# Chapter 5
# Endogeneity and Simultaneity: Outline

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## 5.1 Introduction

## 5.2 Linear models with endogenous regressors

- OLS properties: exogenous/endogenous regressors
- Sources of endogenous regressors (with first implementations of IV as solution)
  - simultaneity - *e.g.* demand/supply curves (Wright, 1928); LSEM & Cowles commission,
  - omitted variables - *e.g.* returns to education (Angrist & Kreuger, 1991)
  - measurement error - in simple linear regression (Wald, 1940; Durbin, 1954), Reirosol (1941,1945), and more modern example *e.g.* monetary policy reaction functions (Clarida, Gali & Gertler, 1990)
- Estimation via 2SLS
  - via IV (Sargan, 1958) Basmann (1957) Theil (1953a,b; 1961); bias (Nagar, 1959)
  - via control function approach (Hausman,1978)

## 5.3 Parametric simultaneous equation models

- Linear: 2SLS/3SLS (Zellner & Theil (1962) ( and connection to LIML/FIML)
- Nonlinear: NL2SLS/NL3SLS (Amemiya,1974; Jorgenson & Laffont, 1974)

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- Aged well? SEM framework depended of characterization of variables as endogenous/exogenous. ("incredible identification" Sims, 1980); also Lucas (1976) policy critique of SEM parameter interpretation in policy analysis. As a result, systems estimation methods are less relevant today than they once were. In contrast, single equation methods 2SLS/LIML can be justified outside this context and are still commonly applied.

## 5.4 Generalized Method of Moments

- Structural macro (Sargent); Sims (2002) economics models place restrictions on dgp via (often) moment conditions; estimation of structural parameters via population moment restrictions → GMM (Hansen, 1982) including GIV (Hansen & Singleton, 1982)
- Statistical properties of GMM: first-order asymptotics (Hansen, 1982)
- Alternatives to GMM: CUGMM (Hansen, Heaton & Yaron, 1996), GEL (Smith, 1997) - possess better second-order properties but are computationally more complex than GMM.
- Sensitivity of GMM properties to choice of moments/instruments
  - optimal instruments (Hansen, 1985)
  - many moments (*e.g.* Bekker, 1994) and data-based moment selection *e.g.* for linear IV: Donald & Newey, 2001; Belloni, Chen, Chernozhukov & Hansen, 2012
  - weak identification
- Aged well? Recognition that many econometric models imply restrictions on the dgp of economic variables that take the form of population moment conditions remains core idea. GMM remains central method for estimation. Caveat: not all moments are equally informative and statistical properties are sensitive to moment choice.

## 5.5 Linear panel data models

- Variable transformation to remove unobserved heterogeneity
- IV estimation of dynamic models: Anderson & Hsiao (1982), Arellano & Bond (1991), Arellano & Bover (1995), Bond & Blundell (1998)

## 5.6 Linear time series models

- stationary, univariate: IV estimation of AR component of stationary ARMA: Stoica & Soderstrom (1985), Hansen & Singleton (1996);
- I(1): IV-based methods, Hall (1987), Pantula & Hall (1991); Phillips & Hansen (1990).
- Impulse response function estimation via external instrument (LPIV and SVAR-IV, *e.g.* Stock & Watson, 2019)

## 5.7 Split- and Two-sample methods

- Split-sample IV, Jacknife IV (e.g., Angrist and Krueger (1995), Angrist, Imbens & Kreuger (1999)
- two-sample IV (e.g., Angrist and Krueger (1992), Inoue and Solon (2010)

## 5.8 Nonparametric models

- Identification and estimation of average affects
  - Separable equations (*e.g.*, Newey, Powell, and Vella, 1999; Newey and Powel, 2003)
  - Triangular models
    - control function (*e.g.*, Imbens and Newey, 2009)
    - Bounds on ATE (*e.g.*, Balke and Pearl, 1997)
  - Simultaneous equation models (Matzkin, 2008)
- Local and marginal treatment effects (Imbens and Angrist, 1994; Angrist, Imbens, and Rubin, 1996; Heckman and Vytlacil, 2005)
- Monotone IV (Manski and Pepper, 2000)

## 5.9 Concluding remarks

- endogeneity & simultaneity have been key features of econometric models since the earliest days of the subject. Recognition of these features led to the development on IV estimation as basis for inference in such models.
- IV and control function methods are to this day important tools for addressing endogeneity & simultaneity. Both rely on availability of suitable instruments.
- Driven by different areas of application, there has been recognition that properties of estimator are sensitive to choice of instrument (or more generally moment conditions). Different scenarios yield different statistical approximations.

- Instrument-based methods remain important in econometrics but inferences need to be performed with care.

## References