This course considers systems of equations, drawing from two complementary approaches: the structural equation modeling with latent variables (SEM) literature and the econometrics literature (SiEM). In contrast to single equation models, these models have at least two equations. These simultaneous models can be grouped into two major types: recursive models, which do not create any special problems, and nonrecursive models, which require special treatment. For each of these major types, we will discuss the specification, identification, estimation, and assessment of these systems of simultaneous equations. Nonrecursive models introduce the problem of identification, or how to establish that the parameters of the model are estimable. These models also require alternative estimation techniques.

As time permits, advanced topics including limited dependent variables, measurement error, and handling longitudinal data will be covered. Students should have a good understanding of multiple regression and matrix algebra.

Most of the readings are drawn from four econometric texts:


Additional readings are drawn from the following structural equation modeling (SEM) texts:


All of the readings are available in the summer program library in the Newberry House.

There will be approximately 6 assignments. Due dates of assignments will be announced in class. We will also be discussing application papers as appropriate to recursive and non-recursive models (listed on last page of syllabus). Lab sessions will be announced in class.
**Topics and Readings:**

**I. Introduction to Simultaneous Equation Models**

a. A brief introduction to simultaneous equation models

**II: Review of the Classical Linear Regression model**

a. Review of matrix algebra

Readings:
Fox, John. 2009. *A Mathematical Primer for Social Statistics.* SAGE Publications, Inc. QASS. Chapter 1, Section 1.1 pp. 2-18 and Section 1.4 pp. 30-40. OR
Johnston and DiNardo: pp. 459-483

b. Classical linear regression model

Readings:
Gujarati: ch.4
Greene: ch.2 (ch. 6)
Johnston & Dinardo: ch.3 (ed 3: ch 5)

Note: for further review, read Gujarati ch.1-3 & 6, or Johnston &DiNardo chp.1-2, etc. first.

**III: Overview of simultaneous equation models**

Recursive vs. nonrecursive models; path diagrams/equations/matrices; reduced vs. structural form; direct, indirect and total effects.

Readings:
Gujarati: chp.18
Bollen: pp.32-34; 36-39

**IV: Recursive models**

a. Specification

Readings:
Gujarati: p. 764
Kmenta: pp.719-720
IV: Recursive models (cont.)

b. Identification

Readings:
Bollen: p. 88-98
Kenny: p. 34-41, 61-62
Greene: 13.3

c. Estimation

Readings:
Gujarati: p. 681-682
Johnston: p. 468-469 (ed. 4: 314-318)
Kmenta: p. 720

d. Decomposition of effects

Readings:
Bollen: pp.36-39

Defining mediation** (**see extended list on z: drive).


Optional Reading:
V: SUR (seemingly unrelated regressions) models

Readings:
Greene: 10.2, 15.6.3
Kmenta: 12.3

Example:

VI: Nonrecursive simultaneous equation models

a. Specification.
Reading:
Gujarati: 18.3-18.4

b. Identification
Readings:
Gujarati: chp.19.1-19.3
Greene: 13.3.1-13.3.2

c. Estimation: ILS, 2SLS, 3SLS, ML
Reading:
Gujarati: 20.1

c1. Indirect least squares
Readings:

c2. Two Stage Least Squares , aka 2SLS
Readings:
Gujarati: 20.4, 20.5
Greene: 13.4, 13.5.2, and 13.5.3
Kmenta: pp.681-687

Examples:

VI: Nonrecursive simultaneous equation models (cont.)

c3. 3SLS
Readings:
Johnston: pp.486-490
Kmenta: pp.695-701
Greene 13.6, 13.6.1

c4. MLE
Readings:
Greene: 13.6.2

d. Comparison of Estimation Methods
Reading:
Greene: 13.7
Kmenta: pp.711-714

e. Decomposition of Effects
Readings: Bollen: pp.376-389

VII. Assessment of models

a. Equation by equation

a1. Endogeneity tests:
Readings:
Gujarati: 19.4-19.5
Greene: 13.8

a2. Assessment of Instruments
Readings:
Optional reading** (see extended list on z: drive):

b. Global goodness of fit statistics for overidentified models

Readings:
Bollen: pp.263-289

**Additional Topics: (covered as time permits)**

**Modeling change**

*Readings:*

*Optional Reading:*

**Consequences of measurement error**

*Reading:*
Bollen: chp.5  , Greene: 9.5
Simultaneous equations with limited dependent variables

Readings:


Optional readings: Maddala 5.1, 5.8, chapter 7 and chapter 8.


Example:

Standard Errors of indirect effects

Readings:

Power Issues in Simultaneous Equations

Readings:

Lagged Endogenous Variables with autocorrelation

Readings:
Kmenta: 13.5

Using simultaneous equations to handle spatial effects

Readings:

Autocorrelation or heteroskedasticity in simultaneous equations

Readings:
Kmenta: 13.5

Application Papers:

**SUR:** Presentation on Wednesday July 28.

**Nonrecursive:** Presentation on Tuesday, Aug 3.

**Nonrecursive:** Presentation on Thursday, Aug 5.

Issues to consider in your reading of the application paper
1. Describe what the paper is trying to do, highlighting the theoretical model and how it is implemented statistically. How well is this accomplished?
2. In what ways do complexities encountered by the authors intersect with issues we’ve discussed in class?