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Carbon tax scenarios and their effects on the Irish energy sector

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AUTHOR-HIGHLIGHTS

- We use annual time series data to estimate the price and income elasticities underlying Irish energy demand.
- We use the elasticities to forecast Irish sectoral energy demand out to 2025.
- We impose two hypothetical carbon tax scenarios on our energy demand model.
- We estimate a potential reduction in emissions of 861kt CO_2, generating €1.1billion in tax revenue.
- Such an emission reduction would be associated with a 0.21% contraction in GDP.

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ABSTRACT

In this paper we use annual time series data from 1960 to 2008 to estimate the long run price and income elasticities underlying energy demand in Ireland. The Irish economy is divided into five sectors: residential, industrial, commercial, agricultural and transport, and separate energy demand equations are estimated for all sectors. Energy demand is broken down by fuel type, and price and income elasticities are estimated for the primary fuels in the Irish fuel mix. Using the estimated price and income elasticities we forecast Irish sectoral energy demand out to 2025. The share of electricity in the Irish fuel mix is predicted to grow over time, as the share of carbon intensive fuels such as coal, oil and peat, falls. The share of electricity in total energy demand grows most in the industrial and commercial sectors, while oil remains an important fuel in the residential and transport sectors.

Having estimated the baseline forecasts, two different carbon tax scenarios are imposed and the impact of these scenarios on energy demand, carbon dioxide emissions, and government revenue is assessed. If it is assumed that the level of the carbon tax will track the futures price of carbon under the EU-ETS, the carbon tax will rise from €21.50 per tonne CO_2 in 2012 (the first year forecasted) to €41 in 2025. Results show that under this scenario total emissions would be reduced by approximately 861,000 tonnes of CO_2 in 2025 relative to a zero carbon tax scenario, and that such a tax would generate €1.1 billion in revenue in the same year. We also examine a high tax scenario under which emissions reductions and revenue generated will be greater.

Finally, in order to assess the macroeconomic effects of a carbon tax, the carbon tax scenarios were run in HERMES, the ESRI's medium-term macroeconomic model. The results from HERMES show that, a carbon tax of €41 per tonne CO_2 would lead to a 0.21% contraction in GDP, and a 0.08% reduction in employment. A higher carbon tax would lead to greater contractions in output.

1. Introduction

In November 2010 the Irish government produced a National Recovery Plan for 2011–2014 which "*provides a blueprint for a return to sustainable growth in* [*the Irish*] *economy*" (Department of Finance, 2010). As part of this proposal the government at the time specifically outlined plans for a carbon tax. They proposed that this carbon tax be included in the 2011 budget at a cost of €15 per tonne CO_2, and be increased gradually to €30 per tonne by 2014. The document states that the tax will "encourage behavioural change", and potential benefits which will accrue from the tax include reduced import dependency, improved environmental sustainability and increased tax revenue. A carbon tax was introduced in the 2010 budget at a rate of €15 per tonne CO_2. At present, the tax only applies to oil and gas, and its application to coal and peat is subject to a commencement order. Electricity is excluded as emissions from electricity generation are already covered under the EU Emissions Trading System (ETS).

While there is much evidence supporting the Irish government's view that implementing a carbon tax is a cost-effective

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method of achieving a significant cut in CO_2 emissions (see, for example, Pearce, 1991, or McIlveen and Helm, 2010), the evidence from countries which have already imposed this tax is mixed (Lin and Li, 2011). In light of this proposed budgetary measure we aim to assess the costs and benefits of a carbon tax in Ireland.

In order to estimate the impact of the tax on consumption patterns we build a model of energy demand for five sectors of the Irish economy: residential, industrial, commercial and public, agricultural, and transport. This energy demand model allows us to estimate price and income elasticities for all the major fuels used in the Irish economy. We find that the price elasticities vary significantly by sector and by fuel, and this will determine how effectively the carbon tax will deliver a reduction in CO_2 emissions. As Ireland is a small country, even a large reduction in CO_2 emissions will not, by itself, make a significant contribution to combating the problem of global warming. However, as Tol et al. (2008) note, it will provide an important signal to other countries, and also to households and industry within Ireland, that the Irish government are serious about tackling climate change.

Our model allows us to estimate the effect of a carbon tax, which is increasing over time, on the fuel mix of the Irish economy, on CO_2 emissions, and on government revenue. This gives us an estimate of some of the potential benefits of the carbon tax; however, it is also important to look at the likely costs. Thus, using HERMES, a medium-term model of the Irish economy, we look at the contractionary effect, a carbon tax will have on some important macroeconomic variables.

The next section of the paper outlines some of the literature that looks at the realised and the potential benefits of a carbon tax, which have been estimated for Ireland and for other countries. Section 3 of the paper gives an overview of the data used in our estimation and it also introduces the carbon tax scenarios we impose, and gives an explanation for why these particular scenarios were chosen. Section 4 presents the energy demand model we have estimated, and gives the main results of the model by sector. Section 5 discusses the effects of the carbon tax on CO_2 emissions and on government revenue. Section 6 presents forecasts from HERMES on how the carbon tax will affect some important macroeconomic variables. Finally, Section 7 concludes.

2. Related literature

Numerous studies have been carried out to analyse the effectiveness of using a carbon tax to achieve a significant cut in CO_2 emissions, and to analyse their broader economic impact. These studies show that carbon taxes have been introduced in different countries with varying degrees of success. Rapanos and Polemis (2005) estimate income and price elasticities for residential energy in Greece using data from 1965 to 1998. Using co-integration techniques, they find significant, negative price elasticities of demand for both oil and electricity. At −0.39 and −0.69, the long run price elasticities for oil and electricity indicate that a contraction in energy demand would occur in the face of rising prices. However, their simulations show that while the imposition of a carbon tax does result in a drop in demand, and thus emissions, even under the highest tax scenario considered, this contraction will not be enough to bring Greek emissions in line with its Kyoto targets. The authors thus conclude that other policy instruments must be combined with a carbon tax to achieve the emissions reduction target.

Lin and Li (2011) use difference-in-differences estimation to examine, ex-post, the effect of a carbon tax on carbon emissions in five northern European countries. Using panel data they find that, of the five countries studied (Norway, Sweden, Denmark, Finland and the Netherlands), only in Finland did the carbon tax cause a significant reduction in CO_2 emissions. In Norway they found that a carbon tax actually led to an increase in CO_2 emissions. In the remaining countries, a carbon tax led to a decrease in emissions which was not statistically significant. The authors conclude that the reason for the ineffectiveness of the carbon tax in these countries is due to the tax reliefs and exemptions granted to energy-intensive industries. In Norway the exemptions granted to energy-intensive industries improved their international competitiveness which led to an increase in CO_2 emissions.

Similar results were found by Bruvoll and Larsen (2004) who also found carbon taxes to be largely ineffective in Norway. They used an applied general equilibrium analysis to decompose observed emissions from the 1990 to 1999 period. Again, they found that the ineffectiveness of the carbon tax was primarily due to the fact that many energy-intensive industries were exempt from paying the tax. They also found that in the residential sector, the inelasticity of demand for transport fuels, with respect to price, meant that a high tax did not result in a significant decline in consumption.

On the other hand, a number of studies have found that a carbon tax can yield significant reductions in CO_2 emissions at a modest cost. For example, a paper by Lu et al. (2010) examines the potential effect of a carbon tax on the Chinese economy using a dynamic recursive general equilibrium model. They find that while a carbon tax will adversely affect competitiveness and consumption, the revenue from a carbon tax could be recycled to minimise these negative impacts. They find that even under the highest carbon tax considered, GDP would only fall by 1.1% whereas emissions would fall by 17.45%, and they thus conclude that a carbon tax would be an effective policy tool.

Using a top-down energy demand model Gerlagh and van der Zwaan (2006) analyse various instruments which could be used to achieve a deep cut in CO_2 emissions, and they find that taxing emissions is almost always a cost-effective way of achieving a deep cut in emissions. They also find that the cost of achieving these cuts can be greatly reduced if the revenue from the carbon tax were used to support non-carbon energy sources.

Wissema and Dellink (2007) look specifically at the case for Ireland. The authors use an applied general equilibrium analysis to estimate the effect of two different taxes—one a carbon tax and the other a uniform tax on energy regardless of the carbon content of the fuel, to achieve a 25.8% reduction in CO_2 emissions relative to 1998 levels. They find that such a reduction can be achieved at a tax as low as €10–15 per tonne CO_2. Furthermore, using the Hicksian equivalent variation approach, they analyse the impact of a carbon tax on welfare and find that achieving this emission reduction target using a carbon tax would result in a decline of only 0.3% in welfare.

Ghalwash (2007) estimates an almost ideal demand system to analyse the effect of environmental taxes on consumption. The author finds that carbon taxes would be effective in reducing emissions from home heating, but that they would be much less effective at reducing emissions from transport.

Finally, Conefrey et al. (2012) examine in the impacts of a carbon tax on emissions and economic growth, using the HERMES medium-term model of the Irish economy. Imposing a carbon tax of €20 per tonne CO_2 would, they find, result in a modest decline in emissions (between 2% and 2.5%). However, they find that a carbon tax could have a positive effect on GDP if the revenue from the tax is used to reduce income taxes. They note that, in the long run, a carbon tax is likely to have a stronger impact on emissions as it will incentivise research and development.

3. Data description

The consumption of energy in Ireland has dramatically increased during the last 20 years across different sectors, as shown by Fig. 1; this is reflected in the higher consumption of different fuels, which have varying levels of carbon intensity.