Australian Emissions Reduction Subsidy Policy under Persistent Productivity Shocks

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By:
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1. Introduction

The Australian emissions reduction systems:

- the Clean Energy Programme under the Prime Ministership of Julia Gillard in 2011 including a carbon tax period from 1 July 2012 to 30 July 2015 following by an emissions trading scheme.

- under the Prime Ministership of Kevin Rudd: the tax period would finish one year earlier, on 30 July 2014.

- under the Prime Ministership of Tony Abbott: the carbon pricing system was abolished from 1 July 2014. The government introduced emissions reduction supporting policies the Emissions Reduction Fund program from 13 December 2014 in which the government funds emissions reduction activities.
1. Introduction

- We study the transitions effects of an abatement subsidy policy under macroeconomic uncertainty conditions.
- To this end we use a real business cycle (RBC) model to compare the dynamic effects of such a policy when productivity shocks occur.
2. Model

- Environment

\[ x_t = \eta x_{t-1} + m_t + m_{t}^{row} \]
\[ m_t = (1 - \mu_t)h(y_t) \]
\[ z_t = g(\mu_t)y_t \]

- Production Sector

\[ y_t = (1 - d(x_t))a_t f(k_{t-1}) \]
\[ \ln a_t = \rho \ln a_{t-1} + \varepsilon_t \]
\[ \pi_t = y_t - r_t k_{t-1} - z_t \]

- Consumption Sector

\[ E_t \sum_{t=0}^{\infty} \beta^t u(c_t) \]
\[ \pi_t + r_t k_{t-1} = c_t + i_t \]
\[ k_t = (1 - \delta)k_{t-1} + i_t \]
2. Model

- Business-as-usual (BAU)

\[ r_t = y_t f'(k_{t-1}) / f(k_{t-1}) \]

\[ m_t = h(y_t) \]

\[ \pi_t + r_t k_{t-1} = c_t + i_t \]

\[ \pi_t = y_t - r_t k_{t-1} \]

\[-u'(c_t) + \beta E_t u'(c_{t+1}) \left[ r_{t+1} + (1 - \delta) \right] = 0 \]

\[ x_t = \eta x_{t-1} + m_t + m_{t}^{row} \]

\[ y_t = (1 - d(x_t)) a_t f(k_{t-1}) \]

\[ k_t = (1 - \delta) k_{t-1} + i_t \]

\[ \ln a_t = \rho \ln a_{t-1} + \varepsilon_t \]
2. Model

• Abatement subsidy

\[ \pi_t + r_t k_{t-1} - s_t \mu_t = c_t + i_t \]
\[ \pi_t = y_t - r_t k_{t-1} + s_t \mu_t \]
\[ g'(\mu_t) y_t = s_t \]
\[ r_t = y_t f''(k_{t-1}) / f(k_{t-1}) [1 - g(\mu_t)] \]

\[ \max_{s_t, k_t, y_t, x_t} \sum_{t=0}^{\infty} \beta^t Eu(c_t) \]

\[-u'(c_t) z'_s (s_t, y_t) + \lambda_t \{u''(c_t)z'_s (s_t, y_t)\} + \lambda_{t-1} \{u''(c_t) (-z'_s (s_t, y_t)) (r_t + 1 - \delta)\} + \zeta_t \{-m'_s (s_t, y_t)\} = 0 \]

\[-u'(c_t) + \beta u'(c_t) (1 - \delta) + \beta \lambda_{t+1} \{-u''(c_{t+1}) (1 - \delta)\} + \lambda_t \{u''(c_t) + \beta u''(c_{t+1}) (1 - \delta) (r_{t+1} + 1 - \delta) + \beta u'(c_{t+1}) r'_k (y_{t+1}, k_t)\} + \lambda_{t-1} \{-u'(c_t) (r_{t+1} + 1 - \delta)\} - \beta \omega_{t+1} [1 - d(x_{t+1})] a_{t+1} f'(k_t) = 0 \]

\[ u'(c_t) \left(1 - z'_y (s_t, y_t)\right) + \lambda_t \{-u''(c_t)z'_y (s_t, y_t)\} + \omega_t + \lambda_{t-1} \{u''(c_t) \left(1 - z'_y (s_t, y_t)\right) (r_t + 1 - \delta) + u'(c_t) r'_y (y_t, k_{t-1})\} + \zeta_t \{-m'_y (s_t, y_t)\} = 0 \]

\[ \zeta_t - \beta \zeta_{t+1} \eta + \omega_t a_t f(k_{t-1}) d'(x_t) = 0 \]
3. Calibration

\[ u(c_t) = \frac{c^{1-\zeta}}{1-\zeta} \]

\[ g(\mu_t) = \theta_1 \mu_t^{\theta_2} \]

\[ h(y_t) = y_t^{1-\gamma} \]

\[ d(x_t) = d_0 + d_1 x_t + d_2 x_t^2 \]

\[ f(k) = k^\alpha \]
## 3. Calibration

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>0.33</td>
<td>Output elasticity of capital</td>
<td>Rees (2013), Gomez-Gonzalez and Rees (2013)</td>
</tr>
<tr>
<td>$\zeta$</td>
<td>1.66</td>
<td>Risk aversion coefficient</td>
<td>Hodge <em>et al.</em> (2008)</td>
</tr>
<tr>
<td>$\beta$</td>
<td>0.99</td>
<td>Discount factor</td>
<td>Jaaskela and Nimark (2011), Gomez-Gonzalez and Rees (2013), Rees (2013)</td>
</tr>
<tr>
<td>$\delta$</td>
<td>0.02</td>
<td>Capital depreciation rate</td>
<td>Rees (2013)</td>
</tr>
<tr>
<td>$\rho$</td>
<td>0.98</td>
<td>Autocorrelation parameter of the productivity shock</td>
<td>Rees (2013)</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>0.007</td>
<td>Standard deviation of $\varepsilon_t$</td>
<td>Rees (2013)</td>
</tr>
<tr>
<td>$\eta$</td>
<td>0.9979</td>
<td>Autocorrelation parameter of the pollution equation</td>
<td>Heutel (2012)</td>
</tr>
<tr>
<td>$d_0$</td>
<td>-0.0011</td>
<td>Intercept of damage function</td>
<td>Estimated by the authors for Australia from the Nordhaus (2010) model</td>
</tr>
<tr>
<td>$d_1$</td>
<td>$-5.6629e^{-10}$</td>
<td>Linear coefficient of damage function</td>
<td>Estimated by the authors for Australia from the Nordhaus (2010) model</td>
</tr>
<tr>
<td>$d_2$</td>
<td>$1.2261e^{38}$</td>
<td>Quadratic coefficient of the damage function</td>
<td>Estimated by the authors for Australia from the Nordhaus (2010) model</td>
</tr>
<tr>
<td>$\theta_1$</td>
<td>0.07</td>
<td>Abatement cost function coefficient</td>
<td>Nordhaus (2010)</td>
</tr>
<tr>
<td>$\theta_2$</td>
<td>2.8</td>
<td>Abatement cost function exponential coefficient</td>
<td>Nordhaus (2010)</td>
</tr>
<tr>
<td>$1-\gamma$</td>
<td>0.0975</td>
<td>Emissions elasticity of output</td>
<td>Estimated by the authors from the Australian emissions and GDP data over the period Q2, 2001 - Q4, 2013</td>
</tr>
</tbody>
</table>
## 3. Simulation Result

<table>
<thead>
<tr>
<th>Variable</th>
<th>BAU</th>
<th>Emissions Reduction Subsidy (% change from BAU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emissions (m)</td>
<td>1.1075</td>
<td>1.0361 (-6.45%)</td>
</tr>
<tr>
<td>Abatement (μ)</td>
<td>0</td>
<td>0.0625</td>
</tr>
<tr>
<td>Output (y)</td>
<td>2.8335</td>
<td>2.7904 (-1.52%)</td>
</tr>
<tr>
<td>Capital (k)</td>
<td>32.0936</td>
<td>30.5901 (-4.68%)</td>
</tr>
<tr>
<td>Consumption (c)</td>
<td>2.1917</td>
<td>2.1785 (-0.60%)</td>
</tr>
<tr>
<td>Welfare Cost</td>
<td>0</td>
<td>0.60%</td>
</tr>
</tbody>
</table>
3. Simulation Result

Impulse Responses of Economic Variables to a TFP Shock

- Proportional Deviation from Steady State
  - TFP
  - Output

- Deviation from Steady State (%)
  - Capital(k)-Subsidy
  - Consumption(c)-Subsidy
3. Simulation Result

Impulse Responses of Environmental Variables to a TFP Shock

- Abatement (\(\mu\)) - Subsidy
- Emissions (\(m\)) - Subsidy
- Abatement Cost (\(z\)) - Subsidy
- Subsidy Rate (\(s\)) - Subsidy
3. Simulation Result

• Business Cycle Simulation of Output
3. Simulation Result

• Business Cycle Simulation of Emissions
4. Conclusion

• The results showed that such a policy results in an emissions reduction but at an output decrease and welfare cost compared with a BAU scenario. In a stochastic situation and in the presence of a TFP shock an emissions subsidy can encourage polluters to move to cleaner technologies such as renewable energies when a positive TFP shock occurs.
4. Conclusion

• the regulator should set the subsidy to be pro-cyclical to business cycles: they increase during expansion and decrease during recessions.

• the abatement subsidy findings are for the scenario specified here in which the firm receives a subsidy for its abatement effort in each period and the policy is run for a long period, which may be different from the Emissions Reduction Fund program which is planned to continue only for 5 years.
Thank you