ECON 7331 — ECONOMETRICS I

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Hours: You can usually drop by anytime, sometimes I am out Thursday-Friday and sometimes I work at home in the morning, so email for an appointment if you want to be sure (emailing about appointments is the best way, because I use my inbox to keep track of appointments).

Required Language for All Courses

Mental Health and Wellness Resources:

The University of Houston has a number of resources to support students mental health and overall wellness, including CoogsCARE and the UH Go App. UH Counseling and Psychological Services (CAPS) offers 24/7 mental health support for all students, addressing various concerns like stress, college adjustment and sadness. CAPS provides individual and couples counseling, group therapy, workshops and connections to other support services on and off-campus. For assistance visit uh.edu/caps, call 713-743-5454, or visit a Lets Talk location in-person or virtually. Lets Talk are daily, informal confidential consultations with CAPS therapists where no appointment or paperwork is needed. Need Support Now? If you or someone you know is struggling or in crisis, help is available. Call CAPS crisis support 24/7 at 713-743-5454, or the National Suicide and Crisis Lifeline: call or text 988, or chat 988lifeline.org.

Title IX/Sexual Misconduct

Per the UHS Sexual Misconduct Policy, your instructor is a responsible employee for reporting purposes under Title IX regulations and state law and must report incidents of sexual misconduct (sexual harassment, non-consensual sexual contact, sexual assault, sexual exploitation, sexual intimidation, intimate partner violence, or stalking) about which they become aware to the Title IX office. Please know there are places on campus where you can make a report in confidence. You can find more information about resources on the Title IX website at https://uh.edu/equal-opportunity/title-ix-sexual-misconduct/resources/. Reasonable Academic Adjustments/Auxiliary Aids The University of Houston is committed to providing an academic environment and educational programs that are accessible for its students. Any student with a disability who is experiencing barriers to learning, assessment or participation is encouraged to contact the Justin Dart, Jr. Student Accessibility Center (Dart Center) to learn more about academic accommodations and support that may be available to them. Students seeking academic accommodations will need to register with the Dart Center as soon as possible to ensure timely implementation of approved accommodations. Please contact the Dart Center by visiting the website: https://uh.edu/accessibility/ calling (713) 743-5400, or emailing jdcenter@Central.UH.EDU. The Student Health Center offers a Psychiatry Clinic for enrolled UH students. Call 713-743-5149 during clinic hours, Monday through Friday 8 a.m. - 4:30 p.m. to schedule an appointment. The A.D. Bruce Religion Center offers spiritual support and a variety of programs centered on well-being. The Center for Student Advocacy

and Community (CSAC) is where you can go if you need help but dont know where to start. CSAC is a home away from home and serves as a resource hub to help you get the resources needed to support academic and personal success. Through our Cougar Cupboard, all students can get up to 30 lbs of FREE groceries a week. Additionally, we provide 1:1 appointments to get you connected to on- and off-campus resources related to essential needs, safety and advocacy, and more. The Cougar Closet is a registered student organization advised by our office and offers free clothes to students so that all Coogs can feel good in their fit. We also host a series of cultural and community-based events that fosters social connection and helps the cougar community come closer together. Visit the CSAC homepage or follow us on Instagram: @uh_CSAC and @uhcupbrd. YOU belong here.

Women and Gender Resource Center
The mission of the WGRC is to advance the University of Houston and promote the success of all students, faculty, and staff through educating, empowering, and supporting the UH community. The WGRC suite is open to you. Stop by the office for a study space, to take a break, grab a snack, or check out one of the WGRC programs or resources. Stop by Student Center South room B12 (Basement floor near Starbucks and down the hall from Creation Station) from 9 am to 5 pm Monday through Friday.

Academic Honesty Policy
High ethical standards are critical to the integrity of any institution, and bear directly on the ultimate value of conferred degrees. All UH community members are expected to contribute to an atmosphere of the highest possible ethical standards. Maintaining such an atmosphere requires that any instances of academic dishonesty be recognized and addressed. The UH Academic Honesty Policy is designed to handle those instances with fairness to all parties involved: the students, the instructors, and the University itself. All students and faculty of the University of Houston are responsible for being familiar with this policy.

Excused Absence Policy
Regular class attendance, participation, and engagement in coursework are important contributors to student success. Absences may be excused as provided in the University of Houston Undergraduate Excused Absence Policy and Graduate Excused Absence Policy for reasons including: medical illness of student or close relative, death of a close family member, legal or government proceeding that a student is obligated to attend, recognized professional and educational activities where the student is presenting, and University-sponsored activity or athletic competition. Under these policies, students with excused absences will be provided with an opportunity to make up any quiz, exam or other work that contributes to the course grade or a satisfactory alternative. Please read the full policy for details regarding reasons for excused absences, the approval process, and extended absences. Additional policies address absences related to military service, religious holy days, pregnancy and related conditions, and disability. Recording of Class Students may not record all or part of class, livestream all or part of class, or make/distribute screen captures, without advanced written consent of the instructor. If you have or think you may have a disability such that you need to record class-related activities, please contact the Justin Dart, Jr. Student Accessibility

Center. If you have an accommodation to record class-related activities, those recordings may not be shared with any other student, whether in this course or not, or with any other person or on any other platform. Classes may be recorded by the instructor. Students may use instructors recordings for their own studying and notetaking. Instructors recordings are not authorized to be shared with anyone without the prior written approval of the instructor. Failure to comply with requirements regarding recordings will result in a disciplinary referral to the Dean of Students Office and may result in disciplinary action.
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Learning Outcomes:

- Students will learn, through lectures, homeworks, and TA-sessions, to master econometric tools at a level that, in conjunction with other core-classes, enables the students to perform statistical analysis of economic models.
- Students will develop their technical skills as a background for doing empirical work to the level expected in graduate economics programs. For this purpose, student will learn to use the econometric software to estimate models on actual economic data.
- Students will learn the basic ideas of advanced econometrics with a focus on empirically relevant issues.

Course Description

I list at the bottom of this file what I taught in the Spring of 2024. Each week we will post programs in Matlab. (Presonally, I am very experienced with Gauss but the TA master's Matlab and in any event matrix languages are quite similar so I can usually hep you). We might also use the Stata econometrics package, which is ubiquitous in applied microeconomics. Programming of econometric estimators (or rather adapting programs that I post) is an essential part of the class. The exams will include computer code (maybe with a line missing that you have to add [maybe in words]) so if you don't understand the code, you will be lost.

The topics you should know for the exam is what is taught in class. It is usually not helpful to read further material at this stage, but it is often very helpful to read an alternative presentation of the same material. Even undergraduate texts, which do not use matrix algebra, may be helpful in getting a better feeling for various tools.

Readings:

Textbook:

I mostly follow Hansen's "Econometrics," but there are many details that you should not read, so you are not expected to know anything outside of my lectures. (The point is to get the basic theoretical skeleton right first, if you have that straigh, the extra details are easier to understand and my be useful.) I use some material from Davidson and MacKinnon: "Econometric Theory and Methods" Oxford University Press 2004 . You migh also consult Econometric Analysis, William H. Greene, 7th Edition, Prentice Hall, 2012 (this book is among the 100 all-time most cited books

in the world according to Prof. Greene's web-site). I find Davidson and MacKinnon more to the point, but if you prefer many examples, there are more in Greene (but I think often that makes it easier to get lost, but we are all different). Personally, I also like Goldberger: A course in Econometrics, which is really to the point, but it is a bit old now. I will assume you have access to Davidson-MacKinnon and Green and will often post homeworks from these books.

I have posted some supplementary papers or links and some notes of my own but, again, you are supposed to know all that has been taught in class and nothing more. If there is some material that you would like me to type up, I can usually be persuaded to do that. Don't hold back!

Notes Notes, homeworks, information, etc. will be posted on the class web-page. The class web-page will be accessible from my home page.
Material covered last year (this is all standard stuff and this will be covered again—we may cover a little more or less. I will shoot for more. Some of the material near the end are given a more introductory treatment and we will return to it in Econometrics II:

1. Matrix algebra. There are good introductions to this material in Davidson-MacKinnon and Greene (I like Greene's appendices better on this). I list some of the more important stuff below (although it is not exhaustive).
   (a) You are expected to know the basic rules about adding and multiplying etc. matrices before taking this class.
   (b) Partitioned matrices are important in econometrics, so you have to able to invert and multiply those.
   (c) A special case of writing a matrix in partitioned form is to write it as a collection of row vectors or a collection of column vectors. For the important issue of consistency of OLS, this is crucial.
   (d) You are expected to be able to find the determinant of a 2×2 matrix and matrices that are block-diagonal with 2×2 matrices or scalars along the diagonal.
   (e) You have to be able to diagonalize a symmetric matrix and you should know the role of the eigenvalues (More often, though, you will need to make a theoretical argument relying on the existence of a diagonalization, as opposed to doing it numerically). You should be able to find eigenvalue for 2×2 matrices. This includes the taking of the square root of a matrix and the square root of the inverse.
   (f) You should know about idempotent matrices and their eigenvalues (0 or 1).
2. Statistics
   (a) You should know the multivariate normal distribution and how it relates to the χ-square distribution.

(b) You have to be comfortable taking means and variances of a stochastic vector (a vector of stochastic variables).

(c) You should (absolutely) know what happens to the mean and variance of a stochastic vector if it is multiplied by a matrix.

(d) You should be able to explain why $e'Me$ follows a χ-square distribution if M is idempotent and e is standard normal (and explain the degrees of freedom).

(e) You have to know (for testing) that if X is $N(0, \Sigma)$ then $X'\Sigma^{-1}X$ is χ-square. This follows because $\Sigma^{-.5}X$ is $N(0, I)$, you should be able to explain this, but the higher priority is to know the result for $X'\Sigma^{-1}X$ which is the multivariate equivalent of dividing by the standard error (if X is a scalar, then $X'\Sigma^{-1}X$ is $X^2/\sigma^2 = (X/\sigma)^2$, i.e., the square of standard normal.

3. Theoretical derivation of the regression coefficient (vector) and its variance.

4. Be able to show the $\hat{\beta}$ (the estimated coefficient in the linear regression model under the standard assumptions [know what those are]) is unbiased. The unbiased estimator of the error variance (be able to prove that it is unbiased).

5. Working with numerical examples—the linear model with 2 regressors will often be used in midterm/exam questions, I may give you some numbers and you should be able to find, say the coefficient and the standard errors.

6. The Frisch-Waugh (FM) theorem and applications. I may ask you to prove the FW theorem, so make sure you are comfortable working with the projection matrix $P_X = X\left(X'X\right)^{-1}X'$ and the residual maker $M_X = I - P_X = I - X\left(X'X\right)^{-1}X'$ Important applications of the FM theorem are

   (a) Regressing on a large number of dummy variables.

   (b) Showing the bias in the case of omitted (left-out) variables.

   (c) Evaluating the marginal impact of an extra regressor.

   (d) "Added value plots" (to check for outliers).

7. R^2, adjusted R^2, and partial R^2

8. The t- and F-test (know how to formulat the test of hypothesis described in words and know the equivalence of the "goodness of fit" version and the version where you directly use $R\hat{\beta} - q$ know how to prove that the F- and t-tests follow the t- and F-distributions). The Chow-test (and similar simple applications of the F-test that I may think of). Confidence intervals.

9. Functional Form (as I covered it in class: dummy variables, interactions, elasticities, semi-log, etc.)

10. Data issues: Classical measurement error, multi-collinearity

11. Asymptotics. You will need to use the Law of Large Numbers (LLN) and the Central Limit Theorem (CLT), but I did not mention the explicit version of the LLN or the CLT, so you can talk about "the" LLN, and "the" CLT.

    (a) Consistency of the OLS estimator (know the assumptions needed on $X'X$ and be able to explain that $X'\epsilon$ is a sum of independent variables so that a LNN holds).

    (b) Consistency of the variance estimator.

    (c) Convergence of the $t-$ test to a Normal test (whether the data are Normally distributed or not, as long a CLT holds).

    (d) Asymptotic χ^2-test of restrictions even if the errors are not Normally distributed (the case where they are, is of course a special case, so this implies that the standard F-test converges to the χ^2-test (and the F-distribution to the χ^2-distribution.

12. GLS. Understand that if Ω is the variance matrix, one can choose a Cholesky factorization so that $\Omega^{-1/2}$ is lower triangular and multiplying the $n'th$ row with the true error vector corresponds to calculating $x_n - E(x_n|x_{n-1}, ...x_1)$ (and scaling with the standard error). (Confer point 2e.) Therefore the elements of $\Omega^{-1/2}e$ are i.i.d., which is equivalent to $var(\Omega^{-1/2}\, e) = \Omega^{-1/2}\, var(e)\, \Omega^{-1/2'} = \Omega^{-1/2}\, \Omega\, \Omega^{-1/2'} = I$. This got a little detailed, but you can take that as a reminder that formulas for the variance of matrix times a stochastic vector are essential for OLS/GLS theory.

13. Feasible GLS. Main examples: 1) autocorrelation in residuals 2) heteroskedasticity

14. White robust variance estimator. Explain why it works (under suitable assumptions).

15. The IV estimator when there are more instruments than regressors and the special case when the number of instruments is equal to the number of regressors.

16. Explain why the IV-estimator is consistent (and list the assumptions) but not unbiased. (Note: there isn't so much to remember about the assumptions, we basically assume "what we need" in order to get consistency.)

17. Maximum Likelihood.

    (a) Be able to show that $\hat{\beta}_{OLS} = \hat{\beta}_{ML}$ under the standard assumptions plus normality and explain the relation between are standard OLS estimate of the error variance and the ML estimate of the error variance.

    (b) Also, be able to derive the (Normal) ML estimator in the case of heteroskedasticity. (I won't ask for the case of autocorrelated residuals.)

    (c) Know the Cramer-Rao lower bound—in particular, that the inverse information matrix is the asymptotic variance of the estimator.

    (d) Be able to prove the information matrix equality (maybe for a particular simple likelihood function).

(e) Be able to find the ML estimator for simple distributions such as exponential, log-normal, Bernoulli.