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Fanny Le Gloux, Marie Laporte, Sabine Duvaleix, Pierre P. Dupraz, Elodie Letort. A payment to support the reduction of enteric methane emissions in dairy farms should be adapted to the type of fodder system. Annual Conference of The Agricultural Economics Society, Mar 2021, Online, United Kingdom. hal-03338454

HAL Id: hal-03338454
https://hal.inrae.fr/hal-03338454

Submitted on 8 Sep 2021

A payment to support the reduction of enteric methane emissions in dairy farms should be adapted to the type of fodder system

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Background

- Methane (CH_4) is a short-lived climate pollutant → a significant reduction of emission rates would have a **rapid positive impact on climate**.
- **81%** of EU-KP agricultural CH_4 emissions result from enteric fermentation.
- For a given productivity, enteric CH_4 emissions decline as dairy cows' feed is enriched with unsaturated **omega-3 fatty acids** → the main natural sources are grass fodders and linseed.
- Since 2011, the Payment for Environmental Services programme **Eco-Methane** rewards French dairy farmers for reducing CH_4 emissions, calculated from cows' productivity and fatty acid composition of milk.

Research aims

To effectively support CH_4 mitigation in dairy farms, the payment design:

1. Should be based on an emission indicator that captures both the effect of productivity and feeding.

→ **We examine how diet affects CH_4 estimates.**

2. Should compensate farmers for the extra-costs of milk production induced by a change of their practices.

→ **We quantify the additional production cost of a change in cows' diet.**

Methods

Data: Balanced panel of 735 French Farm Accountancy Data Network dairy farms for the years 2016 to 2018.

Comparison of two estimates of CH_4 enteric emissions

- **IPCC Tier 2** CH_4 indicator accounting for **productivity:**

$$Tier\ 2 = \frac{\boxed{0.0105 * \frac{Herd\ production}{Number\ of\ dairy\ cows} + 48.971}\ \textbf{Emission factor}}{Productivity}$$

- **Eco-Methane indicator** accounting for **productivity and diet**:

1. Collection of 11 reference emissions from the Bleu-Blanc-Coeur association, coordinator of the Eco-Methane scheme. References are calculated using[1] :

$$Methane = 11.368 * Productivity^{-0.4274} * \frac{FA \leq C16}{totalFA}$$

2. Attribution of a reference to all sample observations based on their localisation and the share of maize in the fodder area.

Estimation of a system of equations with a flexible homogeneous translog function

- **System:**

Equation 1: Fuel cost share
Equation 2: Cattle feed cost share
Equation 3: Variable cost

- **Estimation procedure:**

Three-stage least squares regression at the scale of France and for three production basins.

Dependent variable:
VC: intermediate consumption

Explanatory variables:
Y_1: Milk production
W_1: Fuel price
W_2: Cattle feed price index
Z_1: Grassland
Z_2: Capital
Z_3: Labour

Control variable:
Y_2: Other productions

Instrumental variables:
Milk price
Utilised agricultural area
Permanent pasture area
Number of dairy cows
Regional dummies

- **Estimate of the additional milk production cost:**

1. Derivation of the marginal production cost function from the estimated variable cost function.
2. Calculation of the **extra-cost per unit of milk of adding 1 more hectare of grassland.**

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[1] Patent: "Method for evaluating the quantity of methane produced by a dairy ruminant and method for decreasing and controlling such quantity" (WO2009156453A1) by Weill, P., Chesneau, G., Chilliard, Y., Doreau, M., Martin, C.

Results

Table 1: Average enteric emissions according to the two indicators.

% Sample	Maize in the fodder area	French Production basin	Productivity (L/cow)	Tier 2 (gCH_4/L)	Eco-Methane reference (gCH_4/L)	Difference of emissions by taking into account the feeding system
10%	> 30%	Plains outside the western region	7654.6	**17.35**	**15.75**	-9%
10%	10-30%		6944.4	**18.14**	**15.83**	-13%
12%	< 10%		5717.8	**19.75**	**16.56**	-16%
24%	> 30%	Plains of the western region	7331.8	**17.70**	**15.92**	-10%
17%	10-30%		6789.3	**18.30**	**16.43**	-10%
4%	< 10%		5586.5	**20.20**	**17.38**	-14%
6%	≥ 10%	Mountains	6910.1	**18.10**	**15.96**	-12%
18%	< 10%		5943.8	**19.35**	**16.69**	-14%

- CH_4 emissions significantly differ between indicators, particularly in systems with few maize silage (high share of grasslands).
- Farms with lower productivity emit significantly more CH_4 per litre of milk, but the difference with higher productivity farms decreases when the effect of a diet rich in grass fodders is taken into account.

Table 2: Extra-cost of milk production with an increase of grassland area per production basin.

Production basin	Marginal cost (€/1000L)	Extra-cost (€/1000L/ha)	R^2 of the cost regression
France	275.1	0.30	0.80
Plains outside the western region	286.2	-0.27	0.85
Plains of the western region	171.9	7.15	0.42
Mountains	304.68	**3.73***	0.78

Table 3: Extra-cost of milk production with an increase of grassland area per fodder system in plains.

Maize in the fodder area	Marginal cost (€/1000L)	Extra-cost (€/1000L/ha)	R^2 of the cost regression
≥ 30%	214.17	-10.45	0.75
< 30%	230.97	**7.06*****	0.74

* $p < 0.05$, *** $p < 0.001$

- Extra-costs seem particularly high in dairy systems with already high shares of grasslands:
  → Mountainous areas: less accessible areas already facing high marginal production costs.
  → Plain areas with less than 30% of maize silage.
- We find non-significant additional costs at the scale of France and in the most productive dairy systems.

Discussion and conclusions

- Our results confirm the relevance of using **CH_4 indicators taking both productivity and diet into account** in the design of payment schemes targeting the reduction of GHG emissions.
- The financial support needed to incorporate more grass in their fodder crop rotation system differs from one dairy system to another. Our results suggest that **low productivity dairy systems with already large shares of grassland areas might need higher payments** to enter a scheme such as Eco-Methane, or find less costly ways to decrease their emissions (increasing productivity). They need to be further validated by an improvement of the estimation model.
- Increasing grassland areas in dairy farms is likely to have other direct effects on farm costs that are not considered in this study → **additional barriers** to participation in payment schemes.

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Acknowledgments
This research is funded by the Horizon 2020 programme of the European Union (EU) under Grant Agreement No. 817949 (CONSOLE project, https://console-project.eu/).