UNIVERSITY OF AMSTERDAM

*Accuracy of Method of Moments Based Inference*

R.W. Poldermans

# Summary

Econometrics is mainly concerned with providing tools tailored to estimating economic relationships where fundamental concepts, such as asymptotic distribution theory for example, stem from the discipline of statistics. Depending on the economic context, underlying theory provides the starting point for obtaining candidate variables, which in turn can or must be included when constructing the model being estimated. Providing a framework for identifying causal effects is a major challenge, since the observations on each variable are generally obtained in an uncontrolled environment. As a result, it is likely that other important and often unobserved factors lead to inferential complications since these are absorbed into the error term and at the same time may be correlated with (some of) the included explanatory variable(s). This is also known as omitted variables bias. In pure cross-sectional analysis, the data typically consists of a large number of individuals which are only observed for a single time period. When the same individuals are observed for a small number of consecutive time periods, also denoted as micro panel data, the additional information on each individual is used to control for time invariant individual specific heterogeneity and thereby circumventing the issue of omitted variables bias to a certain extent. Furthermore, models for such panel data may accommodate dynamic economic behavior.

Despite these desirable features of micro panel data, difficulties still arise. Specifying a model requires particular distributional assumptions on the error term, selecting relevant explanatory variables and in addition classification of these as either strictly exogenous, predetermined or endogenous. The latter may arise due to omitted time-varying explanatory variables or from genuine simultaneity, i.e. the endogenous variables are jointly determined in a system of equations. Given the sampled data set, judging whether the model adequately describes the process that actually generated the data requires the availability of an estimation technique corresponding to their actual statistical properties. Since it relies on only a small set of assumptions, while achieving asymptotically valid and efficient inference when these assumptions are satisfied, the generalized method of moments (GMM) is extremely popular in empirical work.

As this limiting distribution is derived under so-called conventional asymptotics, it is not always clear whether it provides a reasonable approximation to the finite sample distribution of the GMM estimator. Obviously, the information contained in the actual sample matters crucially. Related to this, there are unknown nuisance parameters which potentially affect the finite sample properties of the estimator and associated test statistics, while a priori the applied researcher is not particularly interested in their values.

This thesis focuses on the accuracy of GMM based inference, mostly in the context of dynamic panel data, but ultimately regarding the instrumental variables (IV) model, which constitutes the theoretical underpinning of the GMM estimator when considering single indexed data. In Chapter 2, relevant and rather standard inference techniques are examined for a linear dynamic micro panel data model with an additional regressor, possibly endogenous, and when heteroskedasticity may be present. For many major variants of GMM implementations, an extensive treatment is provided for the inference techniques on testing the validity of particular orthogonality assumptions and restrictions on individual coefficient values. Furthermore, various instrument reduction methods being available to mitigate bias are included and the implications regarding initial conditions for separate regressors with respect to individual effect stationarity are analyzed. Next, a comprehensive simulation design is developed which covers areas in the parameter space where the accuracy of asymptotic approximations to the properties of these inferential procedures have not been studied before. The major conclusion from the simulations is that, even when the cross-section sample size is several hundreds, whether inference is reliable depends heavily on a great number of aspects, including the magnitude of the time-dimension sample size, speed of dynamic adjustment and presence of any endogenous regressors. In particular, Wald-type coefficient restrictions tests show serious size problems under simultaneity, which is not mitigated by a Windmeijer correction due to the finite sample bias of the GMM estimators.

In Chapter 3 the Monte Carlo analysis extends to the accuracy of weak identification-robust testing procedures. Regarding the latter, it is first established that a weighting matrix based on centered moments results in size distortions, which is easily avoided by not centering the moments. If one turns to the model in first-differences to get rid of the individual-specific effect, the simulation results show that under the null hypothesis the behavior of the KLM statistic is superior relative to the general tendency of overrejection of the different Wald-type statistics being considered. The degree of overrejection is smaller when the instrument set is reduced, but not always reasonably close to the nominal level. Based on the many weak instrument asymptotics framework, the variance correction for the continuous updating estimator may lead to effective size control, but it is difficult to decide whether the number of instruments is not growing too fast relative to the sample size and/or contain sufficient information for identification. In terms of size-corrected power, the Wald-type statistics are roughly speaking more powerful than statistics with their computation based on restricted estimators. Nevertheless, their behavior under the null hypothesis is more sensitive to the number of instruments and since one cannot adjust the size of a test statistic in practice, the KLM statistic may be a better choice since it has much better size control and the loss in power seems acceptable. In the model being extended by the equation in levels, the weak identification-robust statistics may overreject under the null hypothesis when all the available moments are exploited. Collapsing the set of instruments appears a useful remedy, both in terms of actual size and power. In our simulation results we do not observe any anomalous behavior of the robust AR and KLM statistics when testing a simple null hypothesis on a single parameter.

Chapter 4, the final part of this thesis, is concerned with the issue of underidentification, which is closely related to weak identification. Since many of the available test statistics in the literature are pertained to models concerning single indexed data, the analysis focuses on the instrumental variables (IV) model. By exploiting a recently introduced unifying principle regarding rank test statistics, a Monte Carlo design is developed where the asymptotic local power of different rank tests is controlled in the different DGPs of interest, which, so far, has not been done in the literature. Regarding the most popular rank statistic in the IV model, also known as the rk-statistic, we include finite sample refinements based on a well-known result in numerical analysis. We find that the default LM version of the rk-statistic has a dominating finite sample performance, whereas a very recently proposed Sargan-Hansen rank test shows very similar finite sample behavior, while having the benefit of revealing additional knowledge on the reduced rank restriction.