The Theory/Model Section of a Structural Estimation Paper

Dr. Richard W. Evans

February 2019

Blundell (2017), Structural model def and properties

"Structural models aim to identify three distinct, but related objects:"

- structural "deep" parameters
- underlying mechanisms
- policy counterfactuals

$$\boldsymbol{f}(\boldsymbol{x}, \boldsymbol{z}|\theta) = \mathbf{0}$$

Blundell (2017), Structural model def and properties

"Structural models aim to identify three distinct, but related objects:"

- structural "deep" parameters
- underlying mechanisms
- policy counterfactuals

$$\boldsymbol{f}(\boldsymbol{x}, \boldsymbol{z}|\theta) = \mathbf{0}$$

Earlier Def: Structural Model

Model in which the equations derived from individual optimization or firm optimization (behavioral equations).

- Includes linear models and linear approximations
- Most often nonlinear, dynamic

Theory 1: Formal Model

A set of cause and effect mathematical relationships between variables used to explain, predict, and understand phenomena.

- Exogenous variables: inputs to the model, taken as given, from outside the model
- Endogenous variables: output of the model, dependent exog. vars.
- Has both qualitative and quantitative implications

$$\boldsymbol{f}(\boldsymbol{x}, \boldsymbol{z}|\theta) = \mathbf{0}$$

Model

Theory 2: Informal Model

Narrative qualitative descriptions of relationships between variables, sometimes backed by experimental or anecdotal evidence.

- Often competing informal models are cited to show different possible relationships among variables
- Provides interpretability of results
- Lacks quantitative implications

Data generating process (DGP)

Def: Data generating process (DGP)

- Def. 1: A complete description of the mechanism that causes some observed phenomenon with all its dependencies (too complex)
- Def. 2: A simplified model version of the process that causes some observed phenomenon with its key dependencies.
  - This DGP or model must be specified in such a way that it could be used to simulate data.
  - This is a formal model, described earlier

Reduced Form model

Def: Reduced Form Model

Models in which equations are either not derived from behavioral equations or are only implicitly a linear approximation of some other model.

- Most often static
- There can be gray area or overlap between these two definitions
- Includes machine learning
- Often (but not always) atheoretical

Theory vs. Empirical Strategy

- Theory
  - Statement of model (either formal or informal)
  - Provides interpretability of empirical results
  - Provides testable hypotheses
  - Assumes direction of causality
- Empirical strategy
  - What you do with your model and the data
  - Sometimes empirical strategy implicitly assumed to be the model
    - e.g., reduced form model with no connection to theory

Pure Theory Papers

- Pure theory papers
  - Not what we are doing in this class
  - I love pure theory
  - Theory is the laboratory, rather than data
  - Mathematical analysis can determine results
  - Computational simulation can determine results

Model Section

- Equations plus intuition
- Give the story of what your model is doing and what are the main interactions. This spells it out for the reader

Model Section

- Equations plus intuition
- Give the story of what your model is doing and what are the main interactions. This spells it out for the reader

Model Section

- Equations plus intuition
- Give the story of what your model is doing and what are the main interactions. This spells it out for the reader
- What are the main pieces of your model?

Model Section

- Equations plus intuition
- Give the story of what your model is doing and what are the main interactions. This spells it out for the reader
- What are the main pieces of your model?
- Why did you choose to model some parts of the real world and neglect others?
    - This has to do with your research question

Model Section

- Equations plus intuition
- Give the story of what your model is doing and what are the main interactions. This spells it out for the reader
- What are the main pieces of your model?
- Why did you choose to model some parts of the real world and neglect others?
    - This has to do with your research question
- How do the parts of your model match up with the data?

Model Section

- **Equations plus intuition**. Give the story of what your model is doing and what are the main interactions. This spells it out for the reader

Model Section

- **Equations plus intuition**. Give the story of what your model is doing and what are the main interactions. This spells it out for the reader
- Model is the theoretical version of the data generating process. It is a simplified version of reality

Model Section

- **Equations plus intuition**. Give the story of what your model is doing and what are the main interactions. This spells it out for the reader
- Model is the theoretical version of the data generating process. It is a simplified version of reality
- What are the main pieces of your model? exog, endog

Model Section

- **Equations plus intuition**. Give the story of what your model is doing and what are the main interactions. This spells it out for the reader
- Model is the theoretical version of the data generating process. It is a simplified version of reality
- What are the main pieces of your model? exog, endog
- Why did you choose to model some parts of the real world and neglect others?
    - This has to do with your research question

Model Section

- **Equations plus intuition**. Give the story of what your model is doing and what are the main interactions. This spells it out for the reader
- Model is the theoretical version of the data generating process. It is a simplified version of reality
- What are the main pieces of your model? exog, endog
- Why did you choose to model some parts of the real world and neglect others?
    - This has to do with your research question
- How do the parts of your model match up with the data?

Model Section

- If much of model is standard, you can summarize
  - I am big advocate of technical appendices
  - List all your equations and derivations somewhere
  - You might find an error in the previous work
  - You might find an assumption that could be improved by a different assumption

Model Section

- If much of model is standard, you can summarize
  - I am big advocate of technical appendices
  - List all your equations and derivations somewhere
  - You might find an error in the previous work
  - You might find an assumption that could be improved by a different assumption
- Some models require you to spend a lot of time on solution method

Model Section Examples

- DeBacker, Evans, Phillips (2019)
  - What is question: How do rich tax functions perform in analysis of canonical tax reform?
  - Demographics
  - Heterogeneous ability
  - Overlapping households
  - Taxes
  - How fits with data
  - Appendices

Model Section Examples

- Altonji, Joseph G., Anthony A. Smith, Jr., and Ivan Vidangos, "Modeling Earnings Dynamics," *Econometrica*, pp. 1395-1454 (July 2013)
  - This model is somewhat reduced form
  - Linear or logistic with linear kernel (predictor)
  - System of dynamic equations with constraints

Model Section Examples

- Li, Narajabad, Temzelides (*QE*, 2016) “Robust dynamic energy use and climate change”
  - What is question: What is optimal carbon tax when policy makers have model uncertainty?
  - Household optimization
  - Production: intermediate goods and final goods
  - Aggregate resource constraint
  - Model uncertainty
  - Appendices
  - Given their question, did they have enough model uncertainty? Did they put the model uncertainty in the right place?

Model Section Examples

- Rust, John, "Optimal Replacement of GMC Bus Engines: An Empirical Model of Harold Zurcher," *Econometrica*, 55:5, pp. 999-1033 (Sep. 1987)
    - Great exposition of a model characterized by Bellman equation(s)