Personal statement
By Anna Mikusheva

The main goal of Econometrics is to provide the economics profession with reliable statistical tools and techniques to quantify, assess and test economic theories using available data. The use of statistical techniques is a direct acknowledgement of the uncertainty inherent in data whether due to model specification errors, measurement errors and human indeterminacy. The vast majority of econometric and statistical methods rely on an asymptotic justification in that we assess the validity of a method based on its performance in infinitely-large samples. Since infinitely-large samples are never available in practice, asymptotic statements are merely heuristics suggesting that certain methods may be expected to deliver accurate results. My research studies the limitations of the asymptotic approach in empirically relevant problems in economics, where the blind use of asymptotic approximations can be misleading.

Research

A unifying theme of my research agenda is the demonstration of the fragile nature of existing asymptotic approximations around points of discontinuity of the asymptotic distribution and the creation of more reliable and robust methods for econometric inference.

As a theoretical econometrician I am especially interested in methodological issues, and in particular, unifying principles and concepts that arise in a wide range of empirical settings. The list of my main methodological contributions includes:

- Introducing the concept of uniform asymptotic approximations to common econometric practice and promoting its importance
- Revealing problems with often-used methods such as subsampling and the bootstrap
- Promoting grid testing as a method for producing confidence sets with more reliable properties
- Explaining the phenomenon of weak identification in non-linear models
- Introducing a measure of weak identification unrelated to any asymptotic embedding though geometric properties of models
- Finding weak identification robust test statistics (score and conditional LR) applicable to non-linear and heavily parameterized models
- Discovering weak identification issues in modern large Macroeconomic models (DSGE models)

The above-mentioned methodological advances are applicable to many different empirical settings, including inference in highly persistent time-series models, weak instrumental variable regressions, non-linear models of weak identification and modern DSGE models. Below I summarize my papers, grouped by the application.

Research: Persistent processes.

Time series is a data structure in which observations of the variables of interest arrive each time period as time progresses; examples of time series data include the main macroeconomic indicators such as inflation, GDP or interest rates, or financial series such
as stock prices. The main feature of time series data is the intertemporal dependence of consecutive observations, which may be an object of study by itself. For example, the problem of assessing the costs of inflation is closely related to the question of how long it takes for a shock to inflation to dissipate. From an empirical perspective most macroeconomic indicators are highly persistent, possessing a high degree of intertemporal dependence. The extreme case of time dependence is called a unit root process. Persistent time series offer many illustrations of the fragility of classical asymptotic approximations.

In my paper, “Uniform inference in autoregressive models” (Econometrica, 2007), I introduce the concept of uniformity of asymptotic approximations using autoregressive models with nearly-unit roots as an example. The concept of uniformity of asymptotics answers the question of whether the accuracy of the approximation of the unknown finite-sample distribution of a statistic by its asymptotic (infinite-sample) analogue depends in a significant way on unknown parameters to the extent that the approximation becomes unreliable around some specific parameter value. Methods based on uniform asymptotic approximation tend to provide more reliable results. My paper demonstrates the lack of asymptotic uniformity of some commonly-used methods such as bootstrap and subsampling, applied to inferences on the persistence of shocks around a specific empirically-important point of the unit root. At the same time, this work proves the uniform validity of some other methods based on the grid bootstrap.

My paper, “Second order expansion and grid bootstrap refinement in AR (1) model,” (Econometric Theory, forthcoming) differentiates among the methods whose validity was proven in the above-mentioned Econometrica paper. I show that Hansen’s grid bootstrap provides second-order improvements when compared with local-to-unity asymptotics.

In my paper, “One-dimensional inferences in autoregressive models in a potential presence of a unit root” (Econometrica, 2012), I am interested in constructing confidence sets for impulse responses for persistent series around a point of asymptotic discontinuity, the unit root. This question is of great empirical importance, as impulse responses are the main form of reporting results in Applied Macroeconomics and the majority of macro indicators are highly persistent. A problem arises since a poorly-estimable nuisance parameter characterizing proximity to a unit root is present in the asymptotics and complicates statistical inferences. The paper shows that all known methods fail to control size uniformly over a wide range of prediction horizons. The paper suggests a method with improved size properties based on the grid bootstrap.

In joint work with Yury Gorodnichenko and Serena Ng entitled “Estimators for persistent and possibly non-stationary data with classical properties” (Econometric Theory, 2012), we suggest a method for producing asymptotically normal estimators robust to potential persistence in multivariate Macro models. The paper differs from the existing literature in that it suggests a general principle for constructing an estimator, rather than the usual narrow model-specific approaches. The method works for cointegrating and nearly-cointegrating relationships (a well-known empirical example of which is the testing of efficient market hypotheses in Asset Pricing) and even in nonlinear DSGE models, which are very popular in modern Macroeconomics.
Research: Weak Identification

Econometric models are said to be weakly identified when a scarcity of information in data (relative to noise or unmodelled uncertainty) renders commonly-used statistical techniques unreliable. In such situations the usual (classical) asymptotic approximations fail to accurately approximate the true finite-sample distribution of the statistic of interest. From a methodological perspective it is not always clear why this occurs. One now-accepted way of modeling this phenomenon is to consider a sequence of models or data-generating processes (or, alternatively, a sequence of parameter values) indexed by the sample size such that along this sequence information about some parameters aggregates slowly, making consistent estimation impossible. This modeling device on the one hand allows one to capture the empirically relevant feature of the data that the uncertainty about some parameters is very large, while on the other hand it allows for an appeal to asymptotic reasoning. This approach, called weak identification asymptotic embedding, helps to describe the statistical problem at hand, but is considered by many econometricians to be an artificial construction which does not in general allow a practitioner to detect a weak identification problem.

In my paper with Isaiah Andrews entitled “A geometric approach to weakly identified econometric models” (revised and resubmitted in *Econometrica*) we provide a new explanation of the phenomenon of weak identification without using any artificial asymptotic construction and create an easy-to-calculate measure of weak identification based on finite-sample features of the model one wishes to estimate. Most econometric estimation and inference procedures are based on some non-linear transformations of averages calculated from the data sets. While the asymptotic behavior of averages is well-understood (central limit theorem and its refinements), the asymptotic behavior of non-linear transformations of averages is considered (by classical theory) to be nearly Gaussian under the presumption that this transformation is nearly linear for practical purposes. Weak identification arises when the uncertainty about parameters is so large that the linear approximation to a non-linear function is inaccurate over the set reflecting true uncertainty. That is, the accuracy of classical approximations is related to how non-linear the model (or the restriction) is in the relevant area. We introduce an easy-to-calculate measure of curvature that captures both the non-linearity of the model and the degree of uncertainty in the data, and produce new valid critical values for the minimum-distance statistic based on this new measure of weak identification. As applications of our approach we were able to make new accurate inferences in both New Keynesian Phillips curve and DSGE models. This paper provides a strikingly different perspective on the problem of weak identification, introducing new methodology based on Differential Geometry.

In another joint paper with Isaiah Andrews, “Weak identification in maximum likelihood: a question of information,” (*American Economic Review: P&P*, 2014) we found an empirically relevant quantity which can be used to detect weak identification in highly parameterized modern large-scale Dynamic Stochastic General Equilibrium (DSGE) models such as those employed by the majority of Central Banks and Federal Reserves. We discovered that in weakly identified models, two alternative measures of Fisher information diverge from each other, and the distance between them can be used
to detect the weak identification in practice. We also explain how and why weak identification may arise in DSGE models.

While understanding and detecting weak identification is extremely important, it is crucial to establish new robust procedures that can be used by practitioners who face the problem of weak identification in their application. An almost-complete absence of reliable frequentist methods for making inferences in DSGE models has driven many researchers to adopt the Bayesian framework, which has its own difficulties and challenges. In a joint paper with Isaiah Andrews, entitled “Maximum likelihood inference in weakly identified DSGE models” (Quantitative Economics, forthcoming) we suggest a frequentist method of inference that is fully robust to weak identification, directly applicable to DSGE models and relatively easy to implement within the maximum likelihood framework. This approach is based on the classical Lagrange Multiplier or score statistic which is, as we argue, robust to weak identification. This provides a workable alternative to a Bayesian approach in Applied Macroeconomics.

My new working paper with Isaiah Andrews, entitled “Conditional inference with a functional nuisance parameter,” shows that the problem of testing hypotheses in moment condition models without any assumptions about identification may be considered a problem of testing with an infinite-dimensional nuisance parameter. We introduce a sufficient statistic for this nuisance parameter and propose conditional tests. Our results allow practitioners to use a wide variety of tests in models where identification is a concern, and in particular allow the use of likelihood-ratio-type tests, which are known to have high power in a wide range of other contexts.

**Research: Weak Instruments**

Inference in weakly identified instrumental variable regression is a special case of weak identification that possesses additional structure. Instrumental variables regression is a very powerful method of estimating the causal relation between two or more variables from observational data in the absence of experimental data. It exploits exogenous variation in the explanatory variable generated by an instrument. The weak IV problem arises when this exogenous variation is small relative to the uncertainty in the model, a situation analogous to a low signal-to-noise ratio. The special point where asymptotics break down is the parameter value at which an instrument is uncorrelated with the regressor and thus induces no exogenous variation in the latter. This corresponds to the so-called point of non-identification.

In my paper entitled “Robust confidence sets in the presence of weak instruments” (Journal of Econometrics, 2010), I develop a procedure to construct confidence sets which are asymptotically uniform and thus produce reliable results in the weak IV case. I have written software to support the paper and to implement the procedures described in the paper. There is also related work in a supporting publication in The STATA Journal (2006), joint work with Brian Poi, that describes the method and implementation on a user-friendly level and advertises the method to final users.

In my published comment on the paper by Kleibergen and Mavroeidis “Weak instrument robust tests in GMM and the New Keynesian Phillips curve,” (Journal of Business and Economic Statistics, 2009) the two problems described above - the unit root and weak identification - are brought together to study the important question of estimating the Phillips Curve.
Research: Awards

I am the proud recipient of the 2012 Elaine Bennett Research Prize, a bi-annual prize from the American Economic Association “established to recognize and honor outstanding research in any field of economics by a woman at the beginning of her career.” I was also selected to be a 2013 Sloan Research Fellow.

Teaching

Teaching students at MIT at both the graduate and undergraduate levels has been a very inspiring and rewarding experience for me. I am very proud to be the recipient of the Graduate Teacher of the Year Award for the 2007-2008 academic year, and I have earned consistently high evaluation scores for all courses I have taught. (My scores for the last academic year were 6.6 out of 7 for 14.384 and 6.4 out of 7 for 14.381.)

My courses aim to make students effective final users of econometric techniques who clearly understand the assumptions, limitations and shortcomings of the methods and their potential fixes. My goal for the courses I teach is to help my students develop the skills needed to do empirical research in Economics. I include numerous empirical examples in my courses, and all students are required to do some empirical exercises in their problem sets.

Time Series (14.384) is my signature course, mainly designed for the second-year PhD students in Economics. However, it also attracts many students outside the department, mainly from the Sloan School and the School of Engineering. The course covers a wide range of topics, highlights recent developments in Time Series Analysis and also presents some open questions and areas of ongoing research. I have also been teaching an econometrics course (14.32) to MIT undergraduate students. It is a very exciting course to teach, as it has given me a chance to interact with many highly technically-sophisticated undergraduate students and to introduce them to the beauty of econometrics. In addition, I have also been teaching a course in Statistics (14.381) for the first-year PhD students for seven years.

Mentoring

I served as a primary academic adviser for two MIT PhD graduates: Isaiah Andrews (graduated 2014, first employment is at the Harvard Society of Fellows) and Joseph Doyle (graduated 2012, first employment is at Cornerstone Research). I served as the second adviser for Denis Chetverikov (graduated 2013, University of California-Los Angeles), Alberto Vargas (graduated 2012, Cornerstone Research), Joonwahn Lee (will graduate September 2014). I also served as a member of the dissertation committee for a Harvard PhD student, Tao Jin (graduated 2014, Tsinghua University).