Extended Abstract
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Paper/Poster Title	**Analysis of Marginal Abatement Cost Curve for Ammonia Emissions: Addressing Farm-System Heterogeneity.**

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Abstract	***200 words max***

Abstract

Agriculture is responsible for 99.4% of ammonia emissions in Ireland and the country has failed to comply with limits set down by the EU National Emissions Ceiling Directive (NECD) for 7 of the last 9 reporting years. Hence there exist an urgent need to reduce ammonia (NH_3) emissions to limit air pollution and control environmental and health hazards associated with this gas. Heretofore, Marginal Abatement Cost Curve (MACC) methodology has been used to assess the impact of a suite of ammonia mitigation measures at a national aggregate scale. This study builds on this work by examining the cost-effectiveness of proposed mitigation measures but at a more granular farm typology scale. Results indicate a significant degree of heterogeneity in the cost and efficacy of a given mitigation measure across different farm system types. Additionally, the cost-effectiveness ranking of the mitigation measures changes across the farm system types suggesting a more targeted approach is required in the implementation of these mitigation measures.

Keywords	**Farm-level, MACC, ammonia, environment, mitigation, interactions**
JEL Code	Q53 Air Pollution; Water Pollution; Noise; Hazardous Waste; Solid Waste; Recycling

Introduction	***100 – 250 words***

Introduction

To moderate the extent and impacts of climate change, degradation of aquatic life and loss of species biodiversity actions are required to minimize the negative environmental impacts associated with agricultural production. Agriculture is a significant source of gaseous emissions accounting for approximately 85% of total global ammonia emissions (Bouwman et al., 1997; Zhang et al., 2011; Xu et al., 2018). In the Republic of Ireland, this proportion is even higher as 99.4% of ammonia emissions in the country are accounted for by agriculture (Teagasc, 2020). The European Environment Agency EEA (2019) indicates that poor air quality precipitated by ammonia emissions could lead to over 1000 premature deaths in Ireland. This and limits set down under the EU National Emissions Ceiling Directive signal the need to reduce ammonia emissions from agriculture.

Heretofore, Marginal Abatement Cost Curve (MACC) methodology has been used to assess the impact of a suite of ammonia mitigation measures at national aggregate scale (Lanigan et al., & Buckley et al 2020). This paper seeks to add to this area by exploring the impacts of the proposed mitigation measures at a more granular farm systems scale. The research aims to explore the cost-

effectiveness of a suite of mitigation measures at farm scale thereby exploring the effect of heterogeneity on measure efficacy.

In this context, this paper seeks to address the following research questions, (1.) Is the cost-effectiveness of a mitigation measure significantly different across different farm system types?
(2.) Is the ranking of mitigation measures consistent across farm system types?

Methodology

100 – 250 words

The hypothesis behind this study is that both environmental and farm-level economic models can be combined to generate a cost-effectiveness estimate of potential abatement options for different ammonia emissions across the different farm systems. Marginal abatement cost curve methodology is a technique to assess the abatement potential of different abatement options and the relative cost associated with each measure and can suggest an economically optimal mitigation level (Bockel et al., 2012). MACC also allows a ranking of abatement options from cost-beneficial measures (i.e., measures that not only reduce gaseous emissions but also save money) to cost-prohibitive measures (i.e., measures that save gaseous emissions but are costly). It visualizes the magnitude of the abatement potential of each measure, as indicated by the width of the bar (Schulte & Donnellan, 2012; Lanigan et al., 2018). Heretofore, the MACC methodology has been applied at a national aggregate scale.

This study uses farm-level data from the Teagasc National Farm Survey (NFS) 2020, which is part of the European Union Farm Accountancy Data Network (FADN). A total of 795 farms were included in the analysis, this sample represents 93,244 farms in the national population based on weighting factors provided by the Central Statistics Office of Ireland. The analysis is conducted at farm scale and results are present by farm system type. The farm systems included in this analysis are dairy, cattle, sheep, arable and mixed livestock.

Results

100 – 250 words

There are seven abatement strategies considered in this study and are categorised as fertiliser measures, (that is liming, clover and protected urea) and bovine measures (low emissions slurry spreading techniques, covering of slurry stores, additional chemical amendments to slurry, reduction in the crude protein of animal diets). Results indicate that the cost-effectiveness of abatement measures varies by farm system type. For example, one of the mitigation measures (introduction of clover into grass swards) is cost negative for the dairy it is, however, cost positive for some other farm types like sheep and tillage farms. These variations in the MACC diagram and rank of abatement options may be attributed to the presence of heterogeneity across the farms. Results indicate that for some systems like dairying, no mitigation measure is cost prohibited. Results also explain the importance of combining abatement measures in reducing ammonia emissions in comparison with the implementation of a single measure.

Discussion and Conclusion

100 – 250 words

This study considers the influence of farm system level heterogeneity on the abatement potential, cost and cost-effectiveness of a suite of measures aims at reducing ammonia emissions on farms.

Results from the study showed that one type of MACC curve for all the different farm types may not necessarily represent the optimum abatement potential for a given farm or farm system. This is in contrast to a national aggregate MACC approach which promotes outcomes to all farms without taking account of farm system-specific heterogeneity. Another finding in our study is the existence of overall synergistic relationships amongst the abatement measures Results from this analysis will allow policymakers to consider farm system-specific effects when designing policy to target ammonia emission reductions.