Uncertainty and sensitivity analysis of land shares model over EU

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Introduction

- Agricultural sector contributes up 10.6% of total greenhouse gas (GHG) emission in the EU27 (EEA [1])
  interest in modeling environmental impacts of agricultural activities
- GHG emissions and environmental indicators depend on local land use shares, biophysical characteristics and management factors [2][3]
- Objective: predict the distribution of crop shares over the new Homogenous Spatial Units (HSU)
  - build Land Shares Model at NUTS2 level
  - downscaling at HSU (1km*1km) and quantify the uncertainty

Method: Land Shares Model (LSM)

- Multinomial logit model at administrative (NUTS 2) level
  Let
  $\mathbf{X} = [TEXTURE, SAND, CLAY, OC, ALT, SLP, RAIN, TEMP, VEGP, CLC, Prices]$ be explanatory variables and l be a land use.
  The probability to find l at point i is:

$$\mathbb{P}(Y_i = l) = \frac{\exp^{(\beta_l' \mathbf{x}_i)}}{\sum_{l=1}^{L} \exp^{(\beta_l' \mathbf{x}_i)}},$$

  with β_l a vector of parameters and L is the number of land use.
- Local Multinomial logit: bandwidth selection
  - choose number of points to include in the model at NUTS2 level
  - give a weight to observations to preserve local properties
  Cross validation with F-measure [4] as effectiveness criteria.

Method: prediction of land Shares over HSU

- Statistical disaggregation
  Hypothesis: stability of coefficients within a NUTS 2
  For each HSU (1km*1km), characterized by $\mathbf{X}_h$, the crop share is:

$$\widehat{\mathbb{P}(Y_h = l)} = \frac{\exp^{(\hat{\beta}_l' \mathbf{x}_h)}}{\sum_{l=1}^{L} \exp^{(\hat{\beta}_l' \mathbf{x}_i)}} * A_h,$$

  where A_h is the total area of HSU and $\hat{\beta}_l$ is the weighted likelihood estimator of β_l.

Method: uncertainty and sensitivity analysis

- Multivariate Sensitivity Analysis [5]
  Let $S = [S_1, S_2, \ldots, S_L] = f(\beta, \mathbf{x})$ be model outputs of LSM. Inertia is decomposed like:

$$\mathbb{I}(S) = \sum_{j=1} \mathbb{I}(\beta_j) + \sum_{i<j} \mathbb{I}(\beta_i, \beta_j) + \ldots,$$

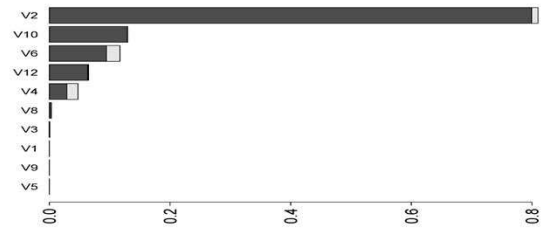
  The first order and total Generalized Sensitivity Indices (GSI) are:

$$GSI_j = \frac{\mathbb{I}(\beta_j)}{\mathbb{I}(S)} \qquad GSI_{T.j} = \frac{\sum_{u \supseteq_j} \mathbb{I}(\beta_u)}{\mathbb{I}(S)}$$

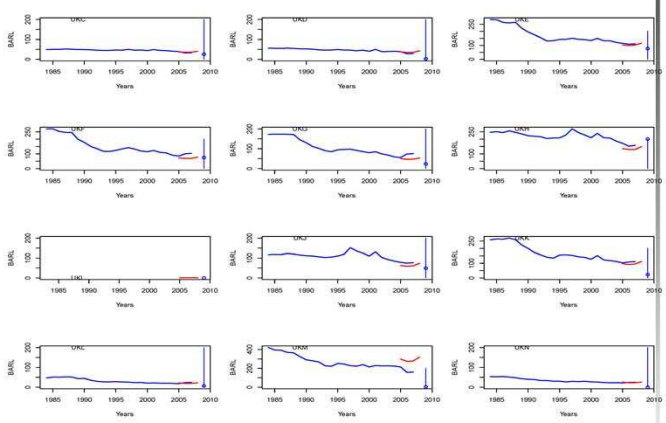
- MSA is applied to select the most influential parameter
  model for UKC1 includes 15 parameters (pre-selected)
- Uncertainty Analysis of prediction shares over HSU
  - perform a LHS design with most influential parameters
  - replicate model prediction for each sample point

Result: GSI Indices of LSM for UKC1

Top ten first order and total GSI



Result: uncertainty of predictions at NUTS 1



Barley Shares from CAPRI (Blue), EUROSTAT (red), prediction in UK

Conclusion

- prediction of the crop shares over the new HSU
- Predicted crop shares follow the trends of statistics in general
- Perspective
  - include the statistics of crop shares in the process of coefficient estimation (Bayesian approach)

References

-[1] EEA, Annual European Community greenhouse gas inventory 1990 - 2010 and inventory report 2012. Submission to the UNFCCC secretariat. European Environment Agency.
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-[4] D. Powers, Evaluation: From precision, recall and f-factor to roc, informedness, markedness | correlation, Journal of Machine Learning Technologies 2 (2011) 37-63.
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