manner of Lilien (1982)
although measured by a share-market dispersion variable following work by

Following this brief review of the empirical literature, we investigated all of
the variables previously used with the exception of the aggregate demand ones. The
latter group was excluded on the basis of the argument that changes in aggregate
economic activity move the economy along the Beveridge Curve and should not
therefore be used as variables in the Beveridge Curve equation since they would then
shift the Beveridge Curve in (u,v)-space rather than move the economy along it. Our
final list of variables will be limited by the availability of data, a matter to which we
now turn.

3. The Data

Following the review in the previous section, we began with the following list of
possible variables to be included in the Beveridge Curve equation: the real wage, the
replacement ratio, the proportion of young workers in the labour force, the proportion
of old workers in the labour force, the proportion of total unemployment accounted
for by the long-term unemployed, the proportion of females in the labour force, the
average educational attainment of the labour force, the average skill level of the
labour force, the ratio of immigration to population, relative export prices and real oil
prices. Many of the crucial labour-market variables are not available before February
of 1978, the beginning of the ABS’s Monthly Labour Market Survey so that the
starting point for our sample period was the first quarter of 1978. Several variables,
particularly those derived from the National Accounts, are available only on a
quarterly basis which determined the frequency of our data. We therefore used only
variables which are available at a quarterly frequency for the period 1978-1999.

Within these constraints, we used the following variables. For the real wage
variable we were unable to use average weekly earnings since they are available only
since 1981. We therefore used National Accounts data for employee compensation
converted to real values using the GDP deflator and divided by total employment so
that the variable has the dimension of real compensation per employee per quarter.
The replacement ratio was also based on National Accounts data. We used the ratio
of Commonwealth unemployment payments per person unemployed to nominal compensation per employee both on a quarterly basis. The proportion of the young in the labour force is measured by the ratio of the labour force aged 15-19 to the total labour force. The importance of long-term unemployment was measured by the ratio of those who have been unemployed for at least 52 weeks to total unemployment. The ratio of females to the total labour force was used as a measure of the importance of females in the work force. The immigration variable used was the ratio of net international migration to total population. Relative export prices were measured by the export price index divided by the GDP deflator and real oil prices by the ratio of the Petroleum and Coal Products component of the Index of Prices of Articles Produced in Manufacturing to the GDP deflator. All data were taken from the ABS time series section of the dX data base and all data were used in seasonally-adjusted form where appropriate.

4. The Results

We begin by considering a minimal Beveridge Curve consisting just of the logs of u and v. We test the variables for stationarity and cointegration before moving to a broader set of variables as discussed in the previous section.

4.1 A Minimal Beveridge Curve

We begin with an analysis just of the two basic variables in the Beveridge Curve, the unemployment and vacancy rates. We use both variables in log form following the theoretical framework set out in section 2. Since we have data for both these variables going back to 1966(3), we use a sample period of 1966(3)-1999(1) in this sub-section even though we will use a truncated sample period when we introduce our more extensive set of variables later in the section. Since stationarity and cointegration both deal with long-run properties of the data, it is important to use as long a time series as possible. We will comment in the next sub-section on the effect on our results of reducing the length of the sample period to begin at 1978(1).

We begin by testing ln(u) and ln(v) for stationarity. Some results obtained are reported in Table 1.
Table 1 Stationarity of ln(u) and ln(v)

<table>
<thead>
<tr>
<th>Variable</th>
<th>ADF</th>
<th>PP</th>
</tr>
</thead>
<tbody>
<tr>
<td>ln(u)</td>
<td>-2.0199</td>
<td>2.1270</td>
</tr>
<tr>
<td>ln(v)</td>
<td>-1.7034</td>
<td>1.6975</td>
</tr>
</tbody>
</table>

Notes: (1) ADF is the augmented version of the test of Dickey and Fuller (1981) and PP is the test of Phillips and Perron (1988).
(2) In the case with no trend the test is a test that $\alpha_1=0$ in the regression $\Delta y_t = \alpha_0 + \alpha_1 y_{t-1} + \epsilon_t$. For both ADF and PP the 10% critical value is -2.57.
(3) In the columns headed "Trend" the test is of the hypothesis that $\alpha_1 = \alpha_2 = 0$ in the regression $\Delta y_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 t + \epsilon_t$. The 10% critical value is 5.34.

It is clear from the results in Table 1 that neither ln(u) nor ln(v) is stationary on the basis of the ADF and PP tests. The tests reported are based on optimal lag lengths chosen using the autocorrelation function. Since test outcomes are sometimes sensitive to lag length, we experimented with alternative lag lengths ranging from 0 to 4 but found no changes in test outcome. We conclude, therefore, that both the unemployment rate and the vacancy rate are non-stationary in log form.3

We turn now to the question of cointegration between ln(u) and ln(v). We begin by applying the Engle-Granger test (see Engle and Granger, 1987). In this case we test the residuals of the regression of ln(u) on ln(v) (or vice versa) for stationarity.

The regression of ln(u) on a constant and ln(v) produces:

$$\ln(u_t) = 1.5945 - 0.9118 \ln(v_t), \quad R^2 = 0.8501$$

Clearly, the equation has very good explanatory power and the coefficients are precisely estimated. However, the high $R^2$ and low Durbin-Watson statistic give strong evidence of spurious correlation resulting from the regression of variables which are non-stationary and not cointegrated. When we test the residuals for stationarity we obtain a t-statistic for the ADF test with one lag of -1.7165 and for the PP test of -2.2191 which should be compared to a 10% critical value of -3.04. This outcome is not affected by including a trend term in the original equation nor by varying the number of lags in the second-stage regression equation. Thus the

3 We are aware that in some cases the outcome of non-stationarity may be reversed if one or more breaks in the data are allowed for following Perron (1989) (a single break at a known date), Zivot and Andrews (1992) (a single break at an unknown date) and Clemente et al. (1998) and Lumashine and Pupolf (1997) (two breaks at unknown dates). Arestis and Mariscal (1999) report empirical evidence on the stationarity of unemployment with two-break tests for a set of OECD countries which includes Australia. Since we will be presenting detailed evidence about the source of breaks between ln(u) and ln(v), we have not used these tests based on breaks at unknown dates and of unknown origin.
conclusion that $\ln(u)$ and $\ln(v)$ are not cointegrated is not dependent on the type of test used nor on the lag length used in the tests to control for autocorrelation in the testing equation.

An alternative testing framework for cointegration is that proposed by Johansen (1988). This is a VAR-based procedure and with two lags produces a trace statistic of 8.344 for the null hypothesis that there are no cointegrating vectors. The 10% critical value for the test is 15.6 so that the null hypothesis cannot be rejected. The same result is obtained from the maximum-eigenvalue test which produces a value of the test statistic of 5.467 for the null hypothesis that the number of cointegrating vectors is zero; the 10% critical value for the test is 12.8 so that again we find no evidence of cointegration between $\ln(u)$ and $\ln(v)$. The test outcome is not changed by varying the lag length in the VAR framework to 3 or 4. We therefore conclude on the basis of both the Johansen and the Engle and Granger tests that the two variables of interest are not cointegrated. Thus, a long-run equilibrium relationship does not exist between these two variables and a Beveridge Curve specified just in terms of these variables is mis-specified. Another way of stating this conclusion is that the $u$-$v$ relationship has been shifted over our sample period by at least one non-stationary variable and we proceed in the next sub-section to consider the importance of shift variables in the Beveridge Curve relationship.

4.2 An Extended Beveridge Curve

As discussed in section 3 on the data used, we experimented with the following as variables which may have shifted the Beveridge Curve over our sample period. Recall that many of the variables which we wished to use are available only since 1978 and we therefore truncate the sample to begin at 1978(1).

Since the results discussed in the previous sub-section were based on data starting at 1966(3), we re-ran the tests reported there to make sure that differences were not due to differences in sample length and found that none of the test outcomes were affected by the shorter sample – both $\ln(u)$ and $\ln(v)$ were found to be non-stationary and not cointegrated. The conclusions were not affected by the type of test used, the presence or absence of a trend or the number of lags in the respective models. We therefore proceed to the inclusion of additional variables.

The variables experimented with are: the real wage ($w$), the replacement ratio ($r$), the real price of oil (oil), the proportion of young workers in the labour force (young),
the proportion of long-term unemployed in total unemployment (long), the proportion of females in the labour force (female), relative export prices (export) and the ratio of net international migration to the population (immig). We began by testing the additional variables for stationarity with the results using the ADF test reported in Table 2.

Table 2: Stationarity of Additional Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>No Trend</th>
<th>Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>w</td>
<td>0.9883</td>
<td>2.6381</td>
</tr>
<tr>
<td>r</td>
<td>-1.6467</td>
<td>1.3956</td>
</tr>
<tr>
<td>oil</td>
<td>-0.9222</td>
<td>5.9426</td>
</tr>
<tr>
<td>young</td>
<td>-1.3277</td>
<td>3.4377</td>
</tr>
<tr>
<td>long</td>
<td>-2.5033</td>
<td>5.1649</td>
</tr>
<tr>
<td>female</td>
<td>-1.8387</td>
<td>1.9286</td>
</tr>
<tr>
<td>export</td>
<td>-0.6262</td>
<td>5.0689</td>
</tr>
<tr>
<td>immig</td>
<td>-2.9120</td>
<td>4.5030</td>
</tr>
</tbody>
</table>

Notes: In the case with no trend the test is a test that \( a_1 = 0 \) in the regression \( \Delta y_t = \alpha_0 + \alpha_1 y_{t-1} + \Sigma \gamma \Delta y_{t-1} + \epsilon_t \). The 10% critical value is -2.57.

In the “Trend” column the null hypothesis is \( a_1 = a_2 = 0 \) in the regression \( \Delta y_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 t + \Sigma \gamma \Delta y_{t-1} + \epsilon_t \). The 10% critical value is 5.34.

On the basis of the test without trend only the immigration variable is stationary at the 10% level of significance. If a trend is included in the testing equation, only the relative price of oil is stationary (while immig is not). Thus, there is little evidence that any of the variables is unambiguously stationary and we treat all of them as non-stationary and therefore as candidates for shifting the u-v relationship in a non-stationary fashion.

When we add all eight variables in Table 2 to the regression of \( \ln(u) \) on \( \ln(v) \) we obtain the following:

\[
\ln(u) = 1.7604 - 0.3527 \ln(v_t) + 12.690 \ w_t + 1.3351 \ r_t - 0.0483 \ oil_t \\
\phantom{=} + 1.4485 \ young_t + 1.3629 \ long_t - 3.1419 \ female_t - 0.2245 \ export_t \\
\phantom{=} - 0.0084 \ immig_t \\
\phantom{=} (2.44) \ (10.68) \ (3.98) \ (3.36) \ (1.93) \\
\phantom{=} (0.77) \ (6.06) \ (2.99) \ (1.36) \ (0.72) \\
R^2 = 0.9281
\]
Clearly the equation has considerable explanatory power and most of the variables are significant at the 5% level. Many of the coefficients also have the expected sign. In particular, ln(v), w, r, young and long are both significant and of the expected sign; the female variable is significant and negative suggesting that the increase in females in the workforce has reduced the unemployment rate at a given vacancy rate compared to what it would otherwise have been. Only oil, young, export and immigr are insignificant and at least oil and immigr have counterintuitive signs. Finally, note that, compared to the results in the bivariate regression of ln(u) on ln(v), the coefficient on ln(v) has fallen considerably in absolute value suggesting that the omission of relevant variables resulted in considerable bias in the estimate of the slope of the Beveridge Curve.

Be all that as it may, a more important question is whether the introduction of these additional variables is able to account for the non-cointegration of ln(u) and ln(v) which we found in the previous sub-section. The application of the Engle-Granger test to the variables in equation (5) provides the results reported in Table 3.

### Table 3: Cointegration in the Extended Beveridge Relationship

<table>
<thead>
<tr>
<th></th>
<th>ADF</th>
<th></th>
<th>PP</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No Trend</td>
<td>Trend</td>
<td>No Trend</td>
<td>Trend</td>
</tr>
<tr>
<td>t-Statistic</td>
<td>-2.7363</td>
<td>-2.7186</td>
<td>-5.5943</td>
<td>-5.6010</td>
</tr>
<tr>
<td>10% Critical Value</td>
<td>-4.42</td>
<td>-4.72</td>
<td>-4.42</td>
<td>-4.72</td>
</tr>
</tbody>
</table>

The tests are for a unit root in the residuals of a cointegrating regression of the form of equation (5) with and without a trend in the cointegrating regression. Since the test is on the residuals from an OLS regression, we use only a t-statistic and do not include a trend term in the second-stage regression equation. The results are ambiguous with the ADF test clearly showing no cointegration and the PP test showing cointegration. These results are not sensitive to lag length.

We therefore turn to the Johansen test. Before considering this test, we re-estimate equation (5) omitting the four insignificant variables, two of which also have the wrong sign. The re-estimated equation is:
(6)  \( \ln(u) = 1.0007 - 0.3459 \ln(v) + 14.086 w_i + 1.8417 n_i + 1.0931 \text{long}, \)
\[ (7.69) \quad (16.67) \quad (6.11) \quad (4.89) \quad (5.82) \]
-2.1442 female,
\[ (4.43) \]
\( R^2 = 0.9159 \)

Clearly, there is little change in the equation compared to the more extended version in equation (5). The Engle-Granger cointegration results for the six variables in (6) are also similar to those for the set of nine in (5); i.e. the ADF test points clearly to the non-cointegration of the variables and the PP test points clearly in the opposite direction.

We continue with the six variables in equation (6) and proceed to the application of the Johansen test for cointegration. The trace test indicates a possible five cointegrating vectors amongst these six variables and the maximum-eigenvalue test indicates two cointegrating relationships. This supports the conclusion reached on the basis of the PP version of the Engle-Granger test that there is at least one cointegrating vector and we conclude that the addition of five variables to \( \ln(u) \) and \( \ln(v) \) has removed the non-cointegration between these two variables.

We proceed to examine all five possible cointegrating relationships in order to choose the one most likely to be the Beveridge Curve. We do this by examining the sign of each of the estimated parameters in the cointegrating vector with the coefficient of \( \ln(u) \) normalised to -1 and require the remaining coefficients to have a plausible sign. Our first requirement is that the coefficient of \( \ln(v) \) be negative. This allows us to eliminate one of the five cointegrating vectors. We then impose the requirement that the coefficients of \( w, r \) and \( \text{long} \) all be positive, consistent with our theoretical priors. Only one vector satisfies all these requirements. It has a negative coefficient on \( \text{female} \), a property shared by all the five vectors. The one remaining vector produces the following cointegrating regression:

(7)  \( \ln(u) = 0.7561 - 0.2576 \ln(v_i) + 12.6783 w_i + 1.9809 n_i + 1.2270 \text{long}, \)
-4.4635 \( \text{female}, \)

which is not identical to the OLS estimate of this equation given in (6) but the signs of the coefficients all match and the magnitudes of the coefficients are not very different.

Before using this equation to investigate the sources of long-run shifts in the Beveridge Curve, we address the question of whether all these additional variables are necessary to achieve cointegration or whether there is a smaller set which is also
cointegrated. We start by adding each of the additional variables one at a time to ln(u) and ln(v) and testing for cointegration. This results in cointegration being established in each case. However, only in the case where w is added to ln(u) and ln(v) are the estimated coefficients of the cointegrating relationship consistent with our priors. It is:

\begin{equation}
\ln(u) = -0.3362 - 0.6400 \ln(v) + 31.0860 \ w_t
\end{equation}

which compares to the corresponding OLS estimate of

\begin{equation}
\ln(u) = 0.4624 - 0.4206 \ln(v) + 20.2427 \ w_t, \quad R^2 = 0.7143
\end{equation}

\begin{tabular}{lcc}
 & (2.51) & (12.23) & (7.72) \\
\end{tabular}

We experiment with both the “minimal extended Beveridge Curve relationship” of ln(u), ln(v) and w as well as with the six-variable one captured in equations (6) and (7).

### 4.3 A Long-Run Decomposition of the Change in the Unemployment Rate

Since the cointegrating relationships are non-linear in u and v, a standard decomposition of the change in u over the sample period into components attributable to changes in the explanatory variables is not possible. However, we can decompose ln(u) and, for small changes in u, use the approximation that \( \Delta \ln(u) \approx \Delta u / u \), the proportional change in the unemployment rate. Since the cointegrating regression captures only the long-run relationship between u and v, we decompose five-year averages of ln(u). Table 4 provides results based on the six-variable extended cointegrating regression.

<table>
<thead>
<tr>
<th>Period</th>
<th>u</th>
<th>( \Delta \ln(u) )</th>
<th>Contribution to predicted ( \Delta \ln(u) )</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>ln(v)</td>
<td>w</td>
</tr>
<tr>
<td>1978/82</td>
<td>6.27</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>1983/87</td>
<td>8.66</td>
<td>0.3243</td>
<td>0.0552</td>
<td>0.0253</td>
</tr>
<tr>
<td>1988/92</td>
<td>8.13</td>
<td>0.2411</td>
<td>0.0972</td>
<td>0.0197</td>
</tr>
<tr>
<td>1993/99</td>
<td>9.02</td>
<td>0.3142</td>
<td>0.0363</td>
<td>0.1174</td>
</tr>
</tbody>
</table>

\footnote{Since the sample does not divide exactly into five-year periods, we include the end of the sample in the last period, 1993(1)-1999(1).}
The first column of figures reports the actual average unemployment rates for each of the five-year periods and the next contains the change in the log of the unemployment rate between the period in question and the first period, 1978/82. Recalling that $\Delta \ln(u)$ has the interpretation of the proportional change in the unemployment rate, the last figure in the $\Delta \ln(u)$ column, for example, states that between 1978/82 and 1993/99 the average unemployment rate rose approximately 31.42%. The final column gives the cointegrating equation's predicted $\Delta \ln(u)$.

Clearly the equation does not predict perfectly but the signs match and the magnitudes are quite close to the actual approximations. The five remaining columns decompose the predicted change in $\ln(u)$ into the parts due to changes in the explanatory variables. In each case the changes are, again, relative to the base period of 1978/82.

There are several noticeable features of the results in Table 4. The first is that the signs of the contributions are consistent across the three periods—the contributions of changes in the vacancy rate, real wages, the replacement ratio and the proportion of long-term unemployed in the labour force are always positive and the contribution of the proportion of females in the labour force is always negative. The second feature of the results in Table 4 is the relatively modest contribution made by changes in vacancies. Thus, comparing the end to the beginning of the sample period, the model predicts that the unemployment rate would increase by almost 40% of which less than four percentage points (i.e., less than 10%) is contributed by the change in the average vacancy rate. In terms of our earlier analysis, the source of the change in the unemployment rate is largely in shifts in the Beveridge Curve rather than movements along the Beveridge Curve. This is rather a surprising finding in the light of our conjecture based on Figure 1, that the Beveridge Curve looked to have been relatively stable over the sample period.

Another feature of the results reported in Table 4 is that there have been some shifts in the importance of the variables over the sample. In particular, the contribution of changes in the real wage was relatively minor in the comparison of 1983/87 and 1988/93 to 1978/82 but contributed almost 30% of the predicted change in $u$ when comparing the end to the beginning of the sample period. Another, smaller, shifts has been the increased importance of the effect of the long-term unemployed in the latter part of the sample.
The fourth feature of the results is the consistently negative effect of the "female" variable; if the proportion of females in the labour force had not rise consistently over the sample, the unemployment rate would have been even higher at the end than it was.

In summary, the cointegration model does a creditable job of explaining the change in the unemployment rate over five-year periods with a surprisingly large part of the change in u coming from "structural" variables which shift the Beveridge Curve rather than from demand-induced shifts along the curve. The distinction between structural and demand influences must be treated with some caution, however, since variables such as the wage rate and the number of long-term unemployed are likely to be endogenous variables in any reasonable macroeconomic explanation of unemployment and are, therefore, themselves likely to be affected by demand shocks.

4.4 A Time-Series for the Frictional Rate of Unemployment

The Beveridge Curve has been associated with the frictional or structural unemployment rate. Thus Fahrer and Pease (1993) use their estimated Beveridge Curve to calculate an annual time series for what they call the "equilibrium" unemployment rate. This unemployment rate is an "equilibrium" one in that it is derived from the Beveridge Curve which itself is based on the assumption of equilibrium between inflows into and outflows from unemployment. However, it is not sufficient simply to assume that the economy is on the Beveridge Curve; the vacancy rate also needs to be pinned down before we can derive a unique equilibrium rate of unemployment on a shifting Beveridge Curve. Fahrer and Pease resolve this problem by assuming the vacancy rate to take its sample average. A weakness of this assumption is that there is nothing necessarily "equilibrium" about the sample average vacancy rate.

An alternative is that used in, e.g., Christl (1994) and Muysken et al. (1994) who also use the Beveridge Curve as a basis for estimating a series for the structural unemployment rate but identify the relevant point on the u-v curve by equating u and v. This is based on the notion that at this point demand for and supply of labour are equal since the demand for labour is employment plus vacancies and supply of labour is employment plus unemployment. However, both these studies use vacancy data which are adjusted for under-reported vacancies, a problem which has not been
addressed in the vacancy data we use. Consequently, the vacancy rate in Australia has been approximately 5-15% of the unemployment rate over our sample period and it would be quite unrealistic to require that \( u = v \) at the point at which the unemployment rate is equal to its structural or frictional level.

We take a different tack. Like the studies just cited, we assume the equilibrium unemployment rate to lie on the Beveridge Curve but we identify the point on the Beveridge Curve as the one where the vacancy rate corresponds to capacity utilisation. In this way we identify our equilibrium unemployment rate as the frictional level of unemployment, i.e., the unemployment rate which reflects only unavoidable labour-market frictions.

We identify the vacancy rate which corresponds to capacity utilisation by regressing the vacancy rate on the ratio of actual to potential GDP (GUT) and then taking the vacancy rate at capacity output to be that for which GUT = 1, i.e. where potential output and actual output are equal. The series for GUT was taken from the NIF section of the dX data base and is based on a potential GDP series constructed by linking peaks of the actual GDP series. We have data for both series for the period 1966(3)-1997(4). If we run the regression on the entire sample period we calculate a vacancy rate at capacity output of 1.62%. Inspection of the data indicates that this vacancy level was never observed during the period used for the estimation of the Beveridge Curve, viz.1978(1)-1999(1), although similar (and higher) levels were observed in the 1960s. Using a figure of 1.62% for \( v \) in the extended Beveridge Curve equation and allowing all the other variables to take their historical values results in a series for the frictional unemployment rate which we have labelled \( u_1 \) in Figure 2.

If we argue that vacancy rates of the sort we observed in the 1960s are not likely to have been attainable in subsequent decades and limit our sample period for the regression of \( v \) on GUT to the same 1978 starting point as that used for the estimation of the Beveridge Curve, we obtain a capacity vacancy rate of 0.86% which is consistent with the higher rates observed during the sample. The resulting frictional unemployment rate series is labelled \( u_2 \) in Figure 2. Both rates have a similar weakly cyclical pattern. Their level is generally below that of comparable natural

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5 See essays in the volume by Muysken (1994) for an extensive discussion of this issue, particularly with respect to European countries.
rate/NAIRU series as found, e.g., in recent papers by Groenewold and Hagger (2000) and Gruen, Pagan and Thompson (1999). Thus \( u_1 \) is everywhere below both the Groenewold and Hagger and Gruen et al.'s preferred series for the natural rate/NAIRU while \( u_2 \) is below the Groenewold and Hagger preferred series but fluctuates about the Gruen et al. series. These relative levels seem in accordance with expectations: the frictional unemployment rate reflects only labour-market frictions which are unavoidable (at least in the short run) while the NAIRU, for example, is constrained by inflation not increasing as well as labour market frictions. Further, the general level is not dissimilar to Bodman's (1999) point estimate of the "minimum, frictional rate of unemployment" of 5.3% for Australia for the period 1978-1997; the average of \( u_1 \) for the period 1978-1997 is 5.05% and for \( u_2 \) it is 5.95%.

Conclusions

This paper has examined the Beveridge Curve for Australia in a cointegration framework. In keeping with the literature in which the Beveridge Curve is derived from a condition of labour market equilibrium, we interpret the curve as a long-run relationship between the unemployment and vacancy rates and a number of shift variables. From this perspective the concept of cointegration is a suitable basis for the analysis of the Beveridge relationship.

We found the (logs of) the unemployment and vacancy rates to be non-stationary and not cointegrated. A cointegration relation was however, established when additional shift variables were added to the equation. In particular, we found a long-run relationship to exit when we added the real wage, the replacement ratio, a long-term unemployment variable and a measure of the importance of females in the labour force to the basic equation.

We used this extended Beveridge Curve to decompose the growth in unemployment since the late 1970s and found that remarkably little of the increase was due to movements along the Beveridge Curve compared to shifts of the curve itself: this points to the greater importance of structural changes rather than aggregate demand shocks in the increase in the unemployment rate over the sample period.

We also used the estimated Beveridge Curve to derive a series for the frictional unemployment rate. We report two alternative series which are consistent with existing estimates of the natural rate/NAIRU and with a recent point estimate of the frictional unemployment rate over a similar period for Australia.
References

Arestis, P. and I. B.-F. Mariscal (1999), 'Unit Roots and Structural Breaks in OECD Unemployment', *Economics Letters*, vol. 65, pp. 149-156.


Figure 1: Unemployment and Vacancy Rates, Australia, 1966:Q3-1999:Q1
Figure 2: Frictional Unemployment Rates