Implementation of SAE to the Dutch Structural Business Survey

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Introduction

- Research into application of small area estimation (SAE) to business surveys.
- Target variables:
  - continuous and skewly distributed,
  - large differences between enterprises and existence of outliers,
  - variables with many zeroes.
- Model specification:
  - random slope models, transformation of variables, unequal variance structure.
- In collaboration with University of Southampton (Nikos Tzavidis, Hukum Chandra): M-Quantile estimation, ...

Aims of current research

- Consideration of Dutch Structural Business Survey (SBS).
  - Measurement of annual total production and cost-benefit structure of enterprises in the Netherlands.
  - Focus on one sector: the retail trade.
- Getting reliable and consistent estimates
  - for a selection of 9 (related) structural variables,
  - at different publication levels,
  - satisfying preconditions imposed by production process.
- Investigating possibilities and (eventually) implementation of SAE.

Structural target variables

- Variables and relations

$$\begin{aligned}\texttt{results} &= \texttt{returns} - \texttt{costs}\\ \texttt{returns} &= \texttt{turnover} + \texttt{other returns}\\ \texttt{costs} &= \texttt{costs of goods sold} + \texttt{personnel costs}\\ &\quad + \texttt{depreciation} + \texttt{other costs}\end{aligned}$$

- Abbreviation of variable names

$$\begin{aligned}R &= T - C\\ T &= T_1 + T_2\\ C &= C_1 + C_2 + C_3 + C_4\end{aligned}$$

Publication levels

- Based on Standard Industrial Classification (SIC):
  - classification of enterprises according to economic activity,
  - represented by 5 digit SIC-code.
- Given by 5digit cells, industries, sectors and whole population
  - formed by combinations of SIC-codes,
  - publication levels are nested,
  - totals should add up to totals at higher level.
- Sampling design SBS stratified at the level of industries
  - sample sizes industries are fixed,
  - sample sizes 5digit cells are random and can be 0.
- Retail trade: 71 5digit cells and 27 industries.

Earlier results

- Considered situations
  - `turnover` per industry,
  - `results`, `returns` and `costs` per 5digit cell.
- Considered estimators
  - EBLUP (J.N.K. Rao, 2003), SAEtrans (C. Chandra and R. Chambers, 2011)
  - M-Quantile estimator (R. Chambers and N. Tzavidis, 2006)
  - GREG, Survey Regression (C. Särndal et al, 1992)
- Results
  - SAE more accurate than GREG and Survey Regression,
  - for industries M-Quantile most accurate, for 5digit cells EBLUP,
  - SAEtrans most accurate if no strong covariate available (`tax turnover`).

Preconditions production process

- Totals of industries must be estimated by linear weighting
    - based on the generalized regression estimator (GREG, Särndal et al, 1992).
- `turnover` is replaced by `tax turnover`
    - totals of `turnover` equated with totals of `tax turnover`,
    - totals of other variables estimated with `turnover` as covariate and totals of `tax turnover` as population totals.

Considered estimator

- EBLUP based on following model (J.N.K. Rao, 2003):

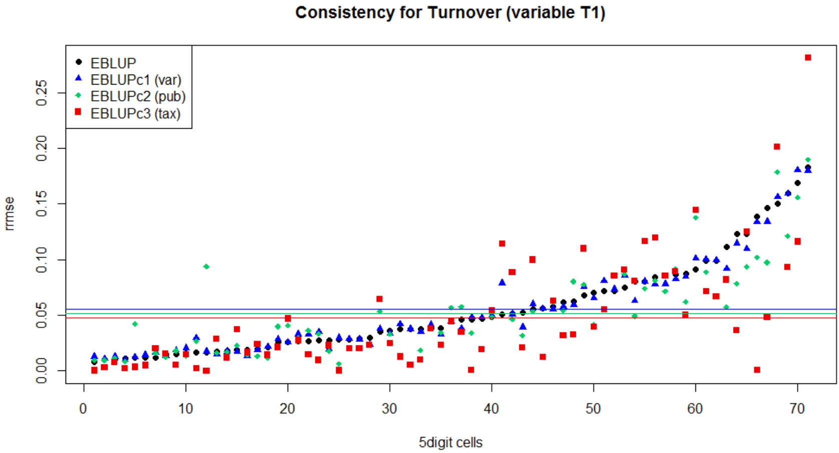
$$\begin{aligned} y_{ij} &= \mathbf{x}_{ij}^{\mathrm{t}}\boldsymbol{\beta} + \mathbf{z}_{ij}^{\mathrm{t}}\boldsymbol{\vartheta}_j + e_{ij}, \text{ where} \\ \boldsymbol{\vartheta}_j &\sim \mathcal{N}(0, \boldsymbol{\Theta}), \\ e_{ij} &\sim \mathcal{N}(0, k_{ij}^2\sigma_e^2), \text{ for 5digit cell } j \text{ and enterprise } i. \end{aligned}$$

- Specification of k_{ij}
  - analysis of heteroscedasticity and skewness residuals e_{ij},
  - stratum standard deviations residuals of estimated regression model.
- Specification of $\mathbf{x}_{ij}$ and $\mathbf{z}_{ij}$
  - analysis of AIC, point estimates, significance estimates of $\boldsymbol{\beta}$,
  - `tax turnover` and `size of enterprise` used as covariates,
  - random slopes for T_2, C_2, C_3 and C_4, otherwise $\mathbf{z}_{ij} = 1$.

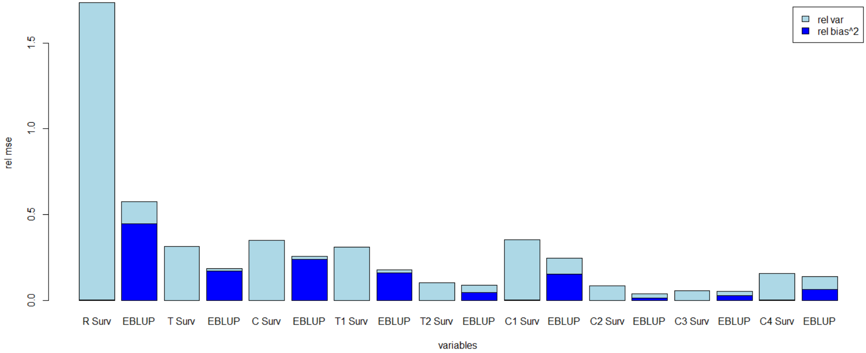
Consistency

- Consistency by Lagrange multiplier with absolute values of point estimates used as weights.
- Three versions of consistent EBLUPs
  1. EBLUPc1: consistent within the 5digit cells, between all variables,
  2. EBLUPc2: consistent between variables and publication levels,
  3. EBLUPc3: consistent between variables, publication levels and equated totals of `turnover` and `tax turnover`.
- Simulation based on response data 2006-2010,
  - $N = 47127$, $n = 3036$, $m = 71$, 10000 runs.
  - Means sample sizes 5digit cells vary from 0.1 to 436.

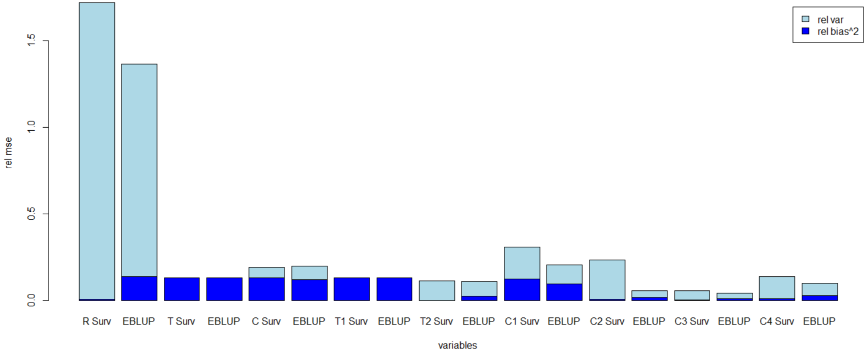
Effects of benchmarking



EBLUP vs Survey regr. (not consistent)



EBLUPc3 vs Survey regr. (consistent)



Conclusions

- SBS estimates 5digit cells can be improved by SAE for most variables, for other variables results are comparable.
- Equating `turnover` with `tax turnover` gives good results for `turnover`, `returns`, `costs`, but has not much effect for other variables.
- Benchmarking with direct estimates at industry level leads to instable estimates at level of 5digit cells for variable `results`.
- Estimates for variables with many zeroes (`results`, `other returns`, `other costs`) could possibly be further improved.