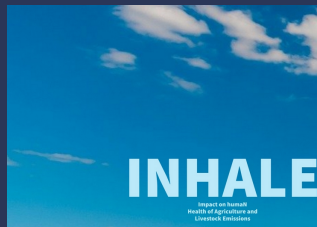


# Contribution of agriculture to the PM pollution in Lombardy A data science study preliminary results



4<sup>th</sup> Expert Panel on Clean Air in Cities (EPCAC)

L. Aleluia Reis<sup>†</sup>, F. Granella, S. Renna, J. Lunghi and M. Malpede

16 November 2022

<sup>†</sup> RFF-CMCC European Institute on Economics and the Environment

**Bocconi**



**RFF  
CMCC** European Institute  
on Economics  
and the Environment



Fondazione  
**CARIPLO**



- ◇ 56.000 premature deaths due to PM2.5 in Italy (EEA 2020),

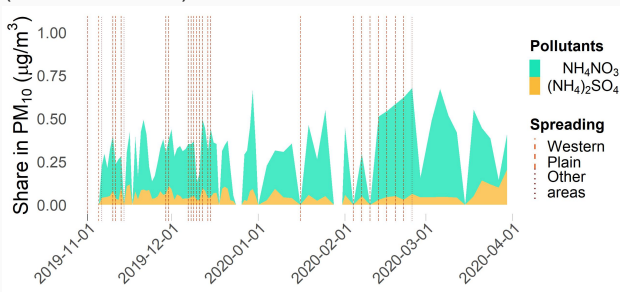
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# MOTIVAZIONE

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## INHALE - IMPATTI SULLA SALUTE UMANA DI AGRICOLTURA ED EMISSIONI DA ALLEVAMENTO

- Analyse the impact of agriculture on the air pollution in Lombardy, using 2 frameworks:
  - **Machine learning** differences-in-differences: using the natural experience of the COVID-19 lockdown (Granella et al 2021 *Environ. Res. Lett.* **16** 035012)

## INHALE - IMPATTI SULLA SALUTE UMANA DI AGRICOLTURA ED EMISSIONI DA ALLEVAMENTO

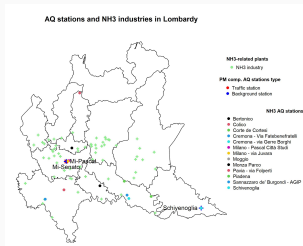
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  - **Causal inference**: Estimate the impact of agriculture intensity policies

- concentrations: Ammonium sulphates and Nitrates, Ammonia [ $\text{NH}_3$ ], nitrogen oxides [ $\text{NO}_x$ ], and in some cases [ $\text{PM}_{2.5}$ ] e [ $\text{PM}_{10}$ ] (from ARPA Lombardia)

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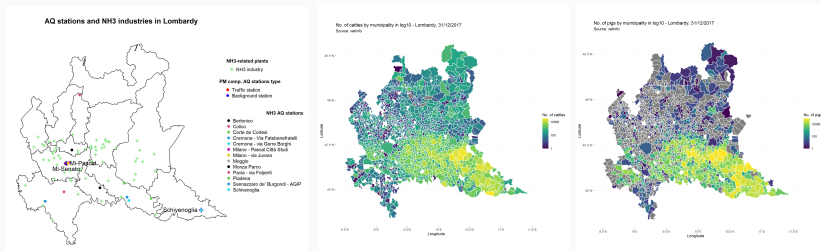
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- Meteorological data <https://dati.lombardia.it/>
- Industries that used NH<sub>3</sub>



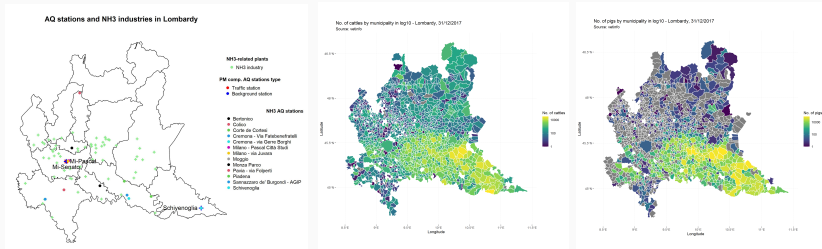
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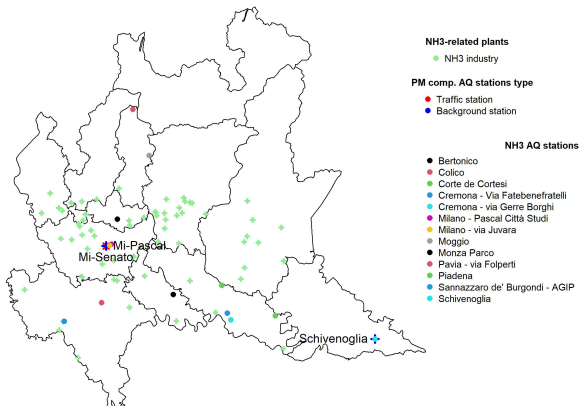
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- National zootechnical registry
- Landuse data (DUSAF, version 6.0)

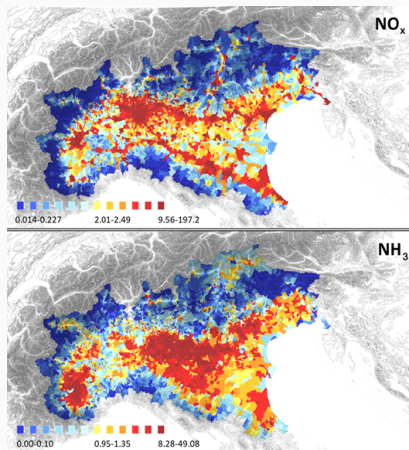


# DATA — STATIONS WITH CHEMICAL COMPOSITION OF PM<sub>10</sub>

## AQ stations and NH<sub>3</sub> industries in Lombardy



# EMISSIONS SPATIAL DISTRIBUTION



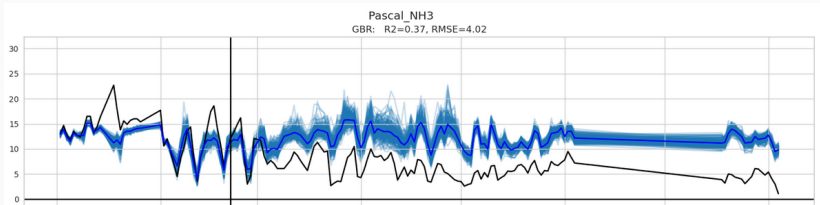
- Marongiu, A. , Angelino, E. , Moretti, M. , Malvestiti, G. and Fossati, G. (2022) Atmospheric Emission Sources in the Po-Basin from the LIFE-IP PREPAIR Project. Open Journal of Air Pollution, 11, 70-83. doi: 10.4236/ojap.2022.113006.

**How can we use the COVID-19 Lockdown to isolate the effect of Agriculture?**

- Building counterfactual models to estimate SIA using only on meteorological variables and their strong relationship with pollution

# SCHIVENOGLIA — RURAL BACKGROUND STATION

- Building counterfactual models to estimate SIA using only on meteorological variables and their strong relationship with pollution



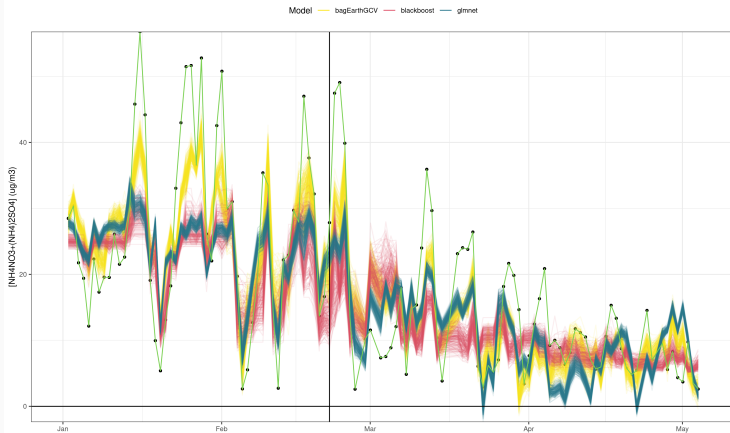
# BUILDING COUNTERFACTUAL - DEALING WITH MODEL UNCERTAINTY

- We have used Machine learning methods to build the SIA counterfactual and estimate what would have been the SIA concentration had the Lockdown not happen:
  - SIA concentrations predicted using only weather variables
- First results showed large variability in out of sample validation
- Low number of available SIA data → high variability in performance

Finally: we used 7 different cross-validated machine learning methods using 200 random samples of train and test sets.

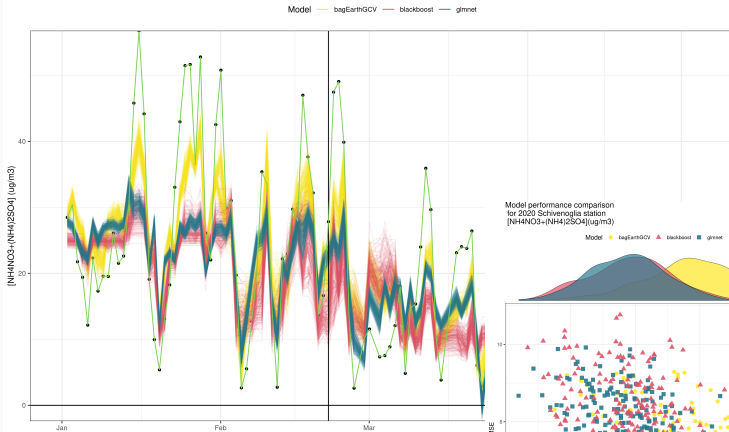
# SCHIVENOGLIA — RURAL BACKGROUND STATION

Model fitting for  
2020 Schivenoglia station  
[NH<sub>4</sub>NO<sub>3</sub>+(NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>]

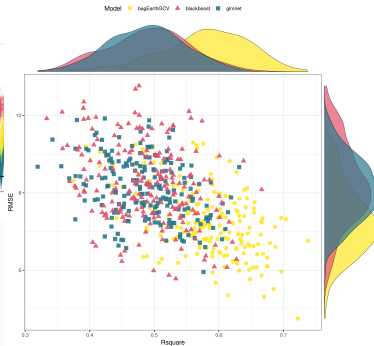


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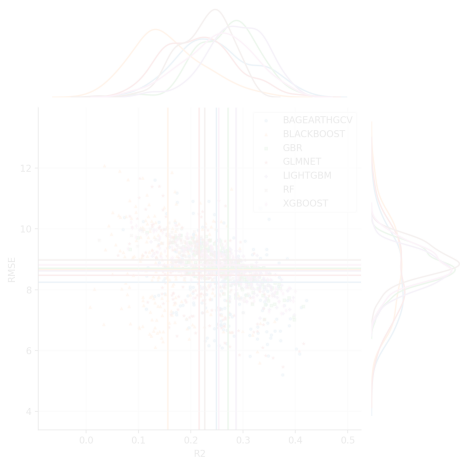


Model performance comparison  
for 2020 Schivenoglia station  
[NH<sub>4</sub>NO<sub>3</sub>+(NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>](ug/m<sup>3</sup>)





Senato [NH4NO3+(NH4)2SO4]



# DO THE MODELS PREDICT A SIGNIFICANT IMPACT OF THE LOCK-DOWN ON SIA?

---

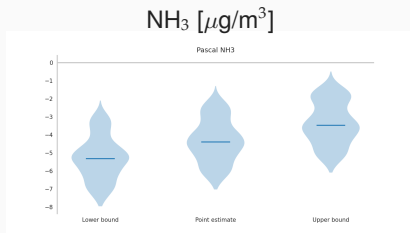
- **Lockdown impact – > differences-in-differences, regression of**

$$y - \hat{y} = \alpha + \beta \textit{lockdown} + \epsilon$$

- **Decision under uncertainty**

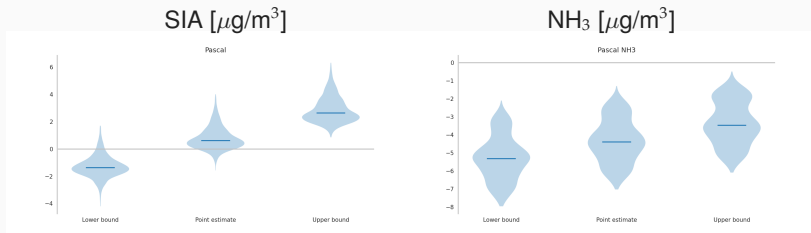
- $\text{NH}_3$  has significantly decreased

# PASCAL URBAN BACKGROUND: DIFFERENCE-IN-DIFFERENCE



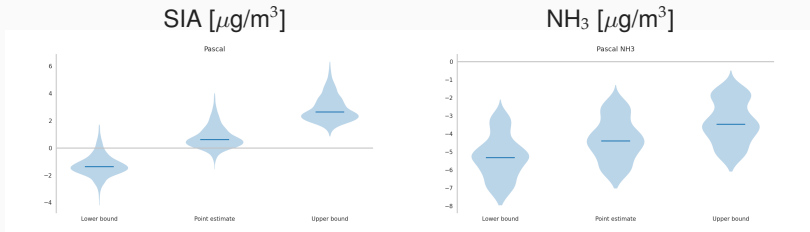
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- NO<sub>x</sub> decreased (Granella et al. 2021)

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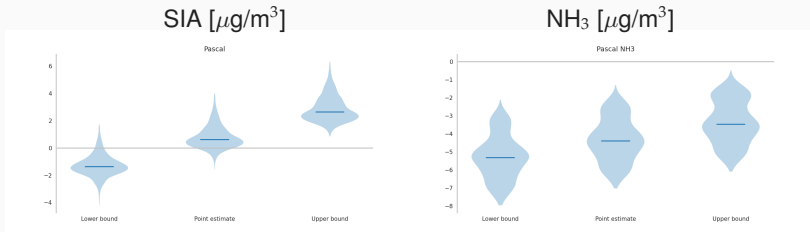
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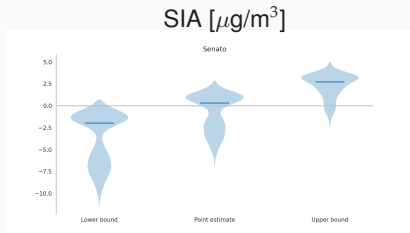


- NH<sub>3</sub> has significantly decreased
- NO<sub>x</sub> decreased (Granella et al. 2021)
- No significant effect on SIA
- as in: P. Thunis et al. (2021)
- NH<sub>3</sub> decrease may be due to traffic activity reduction

- $\text{NH}_3$  decreased in PASCAL (near Senato)

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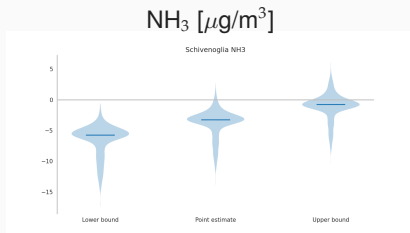
# SENATO TRAFFIC STATION: DIFFERENCE-IN-DIFFERENCE



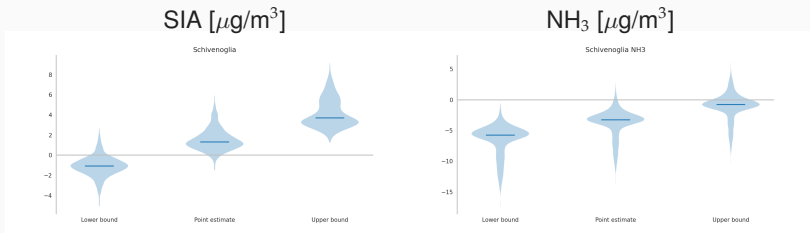
- $\text{NH}_3$  decreased in PASCAL (near Senato)
- $\text{NO}_x$  decreased (Granella et al. 2021)
- Best performing model: significant decrease
- Multi-criteria weighted average: no significant decrease

- $\text{NO}_x$  has decreased (Granella et al. 2021)

# SCHIVENOGLIA RURAL BACKGROUND: DIFFERENCE-IN-DIFFERENCE

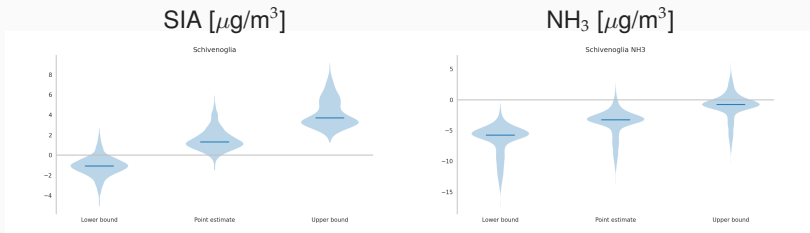


- NO<sub>x</sub> has decreased (Granella et al. 2021)
- NH<sub>3</sub> significantly reduced in best model and multi criteria weighted average decision



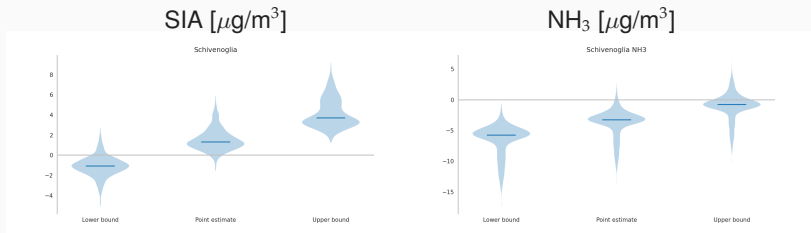
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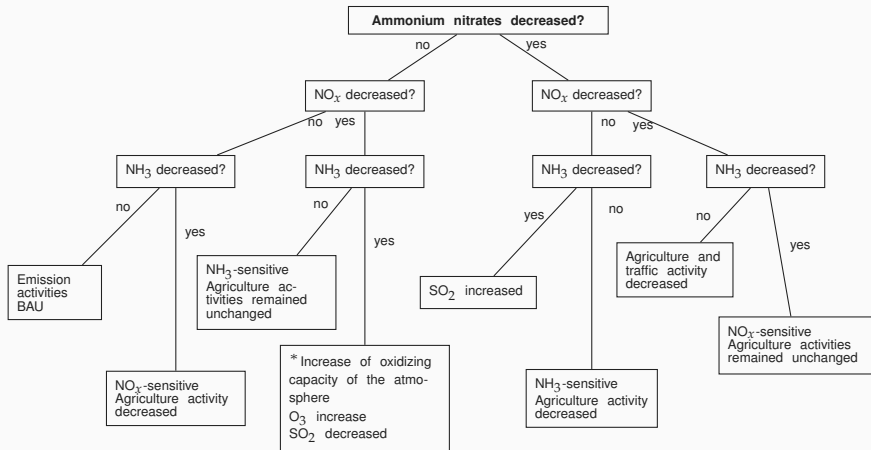
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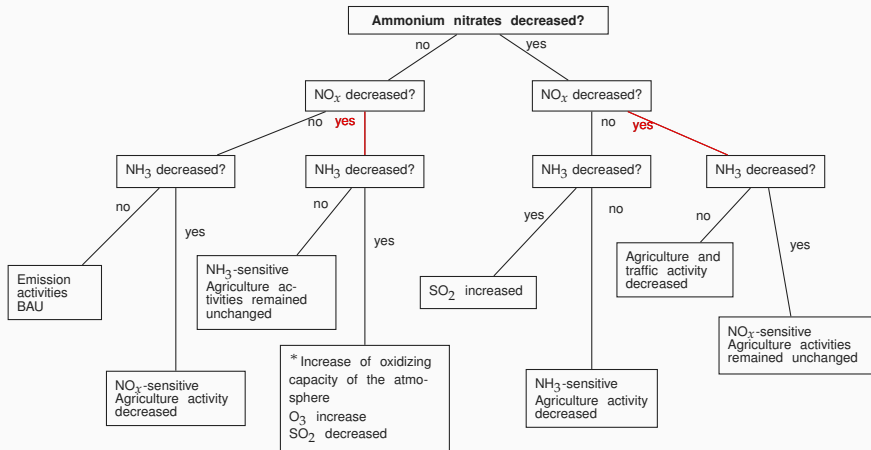
# UNDERSTANDING WHAT HAPPEN DURING THE DRASTIC HALT IN HUMAN ACTIVITIES— DID AGRICULTURE PLAY A ROLE?



\* Thunis, P., Clappier, A., Beekmann, M., Putaud, J. P., Cuvelier, C., Madrazo, J., de Meij, A. (2021). Non-linear response of PM2.5 to

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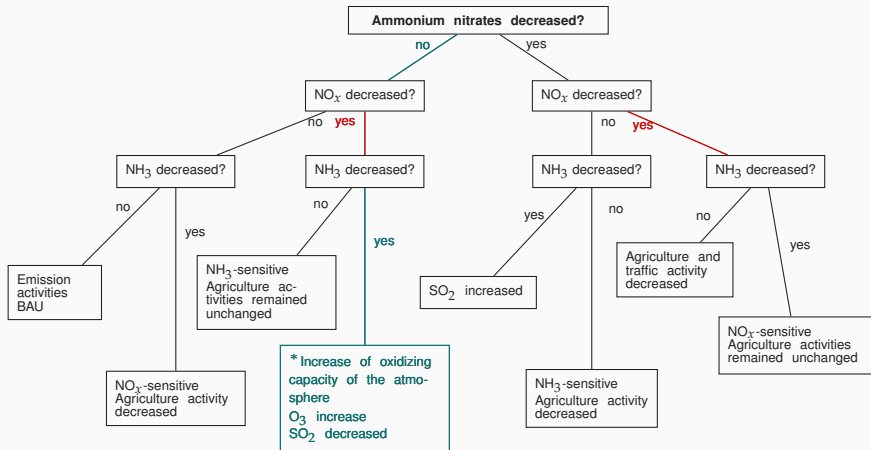
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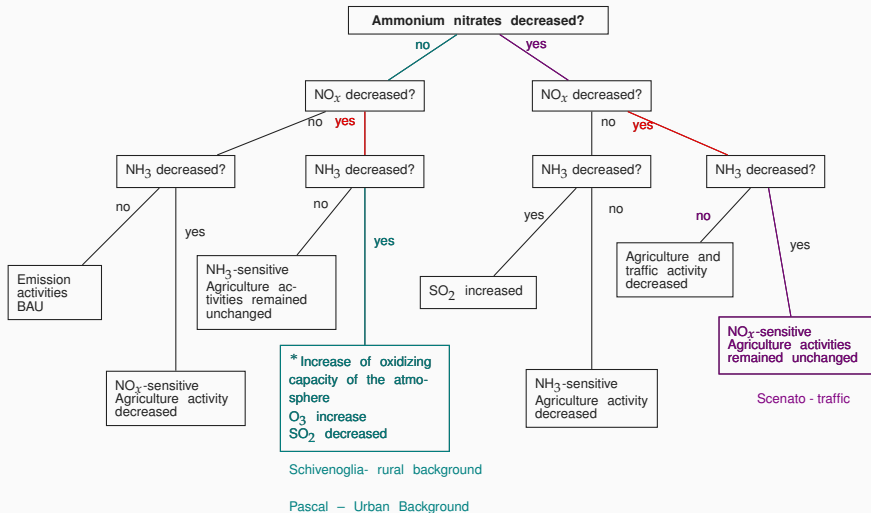


Schivenoglia- rural background

Pascal – Urban Background

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- **What is the marginal effect on pollution when adding or removing one single animal unit?**

# SPECIFICATION — ESTIMATE THE IMPACT OF AGRICULTURE INTENSITY POLICIES

$$C_{p,i,t} = \beta_0 + \sum_{j \in \mathcal{B} \cap \mathcal{G}} \sum_{a \in A} \beta_a \Delta L_{a,j,t} \times \Omega + X'_{i,t} \Gamma + \Lambda_{i,t,d}$$

- $C$  daily concentration of pollutant  $p$  in station  $i$  at time  $t$ ,  $p \in NH_3, PM_{10}$

- $\mathcal{B}$  is defined as

$$\{j \in \mathcal{B} : d_{ij} < \bar{r}\}$$

containing all the municipalities at distance  $\bar{r}$  from  $i$

- $\mathcal{G}$  defined as

$$\{j \in \mathcal{G} : \angle_{ij}, t \in WD_{i,t}\}$$

all the municipalities placed on wind direction measured in  $i$  at time  $t$  ( $WD_{i,t}$ )

- $A$  cattle and swines

$\Rightarrow$  for each station we have the variation of livestock units ( $\Delta L$ ), calculated as the net variation of all municipalities found on the wind direction in time  $t$  and distance  $r$  from the monitoring stations.

# DATA - ESTIMATE THE IMPACT OF AGRICULTURE INTENSITY POLICIES

Average Inflow



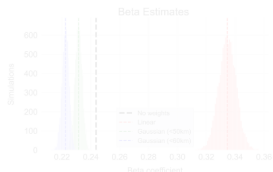
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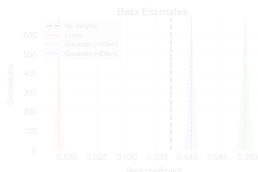
# RESULTS — ESTIMATE THE IMPACT OF AGRICULTURE INTENSITY POLICIES

[I]  $\text{NH}_3$

[A] Cattle

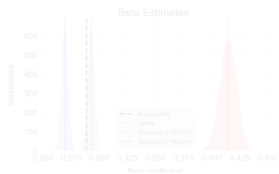


[B] Swine

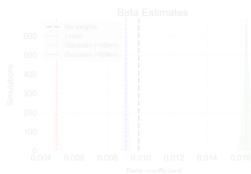


[I]  $\text{PM}_{10}$

[A] Cattle



[B] Swine



## CONCLUSIONS AND FURTHER WORK

- In rural areas the SIA remained insensitive to the lockdown, showing that in these sites air pollution policies need to target livestock emissions.
  - Ongoing work: building  $\text{NO}_x$ - $\text{NH}_3$  SIA isopleths per station
- The ammonia reductions (probably from traffic too) were instrumental in decreasing SIA in the traffic areas
- average effect of 1% increase in cattle livestock intensity translates into 1.8% average increase in ammonia concentrations and up to 0.425  $\text{PM}_{10}$   $\mu\text{g}/\text{m}^3$
- Use the effect of manure broadcasting to estimate health impacts (PhD thesis Lunghi J.)

**Questions?**  
**[lara.aleluia@eiee.org](mailto:lara.aleluia@eiee.org)**