Reconciling information from alternative climate-economic models: a posterior integration approach

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Background
Studies of complex systems are non-separable from the analysis of partial and imprecise information received from alternative sources. A system analyst deals with a set of ensemble outcomes which needs to be integrated into one estimate in order to install the ensemble into the modelling chain or provide support for the informed decision making.

Integration Method
We suppose that several independent models 1, … , 𝑛 are used to estimate a deterministic element 𝑧 (the true value of the output variable of a complex system) and give some probability 𝜋𝑖 to 𝑧 on 𝑍. The posterior integration method (Kryazhimskiy, 2013) is based on the assumption that model outcomes are mutually compatible, i.e. we should observe identical outcomes after the use of model ensemble. Formally, the product probability distribution of original estimates is

\[ \pi(z) = \prod_{i=1}^{n} \pi_i(z) \]

where \( \pi_i(z) \) is the probability of the output variable \( z \) from the \( i \)-th model.

Structural Dynamic Economic Model (SDEM)
- SDEM is an actor-based climate-economy model
- it does not require substantial computational resources in simulations
- climate module: dynamic equations for CO₂ concentration and global mean surface air temperature
- economic module: system dynamic approach

Findings
- Product of original estimates shows that models reconcile to less extreme predictions on the development of the climate-economic system

Original model-based distributions are harmonized by posterior integration method. In the integrated model mean estimate of the global temperature increase is reduced, CO₂ concentration and emissions are expected to grow. Along with this, expected economy growth is higher than each individual model predicts. These effects hold in both scenarios - with and without introduction of carbon tax.

- The range of predictions can expand after integration of original estimates, depending on the way how these estimates were combined

Taking average from the model-based distributions can be viewed as an alternative method. It’s not necessary that qualitative results will coincide with results from the posterior integration method.

- Product of original estimates is more informative

The standard deviation of the product distribution is less than in the original model-based estimates in both scenarios. This means that original probability distributions complement each other (in the context of posterior integration method). From the assumption of posterior integration method original models should be mutually compatible and reconciled on the identical outcomes, consequently their product distribution is not skewed.

References

Acknowledgements
This work received support from the EU FP7 project COMPLEX (grant no. 308601)