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Estimation and determinants of phosphorus balance and use efficiency of dairy farms in Northern Ireland: A within and between farm random effects analysis

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ABSTRACT

The dairy sector is the most important agricultural sub-sector in Northern Ireland both in terms of size and contribution to the economy. However, the abolition of the milk quota regime in 2015 and the government's initiative for industry growth has given rise to concerns about environmental pollution, especially in terms of phosphorus (P) balance. In light of these concerns, this study analyses the level and determinants of P balance and use efficiency on Northern Ireland's dairy farms. The study employs the OECD/EUROSTAT nutrient balance methodology and the within-between farm random effects modelling technique on a balanced panel data set. The results show that P balance in dairy farms in the study area is relatively high. However, the more profitable dairy farms have relatively lower P balance. We also found that the amount of grass grazed, and fertilizer price have a negative and statistically significant relationship with P balance, while stocking density was found to have a positive relationship with P balance. On the other hand, the age of the farmer and the amount of grass grazed where found to have a positive and statistically significant relationship with P use efficiency. The study demonstrates that increasing the percentage of grass-based feeds reduces phosphorus balance and also has a positive impact on the profitability of the dairy farms. The study recommends that farmers in the study area should increase the percentage of grass-based feeds alongside feeding concentrates with lower phosphorus contents. A moderate level of intensification should also be maintained.

1. Introduction

In spite of its significance in agriculture, phosphorus (P) has been identified as a major source of environmental pollution in Northern Ireland with about 50% of farmed grassland having plant-available P (Olsen-P) values greater than the critical value of 25 mg/kg (Bailey, 2015; Kleinman et al., 2015; Cave and McKibbin, 2016; Smith et al., 2003). Application of P in excess of crop requirements results only in marginal yields increases with increased risks of loss to water bodies through run-off, erosion and leaching (Sharpley et al., 2006; Vitousek et al., 2009). P surplus accelerates eutrophication, which has a detrimental effect on biodiversity, environmental and water quality (Vitousek et al., 2009). Bailey (2016) showed that a P surplus above 5 kg/ha/year increases the risk of P losses to water. Eutrophication of inland surface waters has been identified as a significant pollution problem in Northern Ireland (Cave and McKibbin, 2016; DOE, 2011). More than 50% of all rivers in Northern Ireland are classified as "moderate/poor status". Also, about 70% of lakes are still classed as eutrophic (with annual average P concentrations in excess of 0.02 mg/l, the level above which it is considered to be at risk from eutrophication) under the "water framework directive". Agriculture accounts for more than 30% of the incidence of the water pollution in the region (Cave and McKibbin, 2016; Kleinman et al., 2015; "Summary of Findings of Northern Ireland Nitrates", 2012). In a bid to reduce the impact of agriculture on the environment and ensure efficient use of resources, the European Union has formulated and implemented a range of agro-environmental policies to protect water quality and improve rural development (e.g. Common Agricultural Policy (CAP), EU Nitrates Directive (91/676/EEC) and the Water Framework Directive (2000/60/EC) (European Communities, 2000). However, most of these policies

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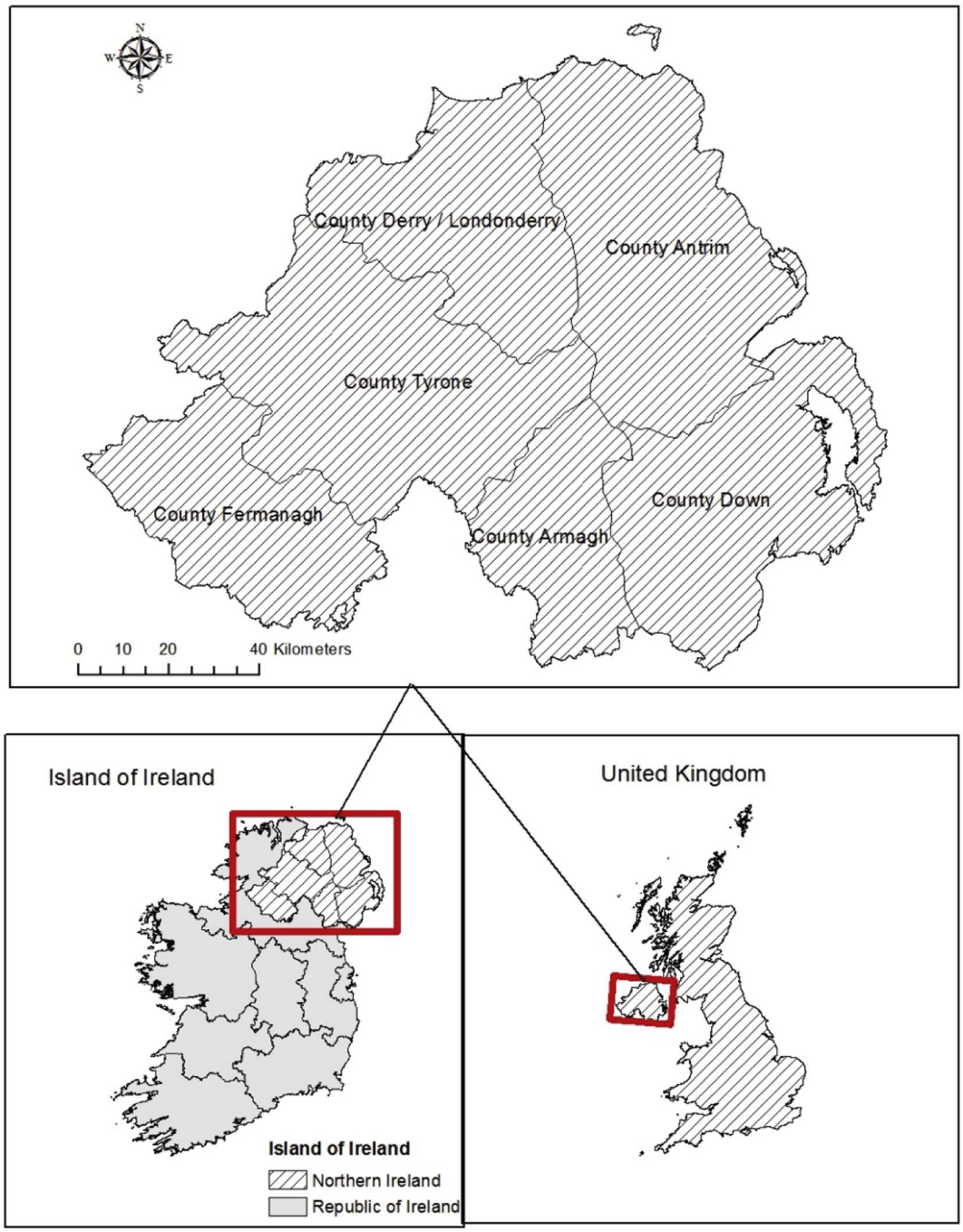

Fig. 1. Map of the study area: inset is the map of United Kingdom and the island of ireland.
Source: Author's compilation.

are focused on nitrogen applications with no overarching EU regulation directly governing P application and loss from agricultural land (Amery and Schoumans, 2014). Northern Ireland is in a minority of EU countries that includes direct controls on the use of P in agriculture through the Nitrates Action Programme and Phosphorus Regulations (DAERA, 2016a). With the abolition of the milk quota regime in 2015 and an industry initiative for growth (Agri-Food Strategy Board, 2013), there are concerns that expansion in the dairy sector might pose increased environmental problems.

The gross P balance (GPB) is increasingly being used at farm, regional, national, and international scales to assess both the environmental impact and potential sustainability of agricultural systems (Buckley et al., 2015; Eurostat, 2013; Gourley et al., 2007; Özbek and Leip, 2015). This approach provides an insight into the interactions between agriculture and the environment, which is useful in evaluating the impact of changes in agricultural policy (Grizzetti et al., 2012; Öborn et al., 2003). They provide a means to estimate nutrient use efficiencies, which has been identified as an indicator of farms' agronomic performance providing insight into farms' resource use and related management decisions (Gourley et al., 2012; Oenema et al., 2003). The concern for water quality affected by P loss from agricultural land, has given rise to the need to ensure that P is used efficiently on farms (Cordell and Neset, 2014; Simpson et al., 2011; Weaver and Wong, 2011; Amery and Schoumans, 2014).

We are not aware of any previous econometric study on P balance and its determinants in Northern Ireland. While a few studies on P