Extended Abstract
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Paper/Poster Title	Comparing the carbon footprint and economic performance of Irish sheep farms

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Abstract	***200 words max***
This study compares the farm level economic and environmental performance of Irish sheep farms based on a bioeconomic model of sheep production system using nationally representative farm accountancy panel data and biological information linked to livestock activities. NFS data enables the evaluation of the farm level Carbon Footprints (CF) and land occupation for the range of Irish sheep flocks. The environmental performance of distinct sheep farming systems operating at different levels of production intensity and input use is presented and compared with key financial and technical performance outcomes. Sheep farming in Ireland is generally considered to be pasture-based and extensive, but large differences in production intensity, and land and input use exist. The application of a farm level modelling approach in this study means the variation in environmental outputs and financial performance across individual (real) farms is described.	

Keywords	Bioeconomic modelling, LCA, GHG emissions
JEL Code	Environmental Economics see: www.aeaweb.org/jel/guide/jel.php?class=Q)

Introduction	***100 – 250 words***

With EU policy focus evolving to foster the competitiveness and sustainability of farming systems in Europe (e.g. EIP-AGRI, Food Harvest 2020) there is an increasing demand for micro level analysis of the environmental, financial and social performance of agricultural systems. In response, a growing number of studies are based on farm-level models aimed at gaining a better understanding of the decision making process of farms across the distribution of farming systems, agronomic and environmental conditions (Louhichi et al., 2015). In the context of a growing population, emerging market trends for meat products and potentially conflicting policy challenges this paper provides a case study of Irish sheep flocks aimed at investigating the sustainability of these ruminant meat production systems from an environmental and economic perspective (Garnett et al., 2013). This study explores these issues by comparing the farm level economic and environmental performance of Irish sheep farms based on bioeconomic model of sheep production system using data from a nationally representative farm accountancy panel data (Hennessy et al., 2016) and biological information linked to livestock. NFS data enables the evaluation of the farm level Carbon Footprints (CF) and land occupation for the range of Irish sheep flocks. The environmental performance of distinct sheep farming systems

operating at different levels of production intensity and input use is presented and compared with key financial and technical performance outcomes. Sheep farming in Ireland is generally considered to be pasture-based and extensive, but large differences in production intensity, and land and input use exist. The application of a farm level modelling approach in this study means the variation in environmental outputs and financial performance across individual (real) farms can be described (Louhichi et al., 2015).

Methodology	***100 – 250 words***

This study performs a Life Cycle Assessment (LCA) of the environment outputs from Irish sheep farms. LCA is an established and standardised method to evaluate environmental impacts across the life cycle of a production system and has been widely applied to livestock production systems, in particular the carbon foot printing of agricultural outputs (Edwards et al., 2008; Yan et al., 2011). While the analysis presented in this study follows the ISO standard layout, the Carbon Footprint calculations represent a partial LCA. This approach to calculating a carbon footprint of sheep farms without undertaking a full LCA as has been applied in a number of previous related studies of UK sheep production, (Saunders et al., 2006; Williams et al., 2006; Jones et al., 2009). In this context, a carbon footprint (CF) analysis represents a single-issue LCA which can be extended to account for a multitude of additional environmental outputs, such as water use, land use, acidification, energy use, eutrophication, etc. (Murphy et al., 2017; Schmidinger et al., 2012; Thomassen et al., 2008).The goal of this analysis is to estimate and compare Carbon Footprint of the full distribution of Irish sheep farms as describe by the nationally representative Teagasc National Farm Survey (NFS). The CFs for sheep farms were calculated in this study according to a cradle to farm gate system boundary, i.e. all GHG emissions from the farm up to the point of product sale from the farm (cradle to farm gate).

Results	***100 – 250 words***

Results from this paper show that the more profitable lowland sheep enterprises are characterised by higher technical performance, stocking and weaning rates, greater production intensity and greater emissions efficiency on a per unit basis. This is in line with previous studies in comparable production settings (Hyland, 2016; Jones et al., 2014a; O'Brien et al., 2016). Improved technical performance is reflected in the average carcass output per hectare of 332 kilos on the top third of lowland mid-season farms, versus 167 kilos on the bottom third of farms. This higher level of lamb output per hectare, combined with tighter control of direct costs is reflected in higher enterprise profitability. In line with previous studies (Jones et al., 2014b), extensive hill production systems on the other hand demonstrated lower overall emissions, lower production efficiency and higher GHG emissions per unit output.

In contrast to most other LCA studies this study enables the application of nationally representative panel data (Hennessy et al., 2016) results in farm level estimation which is scalable and representative at a national level and thus more suitable for agronomic and policy recommendations across the range of farming practices

Discussion and Conclusion	*100 – 250 words*

The farm level modelling framework developed in this study was used to analyse the GHG emissions from the range of sheep production systems consistent with IPCC reporting standards. Additionally, the emissions from upstream input production were estimated to provide a CF of sheep farms. This framework can be readily extended to estimate CFs for cattle and dairy production systems as recorded in the NFS. Furthermore, the use of a consistent panel dataset stretching back to 1972 and before Ireland's accession to the EU means the environmental impact associated with the evolution of farming management practice in response to market and policy stimulus can be investigated. The NFS captures information on farmer participation in agri-environmental schemes which have emerged in line with the general "greening" of the CAP. This study can be developed to compare the emissions profiles of participating and non-participating farms in agri-environmental schemes.

There is also the potential to develop the analysis in this study to produce a full LCA of sheep farms. This would require a Tier II estimate of Enteric Fermentation emissions in line with LCA protocols. Given the structure of NFS data, additional assumptions around animal performance, growth rates, and dry matter intake (DMI) would need to be made in conjunction with livestock specialists and in order to more accurately describe the farm level variability in livestock performance and related emissions.