Estimating the NAIRU and the Output Gap in Australia

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* The views expressed are those of the author and should not be attributed to the Reserve Bank of Australia
Using a Phillips Curve to Estimate the NAIRU

\[ \pi_t = \pi_t^e + \alpha \left( U_t - U_t^* \right) \frac{1}{U_t} + \beta Z_t + \nu_t \]  

(1)

where

\( \pi_t \) : inflation (quarterly)

\( \pi_t^e \) : inflation expectations. Linear combination of lagged inflation and inflation expectations from the bond market, \( \pi_t^B \)

\( U_t \) : the unemployment rate

\( U_t^* \) : the NAIRU

\( Z_t \) : other variables; ‘speed effect’, dynamics, excess import price inflation, excess oil price inflation

\( \nu_t \) : error term

Since \( \pi_t^e = (1 - \delta) \cdot \pi_{t-1} + \delta \cdot \pi_t^B \)

\( = \pi_{t-1} + \delta \cdot (\pi_t^B - \pi_{t-1}) \)

we can rewrite equation (1)

\[ \pi_t - \pi_{t-1} = \alpha \left( U_t - U_t^* \right) \frac{1}{U_t} + \delta (\pi_t^B - \pi_{t-1}) + \beta Z_t + \nu_t \]

Call \((\pi_t^B - \pi_{t-1})\), ‘excess inflation expectations’.
How to estimate?

Assume the NAIRU evolves as a random walk

\[ U_t^* = U_{t-1}^* + \eta_t \]  

(2)

Estimate equations (1) and (2) together (using the Kalman filter) to derive the estimated path for the NAIRU.

**Equation Specification**

\[ \pi_t - \pi_{t-4} = \alpha \{\text{unemployment gap}\} + \beta_1 \{\text{"speed effect"}\} + \beta_2 \{\text{excess inflation expectations}\} + \beta_3 \{\text{excess import price inflation}\} + \beta_4 \{\text{dynamics}\} + \beta_5 \{\text{excess oil price inflation}\} \]

where

\[ \{\text{unemployment gap}\} = \frac{(U_t - U_t^*)}{U_t} \]

\[ \{\text{"speed effect"}\} = \frac{\Delta U_{t-1}}{U_t} \]

\[ \{\text{excess inflation expectations}\} = \text{excess of bond market inflation expectations over last quarter's year-ended inflation rate;} \]

\[ \{\text{excess import price inflation}\} = \text{excess of year-ended import price inflation over last quarter's year-ended inflation rate;} \]
{dynamics} = the difference between lags 1 and 4 of quarterly inflation;

{excess oil price inflation} = the average of past two year's oil price inflation minus last quarter's year-ended inflation.

Results

\[ \pi_t - \pi_{t-4} = \alpha \{\text{unemployment gap}\} + \beta_1 \{\text{"speed effect"}\} + \beta_2 \{\text{excess inflation expectations}\} + \beta_3 \{\text{excess import price inflation}\} + \beta_4 \{\text{dynamics}\} + \beta_5 \{\text{excess oil price inflation}\} \]

Sample: 1966:1 to 2001:4
Included observations: 144

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>t-Statistic</th>
<th>Prob.</th>
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</thead>
<tbody>
<tr>
<td>unemployment gap</td>
<td>-0.521</td>
<td>-2.1</td>
<td>0.017</td>
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<tr>
<td>&quot;speed effect&quot;</td>
<td>-1.331</td>
<td>-1.7</td>
<td>0.042</td>
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<td>excess inflation exp’ns</td>
<td>0.076</td>
<td>2.9</td>
<td>0.020</td>
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<td>excess import price</td>
<td>0.009</td>
<td>1.6</td>
<td>0.060</td>
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<td>inflation dynamics</td>
<td>0.625</td>
<td>7.4</td>
<td>0.000</td>
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<td>excess oil price inflation</td>
<td>0.004</td>
<td>1.3</td>
<td>0.093</td>
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</tbody>
</table>

S.E. of regression 0.455  S.D. of dependent variable 0.705
Core Inflation* (Year-ended percentage change)

Weighted median inflation excluding GST

*
Core Inflation and Inflation Expectations

- Inflation* (year-ended)
- Bond market inflation expectations

* Weighted median inflation excluding GST
Using a Phillips Curve to Estimate Potential Output and the Output Gap

\[ \pi_t = \pi_t^e + \alpha (y_t - y_t^*) + \beta Z_t + \varepsilon_t \]  \hspace{1cm} (1)

where

- \( \pi_t \) : inflation (quarterly)
- \( \pi_t^e \) : inflation expectations (linear combination of lagged inflation and inflation expectations from the bond market)
- \( y_t \) : output (in logs)
- \( y_t^* \) : potential output (in logs)
- \( Z_t \) : other variables; dynamics, excess import price inflation, excess oil price inflation
- \( \varepsilon_t \) : error term

**How to Estimate?**

Choose a smooth path for potential output that gives a best fit to the Phillips Curve (equation 1);

*Or in symbols*

Choose a path for \( y_t^* \) that minimises

\[ \mathcal{L} = \sum_t \varepsilon_t^2 + \lambda \sum_t \left[ \left( y_{t+1}^* - y_t^* \right) - \left( y_t^* - y_{t-1}^* \right) \right]^2 \]
Equation Specification

\[ \pi_t - \frac{1}{4} \{ \pi_{t-4} + \pi_{t-5} + \pi_{t-6} + \pi_{t-7} \} = \]

\[ \alpha \{ \text{output gap} \} + \]
\[ \beta_1 \{ \text{excess inflation expectations} \} + \]
\[ \beta_2 \{ \text{excess oil price inflation} \} + \]
\[ \beta_3 \{ \text{dynamics} \} + \]
\[ \beta_4 \{ \text{excess import price inflation} \} \]

where

\{\text{excess inflation expectations}\} = \text{excess of bond market inflation expectations over last quarter's year-ended inflation rate;}

\{\text{excess oil price inflation}\} = \text{the sum of lags 2,3 and 7 of excess quarterly oil price growth over last quarter's inflation rate;}

\{\text{dynamics}\} = \text{the difference between lags 1 and 4 of the year-ended inflation rate; and}

\{\text{excess import price inflation}\} = \text{the sum of lags 0 and 1 of excess quarterly import price growth over last quarter's inflation rate.}
Results

\[ \pi_t - \frac{1}{4} \{ \pi_{t-4} + \pi_{t-5} + \pi_{t-6} + \pi_{t-7} \} = \]

\[ \alpha \{ \text{output gap} \} + \]
\[ \beta_1 \{ \text{excess inflation expectations} \} + \]
\[ \beta_2 \{ \text{excess oil price inflation} \} + \]
\[ \beta_3 \{ \text{dynamics} \} + \]
\[ \beta_4 \{ \text{excess import price inflation} \} \]

Sample: 1960:1 to 2001:4
Included observations: 168

<table>
<thead>
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<tbody>
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<td>output gap</td>
<td>0.069</td>
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<td>excess inflation exp’ns</td>
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<td>excess oil price inflation</td>
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<td>dynamics</td>
<td>0.329</td>
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<td>import price inflation</td>
<td>0.023</td>
<td>3.222</td>
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</table>

R-squared 0.712
Adjusted R-squared 0.705
S.E. of regression 0.004
Sum squared resid 0.003
Log likelihood 690.2
Mean dep var 6.41E-05
S.D. dep var 0.007
Akaike info crit’n -8.157
Schwarz criterion -8.064
Durbin-Watson stat 1.910
Actual and Potential Output
(Year-ended percentage change)