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Analysis

The economic and environmental impact of a carbon tax for Scotland: A computable general equilibrium analysis

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ABSTRACT

Using a disaggregated energy–economy–environmental model, we investigate the economic and environmental impact of a Scottish specific carbon tax under three alternative assumptions about the use of the revenue raised by the tax: revenues raised are not recycled within Scotland; revenues are used to increase general government expenditure or to reduce Scottish income tax. We find that by imposing a tax of £50 per tonne of CO_2 the 37% CO_2 reduction target is met with a very rapid adjustment in all three cases if the model incorporates forward-looking behaviour. However, the adjustment is much slower if agents are myopic. In addition, the results of the model suggest that a carbon tax might simultaneously stimulate economic activity whilst reducing emissions and thus secure a double dividend, but only for the case in which the revenue is recycled through income tax.

1. Introduction

Since devolution, the Scottish Government has increasingly adopted a distinctive environmental and energy policy (Allan et al., 2008). The Climate Change (Scotland) Act includes a target to reduce CO_2 emissions to 42% below in 1990 levels by 2020. This is stricter than the 34% CO_2 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.

However, earlier discussions have established that whilst Scotland has adopted challenging targets, many key policy instruments are reserved to the UK government (Allan et al., 2008; McGregor et al., 2013). 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 and regulation of the electricity market; Renewable Obligation Certificates, the Renewable Transport Fuel Obligation and the Renewable Heat Incentive; Climate Change Agreements; and the Carbon Reduction Commitment.

The Scottish Government has succeeded in making Scottish energy policy more distinctive, first through setting different targets (as described above) and second by developing specific policies within the non-reserved powers at their discretion. These powers 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 Household Renewable Initiative. Nevertheless, the Committee on Climate Change report into Scottish emission targets concluded that with current policies, and assuming the current cap on emissions under the EU ETS, the Scottish Government's target of a 42% reduction will be missed, with emissions only falling by 38% in 1990 levels.

Economists typically regard a carbon tax as the most efficient way to reduce carbon emissions (Pearce, 1991; Tullock, 1967). Furthermore, continuing pressure for greater fiscal autonomy is likely to expand the range of climate change policies that the Scottish Government has at its disposal (McGregor and Swales, 2013). It is therefore of interest to consider the effect of a Scottish specific carbon tax. This is particularly relevant given the more demanding environmental targets set by the Scottish Government and the present discussions around increased

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fiscal autonomy for Scotland. The Scotland Act (2012) has augmented the income tax raising power of the Scottish Parliament, so that it will have the power to make a balanced-budget adjustment in public expenditure funded by corresponding changes in the basic as well as higher rates of income tax of up to 10 p in the pound.[1]

In this paper we employ an empirical energy–economy–environmental model[2] of Scotland to simulate the impact of a Scottish specific carbon tax on the levels of carbon emissions and of aggregate and sectoral economic activity. The simulations are conducted under alternative assumptions about the use of the revenues raised by the tax, for example, to increase general Government expenditure or to reduce the rate of income tax.

The remainder of the paper is organised as follows. Section 2 outlines the arguments for a carbon tax and introduces the notion of the double dividend. Section 3 summarises the key features of the model. Section 4 briefly describes the model parameterization and discusses the simulation set up. Section 5 discusses the simulation results. In Section 6 we provide a sensitivity analysis and in Section 7 we present brief conclusions.

2. The Case for a Carbon Tax

Firms, households and governments generate emissions of CO_2 that impose a cost on present and future generations in the form of global climate change.[3] However, those directly emitting CO_2 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 CO_2. This is the basis for the use of tradable permits for controlling emissions.[4] However, the fundamental principle behind carbon taxes and carbon trading is the same.[5] 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. It is 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 foregone consumption. Setting a price on carbon emissions generates an appropriate set of incentives. For instance, firms will seek to adopt less emissions-intensive production techniques. Given that the price of products that embody carbon emissions will rise, consumers will tend to consume less of these products. Further there is an increased incentive for technical change that involves reducing carbon emissions in the future (Goulder and Mathai, 2000; Goulder and Schneider, 1999).

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.[6] 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 the CO_2 emissions are reduced (the first dividend), but also the efficiency with which other elements of the economy operate can be simultaneously improved (the second dividend) generating a decrease in the unemployment rate, increase in employment rate and in GDP. In the literature, there is an extensive discussion concerning the possible nature of this second dividend and the circumstances under which it exists.[7] Using applied general equilibrium models, Bor and Huang (2010), Bovenberg and Van der Ploeg (1998), Glomm et al. (2008), Goulder (1995), Manresa and Ferran (2005), Hoel and Schneider (1997), all find evidence of the existence of the second dividend and in some cases even a triple dividend, which is associated with a decrease in poverty (Van Heerden et al., 2006).

3. The AMOSENVI Model of Scotland

3.1. General model features

AMOSENVI is a large scale, multi-sectoral energy–economy–environment computable general equilibrium model for Scotland. The model has seventeen industry sectors[8] of which thirteen are energy sectors. Among energy sectors we identify nine electricity generation sectors. Production inputs include the primary factors (labour and capital) and intermediate purchases. The model includes three domestic institutional sectors: Firms, Households and Government.

External institutions are split into the Rest of the UK (RUK) and the Rest of the World (ROW). We adopt assumptions typically used for a small open economy. In particular the region is too small to affect prices in international and interregional markets so that the RUK and ROW prices are taken to be exogenous.[9]

The model can be solved with either myopic or forward-looking expectations. In the former case agents have adaptive expectations so that they abstract from future periods, whilst in the latter case firms and consumers have perfect foresight and react to anticipated future events. Except where explicitly stated that the model is run here under perfect foresight.

3.2. Production structure

Production is characterized by cost minimization with standard, well-behaved production functions. The production structure of the model is represented by a multi-level constant elasticity of substitution (CES) production function as is illustrated in Figs. 1 and 2. Fig. 1 shows the structure of the Electricity supply sector whilst Fig. 2 is a schematic of the structure of production for all the other sectors of the economy.

For all sectors, value added and intermediate inputs combine to produce total gross output. Value added is obtained by combining capital and labour. Intermediate inputs are decomposed into energy and non-energy inputs. Then energy is split in electricity and non-electricity. The latter is divided between oil and non-oil then non-oil is further disaggregated between gas and coal.

[1] Originally the Scottish Parliament had the authority to change only the basic rate of income tax up to 3 p in the pound.

[2] Several works analyses the macroeconomic impact of introducing a carbon tax using macroeconomic modelling: See e.g., Symons et al. (1994) for the UK, Wissema and Dellink (2007), for Ireland, Bovenberg and Goulder (1996) and Goulder (1995) for the US and Cornwall and Creedy (1996) and Adams and Parmenter (2013) for Australia.

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

[4] Adams and Parmenter (2013) using a single-country multiregional CGE model of Australia interfaced with a multi-country global economic model such as GTEM (Pant, 2007) evaluates the impact of a global emission trading scheme.

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

[6] 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.

[7] See Goulder (1995), Bovenberg and Goulder (1996), Fulloerton and Metcalf (1998) for a clear account of the issues and Bosquet (2000) for a survey of the double dividend literature on environmental taxes.

[8] See Table A1 in the Appendix for details about sectoral aggregation.

[9] AMOSENVI is a single country model where the RUK and the ROW are exogenous in the model therefore we are not able to capture the spillover coming from the RUK or the ROW. This seems a reasonable first approximation given that the Scottish economy is less than 9% of the UK economy on any measure of scale.