Extended Abstract

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Paper Title	Feed substitution in Irish dairy and cattle farms due to the adoption of mitigation measures to reduce N_2O emissions

Abstract prepared for presentation at the 98th Annual Conference of The Agricultural Economics Society will be held at The University of Edinburgh, UK, 18th - 20th March 2024.

Abstract	***200 words max***
This paper aims to estimate the capacity to substitute concentrate feed for home-produced feed by adopting two specific mitigation strategies to reduce Nitrous Oxide (N_2O) emissions in the agriculture sector: (i) Low Emissions Slurry Spreading (LESS) and (ii) applying protected urea instead of CAN fertiliser. A translog cost function is estimated to obtain the price and cross-price elasticities of demand for concentrate and home-produced feed. To achieve our aim, we use the Teagasc National Farm Survey (NFS) from 2014 to 2022, which contains detailed information on agricultural activity. Furthermore, farms are categorised into four groups based on their environmental characteristics to show how environmental conditions influence farmers' decision-making processes. Our results show a marginal change in the purchase of concentrates due to adopting the two mitigation measures analysed, which is reflected in an increase in cross-price elasticity. However, these results are conditioned to the biophysical conditions of the farm soils.	

Keywords	Feed substitution, Price and Cross-Price Elasticity, Mitigation Measures, N_2O Emissions
JEL Code	Agriculture: Aggregate Supply and Demand Analysis; Prices Q110 see: www.aeaweb.org/jel/guide/jel.php?class=Q)

Introduction	***100 – 250 words***
Ireland's total GHGs were 60.76 Mt CO2eq in 2022 (excluding LULUCF) (EPA, 2023). Meanwhile, the GHGs from the agriculture sector were 23.33 Mt CO2eq, representing 38.4% of the total GHGs. N_2O emissions contributed 22.8% to agriculture's GHGs, and the agriculture sector contributed 92.9% of total N_2O in the country. In recent years, agriculture N_2O emissions have only reduced by 1.1% compared with 1990 levels (EPA, 2023). In this context, dairy and cattle farms are the main emitters of N_2O emissions in the country. Their emissions are mainly a consequence of applying chemical N fertilisers as well as manure, urine and dung deposited directly or indirectly (land spreading) to soils to grow grass to feed cows and cattle animals. Therefore, the measures to reduce the sector's N_2O emissions focus on reducing N inputs into agriculture soils. These mitigation measures are changes in management and adoption of technologies for reducing the application of chemical N fertilisers to soils. Two easy measures to implement in this context are (i) LESS and (ii) substitution towards protected urea fertiliser formulation, which increase nitrogen recovery in soils and farmers need less chemical N fertilisers for growing grass. However, the adoption	

and applicability of these measures depend on many factors (O'Brien et al., 2014) such as farm location, environmental conditions, type of production system, and market/policy conditions.

Currently there is some evidence that shows the efficacy of these measures in reducing N_2O emissions in the agricultural sector (Harty et al., 2016; Krol et al., 2021; Rodriguez, et al.,2021). Nevertheless, there is little evidence that shows the economic impact on farms for adopting these measures. Previous research shows that reducing the use of chemical fertilisers, such as CAN, reduces the production of grasses for animal consumption, so production levels are affected. To counteract this effect, farmers resort to purchasing concentrates to complement or substitute animal feed. This paper aims to estimate the price and cross-price elasticities of demand for concentrate and home-produced feed and show whether it is affected as consequence for adopting (i) LESS and (ii) urea protected measures. Furthermore, the analysis includes the grouping of farms into four categories according to their biophysical conditions, which are related with their production levels and emissions of N_2O.

Methodology	***100 – 250 words***

The model to estimate the price and cross-price elasticities of demand for concentrate and home-produced feed is based on the translog demand model (Christensen et al., 1973). The translog demand model assumes a cost production (CP) as function of cost factors: livestock animals used (LU), purchased concentrate (CO), home-produced feed (grass and crop production) (HP), veterinary and breeding services (V), and land devoted for grass and crop production (L):

$$CP_{it} = \beta_0 + \beta_1 Q_{it} + \frac{1}{2}\beta_2 Q_{it}^2 + \beta_3 T_{it} + \frac{1}{2}\beta_4 T_{it}^2 + \beta_5 L_{it} + \frac{1}{2}\beta_6 L_{it}^2 + \sum_1^n \beta_7 P_{it}$$
$$+ \frac{1}{2}\sum_1^n \beta_8 P_n * P_{m_{it}} + \sum_1^n \beta_9 P_n * Q_{it} + \sum_1^n \beta_{10} P_n * L_{it} + \sum_1^n \beta_{11} P_n * T_{it}$$
$$+ \beta_{12} L * Q_{it} + \beta_{13} T * Q_{it} + \beta_{14} L * T_{it}$$

Where Q represents farm production, T time, P prices for n costs (LU, CO, HP, V, L) for i farms in time t. The P variables are included in the model as index. The price (β_7) and cross-price (β_8) elasticities of demand for each cost are obtained as the proportionate change in the demanded quantity of a cost n with respect to a proportionate change in its own price and change in the price of another cost, respectively.

To estimate the translog function, we use the Teagasc National Farm Survey (NFS) from 2014 to 2022, which is an unbalance data panel of farms with detailed information on agricultural activity. Due to the characteristics of each type of farm, we estimate a cost function for dairy farms and another for cattle farms to be more precise with the interpretation of the results.

Results	***100 – 250 words***

The results show that the price elasticity of concentrates is higher than the elasticity of home production in both dairy and cattle farms, which means that farms have a great reaction to changes in prices for concentrates. Besides, the cross-price elasticity of demand for concentrate and home-produced feed is marginally greater in farms implementing mitigation measures to reduce N_2O emissions. Nevertheless, this observed increment signifies a modest economic impact when juxtaposed with the consequential reduction in N_2O emissions.

Additionally, the results vary according to the environmental conditions of the farms. Farms located in better environmental conditions tend to use fewer inputs for local production, so they are less affected by adopting mitigation measures to reduce N_2O emissions. This contrasts with farms that use a greater amount of inputs for grass production, which shows a greater reaction to changes in the prices of concentrates and local production.

Discussion and Conclusion	***100 – 250 words***

This paper contributes to the economic analysis on the adoption of mitigation measures to reduce N_2O emissions in the agricultural sector. Our findings underscore the feasibility of these mitigation measures for farmers seeking to sustain home production feed while concurrently diminishing N_2O emissions. However, an integral aspect emerges concerning the necessity for concurrent economic policies or subsidies to facilitate and incentivize the comprehensive adoption of these mitigation measures. This underscores the importance of an integral approach, where economic instruments complement the environmental objectives, ensuring a more effective and sustainable transition toward reduced N_2O emissions in agriculture.