607
Elementary to advanced
and on to modern advanced econometrics

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- **From elementary econometrics to advanced time series**
  - The key in going from elementary to advanced econometrics is leaving behind exact results and accepting accepting asypmtotic approximations in their place.
  - This involves some new challenges, but viewed properly mainly involves conceptual simplification
  - An immense class of nonlinear models with dependent and heterogeneously distributed data become analyzable using little more than familiar tools from the least squares family (OLS, GLS, IV).
- **Quadratics and the GLS principle**
  - So long as we have a consistent estimator (and sufficient regularity conditions), we can limit ourselves to quadratic approximations

    And many estimators look no more complicated than OLS after this approximation...
  - And with quadratic objectives, a main building block for efficiency is the GLS principle.
- **Life in advanced econometrics is pretty simple**
- **Time series**
  - Time series is largely a side-show in this transition from elemetary to advanced econometrics
  - We only need to learn some time series theory in order to put enough structure on sums of random variables that we can apply our CLTs and WLLNs.

- That is, we need to learn new regularity conditions

  We only need time series if we want to know what is behind statements that some series is 'sufficiently well-behaved' to apply a CLT or WLLN.

▶ **What advanced stuff have we left out?**

- We have mainly laid out the superstructure of advanced econometrics.
- This is the stuff that should drive your perspective as an applied worker
- And that should drive your intuitions as a theorist.

▶ **But. . .**

- But for the theorist, the devil is in the details.
- We have only gestured at the regularity conditions required for our extremum estimators to be CAN.
- Further, details of conditions for CLTs and then the proofs of those CLTs have been omitted.
- Finally, strange cases such as super efficient estimators (that beat the MLE) and how and why we rule them out are left aside.

▶ **Details**

- If you want to contribute to theory, I've given a bit of a road map, but we won't go far down that road in this class.
- We will be exploring the details that seem to matter in practice.

▶ **Are we done with theory? No.**

▶ **More theory**

- We'll need some new concepts.
- I'll call this: from advanced econometrics to modern advanced econometrics

▶ **Historical comment**

- Much of what I called advanced econometrics was either understood or was a direct implication of stuff understood nearly a century ago.
- While robust variance-covariance matrix estimation and GMM are pretty new, it is amazing, given our current perpsective, that they were not worked out in the 1930s.

  No new concepts were needed, just clear thinking.

▶ **Modern advanced econometrics**

- What I'll call modern advanced econometrics involves more recent theoretical break throughs.
- Two key elements here can both be viewed in terms of advances in how we deal with asymptotics

▶ **Functional central limit theorems (FCLTs)**

- Around the 1950s theory was solidifying around central limit theorems in which random variables converge not to Gaussian random variables, but to functions of Brownian motions.

  These results are known as functional central limit theorems.

- Over the second half of the 20th century, FCLTs became the key to analyzing many problems
- Prominent among the problems illuminated using FCLTs are those raised by nonstationary time series—the with unit root problem.

  In short, this is a big deal in macro time series.

▶ **Higher order asymptotics**

- The other advance involves higher order asymptotics.
- The asymptotics we have been describing so far is called first order asymptotics.
- Essentially, this means that we neglect any terms that go to zero as the sample size increases even after being 'blown up' or multiplied by $\sqrt{T}$.

  That is, the terms are shrinking fast enough to overwhelm the growth of $\sqrt{T}$.

- We could instead keep terms unless they go to zero when 'blown up' by T or $T^{3/2}$ or T^2.
- This kind of thinking is not new.
- For example, Edgeworth (of Edgeworth box fame) made significant contributions in this regard

  Edgeworth thought outside the box (sorry) and is immortalized in the term 'Edgeworth expansions'

▶ **But what is new?**

- As it turns out, first-order asymptotic terms are often very simple to deal with: they tend to be Gaussian.

  More specifically, we tend to make sufficient assumptions that these first order terms are Gaussian.

- The higher-order terms tend to be messy and a bit of a pain.
- Thus, first order asymptotics ruled the day, at least from the standpoint of applied work, for most of the 20th century.
- In the 1980s and 1990s, bootstrapping techniques were shown to be able to capture or incorporate higher order terms without having to analyze them directly.

In short, Monte Carlo methods almost magically capture these terms.

- And cheap fast computing power made elaborate Monte Carlo methods practical
- These breakthroughs dramatically changed practice in applied macro.
- From the 1990s onward, a large and increasing share of inference in applied macro time series has been based on bootstrap methods.
- And we'll spend a good deal of time on these issues.

▶ **A note of realism**

- First order asymptotics gave us some pretty clear and guidance; this guidance has been well digested and incorporated in how econometrics is done.
- It turns out that these modern advances have not yet yielded one very clearly dominant way to proceed.
- As of now, we understand some things and others are yet to be mastered.
- Thus, we find ourselves needing to proceed in ways that are ad hoc, which is to say, 'good practice'-based
- That's good news: you can help advance the theory and/or good practice.

▶ **Wrapping up**

- The reason we delve into these methods is because of the problems that make applied macro hard.

  Small samples, persistent movements, imprecise theories, etc.

- Before we move on to the modern advanced techniques, we'll spend some time on why the problems in macro have driven us to those techniques.
- There are lectures on relevant sample size issues in estimating variance-covariance matrices, model selection, and GMM

  These are intended to motivate digging a bit further. . . .