

Extended Abstract

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Paper/Poster Title	A Meta-analysis of Environmental Efficiency of Agricultural Production in Europe
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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
<p>Environmental pressures associated with agricultural production remains a pressing issues for policy attention. In this study, We use meta-regression analysis to examine variation in environmental performance of farms, proxied by environmental efficiency (EE) based on 49 eligible research papers published between 1991 and 2022, resulting in 150 observations. We also analyse the factors influencing environmental efficiency. A key result from the analysis is that the average EE reported across these studies is 65.4%. Our results reveal significant factors influencing the EE score across different farms. Education, investment per cow, and participation in agri-environmental scheme have a significantly positive effects on EE scores across all farms while concentrate feeds per hectare have a negative effects of environmental efficiency of livestock production farms. We conclude that investment on environmental -friendly technology and practice as well as farmers' skills and knowledge of the use of these technologies are key.</p>	
Keywords	Environmental Efficiency, farming, meta-regression analysis
JEL Code	Q12, Q57 see: www.aeaweb.org/jel/guide/jel.php?class=Q)
Introduction	100 – 250 words
<p>Agriculture is continuing to change the global natural ecosystems and degrade the environment at unprecedented rates. As one of the key drivers of global environmental change, agriculture is responsible for a substantial share of global carbon emissions, leads to massive losses of biodiversity and degrades land, soil, and freshwater systems. With a growing world population and increasing food consumption, pressures will rise further, threatening resilience of agro-ecological systems. Addressing this challenges require policy support targeted at reconciling production and environmental sustainability of the agricultural sector.</p> <p>We contribute to the understanding of the estimates of environmental performance of agricultural production in Europe and associated driving factors, filling important gaps in the literature. Firstly, no comprehensive systematic review exists on the environmental efficiency of agricultural production. Secondly, existing studies often argue on the best way to treat undesirable factors (either bad output or bad input) - our meta-analysis allows us to holistically analyse the changes in environmental efficiency scores accounting all possible ways in different undesirable factors are treated.</p>	

We conduct a meta-regression analysis to synthesise existing empirical studies on the environmental efficiencies of European farms and factors influencing them. Our dependent variable is based on environmental efficiency measure of farms reported in existing studies. The variation of environmental efficiency scores across and within studies is explained using several specific methods and case study differences.

The findings from this study will assist policy makers in understanding the factors that influence environmental performance. This will be important in devising balanced policies required to enhance the sustainability of production systems and will help shape future agri-environmental scheme.

Methodology	100 – 250 words
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Our analysis consists of three main parts. First, we conduct a systematic literature review based on the PRISMA framework to identify studies that estimated environmental efficiency and associated factors influencing it (Moher et al. 2015). Second, we transfer eco-efficiency scores estimates as well as explanatory variables into a meta-database. Third, we use the fractional regression analysis to estimate the factors influencing environmental efficiency while accounting study characteristics.

The estimation of meta-regressions to explain the variation in environmental efficiency as a function of the key attributes of the studies requires dealing with the fact that the dependent variable, EE scores, range between 0 and 1. Following Ogundari (2021), we used the Fractional Regression Model (FRM) a suitable framework to deal with dependent variables defined on the unit interval, irrespective of whether boundary values are observed or not. The FRM employed is estimated using a Quasi Maximum Likelihood Estimator (QMLE) characterised with consistent and asymptotically normally distributed standard errors (Davidson and Mackinnon, 2004).

Collinearity problems were identified by analysing correlations between variables. The variance inflation factors of the selected model were estimated to test for any remaining potential problems of multicollinearity (Fox and Monette, 1992). Variables with potential multicollinearity problems were excluded.

The independent variables were coded in three categories (i) direction of socioeconomic and structural variables (ii) methodological design, and (iii) case study characteristics

In total, the number of eligible papers analysed is 49 published between 1991 and 2022, resulting in 150 observations.

Results	100 – 250 words
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Our analysis show that the average EE is 65.4% with a range from 45.1% (observed in Hungary) to 94.2% highest estimate 94.2% (observed in Dutch farms). This kind of variation across studies is typical for efficiency studies and an important motivation for meta-analysis (Bravo-Ureta et al., 2015).

We use three variables to capture the effect of the methodology: parametric stochastic frontier, parametric deterministic frontiers and the omitted category is the non-parametric studies. The results show that the latter category exhibits a significantly higher MTE than the deterministic parametric approach.

The results show that factors including forage per hectare, education, investment per cow, and participation in agri-environmental scheme have a significantly positive effects on environmental efficiency on all he farms. More specially, concentrate feeds per hectare have a negative effects of environmental efficiency of livestock production.

Discussion and Conclusion

100 – 250 words

This study analysed the environmental technical efficiency and associated driving factors. It provides empirical evidence to inform the formulation of policies relating to improvement of environmental performance in livestock production systems. The results of the study show that the environmental technical efficiency of livestock farms in the study area is about 65.4% suggesting that there exist more room for improvement in terms of increasing productivity and reducing undesirable environmental impacts.

Considering the significance of forage grazed per hectare in improving nutrient management, it is important that more emphasis is placed on increased incorporation of grass-based feeding systems and better inputs management. In addition, education variable is significant, suggesting that enhancement of farmers' skills and knowledge of the use of environmentally friendly techniques and practices is also very essential. Another way to ensure improved nutrient management is to ensure a broader and more practical implementation of the agri-environmental schemes and ensuring stricter compliance given its positive relationship with environmental efficiency.