2015

General equilibrium models and uncertainty in environmental policies: implications for Australia

Fariba Ramezani Khansari

University of Wollongong, frk762@uowmail.edu.au

Publication Details

Research Online is the open access institutional repository for the University of Wollongong. For further information contact the UOW Library: research-pubs@uow.edu.au
General equilibrium models and uncertainty in environmental policies: implications for Australia

Abstract
Presentation only.

Publication Details
HDR Student Conference
2015
General Equilibrium Models and Uncertainty in Environmental Policies: Implications for Australia

By:
Fariba Ramezani Khansari

Supervisors:
Associate Professor Charles Harvie
Dr Amir Arjomandi
Dr Michelle Dunbar
2- Aims and Significance of Study

- To study the effects of policies on a whole economy, general equilibrium models have been broadly used since they can embrace all sectors and markets in an economy.

- We review the literature on **computable general equilibrium (CGE)** and **dynamic stochastic general equilibrium (DSGE)** models in environmental economics.

- The contribution of CGE models in Australian environmental policy analysis is significant (Asafu-Adjaye, 2004; Clarke and Waschik, 2012; Asafu-Adjaye and Mahadevan, 2013; Fraser and Waschik, 2013; Meng *et al.*, 2013; Adams *et al.*, 2014; Meng, 2014).
2- Aims and Significance of Study

- The Australian emissions pricing system:
- 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 the Emissions Reduction Fund program from 13 December 2014 in which the government funds emissions reduction activities.
2- Aims and Significance of Study

Uncertainties relating environmental policies:

1. **environmental uncertainty** arising from unknown geological and environmental factors.
   - the life of carbon in the atmosphere
   - the contribution of GHGs to climate change and global warming
   - the sensitivity of the earth to global warming
   - the level and timing of the damages due to pollution

In Australia, the annual average temperature would increase by 2.8 to 5.1°C by the end of this century (CSIRO and the Australian Bureau of Meteorology, 2015).
2. economic uncertainty related to:

- the social economic costs of emissions abatement, the costs of climate change damage and the trade-off between these two expenses and other factors which can affect the future of this trade-off such as substitution between fuels
- the progress of backstop technology
- the arrival of new, cleaner technology

In Australia, the progress of renewable energy technology can significantly affect the approaches policy makers can follow to achieve emissions targets since the production sector heavily relies on fossil fuels, e.g. 86.9% of Australian electricity was generated by fossil fuels in 2012-13
Dissou and Karnizova (2012) discuss that macroeconomic uncertainty in environmental policies should be considered, since, firstly, it would result in fluctuations in consumption which would influence the costs of emissions policies; secondly, it is known as the main factor of a quantity versus a price emissions policy since Weitzman (1974).

In order to track the effects of uncertainties on the economy over time, DSGE models can be applied.
3- Methodology

- Conceptual Issues relating to CGE and DSGE Modelling:
  - Both CGE and DSGE models are based on micro-foundations containing similar micro principles:
    1) utility maximisation by households
    2) profit maximization by firms
    3) market clearing: all markets are in equilibrium.
  - Both models assume rational behaviour by different economic agents and, thus, they are less likely to be subject to the Lucas critique (Lucas, 1976).
  - The Lucas critique is a criticism of econometric models which evaluates historical data in order to predict the effects of a change in a policy without recognizing the optimal decision rules of economic agents.
3- Methodology

- **CGE models**
- the antecedents to DSGE models
- CGE models generally include four features:
  1. the focus of the model is on equilibrium resource allocation patterns
  2. assumes perfectly competitive markets
  3. the production side is represented by a profit maximising producer subject to technology constraints who chooses the optimal supply of a product and demand for factors.
  4. the consumption side is shown by a representative utility maximising household who chooses the optimal supply of factors and demand for a product (Pezzey and Lambie, 2001).
Following these four steps the outcome of a CGE model will be a system of equations:

For parameterization, CGE models mostly employ calibration, using a transaction table which is usually an input-output table or a social accounting matrix contains (Dejuan et al., 2013; Guo et al., 2014; Hosoe, 2014; Okuyama and Santos, 2014).
The structure of a DSGE model is similar to that of a CGE model. The main difference is that agent optimizations take place within a deterministic environment in a CGE model while in a DSGE model the environment is stochastic due to uncertainties, usually specified as random shocks occurring in the model.

There are two schools of DSGE models, real business cycle (RBC) and New-Keynesian.

RBC models were first introduced by Kydland and Prescott (1982) to investigate if real shocks are the main source of business cycle fluctuations.

Adding friction on the monetary side, specifically price and wage adjustment, and monopolistically competitive markets to RBC models led to the second school of DSGE models, New-Keynesian by Rotemberg and Woodford (1997).
3- Methodology

- For parameterization early DSGE models usually employed calibration, but new parameterization procedures were developed including Bayesian estimation, generalised methods of moment estimation, full-information maximum likelihood estimation and matching VAR and DSGE dynamic responses to structural shocks.

* The progress made in DSGE modelling made it an appropriate tool for fiscal and monetary policy analysis:
  - the Federal Reserve Board's SIGMA model
  - The Central Bank of Chile MAS model
## Advances over time

<table>
<thead>
<tr>
<th>CGE</th>
<th>DSGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>• From static to dynamic models: to show the time path of policy changes</td>
<td>• From perfectly competitive markets (in RBC models) to monopolistically competitive markets (in NK models): adding friction, specifically price and wage adjustment, and monopolistically competitive markets to make it appropriate for monetary policy analysis</td>
</tr>
<tr>
<td>• Development of computer programs (such as GAMS, MPSGE and GEMPACK): this facilitate researchers to run large scale CGE models</td>
<td>• From calibration to estimation in parameterization: including Bayesian estimation, generalised methods of moment and full-information maximum likelihood. This makes DSGE models fit to actual data.</td>
</tr>
</tbody>
</table>

## As Macroeconomics Models

<table>
<thead>
<tr>
<th>CGE</th>
<th>DSGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Deterministic</td>
<td>• Stochastic</td>
</tr>
<tr>
<td>• Static/ dynamic</td>
<td>• Dynamic</td>
</tr>
<tr>
<td>• Perfectly competitive markets</td>
<td>• Perfectly competitive markets (in RBC models) and monopolistically competitive markets (in NK models)</td>
</tr>
<tr>
<td>• Calibration for parameterization</td>
<td>• Calibration and estimation for parameterization</td>
</tr>
</tbody>
</table>

## As Environmental Models (mostly)

<table>
<thead>
<tr>
<th>CGE</th>
<th>DSGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Deterministic</td>
<td>• Stochastic emphasising real shocks</td>
</tr>
<tr>
<td>• Static/ dynamic</td>
<td>• Dynamic</td>
</tr>
<tr>
<td>• Calibration for parameterization</td>
<td>• Calibration for parameterization</td>
</tr>
<tr>
<td>• Large-scale multi-sectoral models</td>
<td>• Small-scale models with integrated sectors</td>
</tr>
<tr>
<td>Year</td>
<td>Author</td>
</tr>
<tr>
<td>------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td>1993</td>
<td>McDougall</td>
</tr>
<tr>
<td>1998</td>
<td>Kennedy</td>
</tr>
<tr>
<td>1999</td>
<td>Brown et al.</td>
</tr>
<tr>
<td>2000</td>
<td>Adams et al.</td>
</tr>
<tr>
<td>1992</td>
<td>McKibbin and Wilcoxen</td>
</tr>
<tr>
<td>2011</td>
<td>Commonwealth of Australia Treasury</td>
</tr>
</tbody>
</table>
4- Background

- The literature on environmental policy comparison under uncertain conditions began with Weitzman (1974), followed by many other researchers (Hoel and Karp, 2002; Pizer, 2002; Newell and Pizer, 2003; Quirion, 2005; Fell et al., 2012) who have applied a **partial equilibrium approach** to investigate the role of uncertainty, usually about abatement cost, in environmental policy.

- In a **static stochastic general equilibrium** model, Kelly (2005) investigates the effects of productivity shocks on environmental policy in a static framework.

* Investigating environmental economics under a type of **uncertainty** and in a **dynamic general equilibrium** model is still in its primary stage, involving the limitations that the early DSGE models had over three decades ago.
<table>
<thead>
<tr>
<th>Year</th>
<th>Author</th>
<th>Uncertainty</th>
<th>Region</th>
<th>Main (Theoretical) Contribution</th>
<th>Findings/ Policy Implications</th>
</tr>
</thead>
</table>
| 2011 | Fischer and Springborn       | TFP                         | US     | Introducing DSGE model (RBC) in environmental economics under intensity target policy and emissions pricing policies                                                                                                                                 | • Both emissions tax and cap result in the same outcomes although the tax policy leads to greater volatility.  
• Intensity target result in higher output, employment and capital compare to a cap and a tax policy. |
| 2012 | Heutel                        | TFP                         | US     | Testing flexible emissions pricing policies where the government can set the tax (or cap) at the beginning of each period, adding asymmetric information                                                                                     | • An optimal policy should be pro-cyclical: stringent during recessions and gentle during expansions.  
• Under asymmetric information, the variation of the tax policy is significantly greater than the quantity policy. |
| 2012 | Dissou and Karnizova          | TFP and sector-specific technology | US     | Developing a multi-sectoral model to investigate the sectoral and aggregate effects of emissions pricing                                                                                                                                 | Although the emissions permit policy imposes less volatility, it can lead to asymmetries in economic responses to shocks.  
• The welfare effects of each policy depend on the origin of the shocks. |
| 2012 | Hassler and Krusell           | TFP                         | Global | Extending the RICE model to a stochastic one                                                                                                                                                                                                 | • Levying an oil tax in oil-producing countries can improve the climate while it has no climate consequences in the oil-consuming countries.  
• The economic effects of such taxes in oil-producing countries are significant, especially when the proceeds of the taxes recycle in a lump-sum manner to the payer countries. |
| 2013 | Angelopoulos et al.           | TFP and pollution technology | US     | Adding a pollution technology shock measured as emissions per unit of output                                                                                                                                                     | • An optimal environmental policy is pro-cyclical when an economic shock occurs, and counter-cyclical in the case of an environmental shock. |
| 2014 | Roach                         | TFP and the energy price    | US     | Developing a New-Keynesian model with the assumption of monopolistic competition and friction, testing the effects of energy shocks                                                                                           | • An optimal tax should be pro-cyclical  
• The tax revenue should be recycled to the household in both scenarios. |
| 2014 | Golosov et al.                | the long-run value of the scale of damages from atmospheric CO2 concentration | Global | Developing a new DSGE model without any structural shock, incorporating the long-run value of the scale of damages from atmospheric CO2 concentration                                                                 | • The damage is determined by three factors: discounting, the sensitivity of damage and the structure of carbon depreciation in the atmosphere. |
The limitations of environmental DSGE models:

1. mostly emphasise real shocks only, ignoring other economic and environmental shocks. This issue is also pointed to by Fischer and Heutel (2013) who conclude that other types of uncertainties should be added beside productivity to the environmental RBC models.

2. calibration

3. As a result of calibration, they focus on forecasting deviations from the steady state of macroeconomic variables rather than the level of such variables.

4. The size, usually one integrated sector, while an appropriate environmental policy analysis requires a multi-sectoral macroeconomics models.
Constructing large-scale multi-sectoral DSGE models can tailor these models to environmental analysis since the imposed economic costs and the optimal outcome of environmental policies varies across sectors.

- The current environmental DSGE models are similar to early DSGE models and further development is required to make DSGE as a solid, efficient modelling tool in environmental economic analysis.

- For Australia, in particular, the literature of DSGE models for quantitative policy assessment remains limited to a few studies (Jaaskela and Nimark, 2011; Robinson, 2013; Rees, 2013).
5- Results: Implications for Australia

- investigating the relationship between Australian emissions and business (TFP or foreign shocks)
- The policy implications of such studies would be significant by representing how an environmental policy should be adjusted to business cycles.
- improving the empirical results of the existing CGE models by specifying different shocks to them to investigate the sectoral responses.
- simulating the effects of unexpected environmental changes which can be done by developing a DSGE model including the special environmental features of Australia.
- Exploring the limitations and other issues of these models within the context of Australian environmental policy analysis and Australian policy makers can learn a lot about the outcome of their policies along the way.
Thank you