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Combining estimators to improve structural model estimation and inference under quadratic loss

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Abstract

Asymptotically, semi parametric estimators of the parameters in linear structural models have the same sampling properties. In finite samples the sampling properties of these estimators vary and large biases may result for sample sizes often found in practice. With a goal of improving asymptotic risk performance and finite sample efficiency properties, we investigate the idea of combining correlated structural equation estimators with different finite and asymptotic sampling characteristics. Based on a quadratic loss measure, we present evidence that the finite sample performance of the resulting combination estimator can be notably superior to that of a leading traditional moment based estimator.

JEL Classifications: C10; C24

Keywords: Combined estimators; Quadratic loss; Semiparametric estimation; Data dependent shrinkage; Instrumental variables

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1. Introduction

A frequently occurring problem in econometrics is that a statistical model, representing an underlying data sampling process, has to be inferred from insufficient theoretical and nonsample information that supports only a feasible set of models. Traditionally, using creative assumptions, the researcher proceeds by choosing a *single* statistical model from the feasible set of models and then uses a *single* ad hoc rule, such as $\mathbf{L}_2$ norm minimization or some pseudo-Kullback–Leibler type of distance measure, as the estimator basis for processing and statistically analyzing the data. A partial-possibly incomplete sample of data is then used, along with the chosen statistical model and estimation rule, as a basis for model discovery and information recovery in the form of estimation and inference. This process suggests a great deal of uncertainty relative to the econometric enterprise as one considers how best to represent the sampling process and to process the data and carry through the estimation and inference objectives. The choice of a single statistical model when only a feasible set is implied can lead to unstable parameter estimates and prediction, as well as poor estimation sampling performance.

As a basis for demonstrating the statistical implications of sampling model–estimator uncertainty and devising a basis for mitigating it, *we study a semiparametric linear statistical model of the form*

$$\mathbf{y} = \mathbf{X}\boldsymbol{\beta} + \boldsymbol{\varepsilon}, \tag{1.1}$$

where a vector of sample outcomes $\mathbf{y} = \left(y_1, y_2, \ldots, y_n\right)'$ is observed, $\mathbf{X}$ is a $(\mathrm{n} \times \mathrm{k})$ matrix of stochastic explanatory variables, $\boldsymbol{\beta} \in \mathrm{B}$ is a $(k \times 1)$ vector of unknown parameters and we assume that $\boldsymbol{\varepsilon} = (\varepsilon_1, \varepsilon_2, \ldots, \varepsilon_n)$ is an unobservable random noise vector with mean vector $\mathbf{0}$ and covariance matrix $\sigma^2\mathbf{I}_n$. We also assume that one or more of the regressors is correlated with the equation noise and thus $\mathrm{E}\left[n^{-1}\mathbf{X}'\boldsymbol{\varepsilon}\right] \neq \mathbf{0}$ or $\mathrm{plim}\left[n^{-1}\mathbf{X}'\boldsymbol{\varepsilon}\right] \neq \mathbf{0}$. Several important econometric problems may be formalized in this way and include, for example, the simultaneous equation linear statistical model and the linear errors in variables models. Based only on the primary observable data, if one selects the unknown $\boldsymbol{\beta}$ vector by some ad hoc rule such as the traditional Gauss–Markov-based $\mathbf{L}_2$ norm-minimizing least-squares (LS) estimator, or equivalently the method of moments (MOM)-extremum estimator defined by

$$\tilde{\boldsymbol{\beta}}_{\mathrm{LS}} = \arg_{\boldsymbol{\beta}\in\mathbf{B}}\left[n^{-1}\mathbf{X}'(\mathbf{Y} - \mathbf{X}\boldsymbol{\beta}) = \mathbf{0}\right], \tag{1.2}$$

the results are biased and inconsistent, with unconditional expectation and probability limit given by $\mathrm{E}\left[\hat{\boldsymbol{\beta}}_{\mathrm{LS}}\right] \neq \boldsymbol{\beta}$ and $\mathrm{plim}\ \left[\hat{\boldsymbol{\beta}}_{\mathrm{LS}}\right] = \boldsymbol{\beta} + \mathrm{p\ lim}\left([\mathbf{X}'\mathbf{X}]^{-1}\mathbf{X}'\boldsymbol{\varepsilon}\right) \neq \boldsymbol{\beta}$.

1.1. Traditional moment-based estimators

In order to achieve estimators that have acceptable asymptotic properties, a rich literature has evolved over the last 6 decades concerning estimation and inference procedures for data sampling processes consistent with simultaneous equation statistical models. Given an economic data sampling process characterized by