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Student Topic

Error correlation in input-output frameworks

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Rationale

Today, many frameworks for environmental and sustainability assessment utilise input-output techniques (Forssell and Polenske 1998). These techniques are based on input-output analysis, a discipline founded by Nobel Prize Laureate Wassily Leontief in the 1940s (Leontief 1936). Since its invention, numerous analysts in academia, industry and government alike, use input-output analysis for economic and environmental studies (Foran, Lenzen et al. 2005; Foran, Lenzen et al. 2005). More than 100 countries worldwide regularly publish input-output tables, according to guidelines governed by the (United Nations Department for Economic and Social Affairs Statistics Division 1999).

More recently, users of environmental assessments are increasingly asking for uncertainty appraisals to be provided along with main findings. In any quantitative study, this requires uncertainty techniques to be applied.

There are a number of examples that demonstrate state-of-the-art uncertainty analysis, however these are still the exception. The rationale of this project is to contribute to the advancement of uncertainty calculus in environmental analysis.

Research question

Soon after Leontief's initial publications, researchers started to apply uncertainty calculus to input-output analysis. One prominent technique that has been utilised is Monte-Carlo analysis (Bullard and Sebald 1988). This is because researchers recognised that Leontief's basic input-output relationship $\boldsymbol{x} = (\mathbf{I} - \mathbf{A})^{-1} \boldsymbol{y}$, linking final demand $\boldsymbol{y}$ with gross output requirements $\boldsymbol{x}$, cannot be differentiated analytically with regard to single elements A_{ij} of $\mathbf{A}$ (Quandt 1958; Quandt 1959; Bullard and Sebald 1977).

In the majority of Monte-Carlo analyses of input-output systems, researchers have assumed that the uncertainty of basic input-output data can be formulated in terms of normally distributed, uncorrelated, stochastic errors, with defined standard deviations (Quandt 1958; Goicoechea and Hansen 1978; Hanseman and Gustafson 1981; Hanseman 1982; Lenzen 2001). These standard deviations are sourced for components of $\boldsymbol{y}$ and of $\mathbf{A}$, and used for perturbing $\boldsymbol{y}$ and $\mathbf{A}$ to $\boldsymbol{y}^*$ and $\mathbf{A}^*$. From the latter, perturbed input-output multipliers $\boldsymbol{m}^* = (\mathbf{I} - \mathbf{A}^*)^{-1}$ are calculated, and compared with the initial multipliers $\boldsymbol{m} = (\mathbf{I} - \mathbf{A})^{-1}$ (Sakai, Tanno et al. 2000). Relative standard deviations $\Delta\boldsymbol{m} = (\boldsymbol{m}^* - \boldsymbol{m}) / \boldsymbol{m}$ for these multipliers are then estimated from typically many thousand perturbation runs (Evans 1954; Park 1973; Bullard and Sebald 1977).

However, due to the data collection procedures followed in national statistical agencies, it is likely that deviations from mean of a particular input-output data point are neither normally distributed, nor uncorrelated (Stevens and Trainer 1980; Park, Mohtadi et al. 1981; Rey, West et al. 2004). This project will focus on these two assumptions.

Tasks

For the example of the Australian input-output system (Australian Bureau of Statistics 2004; Australian Bureau of Statistics 2004; Australian Bureau of Statistics 2005), this project will test the influence of

a) error data that is distributed other than normally, and
b) correlation structures between the errors of certain entries A_{ij} in $\mathbf{A}$,

on resulting standard deviations $\Delta \boldsymbol{m}$ for input-output multipliers (West 1986; Jackson and West 1989; Kop Jansen 1994; Ten Raa and Steel 1994).

For examples, it will be assumed that the errors of a particular entry A_{ij} of $\mathbf{A}$ are partly correlated with other entries A_{ik} in the same rows, and other entries A_{kj} in the same columns. Such a correlation will likely increase overall errors of multipliers compared to the fully uncorrelated case.

Particular tasks:

- Literature review of approaches to uncertainty calculus applied to input-output systems;
- Collection of information on the distribution and correlation of errors in Australian National Accounts data;
- Tailoring of existing Monte-Carlo code to include distributions other than normal, and partial error correlation;
- Calculation of revised multiplier error estimates;
- Preparation of a manuscript for submission to an international, peer-reviewed journal such as *Economic Systems Research*, or *Journal of Regional Science*.

Results

The results of this project will be valuable, because they will cast light on the question whether traditional assumptions of uncorrelated, normally distributed raw data errors lead to uncertainty estimates of environmental assessment results that are too low, and hence provide decision-makers using these results with expectations that are too optimistic in terms of analytical reliability.

Skills required

- Good understanding of matrix algebra
- Understanding of basic statistics, such as distributions
- Programming in MatLab, FORTRAN or C
- Basic understanding of economics, or willingness to learn
- Good scientific writing style

Supervisor

Prof Manfred Lenzen

Further reading

For a basic overview of input-output analysis, see the Introduction in Vol. 1 of (Foran, Lenzen et al. 2005), or read (Duchin 1992; Dixon 1996; Forssell and Polenske 1998). For a historical overview of input-output analysis, see (Rose and Miernyk 1989).

For approaches to uncertainty analysis of input-output systems other than Monte-Carlo, see (Zadeh 1967; Sonis and Hewings 1989; Sonis and Hewings 1995).

For examples of Monte-Carlo algorithms, see (Peters 2007).

For examples how uncertainty analysis is important in Life-Cycle Assessment (LCA), see (Morgan, Morris et al. 1984; Hoffmann, Weidema et al. 1994; Huijbregts 1998; Huijbregts 1998; Hofstetter 2000; Nansai, Tohno et al. 2001; Yoshida, Ishitani et al. 2001; Yoshida, Ishitani et al. 2002; Lenzen 2006).

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