Measuring the Marginal Abatement Cost of Reducing Nitrogen Pollution in Agriculture

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Presentation outline:

1. Introduction
2. Methodology & Data
3. Results
   - Model Results
   - Simulated MAC results
4. Conclusion & Further Discussion

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Introduction

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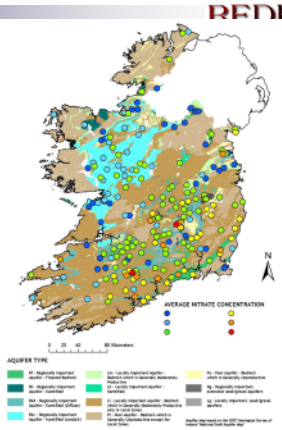
- In Ireland, as in other EU countries, Nitrate pollution of water resources is an environmental issue.
- EPA Ireland (EPAI) reports that in 2008 7% of groundwater EPAI monitoring sites failed to comply with the Irish Threshold Value concentration of 37.5 mgNO_3/L and 1% failed to comply with the Drinking Water MAC of 50 mgNO_3/L.
- Schulte *et. al.* (2006) highlight that historic intensive agricultural practices have had an important contribution to the levels of Nitrogen (N) loads in Irish rivers.

EPA Ireland

- *The percentage of wate to meet the WFD good*
  - rivers (64%),
  - lakes (64%),
  - estuarine waters (53%),
  - coastal waters (27%)
  - groundwaters (62%).



There is a wide range of literature proposing pollution mitigation measures to deal with the N emissions from agriculture:

Cuttle *et. al.* (2004)

Novotny (2003)

Merrington (2002)

Ritter (2001).

Chyzheuskaya A. et. al. "Measuring the Marginal Abatement Cost of Reducing Nitrogen Pollution in Agriculture"

Proposed Mitigation Strategies:

- **inorganic fertiliser reduction by 10%**
- **inorganic fertiliser reduction by 20%**
- **LU* reduction to achieve N 170kg/ha**
- **20% LU reduction**
- **change in feed mix**
- **fencing off adjacent streams (2 sub-scenarios)**
- **higher yield dairy cows**
- **efficient slurry application (3 sub-scenarios)**

Model is driven by previous research:

- **Cuttle et. al. (2005)**
  - used linear Programming Approach to estimate 43 measures
- **Fezzi et. al. (2007)**
  - used Farm Accounting approach to estimate 4 of measures proposed by Cuttle et al
- **Hennessy *et. al.***
  - used economic modelling to determine the effect of introducing a limit on organic nitrogen (N) of 170 kg/ha on a dairy system and farm profit.

Methodology & Data

Model

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Step 1 – Data Analysis
- ❑NFS 2008: collected annually since 1972
- ❑Dairy + Dairy Other Farms: defined on the basis of the prevalent enterprise on the farm
- ❑GIS data

Step 2 – Estimation of Production and Cost functions
- ❑ Estimate Production and Cost Functions for each enterprise using Log – Polynomial Regression,
  - **dependent** log variables are GM, GO, DC per LU
  - **explanatory** variables related enterprise variables

Y = B0+B1X1+....BnXn + e
- ❑Save betas and error terms for microsimulation.

Scenarios:
1. Baseline
2. Fert. reduction by 10%
3. Fert. reduction by 20%
4. LU reduction to achieve 170kg/ha
5. LU reduction by 20%
6. Use new feed mix
7. Fencing off streams
8. Increase breeding index
9. Slurry Efficiency

Step 3 – Microsimulation
- ❑Change independent variables according to scenarios
- ❑Estimate new dependent variables using changed Xs and betas & error terms from previous estimation

Step 4 -Calculate Nitrogen production → MAC

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Scenarios

1. Fertiliser Reduction by 10%

2. Fertiliser Reduction by 20%

Number of kg of N fertiliser per LU is reduced by 10 & 20 % respectively

3. LU* reduction to achieve N 170kg/ha

4. 20% LU reduction

In (3) the measure are modelled that the farmers would drop the LU with the lowest GM first.

In (4) all LU are reduced by 20%

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Scenarios 2

5. Change in feed mix

Through utilising more efficient feed the amount of N excreted can be reduced by 10-15%, extra cost is assumed to be 25%.

6. Fencing off Adjacent Streams

The 10m zones are assumed to be fenced off

Two possible sub-scenarios estimated:

1) the possible intensification of production

2) the decrease in intensity

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Scenarios 3

7. Efficient Slurry Application

Method	Splashplate		Trailing Shoe	
Timing	Summer	Spring	Summer	Spring
Total N content (kg/m^3)	3.6	3.6	3.6	3.6
NFRV %	12%	21%	22%	30%
Available N in slurry (kg/m^3)	0.43	0.76	0.79	1.08
N fertilizer advice per cow at stocking rate of 2 LU/ha (kg/ha)	100.5			
Slurry production per cow (m^3 in a 16 week winter period)	5.3			

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Higher Yield Dairy Cows

New reduced size of the dairy herd is calculated and the effect of the reduction on direct costs, gross margin and N reduction is estimate through microsimulation as explained in the simulation paragraph.

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Results

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Results 1: Changes in GM, GO, DC

Scenario	GM	DGM	DGO	DDC	CGM	CGO	CDC	SGM	SGO	SDC
fert -10%	-1.31	-1.07	-1.24	-1.52	-0.47	-1.41	-1.84	-22.37	-3.81	11.66
fert-20%	-2.82	-2.50	-2.77	-3.21	-0.86	-2.87	-3.77	-43.43	-6.73	23.87
reduce LU 170kg	-0.02	0.00	0.00	0.00	-0.12	-0.22	-0.27	0.00	0.00	0.00
reduce LU -20%	-20.01	-19.89	-18.63	-16.55	-13.60	-15.70	-16.65	-36.61	-17.99	-2.45
feed change	-5.69	-6.13	0.00	10.09	0.00	0.00	0.00	0.00	0.00	0.00
fencing-off (intensif)	-0.22	-0.12	-0.10	-0.06	0.88	0.14	-0.19	2.55	1.20	0.08
fencing-off (de-intensif)	-2.07	-1.69	-1.63	-1.51	-0.12	-1.17	-1.64	-3.67	-0.51	2.13
slurry 1	-0.35	0.25	0.00	-0.42	0.00	0.00	0.00	0.00	0.00	0.00
slurry 2	-0.22	0.41	0.00	-0.68	0.00	0.00	0.00	0.00	0.00	0.00
slurry 3	-0.11	0.54	0.00	-0.88	0.00	0.00	0.00	0.00	0.00	0.00
Breeding Index	3.67	4.47	0.00	-7.35	0.00	0.00	0.00	0.00	0.00	0.00

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Results 2: Changes in N

Scenario	OrgN	InOrgN	Total N
fert -10%	0.00	-10.00	-6.12
fert-20%	0.00	-20.00	-12.23
reduce LU 170kg	-0.12	0.00	-0.05
reduce LU -20%	-20.00	0.00	-7.77
feed change	0.00	-15.00	-7.50
fencing-off (de-intensif)	-1.52	-1.49	-1.50
slurry 1	0.00	-0.85	-0.52
slurry 2	0.00	-1.38	-0.85
slurry 3	0.00	-1.88	-1.15
Breeding Index	-6.64	0.00	-2.58

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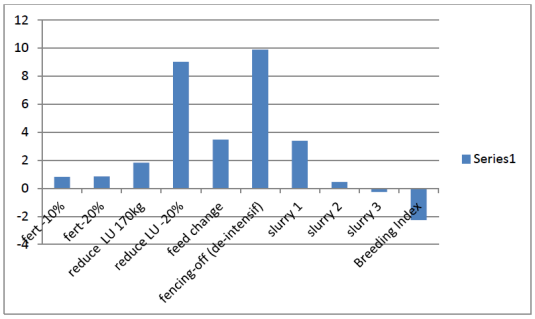
Results 3: Average MAC



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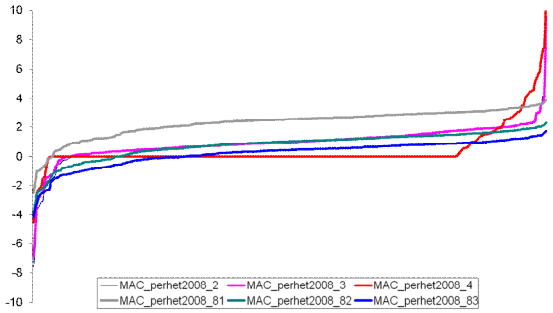
Results 4. MAC per farm



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Conclusion & Further Discussion

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Limitations of the model:

- *The model doesn't utilise the N balance on the farms. Full N inputs= N outputs model needs to be included*
- *Needs to be estimated for different farm systems (different cost-efficiency for different systems)*
- *Lack temporal and spatial dimension*
- *Combination of different measures*

Thank you!