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:**

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

- **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.

[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.

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.**

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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