The impact of the introduction of a carbon tax for Scotland

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Introduction

Since devolution, the Scottish Government has progressively adopted a distinctive environmental and energy policy (Allan *et al*, 2008). This is expressed in two forms: first through setting emissions and renewables targets that differ from those set in the rest of the UK, and second by developing specific policies within the non-reserved powers at its discretion.

The Climate Change (Scotland) Act includes a target to reduce CO2 emissions to 42% below 1990 levels by 2020. This is stricter than the 34% CO2 emissions reduction adopted by the UK Government. Moreover, the corresponding Scottish Government target for renewable electricity generation in 2020 is equivalent to 100% of electricity consumption in Scotland and preliminary data suggest that the interim 2011 target of 31% was exceeded by 4 percentage points.

The powers under the Scottish Government's control that it can use to affect energy outcomes include the judicious use of the planning system and additional funding for alternative renewable technologies in pre-commercial scales, such as the Wave and Tidal Energy Scheme (WATES), The Saltire Prize, and the Scottish Community and Households Renewables Initiative.

Nevertheless, the Committee on Climate Change report into Scottish emissions targets concluded that with current policies and the current cap on emissions under the EU ETS, the Scottish Government's target of a 42% CO2 reduction will be missed, with emissions only falling by 38% on 1990 levels.

It is clear that whilst Scotland has adopted challenging targets, many key policy instruments are reserved to the UK Government (Allan *et al*, 2008; McGregor *et al*, 2011). At present the main "green" elements of the tax system remain under Westminster control. This includes fuel duties, air passenger duty and the climate change levy. Also reserved to the UK Government are: the tax-transfer system; powers over the structure of the electricity market; Renewable Obligations Certificates, the Renewable Transport Fuels Obligation and the Renewable Heat Incentive; Climate Change Agreements; and the Carbon Reduction Commitment.

Many economists regard a carbon tax as the most efficient way to reduce carbon emissions (Tullock, 1967; Pearce, 1991). It is therefore of interest to consider the possibility of the Scottish Government's adopting such a tax. This is particularly relevant given the present discussions concerning fiscal autonomy that are taking place around the Scotland Bill and the impending independence referendum in Scotland. In this paper we use an energy-economy-environmental model of Scotland to simulate the impact of a Scottish specific tax on carbon emissions. The model quantifies the effect on carbon emissions and the level of aggregate economic activity in Scotland.

Section 2 outlines the arguments for a carbon tax and introduces the notion of the double dividend. Section 3 briefly describes the Scottish simulation model that we use. Section 4 gives the specific simulation set up. Section 5 reports the simulation results and Section 6 is a short conclusion.

General arguments for carbon tax

Firms, households and governments generate emissions of CO2 that impose a cost on present and future generations in the form of global climate change[i] However, those who directly emit CO2 do not directly bear the cost of their own emissions. That is to say, they are not forced specifically to take these costs into account when they make production and consumption decisions. These costs are known generically as externalities and the notion that they can be internalised by the governments' setting a tax equal to the marginal cost imposed on others was first suggested by Pigou (1920). Coase (1960) persuasively argues that imposing appropriate property rights can also solve this problem. In this case, the owners of the right to pollute the atmosphere would charge for allowing individuals and organisations to emit CO2. This is the basis for the use of tradable permits for controlling emissions. However, the principles behind carbon taxes and carbon trading are fundamentally the same[ii]. A price should be set for emitting carbon, either through a specific tax or the requirement to acquire a permit.

Essentially, the arguments that favour treating externalities in this way are similar to those that favour the use of free markets in general. They are an effective means of decentralised decision making. In this specific case, the government has set targets for the level of carbon emissions. However, this decentralised approach should lead to these targets being met at minimum cost in terms of consumption foregone. Setting a price on carbon emissions generates an appropriate set of incentives: individual governments, firms and consumers can decide how best to adjust to the increase in price. If there are possibilities to reduce the inputs of carbon then it is optimal for agents to

seek out and implement these reductions. Therefore firms will seek to adopt less emission intensive production techniques. The price of products that embody carbon emissions will rise. Therefore consumers will tend to consume less of these products. There is an increased incentive for technical change that involves reducing carbon emissions in the future. Therefore more resources will be channelled into generating sustainable technologies.

However, there is an additional potential benefit from the use of carbon taxes. Carbon taxes (or tradeable permits, if owned by the state) are sources of revenue for the government[iii]. This additional revenue can be used to reduce other taxes that generate distortions in the operation of the economy, thereby producing a so-called 'double dividend'. Here, not only are CO2 emissions reduced (the first dividend), but the efficiency with which other elements of the economy operate can be simultaneously improved (the second dividend). There is an extensive literature concerning the possible nature of this second dividend and the conditions under which it exists[iv]. The most popular formulation suggests a cut in the taxes on employment. The reduction in the price of labour to the firm produces a net reduction in costs to labour intensive firms, and encourages the substitution of labour for other inputs in all production. This may increase employment and in almost all economies such labour market improvements are highly valued, particularly under present circumstances.

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 Public expenditure		Internally recycled Income tax	
	Short-run	**Long-run**	**Short-run**	**Long-run**	**Short-run**	**Long-run**
CO2 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

The AMOS model for Scotland

In this paper we explore and quantify the impact of introducing energy taxation to reduce carbon dioxide (CO2) emissions in Scotland. To do this we use AMOSENVI, a multi-sectoral energy-economy-environment computable general equilibrium model for the Scotland developed for policy analysis by the Fraser of Allander Institute. The model has 17 industry sectors: 13 are energy sectors, of which 9 are forms of electricity generation. Production is characterized by cost minimization with standard, well-behaved production functions. Firms sell output in competitive markets and household consumption is dependent on the population level, average income and consumer prices. In the simulations performed here wage setting follows a bargaining procedure where the real wage is inversely related to the unemployment rate.

When the model is run in a period-by period mode, the population and the capital stock are upgraded between periods. We incorporate flow equilibrium migration, where net immigration is positively related to the Scottish real wage and negatively related to the unemployment rate. Investment is determined by profit maximizing behaviour, with an assumed internationally integrated capital market. The model can be solved in either myopic or forward-looking mode. In the first case agents use adaptive expectations so that they abstract from future periods, while in the second case firms and consumers have perfect foresight and react optimally to anticipated future events. Except where explicitly stated the model is run here with perfect foresight.

Simulation set up

The simulations impose a tax on carbon emissions generated in production. This is achieved by introducing an

Figure 1: The short and long-run percentage change in sectoral output for a £50 per tonne tax on CO_2 emissions with revenue recycling through a reduction in income tax

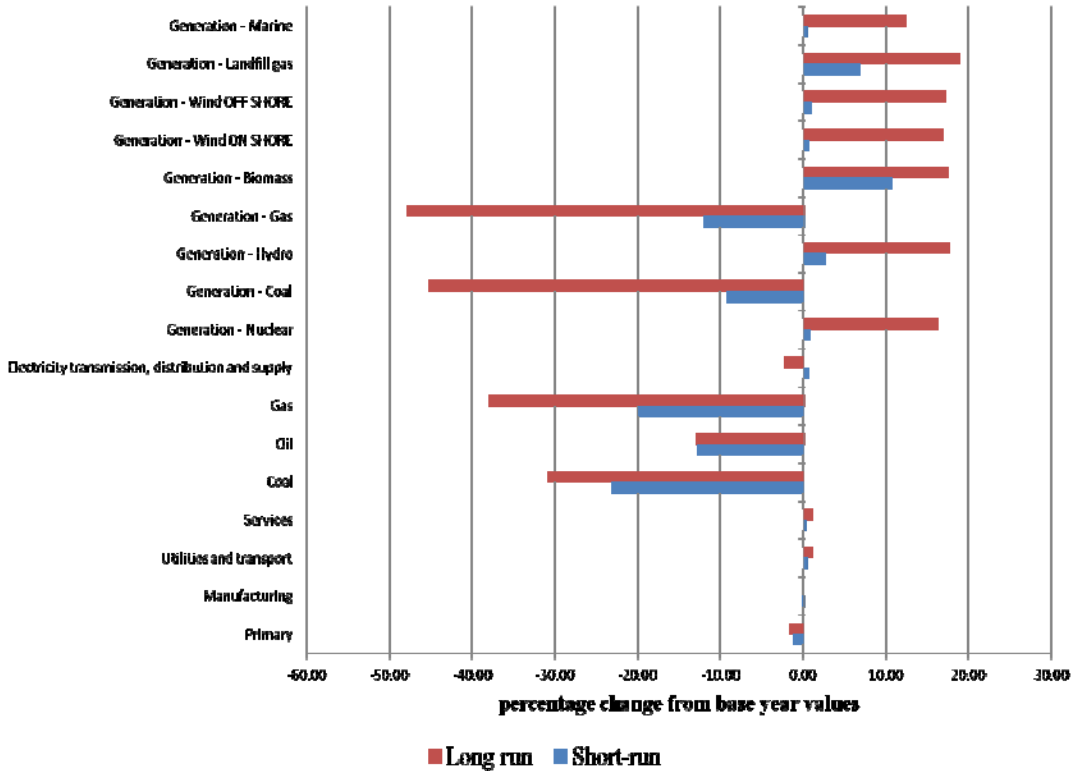
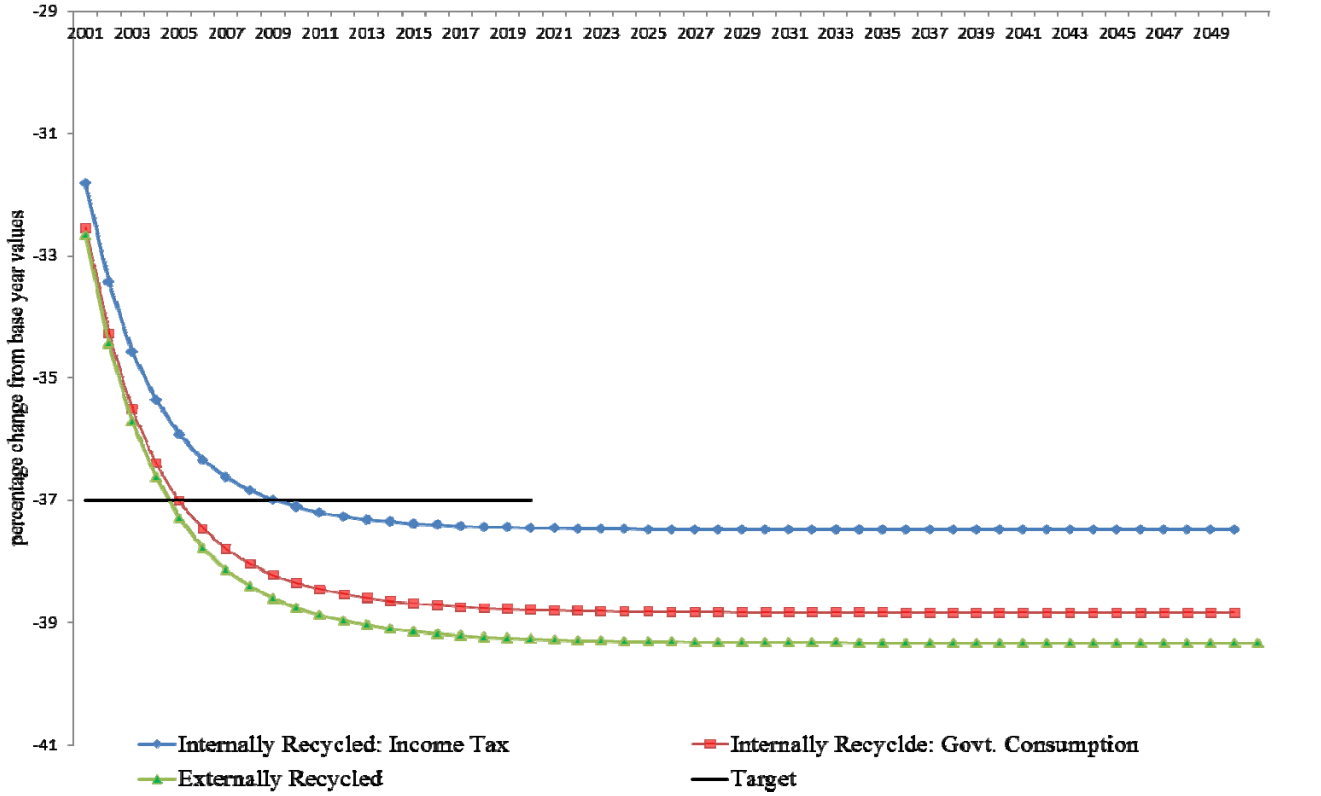


Figure 2: Change in total CO2 emissions for a £50 per tonne tax on carbon emissions for all three forms of revenue recycling



differentiated according to the carbon content of each fuel. The tax is imposed in the first period and maintained at a constant rate. The model is run forward with no other changes until we reach a new long-run equilibrium.

The tax generates revenue for the public sector. We run three simulations that differ in the way in which these funds are recycled. In one simulation the revenues revert to the UK Government and are spent outwith Scotland. In the other two simulations, the funds are used in Scotland. In one the revenues are recycled through an expansion in government expenditure. In the other the revenues are used to reduce the tax on labour.

The Scottish Government's target is to reduce CO2 emissions by 42% in 2020, compared to the total in 1990. Our model is calibrated for the year 2000. Because there had already been some reduction in emissions in the decade leading up to 2000, to achieve the Scottish target requires a 37% reduction of CO2 emissions in the 20 years to 2020. By trial and error, simulation indicates that the target can be met by a carbon tax of £50 per tonne of CO2.

Simulation results

Table 1 reports results for key economic variables for the simulations with each of the three forms of revenue recycling. Figures are presented for the short and the long run. The short-run results give the impact in period one. In this period capacity constraints are imposed so that both capital and labour supplies are fixed to their base-year value. The long-run results apply where all supply constraints are relaxed, so that both capital and the labour supply are free to adjust totally. In all three cases the introduction of the carbon tax is able to substantially reduce CO2 emissions. The 37% CO2 reduction target is met with a very rapid adjustment even in the first period. However, the impacts on the aggregate activity variables, GDP and total employment, are much smaller and their sign depends on how the tax revenues are recycled.

Where the tax revenue is externally recycled the carbon tax clearly has a depressing effect on the Scottish economy. The cost of fuels used in production has increased and this has a contractionary impact. Initially this contraction is generated by a fall in household consumption, and there is actually some crowding in of exports. However, in the long run there is an increase in nominal wages as workers attempt to maintain their real wages and exports fall, together with household consumption, as competitiveness is reduced. The GDP decreases by 0.3% in the short run and 2.68% in the long run. Employment initially declines by more than GDP, as labour is more flexible than capital in the short run, thereby producing a short-run rise in unemployment of 4.1%. But the impact of outmigration, triggered by the adverse local labour market conditions, means that in the long run the unemployment rate moves back to its original level. However, in this time interval the labour force, and therefore also employment, has been reduced by 2.6%, just less than the fall in GDP.

For the case where revenues are recycled through increased Scottish Government expenditure, the net effect on aggregate economic activity is again contractionary. In this simulation there is an increase in public expenditure of 4.66% in the short-run and 3.97% in the long-run, funded by the additional carbon tax revenues. However, this expenditure stimulus is not able totally to offset the negative supply side effects of the increase in energy taxation. In this case the long-run fall in GDP and employment are 1.37% and 1.27% respectively. The increase in public spending only goes some way to mitigating the adverse supply side effects of the tax. However, it is important to remember that in this case the Scottish population do benefit from an increased supply of public goods.

A qualitatively different outcome for the overall economy is obtained if the carbon tax revenues are used to reduce the tax on labour. In our model this takes the form of a reduction in income tax, which falls in both the short and the long run by 6.16% and 5.37% respectively. This would be within the range of income tax variation proposed in the Scotland Bill. The net impact on the Scottish economy is positive, resulting in an increase in GDP and household consumption in both time periods. The expansion in economic activity reduces unemployment in the short run by 3.77%. The resulting immigration increases the labour supply, again pulling the real wage and the unemployment rate back to their base year value.

This result indicates that under the circumstances assumed in this simulation, the implementation of such a revenue-neutral set of tax changes not only reduces CO2 emissions but also stimulates economic activity and jobs. Employment increases by 0.42% in the short run and 1.06% in the long run. In this scenario the percentage change in employment is greater than the percentage change in GDP in both of the time frames shown here. The increase in the real wage in the short run stimulates household consumption, with some crowding out of exports. However, in the long run nominal wages fall, with the labour supply and competitiveness rising, so that increased household consumption and exports drive the expansion in the economy.

In Figure 1 we report the short and the long-run changes in sectoral output where the revenue is recycled through reduced income taxes. Of course the introduction of the carbon tax directly increases the price of coal, oil and gas when these are used as an input in production. The demand for these fuels falls, reducing dramatically their production and import levels. Electricity supply increases in the short run, as a result of the small increase in economic activity. However, in the long run, when there has been a full adjustment to the new prices, electricity supply falls. There is, however, a significant increase in electricity generated from renewable energy. The share of electricity generated by renewables increases in the long run by slightly more than 42%, reflecting also the large fall in output in the coal and gas electricity generation sectors. As for the non-energy

Figure 3: % reduction in total CO2 emissions for a £50 per tonne tax with revenue recycling through a reduction in income tax. A comparison between myopic and perfect foresight agents

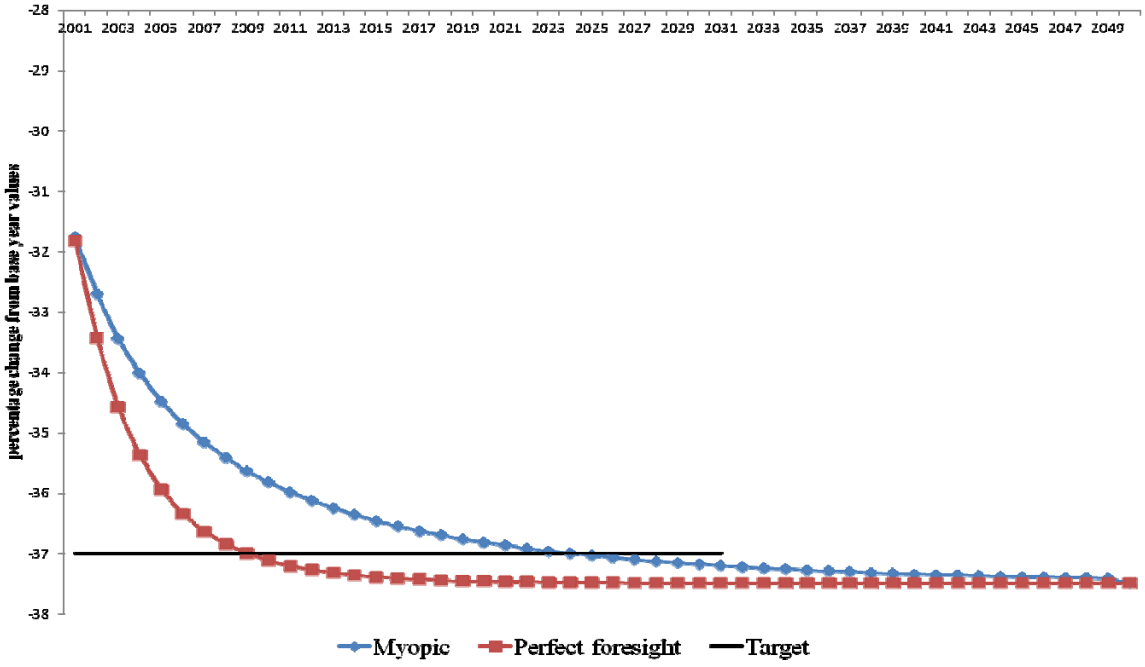
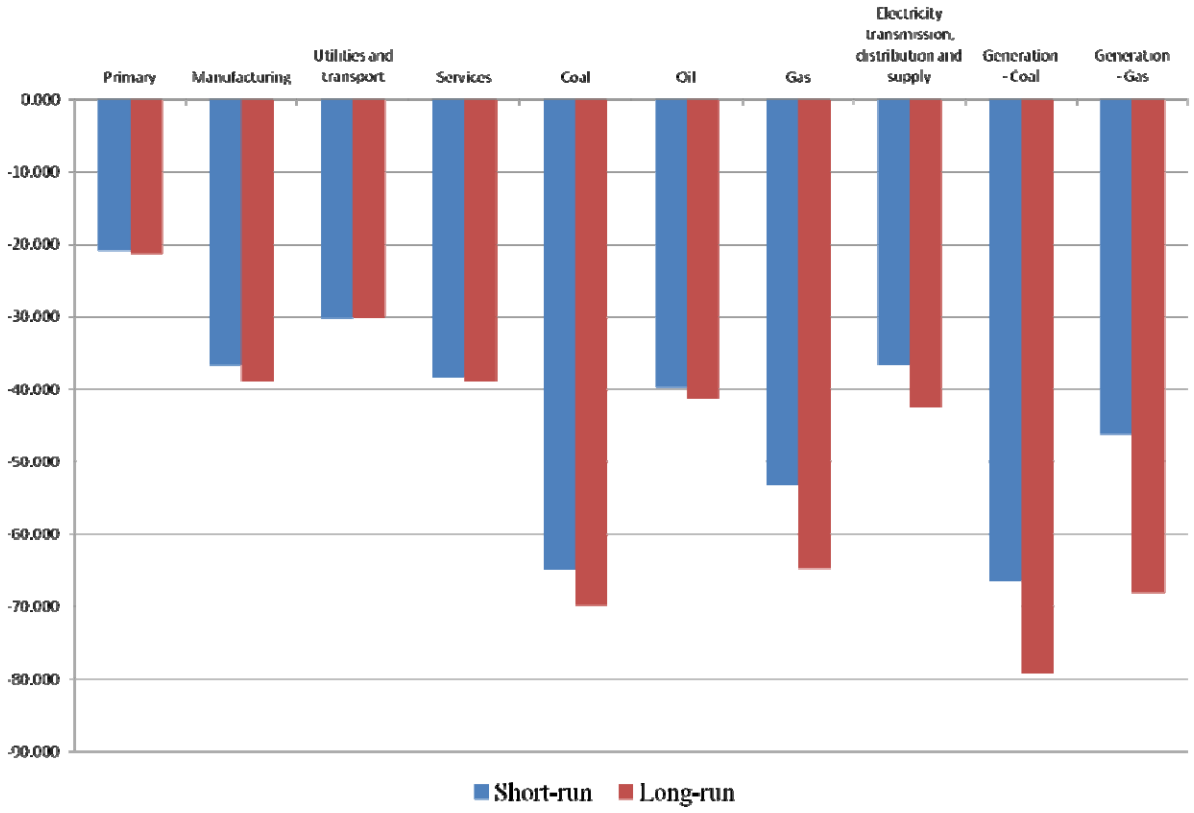


Figure 4: The short and long-run % reductions in sectoral CO2 emissions for a £50 tonne tax with revenue recycling through a reduction in income tax



sectors, only the primary sector shows a long-run reduction in output.

In Figure 2, we show the period-by-period reduction in CO2 emissions from the base period. Note that for all three shocks the carbon tax is able to achieve the 37% target emissions reduction by the year 2020. This target is met after only 5 years when the revenue is either externally recycled or used to increase public expenditure within Scotland. With revenue recycling through a reduction in Scottish income tax, the target is achieved after ten years.

All the simulations reported up to now have incorporated forward-looking behaviour on the part of all agents. In Figure 3 we compare the period-by-period impact of the carbon tax on the level of CO2 emissions under both forward looking and myopic assumptions. Again we report the percentage change from base year values of total CO2 emissions for the simulations where the carbon tax revenue is used to reduce income tax. As we would intuitively expect, both the myopic and forward-looking model reach the same long-run equilibrium, regardless of the dynamic structure. However, whilst with perfect foresight the target is achieved in less than ten years, with the myopic model we are only able to reach the target by 2025.

This has implications for the need for credibility in the implementation of the environmental policy by the Scottish Government. In order that agents can optimally adjust to policy by anticipating its future effects, those agents must believe that the policy will be maintained in the future. In the myopic case, the agents have adaptive expectations. They adjust only with respect to present prices and outputs. The adjustment is much slower without this commitment to the future.

In Figure 4 we show the short-run and long-run change in CO2 emissions at the sectoral level (for those sectors that emit carbon). Note that there are huge reductions in emissions in all energy sectors. In the long run, the reductions in the coal and the coal electricity generation sectors are 70% and 79% respectively. As for the non-energy sectors the biggest reductions in emissions are in the manufacturing and the service sectors, which are the most energy-intensive sectors.

Conclusions

There is no doubt about the level of ambition of the Scottish Government's emissions targets; but there must be some doubt about whether it has sufficient policy instruments under its direct control to induce households and firms to behave in a way that ensures these targets are met. Yet this is the challenge that the Scottish Government faces in the context of liberalised energy markets. While credibility is enhanced by enshrining emissions targets in a legal framework, this is generally insufficient to ensure their satisfaction (McGregor *et al*, 2011).

The debate on constitutional change continues to gain momentum in the run up to the referendum on independence. However, regardless of the outcome of that debate, the Scottish Government is destined to benefit from a significant enhancement in the extent of its fiscal powers. Against this background, it seems natural to consider the possibility of a Scottish-specific carbon tax. It seems natural because: this would be a genuine option under both devo max and independence. Such a tax is focused on the "bad" of emissions directly and if implemented in a fiscally neutral way offers the potential of a double dividend if the revenues are used to subsidise (or more realistically reduce the tax on) the "good" of employment. Our simulations demonstrate that a carbon tax could simultaneously stimulate employment while reducing emissions: the double dividend.

We end on a cautionary note. Our analysis is still in a preliminary stage, and we plan more extensive systematic analysis of the factors that govern both the direction and the scale of the Scottish economy's response to a carbon tax. Furthermore, extensions to explore the impact on the economy of the rest-of-the UK would also be of considerable policy interest. However, the estimates we present here are by no means an upper bound for the potential beneficial impacts of the tax for, in the longer term, we would expect the tax to stimulate innovation in low-carbon technologies, a positive effect that is absent from our current analysis. Furthermore, in current circumstances, it may be thought desirable to focus the good news by recycling revenues to subsidise employment among the younger age groups who have been most adversely impacted by the recession and its aftermath. We believe that our initial investigations are sufficiently promising to merit more extensive analysis of a Scottish carbon tax.

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Endnotes

[i]We do not question the science here. For a robust rebuttal of the climate change sceptics, see Nordhaus (2012).

[iii]Weitzman (1974) discusses the cases where these approaches differ under uncertainty.

[iv]A key role of the government is to produce public goods: goods that provide freely available services where it is difficult to exclude individuals from benefiting from these services. These goods are provided inadequately by the private market. The classic example is defence.

[v]See Fullerton and Metcalf (1998) for a clear account of the issues and Bosquet (2000) for an survey of the double dividend literature on environmental taxes.