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Analysis

Adoption of greenhouse gas mitigation in agriculture: An analysis of dairy farmers' perceptions and adoption behaviour

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ABSTRACT

The agenda towards greenhouse gas mitigation within agriculture implies changes in farm management practices. Based on a survey of Scottish dairy farmers, this study investigates farmers' perceptions of how different GHG mitigation practices affect the economic and environmental performance of their farms, and the degree to which those farmers have adopted those practices. The results of the farm survey data are used to identify promising mitigation practices for immediate policy support based on their potential for additional adoption by farmers, their perceived contribution to the farm's financial and environmental performance and information on their cost-effectiveness. The study demonstrates the usefulness of including adoption behaviour and farmers' perception of mitigation practices to inform early stages of policy development. This would ultimately contribute to the robustness and effectiveness of climate change mitigation policies in the agricultural sector.

1. Introduction

There has been an increasing policy interest in reducing greenhouse gas (GHG) emissions from agriculture in recent years (European Commission, 2008; Gerber et al., 2013; Scottish Government, 2009, 2013b; Smith et al., 2008; UNFCCC, 2008). This can be attributed to the contribution of the agricultural sector to GHG emissions globally and nationally, and to the cost-effectiveness of agricultural GHG mitigation relative to emission reductions in other sectors (DECC, 2013). Policy makers face a challenge to develop and implement effective GHG abatement strategies for agriculture. This requires identifying those mitigation practices that are cost-effective and promise considerable potential for abatement, followed by a choice of suitable policy mechanisms to encourage their uptake.

A key tool for prioritising mitigation measures for policy support are marginal abatement cost curves (MACCs) for agriculture (Moran et al., 2011), combining both information on cost-effectiveness and abatement potential of a large number of mitigation practices. MACCs show the cost of reducing GHG emissions by one additional (marginal) unit as total GHG abatement increases. Therefore, mitigation practices are arranged in the order of their cost-effectiveness. The abatement potential is estimated against a baseline that represents business-as-usual adoption of mitigation practices. Despite recent methodological refinements (Eory et al., 2012), MACCs developed at the national scale often draw on aggregate information and are therefore mainly useful to provide rankings of mitigation practices that can inform high-level strategic decisions and provide a rationale for investments in GHG abatement within a particular sector of the economy. For example, the MACCs developed for the UK model large regions as one farm and thus largely ignore heterogeneity between farms and farm types. Further, outcomes of MACCs are sensitive to a large number of assumptions made via scientific expert judgement, for example regarding adoption rates, effectiveness and costs (Eory et al., under review). There is likely to be significant heterogeneity of adoption patterns, effectiveness and costs across farms, which can influence overall cost-effectiveness depending on their distribution around the mean values applied in MACCs (De Cara and Jayet, 2000; Vellinga et al., 2011). Another result of MACC analysis is the significant mitigation potential of practices identified to have negative cost. These have been referred to as 'win–win' mitigation practices, the result of which has influenced several policy and industry documents (DSCF, 2008; TSB, 2013). These mitigation practices would be expected to be adopted by profit-maximising farmers without requiring any incentive as they reduce the cost burden of production. However, the lack of uptake of practices with negative costs suggests that adoption behaviour is driven by a more complex set of motivating factors (Barnes et al., 2009; Barnes and Toma, 2012; Moran et al., 2013) not accounted for in the MACC approach. Further, the currently developed MACCs only comprise a subset of the potential mitigation practices available in agriculture.

Accordingly, when advancing agricultural mitigation policy, MACC approaches may be of limited use as they are based on strong assumptions regarding current adoption rates and largely lack up-to-date

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information on farmers' views regarding the farm management practices. Consequently, the main aim of this paper is to contribute to filling the gap between national strategy development and implementation in agricultural GHG mitigation by complementing and substantiating the information entailed in MACCs with information on adoption rates and on farmers' views regarding the farm management practices that are expected to result in considerable GHG emission reductions. Such information is important for informing targeting and for prioritisation of GHG mitigation practices for policy support, either via awareness raising campaigns or as part of positive financial incentive schemes within the agricultural policy architecture.

Given the large number (>100) of potential GHG mitigation practices in the agricultural sector (Weiske, 2005), and the heterogeneity in farming systems, it is difficult to obtain comprehensive information across the whole industry in a single study. The research presented in this paper thus focuses on GHG abatement in dairy farms in Scotland. Scotland provides an example of a country with highly ambitious GHG reduction goals (Scottish Government, 2009) relative to the rest of other developed country economies, and the dairying sector is more intensive and technically advanced (Barnes, 2008; Barnes et al., 2010; Hadley, 2006) and has a considerable GHG mitigation potential (Barnes and Toma, 2012).

This paper presents results of a survey of dairy farmers aimed at deriving a ranking of mitigation practices that may be associated with their likely adoption. The methodological approach used to obtain rankings of mitigation practices is Best–Worst Scaling (BWS). In the type of BWS study applied here, respondents are asked to repeatedly choose from subsets of four to five different mitigation practices those that are perceived to be 'best' and 'worst' with respect to the farm's financial and environmental performance. The suitability to accommodate a large number of mitigation practices (Louviere et al., 2013) is a main reason for using BWS in this study — direct rankings of a large number of items can be too difficult for respondents to perform. BWS has been shown to have a number of other advantages over alternative rating and direct ranking techniques. For example, BWS does not suffer from rating scale bias (Auger et al., 2007) and is likely to better discriminate amongst objects that are perceived to be of similar importance (Lee et al., 2007). However, some respondents may dislike having to make repeated trade-offs (Hein et al., 2008), i.e. to repeatedly select the 'best' and 'worst' from different subsets of mitigation practices.

In recent years, Best–Worst Scaling (BWS) has been applied in a range of contexts related to food choice and agricultural management to derive rankings of long 'lists' of objects (Cross et al., 2011; Erdem et al., 2012; Jones et al., 2013; Lagerkvist et al., 2012; Lusk and Briggeman, 2009). This study therefore contributes to the increasing body of literature applying BWS to understand and inform agricultural decision making, and assesses the usefulness of the BWS methodology to identify priorities for policy support, especially at early stages of planning when policy makers are faced with a choice amongst a large number of options. To our knowledge, only one study that applied BWS was concerned with GHG mitigation options (Jones et al., 2013). The authors investigated perceptions of Welsh sheep farmers regarding the effectiveness and practicality of GHG mitigation options. A key advance of our study on Jones et al. (2013) is the explicit consideration of current adoption rates in the BWS choice model, which is expected to be of high significance for policy implications drawn from results.

Specifically, this study aims to address the following questions. How do farmers rank mitigation practices with respect to their farm's financial and environmental performance? How does current adoption affect rankings? How do rankings based on farmers' perceptions of the impact of mitigation practices on their farm's financial and environmental performance compare to cost-effectiveness and rankings in MACCs? In combination with available information on cost-effectiveness, the information on rankings of mitigation practices and adoption behaviour can be used to evaluate plans for policy support that are currently in development. Practices ranked highly by non-adopters with fairly low current adoption rates but high effectiveness should be considered for immediate policy support. Other, less preferred practices that are still deemed to be cost-effective may benefit from continued awareness raising campaigns, and may still be relevant to particular sub-groups of farmers.

The paper proceeds with a description of GHG mitigation options in dairy farms and how GHG mitigation is embedded in the current policy framework and ongoing developments. This is followed by an introduction to BWS and the modelling approach taken. After describing the case study of Scottish dairy farms, the survey and the sampling procedure, we report the results of the survey data analysis and BWS modelling. We discuss the findings in the light of the current policy framework, develop policy recommendations based on the study's results and reflect on how rankings derived through BWS compare to previous MACC analyses.

2. GHG mitigation and dairy farms: policy context

Scotland is committed to GHG emission reductions of 42% by 2020, and an 80% reduction by 2050 compared to the 1990 baseline. Agriculture contributes approximately 20% to total emissions (Scottish Government, 2013a), and abatement in agriculture is pivotal for achieving this target: an emission reduction of 1.2 Mt CO_2 equivalent by 2020 is expected for the agricultural sector (Scottish Government, 2013b). Climate change mitigation has also been highlighted to be a key part of the multi-functional role Scottish agriculture is expected to play (Pack, 2010), which is in line with the general direction that the Common Agricultural Policy (CAP) post-2013 is expected to take (EC, 2010).

Dairy farming is an important agricultural activity both globally and in Scotland, and its importance is going to increase as per capita consumption of fresh milk and milk products is projected to grow by 10% in the next 10 years. This is more than the consumption of any other agricultural product group, including cereals, sugar, meat or fish (OECD-FAO Agricultural Outlook 2013–2022 database). In Scotland, dairy farms occupy 4% of the agricultural land area (Shepherd et al., 2007), and fresh milk and milk products account for 13% of the total Scottish agricultural output of £2.8 billion (Scottish Executive, 2013). At the same time, the dairy sector's contribution to global warming is also notable: globally, 4% of the total anthropogenic GHG emissions originate in the dairy product chain (Gerber et al., 2010). Although the per litre GHG emissions of milk produced in Western Europe are only two-thirds of the global average (Gerber et al., 2010), the dairy product supply chain is responsible for 3% of the total Scottish GHG emissions (Scottish Government, 2013a; Sheane et al., 2011). Importantly, dairy farming is well-placed to offer many opportunities to reduce GHG emissions.

GHG emissions arising from land management associated with dairy farming can be reduced by altering nitrogen fertilisation practices, soil management, or crop types and varieties. The feed composition is another focal point of GHG mitigation efforts in the dairy sector: methane emissions from the rumen and both methane and nitrous-oxide emissions from manure can be significantly decreased by modifying the ration or by using feed additives (e.g. probiotics). Housing dairy cattle provides the basis for a set of GHG mitigation interventions related to improving manure management to reduce methane and nitrous-oxide emissions. Finally, the health and productivity of the animals and the herd structure affect the overall input use — milk production ratio, and therefore the GHG emissions embedded in the product. Dairy farmers represent the most technically advanced producers within the Scottish agricultural sector (Barnes et al., 2010) and not much is known regarding their current behaviour and preferences regarding management practices aimed at climate change mitigation (Vellinga et al., 2011).

Currently there are three main pathways to provide policy support for increasing GHG abatement in the Scottish agricultural sector, using a mix of extension and awareness raising, regulation, and positive