Department of Resource Economics
University of Massachusetts
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Res Ec 797D: Panel Data Econometrics

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Panel data econometrics has its underpinnings in experimental design and analysis of variance (ANOVA). The techniques implemented in panel data econometrics can be a source of frustration for the student because they require a good working knowledge of ANOVA procedures that have to do with calculating "within" variation and "between" variation and knowing how to apply various "sweep-out" procedures to obtain parameter estimates. Basically, the background mathematics for this topic is tedious. Furthermore, advancing this background mathematics to a matrix setting, which is the standard format in the published literature and in advanced textbooks on the topic, can result in additional frustration.

Textbook treatment of this area of econometrics is quite heterogeneous both in terms of level of mathematical sophistication and how the topics and estimation issues are explained. The different texts presented in the reference section illustrate this point. It is not that one or a few of these are bad or that one in particular is superior. On the contrary, all are very well written. Each provides a different slant on the topic. Each possesses an element of orthogonality that distinguishes it from the others. All considered together promote a very complete understanding of this topic.

There is a rich history to panel-data econometrics. Out of Fisher's development of ANOVA in the very early 1900s came Wold's econometric applications in the 1920s. This set the stage for Cowles Commission rudimentary macroeconometric modeling that initiated during the Great Depression. Klein models flourished during the 1940s through the 1960s and played a role in economic policy decisions. Econometric topics of the time were structural estimation and simultaneity. Chamberlain later focused on issues related to reduced-form, which blossomed into a rich literature on instrumental-variables estimation. It was inevitable that the literature on instrumental variables would become linked with method-of-moments estimation, first proposed by Hansen. Authors like Hoch, Mundlak, Nerlov, Griliches, Maddala, Zellner, Swamy, and Park – to name only a few – pointed the profession in the direction of estimation gains to be made by combining cross-section with time-series data. A variety of excellent texts flourished during the 1980s and 1990s that presented the state of the art under their own separate cover. Examples are Griffiths et al., Baltagi, and Judge, et al. Time-series issues like stationarity in panel models began to receive considerable attention in the early 2000s. An example is Enders. Texts authored in the 2000s by Wooldridge, Cameron and Trivedi, and Arellano are touted as taking a modern approach to panel-data estimation by emphasizing the microeconometric perspective in topic presentation.

General Topic Coverage

1. **ANOVA background**: Neter, *et al.* (1996, pp. 958-983) link ANOVA with regression and develop the variance components that are basic to random effects models. Judge, *et al.* (1985, p. 551) put these items into a matrix setting.
2. **Classical econometric approach**: Hill, *et al.* (2008, pp. 382-416) provide basic treatment and explanations of fixed-effects and random-effects models. They address balanced and unbalanced panels. They provide detailed coverage of testing procedures for each model.
3. **Classical approach extended to and linking a broad spectrum of models**: Judge, *et al.* (1985, pp. 515-560) and Judge, *et al.* (1988, pp. 468-496) present and develop a complete catalog of fixed-effects and random-effects models, where the fixed effects can be captured through the intercepts or the slope variables or both and the random effects can be captured over the cross-sectional units or through time or both. Examples of different models fitting these descriptions are Zellner's seemingly unrelated regression (SUR), Park's procedure for fixed effects, the Fuller-Battesse procedure for random effects, the error components model, and Swamy's random coefficient regression (RCR) model.
4. **Alternative mathematical treatments of fixed-effects and random-effects**: Frees (2004) and Baltagi (1995) do a good job in this area.
5. **Movement to a microeconometrics approach and to a time-series approach when dealing with panel data**: Wooldridge (2002), Arellano (2003), and Cameron and Trivedi (2005) emphasize microeconometrics. Enders (2004) goes into great detail with nonstationarity of right-hand-side variables, cointegration, and panel unit-root tests.
6. **Estimation using different panel data sets**: We have access to different panel data sets. We will be programming the various models using SAS' Interactive Matrix Language (IML) and comparing estimation results with the standard canned procedures available in SAS and also in STATA.

Specific Topics

Background and Review

·Assumptions of the classical linear model and what happens when assumptions are violated
·Normal equations; asymptotic behavior of estimators; small-and large-sample properties
·Data: Cross-section set-up of a model; time-series set-up of a model
·Block structure of the grand design matrix for a system of equations
·Grand error-covariance matrix Ω when cross-section and time-series data are combined
·Accommodating heteroscedasticity, autocorrelation, and mutual correlation
·How to get $\hat{\Omega}$ for a particular characterization of Ω
·Treating the grand design matrix as not fixed
·The instrumental-variables estimator
·Hausman test

Fixed Effects

·The "covariance model": classic dummy-variable ("fixed-effects") set-up
·Comparison between an all-dummy regression model and ANOVA
·Regression coefficients vs. ANOVA treatment means
·Regression sums-of-squares vs. ANOVA sums-of-squares
·Two ways to set up and estimate the fixed-effects (dummy variables) model
·Straightforward all-dummy regression model vs. deviation-from-the-mean approach
·Testing fixed effects: unrestricted vs. fully restricted model

Random Effects
·The error-components model (another name for the random-effects model)
·Behavior of the error term; a look at how each variance component actually evolves
·GLS specification for the random-effects model, inclusive of its variance components
·Developing the inverse of Ω in the random-effects model (Ω^{-1}) via a matrix inversion formula
·Role of the matrix-inversion formula to provide a transformation that permits estimation by OLS
·Swamy-Arora method to get variance-components estimates
·Testing for random individual heterogeneity; using the Breusch-Pagan test
·Breusch-Pagan as a Lagrange-multiplier test; how its arguments are calculated

·Testing between fixed effects and random effects
·What are the appropriate null and alternative hypotheses?
·Using the Hausman test; how its arguments are calculated

·Predicting each error component μ_i and comparing it to an estimated dummy-variable coefficient
·Comparison between the fixed-effects model and the random-effects model (each in deviation form)

Instrumental Variables
·Revisiting the grand design matrix
·Consequences of using OLS when a right-hand-side variable is random or endogenous
·Purpose of instrumental-variables estimation
·Characteristics of a good instrument
·Meaning of the statement: Variance / Bias trade-off between OLS and IV estimators
·How to carry out two-stage least squares estimation and three-stage least squares estimation

Method of Moments
·Basics of Method-of-Moments
·How to derive moment estimators for the population mean and population variance
·Method-of-Moments applied to the bivariate regression model (for illustration)
·Population moment conditions vs. sample moment conditions
·Using moment conditions to derive estimators
·Meaning of "population orthogonality condition" and its "sample analog"
·How to proceed when a moment condition is violated
·Using moment conditions to derive an appropriate IV estimator
·What to do when we have a surplus of instruments
·Negative consequences of having a surplus of instruments
·Most efficient way to proceed when we have a surplus of instrument
·Hansen's suggestion for a weighting matrix: how to select a weighting matrix
·Meaning of "generalized" method-of-moments
·The various exogeneity assumptions: Summation; Contemporaneous; Weak; Strong
·Impact of different exogeneity assumptions on moment conditions and instrument possibilities
·One-Step GMM vs. Two-Step GMM: how they differ; weighting matrix for each
·Weak instruments: what this means; standard procedure for assessing if an instrument is weak
·Amending fixed and random effects models to accommodate endogenous regressors
·Best methods of estimation under these circumstances
·Deficiencies of estimation techniques that worked when we had no endogenous regressors

Specific Panel Situations and Model Set-Ups
·Arellano and dynamic regressors: model set-up
·How to choose instruments when dynamic regressors become part of the model
·Nonstationary panels and unit root testing
·Difference-in-differences estimator
·Mixed linear models
·Random coefficient regression models
·Nonlinear estimation

Text Readings

Arellano, Manuel. Panel Data Econometrics. Oxford University Press: 2003. 231 pages.

Asteriou, Dimitrios and Stephen G. Hall. Applied Econometrics. Palgrave Macmillan: 2007. 397 pages.

Baltagi, Badi H. Econometric Analysis of Panel Data. Wiley: 1995. 253 pages.

Cameron, A. Colin and Pravin K. Trivedi. Microeconometrics: Methods and Applications. Cambridge University Press: 2005. Chapters 21-23.

Enders, Walter. Applied Econometric Time Series. 2nd edition. Wiley: 2004. pp. 225-228.

Frees, Edward W. Longitudinal and Panel Data. Cambridge University Press: 2004. 467 pages.

Greene, William H. Econometric Analysis. Macmillan Publishing Company: 1990. pp. 461-505.

Griffiths, William E., R. Carter Hill, and George C. Judge. Learning and Practicing Econometrics. Wiley: 1993. pp. 571-579.

Hill, R. Carter, William E. Griffiths, and Guay C. Lim. Principles of Econometrics. 3rd Edition. Wiley: 2008. pp. 382-416.

Judge, George G., W.E. Griffiths, R. Carter Hill, Helmut Lutkepohl, and Tsoung-Chao Lee. The Theory And Practice Of Econometrics. 2nd Edition, Wiley Publishing Company: 1985. pp. 515-560.

Judge, George G., R. Carter Hill, William.E. Griffiths, Helmut Lutkepohl, and Tsoung-Chao Lee. Introduction To The Theory And Practice Of Econometrics. 2nd Edition, Wiley Publishing Company: 1988. pp. 468-496.

Neter, John, Michael H. Kutner, Christopher J. Nachtshei8m, and William Wasserman. Applied Linear Statistical Models. Irwin: 1996. pp. 958-983.

Wooldridge, Jeffrrey M. Econometric Analysis Of Cross Section And Panel Data. The MIT Press: 2002. pp. 247-332.

Exams

We will have two exams. Each is worth 40% of your final grade. The first exam is scheduled for Thursday, March 8 from 6:00 p.m. to 8:00 p.m. The second exam will be during finals week. The date and time for the final exam have yet to be determined. (You will notice that Exam 1 is scheduled on the Thursday directly before spring break, which begins Saturday, March 10.)

Assignments

Assignments are based on data sets that I obtain over the Internet and from texts and journal articles. We may attempt to replicate results reported by researchers who use these data sets, or we may simply attempt to apply the topic that we are addressing at the time. I may also ask you to try your hand at a mathematical proof. You can expect somewhere in the vicinity of 10 assignments throughout the semester. Assignments will be worth 20% of your final grade.