A robust Bayesian analysis of the impact of policy decisions on crop rotations

Lewis Paton[1],Matthias Troffaes[1]
Nigel Boatman[2], Mohamud Hussein[2]

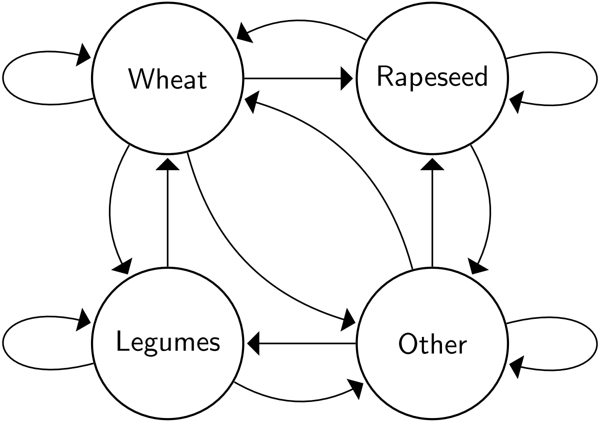
1: Department of Mathematical Sciences, Durham University
2: The Food and Environment Research Agency

20th July, 2015

Introduction

- Model and predict agricultural land use.
- Aim to aid a policy decision e.g level of taxation, level of subsidy etc.
- Problem: Some crop types are rare - few observations.
- Problem: Prior expert opinion can be difficult to obtain.
- Use Markov chains with a robust multinomial logit model.

The model



The model

- Transition probabilities influenced by external factors e.g. rainfall, nitrogen price etc.
- Assume parametric model for these probabilities - multinomial logit model.
- Specify a prior distribution for the parameters of this model.

The model

- Transition probabilities influenced by external factors e.g. rainfall, nitrogen price etc.
- Assume parametric model for these probabilities - multinomial logit model.
- Specify a prior distribution for the parameters of this model.
- Prior expert opinion difficult to obtain $\rightarrow$ use sets of prior distributions.
- Similar approach to the imprecise Dirichlet model – near vacuous set of priors.
- Model gives lower and upper posterior transition probabilities.

Policy example

- Interest in analysing impact of policy changes.
- Governments can influence crop choice through policy to meet the needs of society.
- Increased global meat demand, so increased demand for protein crops e.g legumes.
- Higher nitrogen price $\rightarrow$ more legumes being grown.
- Use imprecise model to aid policy makers.

Policy example

- Assume a utility function:

$$U(a, b) = 100a - \kappa b$$

- a = fraction of legumes across all farms.
- b = nitrogen price.
- κ is chosen to control how b is weighted against the level of legumes.

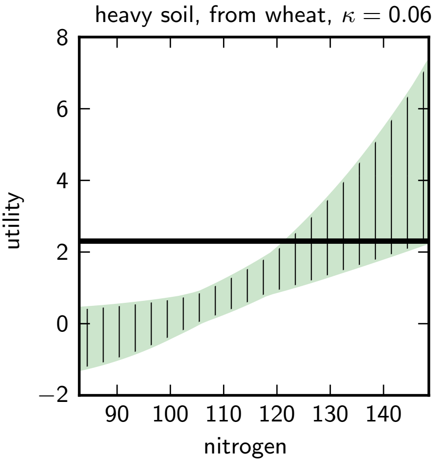
Policy example

- Imprecise model gives $\underline{U}(a, b)$ and $\overline{U}(a, b)$.
- Use interval dominance.
- Set $\mathcal{B}$ of feasible b values.
- All $b \in \mathcal{B}$ such that

$$\overline{U}(a, b) \geq \max_{b \in \mathcal{B}} \underline{U}(a, b)$$

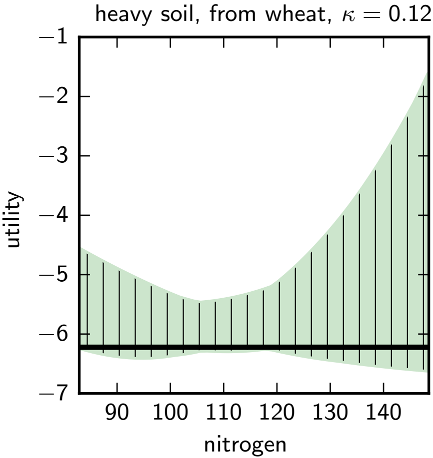
are deemed optimal by interval dominance.

Policy example



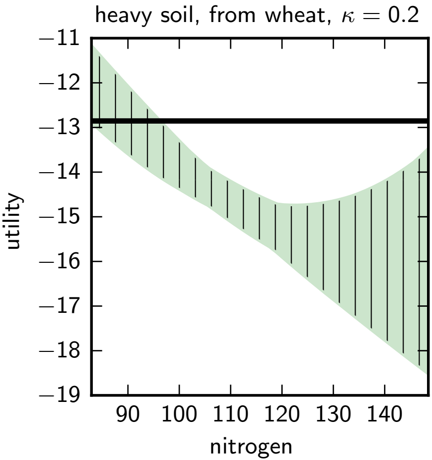
- Higher nitrogen price preferred. Suggested policy decision – higher tax on nitrogen.

Policy example



- All nitrogen prices optimal by interval dominance.

Policy example



- Lower nitrogen price preferred. Suggested policy decision – lower tax on nitrogen.

Conclusion

- Robustly model and predict agricultural land use.
- Can answer (hypothetical) decision problems with real-world relevance.
- Can show benefits of imprecise probabilistic methods to policy makers.
- Could use more realistic utility function – needs elicitation from experts.