



University of  
**Strathclyde**  
Business  
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**International Association of Energy Economists**

***The Economic and Environmental Impact of the  
Introduction of a Carbon Tax for Scotland:  
A Computable General Equilibrium Analysis\****

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\* The presentation reflects joint research with colleagues in Fraser of Allander Institute, Department of Economics: Grant Allan, Patrizio Lecca, Kim Swales, Marie Tamba and Matt Winning



# 1. Introduction and background

- Successive Scottish Governments have sought to pursue a distinctive energy and climate change policies (relative to UK)
- Reflected in:
  - Emissions [and renewables] targets that are tougher than UK: emissions 42% below 1990 levels by 2020 (UK 34%) [renewables equivalent to 100% electricity consumption by 2020]
  - Use of planning system (no new nuclear), schemes to encourage new renewable technologies (marine) within scope of devolution settlement
- But Climate Change Committee expects Scotland to miss emissions targets, and
  - While Scottish targets ambitious, limited instruments: major elements of policy reserved to Westminster (tax-transfer system; ROCs; electricity market)
  - Many argue carbon tax most efficient way to tackle emissions
  - Not feasible under current constitutional arrangements, but these are under pressure: move to greater fiscal autonomy



## 2. Pressure for greater fiscal autonomy

- Continuing lively debate shifting in favour of Scottish Parliament having greater fiscal autonomy/ independence:
  - SNP (independence party) formed a minority administration in 2007 and first ever majority Government in 2011
  - Committed to holding referendum on independence in 2014
  - General agreement that greater fiscal autonomy likely, though no unanimity on extent: new status quo – Scotland Act 2012; “devo(lution) plus”, “devo max”, independence
- Given ambitious emissions targets, expectations that current policy will not deliver on these and pressure for greater fiscal autonomy, seems natural to consider impact of a Scottish carbon tax (if EU ETS not expected to deliver appropriate carbon price).
- We consider the implications of meeting the emissions reduction targets through a (currently hypothetical) Scottish-specific carbon tax



### 3. The likely impact of a Scottish-specific carbon tax

- Carbon tax would be possible under “devo max” or independence (not under status quo)
  - Classic motivation: internalise externality – polluters pay (using market)
  - Relative price changes induce production and consumption changes away from carbon intensive production and consumption
- Carbon tax also raises revenues: and overall impact may vary with assumptions about their recycling (“double dividend”?)
  - No recycling within the Scottish economy (external- Westminster)
  - Used to finance a expansion in Scottish Government expenditure
  - Alternatively, revenues are recycled to cut tax on labour Scotland
- “No recycling” option:
  - Big increase in fuel prices, contractionary demand and supply effects
  - Increases the relative price of carbon-intensive goods
  - Reallocation of consumption and production away from such goods
  - Likely reduction in emissions, but also economic activity



### 3. The likely impact of a Scottish-specific carbon tax (continued)

- Revenues used to finance increased government expenditures
  - Ambiguous impact on economic activity in general: carbon tax reduces it, government expenditure increases it, and supply side and bargaining
  - However, as before carbon-intensive goods and modes of production discouraged ; but if economic activity rises, limits reduction in emissions
- Revenues used to reduce other taxes e.g. on labour:
  - Again ambiguous impact on overall activity: countervailing effects
  - Again, however, has desirable impact on distribution of economic activity across commodities and sectors, and ultimately technical change
- In general ambiguity about even the **direction** of effects on the macro-economy (except where no recycling of revenues within Scotland). Of course, even where we know direction of impacts, need a numerical model to indicate the **scale** of any impact.
  - Need modelling: here use AMOSENVI energy-economy-environment CGE model of Scotland to explore the likely impacts of securing emissions targets through a carbon tax



## 4. AMOSENVI: energy-economy-environment model of the Scottish economy

- AMOSENVI
  - Multi-sectoral, energy-economy-environment model of economy
  - 17 industry sectors (13 energy, 9 generation technologies): big variations in energy and emissions intensities across sectors
  - Interdependence of energy, economy, environment subsystems captured
- Firms cost-minimisers, who sell in competitive markets and consumption is dependent on population, average income and consumer prices
- Wage-setting determined by bargaining – with real wage inversely related to unemployment rate.
- In period by period mode, population and capital stocks updated every period.
  - Flow in-migration – positively related to Scottish real wage and inversely related to Scottish unemployment rate
  - Investment essentially driven by profits
- Transactors either myopic or have perfect foresight: in latter case react to anticipated future events



## 5. Simulation strategy and results

- We introduce a tax on carbon emissions that ensures satisfaction of the Scottish emissions targets (£50 per tonne)
  - Ad valorem tax on the use of the three domestic and imported fossil fuel energy sources – coal, oil and gas – in their use as intermediate inputs in the production of other goods and services
  - Tax rate differentiated according to carbon content of each fuel (price hikes of: 67%, 42% and 31% respectively)
  - Tax introduced in period 1 and maintained throughout
- The tax raises revenues, and we consider three cases identified above:
  - The revenues are not recycled within Scotland
  - They are used to expand general government expenditure in Scotland
  - They are used to reduce other taxes – here income tax

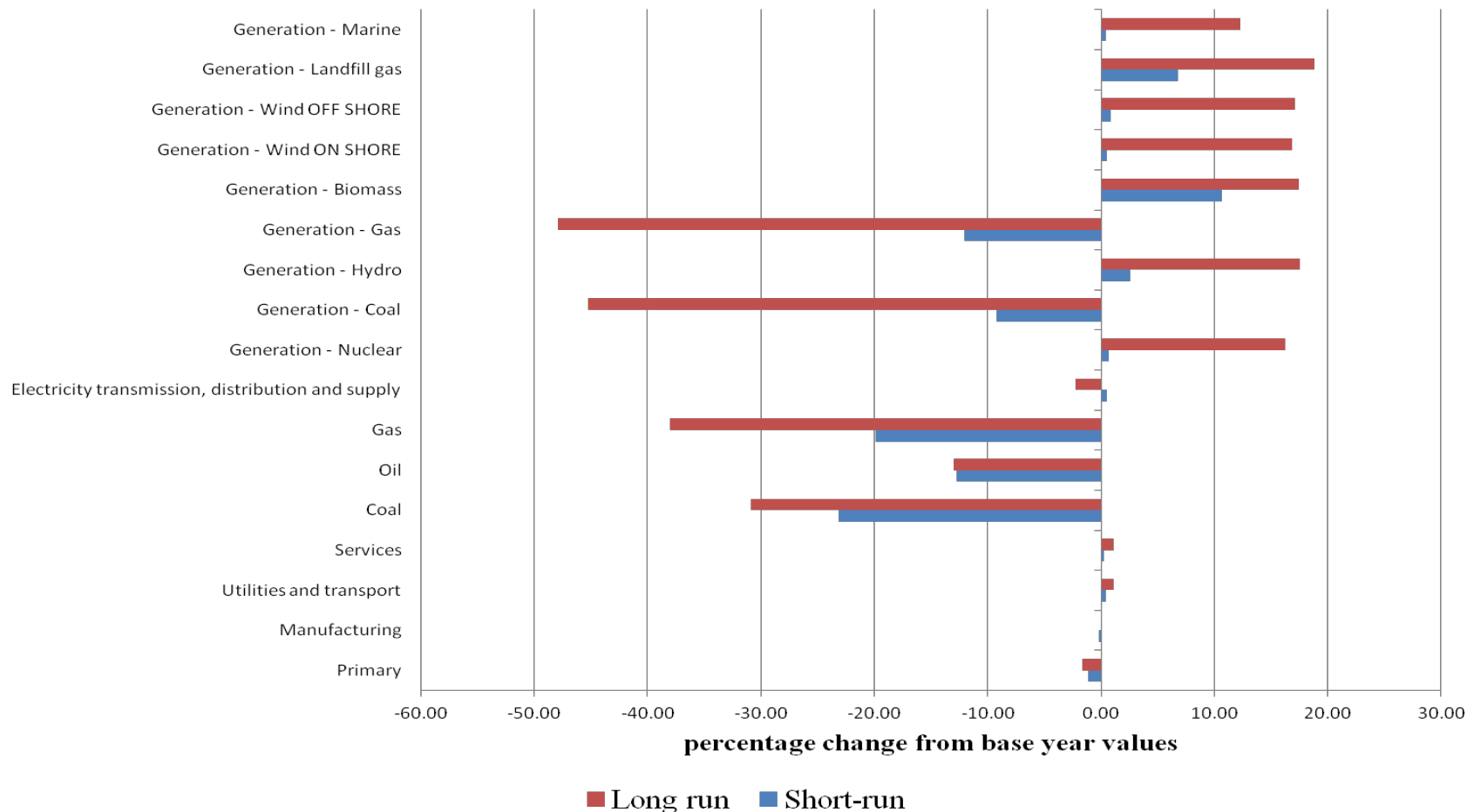
**Table 1. Impact of implementing a £50 per tonne carbon tax in Scotland on key macro-variables (percentage change from base year values)**

|                             | Externally Recycled |          | Internally Recycled |          | Internally Recycled |          |
|-----------------------------|---------------------|----------|---------------------|----------|---------------------|----------|
|                             | Short-run           | Long-run | Public Expenditure  |          | Income Tax          |          |
|                             |                     |          | Short-run           | Long-run | Short-run           | Long-run |
| CO <sub>2</sub> Emissions   | -32.66              | -39.34   | -32.55              | -38.84   | -31.83              | -37.49   |
| GDP                         | -0.30               | -2.68    | -0.14               | -1.37    | 0.26                | 0.83     |
| Unemployment Rate           | 4.08                | 0.00     | 1.79                | 0.00     | -3.77               | 0.00     |
| Total Employment            | -0.45               | -2.60    | -0.20               | -1.27    | 0.42                | 1.06     |
| Nominal Gross Wage          | -0.60               | 0.81     | 0.24                | 0.81     | -0.88               | -1.43    |
| Real Wage After Tax         | -0.45               | 0.00     | -0.20               | 0.00     | 0.43                | 0.00     |
| Replacement Cost of Capital | -0.26               | 0.63     | 0.50                | 0.63     | 0.07                | -0.36    |
| Labour Supply               | 0.00                | -2.60    | 0.00                | -1.27    | 0.00                | 1.06     |
| Household Consumption       | -0.90               | -1.68    | -0.56               | -0.87    | 1.18                | 1.45     |
| Govt. Consumption           | -                   | -        | 4.66                | 3.97     | -                   | -        |
| Income Tax Rate             | -                   | -        | -                   | -        | -6.16               | -5.37    |
| Capital Stock               | 0.00                | -2.82    | 0.00                | -1.53    | 0.00                | 0.40     |
| Export                      | 0.14                | -1.23    | -0.55               | -1.23    | -0.29               | 0.05     |



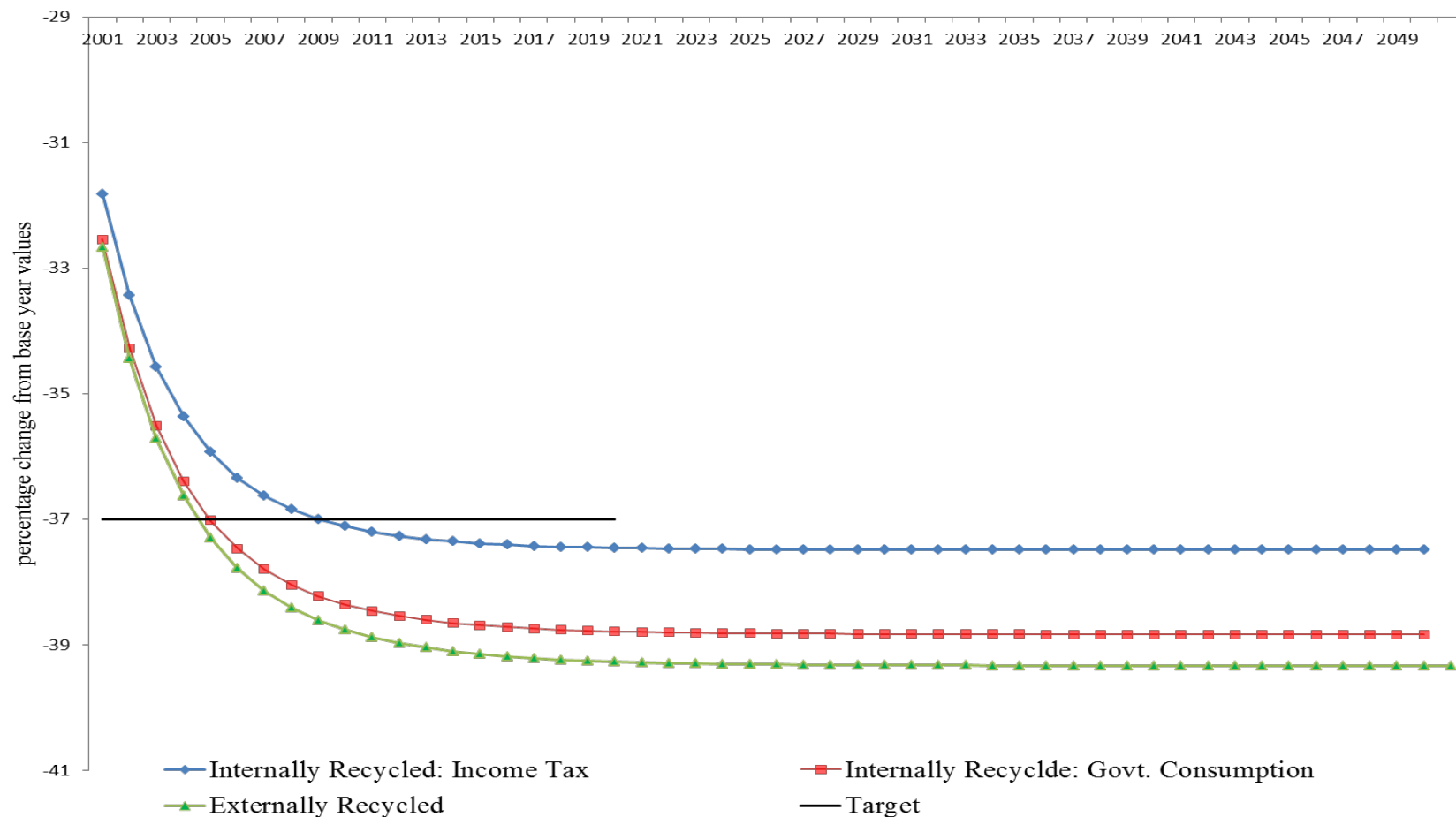


**Figure 1. The short and long-run percentage change in sectoral output for a £50 per tonne tax on CO<sub>2</sub> emissions with revenue recycling through a reduction in income tax**



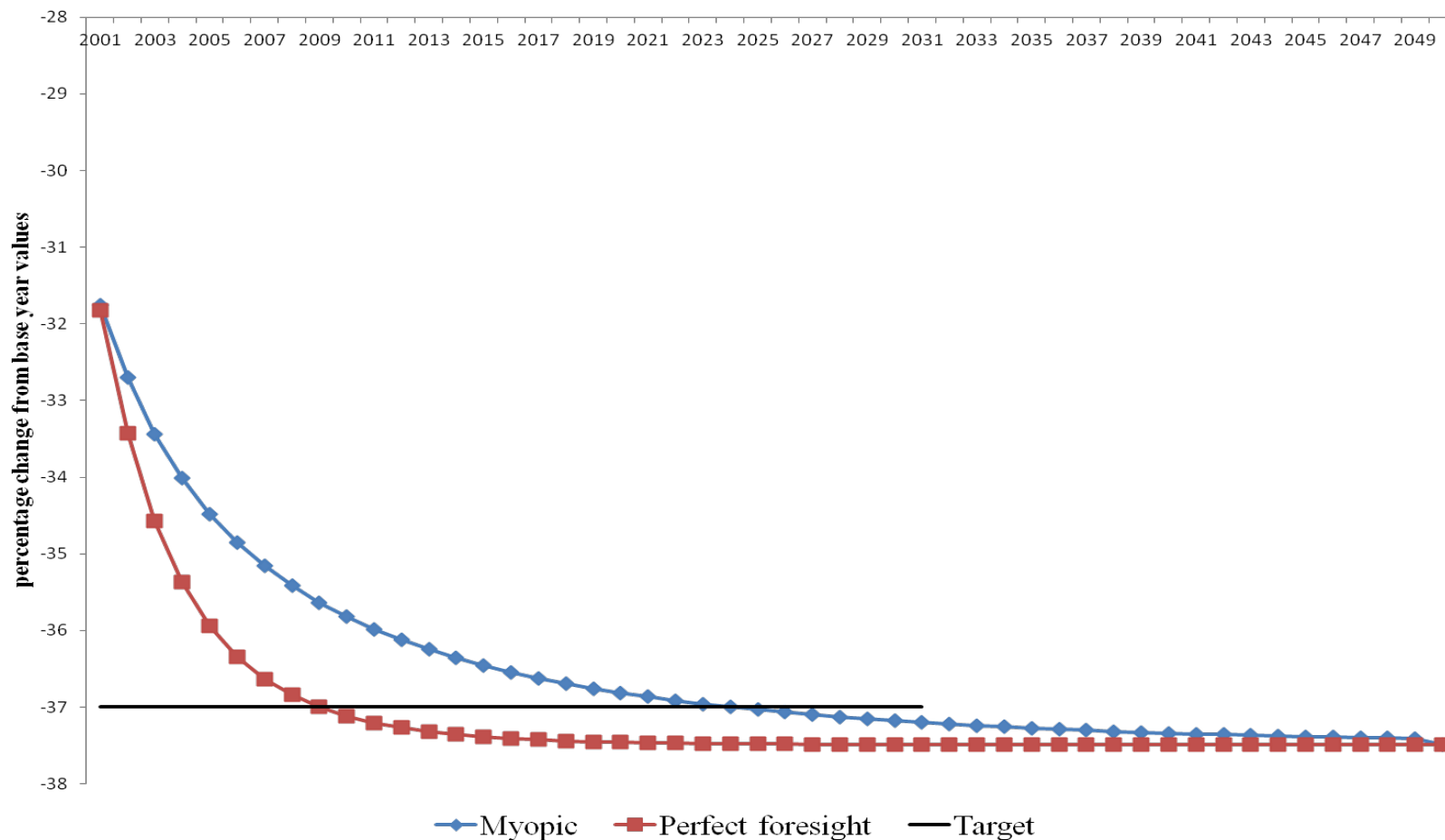


# Figure 2. Change in total CO2 emissions for a £50 per tonne tax on carbon emissions for all three forms of revenue recycling



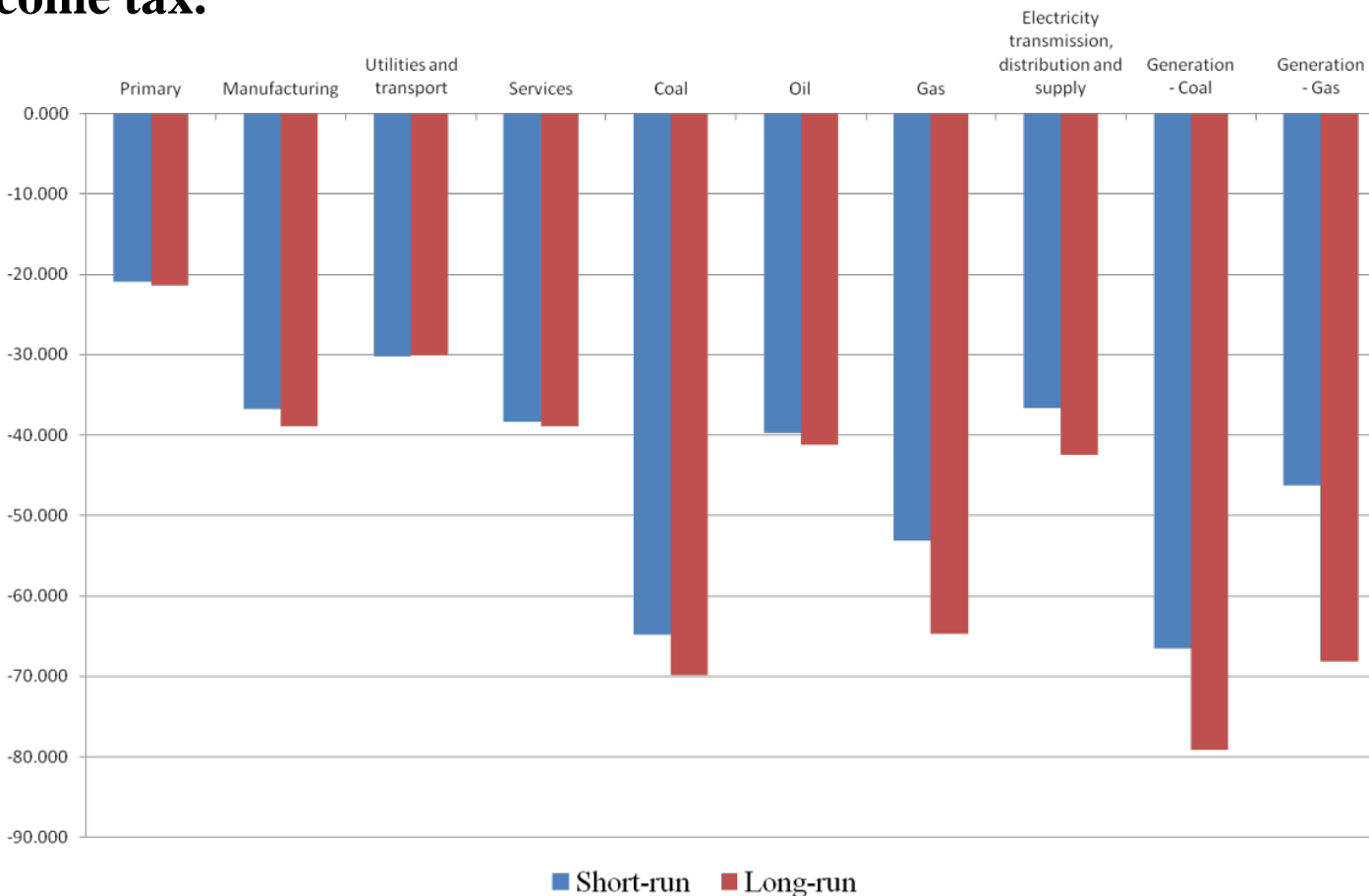


**Figure 3. % reduction in total CO<sub>2</sub> emissions for a £50 per tonne tax with revenue recycling through a reduction in income tax. A comparison between myopic and perfect foresight agents**



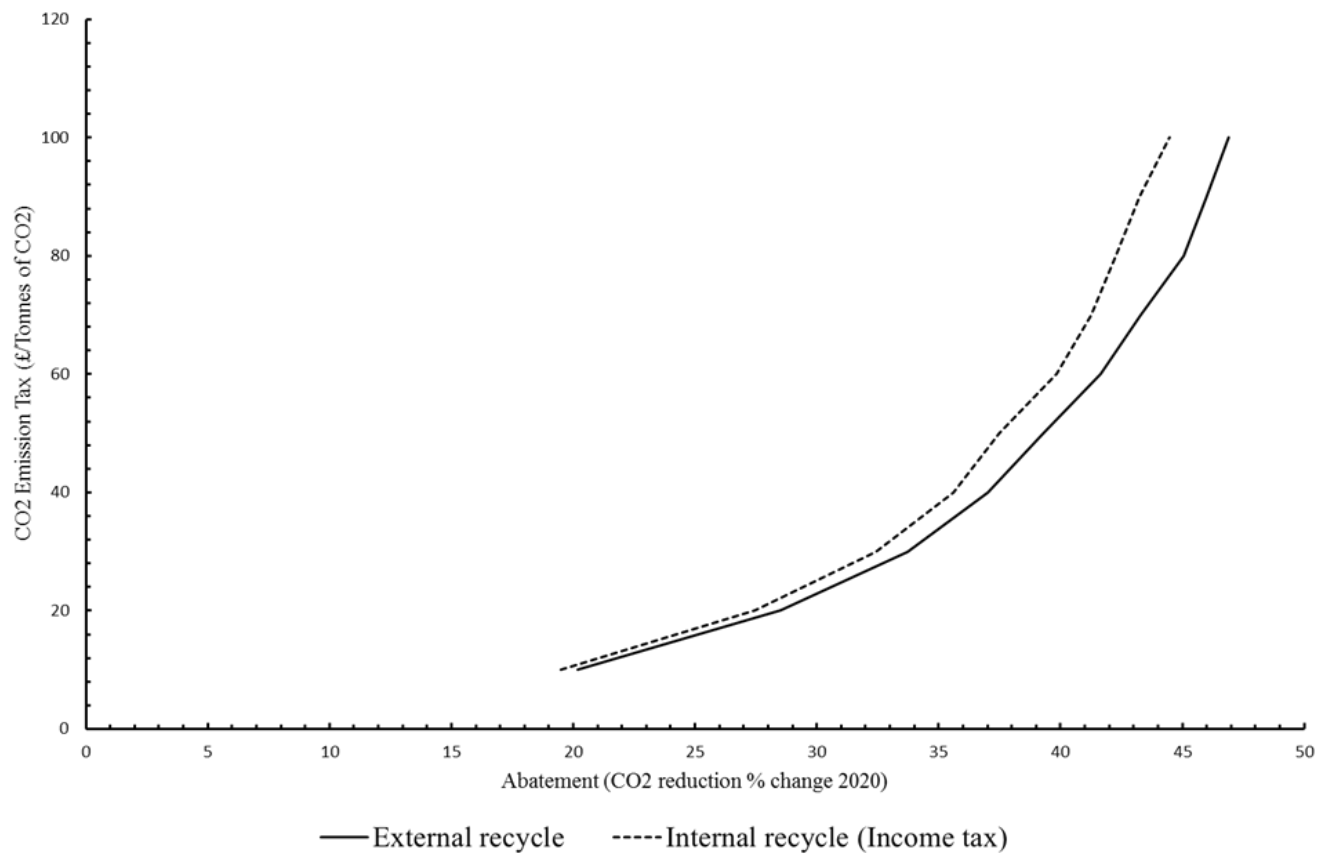


**Figure 4: The short and long-run % reductions in sectoral CO<sub>2</sub> emissions for a £50 tonne tax with revenue recycling through a reduction in income tax.**





# Figure 5: Marginal Abatement Cost Curve





## 6. Conclusions

- Our results suggest that:
  - A Scottish-specific carbon tax could achieve the Government's emissions targets, but is only likely to generate a double dividend if revenues are used to reduce other taxes
  - The credibility of the policies has a positive impact on their effectiveness
- However, this is a preliminary analysis:
  - Systematic sensitivity analysis required
  - Sector-specific detail on abatement costs
  - Explore interaction with EU ETS (carbon price floor? tax non-traded?)
  - Allow for endogenous technological change in response to CT
  - Impacts on the rest-of-the UK?
  - Equity issues?
  - Investigate the possible targeting of recycled revenues on:
    - The young who have borne the brunt of recession and its aftermath?
    - Renewables development?
    - Energy infrastructure: government **capital** expenditure has distinctive impacts