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A spatial micro-simulation analysis of methane emissions from Irish agriculture

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ABSTRACT

Using micro-simulation modelling techniques this paper examines methane emissions across Irish farms. The effects of a carbon equivalent tax on average family farm income are analysed at both the farm and regional level. The spatial micro-simulation model developed uses a technique called simulated annealing to match the Irish Census of Agriculture data to a National Farm Survey. The main advantage of the spatial micro-simulation approach is the fact that it allows one to account for the heterogeneity in the farm population across space. The results of the modelling process are presented using GIS mapping techniques and highlight the fact that there would be significant regional variation in the burden of an agricultural tax that was based on a rate per unit of methane emissions. The results also demonstrate that if the methane tax revenue raised was redistributed in the form of an environmental subsidy to farmers participating in an agri-environmental scheme (the Rural Environment Protection Scheme (REPS)) it would encourage farmers to participate in the scheme and could also have the effect of moving low income farms up the earnings distribution ladder.

1. Introduction

Agriculture in a developed country such as Ireland uses intensive tillage systems, high energy and large fertiliser applications, resulting in fossil fuel-based emissions, reductions in soil carbon, and emissions of nitrous oxides. In addition, animal herds emit high methane levels. Accompanying this is the fact that environmental policy within agriculture and its effects on the revenue and output of Irish farmers is an important issue in Ireland due to the relative strength of the agriculture sector. Even though Ireland's sustained strong economic performance since the mid-1990s benefited other sectors more than agriculture, the agri-food sector as a whole still accounted for an estimated 8.6% of GDP in 2005. Primary agriculture remains more important to the Irish economy than is the case in most other EU member states. Irish agriculture accounted for 2.7% of GDP at market prices in 2005 in Ireland, compared to an EU average of 1.6%.

Given the relative strength of the agriculture sector in the Irish economy and the high level of associated greenhouse gas emissions from the sector it is not surprising that the Irish government is targeting large reductions of methane emissions from this sector as one of the main ways of Ireland meeting its Kyoto commitments. The Kyoto Protocol set targets for the reduction of greenhouse gases by 2012, which included an 8% cut from 1990 levels for the European Union (EEA, 2000). The commitments of different EU member states were differentiated to reflect their different circumstances. Ireland committed to a net growth in emissions of 13% on 1990 levels, reflecting the high levels of actual and expected

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economic growth in the country at the time of agreement. However, conservative estimates predict that Ireland will overshoot its emissions quota by 13–14 million tonnes of CO_2 equivalent under a ''business as usual'' scenario by 2008 (Convery and Roberts, 2000).

Irelands National Climate Change Strategy (NCCS) (Department of the Environment, 2000) turned Ireland's commitments under the Kyoto Protocol into a programme for action. From an agricultural viewpoint, it outlines the government's objective to reduce methane emissions from the national herd by 1.2 mt CO_2 equivalent. The strategy also requires a reduction in methane (CH_4) levels, which would be roughly equivalent to a reduction of 10% in the national herd on projected 2010 levels. In this paper, we use a spatial micro-simulation modelling framework to examine the regional implications of a methane tax being introduced in order to meet the agricultural targets set out in the National Climate Change Strategy (NCCS). The spatial micro-simulation model employed uses a combinatorial optimisation method to construct a synthetic population of Irish farms using two existing databases. This allows us to examine the spatial impact on farms of an agricultural tax that is based on a rate per unit of methane emissions.

In the next section, we will review the issues surrounding greenhouse gas emissions in Irish agriculture and the current state of research on the subject. In Section 3 we then briefly describe the data used in this paper. In Section 4 we discuss the spatial micro-simulation approach used to calculate the methane emissions from Irish agriculture at a regional level of analysis. This section also reviews the approaches used to calculate a methane emissions tax and to calculate the impact of a redistribution policy that would redistribute the tax revenue raised to farmers who have volunteered to participate in an agri-environmental scheme. The results of our analysis are presented in Section 5. Finally, Section 6 concludes with some recommendations for further research.

2. Greenhouse gas emissions in Irish agriculture and the current state of research

The Intergovernmental Panel on Climate Change (IPCC, 2001) estimates that globally, agriculture's share of total anthropogenic emissions amounts to about 50% of methane, about 70% of nitrous oxide, and about 20% of carbon dioxide. Agricultural emissions of greenhouse gases are even more significant from an Irish perspective. In Ireland, emissions from the agricultural sector accounted for 35% of all greenhouse gas emissions in 1990 (the baseline date for the Kyoto Agreement), the highest of all sectors. In 2008 this figure stood at 27% and it is only projected to fall to 26% by 2010 (EPA, 2008).

According to Bullock and Styles (2006), livestock enteric fermentation in 2004 accounted for 81% of agricultural CH_4 emissions (which in turn accounted for 91% of national CH_4 emissions), whilst manure management accounted for the remaining 19%. The National Inventory Report (McGettigan et al., 2006) contains detailed information on green house gases (GHG) for Ireland. According to this report, GHG emissions from the agricultural sector amounted to 18.96 mt of carbon-dioxide equivalent (Mt CO_2 eq.), or 27.7% of total recorded GHG emissions from Ireland in 2004. These were dominated by methane (CH_4) which has a global warming potential (GWP) 21 times that of CO_2 and nitrous oxide (N_2O), with a GWP 310 times that of CO_2 (IPCC, 2001).

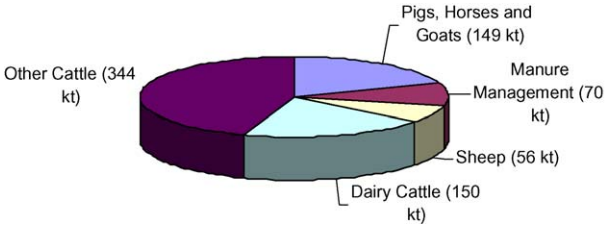

Fig. 1 – Relative contribution of different agricultural methane sources.

As shown in Fig. 1, the main contributors of CH_4 from ruminant animals in Ireland are cattle (87%) and sheep (13%). Overall, enteric fermentation emissions declined by 335,580 t CO_2 eq. between 1995 and 2004. This decrease in levels reflects a 100,000 decrease in dairy cattle numbers over that period, although non-dairy cattle numbers increased by 82,000. The NCCS predicts that agricultural emissions will increase by 3.3% over the period 1990–2010. However, reflecting the decrease in non-dairy cattle numbers, ruminant digestion is predicted to only increase CH_4 emissions by 0.2% during this period. On the other hand, soils and manure management are expected to increase CH_4 emissions by 5.1% and 6.3%, respectively.

Interest in the area of climate change has significantly increased in both the environmental and economic research arenas (Chakraborty et al., 2006; Reilly and Richards, 1993; Tol, 2001). Environmental issues such as greenhouse gas emission abatement are also increasingly becoming a more important aspect of Irish agricultural reform. Research focused on greenhouse gas emission reduction in Irish agriculture however, is limited to a number of more recent studies. One such study by McQuinn and Binfield (2002) used an econometric model of the Irish agricultural sector (FAPRI-Ireland) to project emissions of greenhouse gases as outlined in the Kyoto Protocol from the Irish agri-economy. The model was used to project values of key agricultural variables over a 9-year timeframe, 2001–2010. Using environmental coefficients these values were then converted into greenhouse gas emission levels. Two series of projections were examined—a baseline or ''no policy change'' projection and a specific scenario, which reduced World Trade Organisation (WTO) export subsidy levels. The difference between these two results was then used to compute a marginal cost to the Irish agricultural sector of reducing emissions.

The results from the McQuinn and Binfield study showed that emission levels from Irish agriculture are set to fall over the period 2001–2010. This reduction is due mainly to falling suckler cow numbers in the beef sector and the lower projected intensity of production in this sector. Under the WTO export reduction scenario McQuinn and Binfield estimated that the average cost of reducing greenhouse gas emissions to Irish agriculture would be €4.87 per tonne of CO_2. In a follow on paper, Behan and McQuinn (2002) present