Micro Data for Macro Models

Topic 0: Course Intro and Representative Agent Macroeconomics

Thomas Winberry

January 7th, 2019
Some Thoughts on the Research Process:
Three Key Skills

1. **Ask important questions**
   - What do you want to understand about the world?
   - Why is it important to understand that?
   - Why don’t we understand it already?
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   - Presentations (job talks)
   - Papers (job market paper)
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Typical Chicago Placements

- Slightly more than half go to academic jobs
  - About one-quarter go to top 40 departments
  - Even less end up getting tenured...

- About one quarter go to government agencies (central banks, World Bank, etc.)

- Another quarter to private sector (primarily consulting)
Publishing

• The median Ph.D. from a top 20 department never publishes in a peer-reviewed journal

• The median peer-reviewed paper has less than 15 citations

• See https://www.jstor.org/stable/2138379
The Good News

• The creation of research is a skill just like inverting a matrix, solving a DSGE model, computing a standard error, etc.
  • The more you practice, the better you’ll become
  • Read papers of those recently tenured at top schools. *Every one of you could have written those papers.*

• Impact on the profession comes from *good ideas*

• But that’s something Ph.D. students are not directly taught. Typical skills that are lacking:
  • Identifying interesting research questions
  • Explaining why anyone should care about their research
  • Knowing that technical skills are means, not an end
“Where Do Good Ideas Come From?”

1. **Reading literature** (finding holes, being unsatisfied with consensus, etc.)

2. **Understand the world** around us (“what drives employment?,” “how does one measure uncertainty?,” “which firms respond to interest rate cuts?,” etc.)

3. **Playing around with data**

4. **Talking** with other graduate students
“Where Do Good Ideas Come From?”

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- **Pick projects you’re interested in!**
  If you’re not interested, no one else will be either.
Some Tips From a (Not So) Recent Grad Student

- **Treat this like a job** (it is one)
  - Do 30-40 hours of research per week, 48 weeks per year
  - Keep regular hours

- **Organize your workflow**
  - Write down everything you do (record your progress)
  - Make your work readable and replicable by your future self

- **Talk to faculty!**
  - Come to every meeting with something written
  - Big question → your last steps → what you did since then → your next steps


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• Talk to faculty!
  • Come to every meeting with something written
  • Big question → your last steps → what you did since then → your next steps

• Be happy
  • Take one day off per week

• Don’t be mean, aggressive, arrogant, etc.
Our Half of the Course
Firm Size Distribution Has Fat Tails

Source: Axtell (2001)
Huge Amount of Churning Among Firms

Source: Davis and Haltiwanger (1992)
Firms Have Very Different Productivity

Source: Hsieh and Klenow (2009)
Firms Have Very Different Investment Rates

Source: Cooper and Haltiwanger (2006)
Our Course

• **How does firm heterogeneity matter for aggregate outcomes?**
  - Implicit: relative to representative firm models
  - Focus on business cycles
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  - Focus on business cycles

• Two main answers to this question:
  1. Micro data provides information to discipline models
  2. Distribution of heterogeneous firms matters for aggregates
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- Two main answers to this question:
  1. Micro data provides information to discipline models
  2. Distribution of heterogeneous firms matters for aggregates

- Emphasize the interaction between
  1. **Empirical work**: documenting key features of firm behavior
  2. **Models**: draw implications for aggregate dynamics
Logistics

• Be prepared to discuss required readings in lecture

• Homework designed to introduce two skills:
  1. Empirical homework: estimate productivity in Compustat (due January 18th)
  2. Model homework: solve simple investment model in Matlab (due February 1st)

• Presentations of existing papers
  • Read my guide to presenting posted on my web site!!!
Representative Agent RBC Model
Preferences

- Representative household with preferences over consumption $C_t$ and labor supply $N_t$

$$\mathbb{E}\left[\sum_{t=0}^{\infty} \beta^t \left( \frac{C_t^{1-\gamma} - 1}{1 - \gamma} - \chi \frac{N_t^{1+\frac{1}{\eta}}}{1 + \frac{1}{\eta}} \right) \right]$$
Environment

Preferences

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Technology

• Aggregate production function $Y_t = e^{Z_t} K_t^\alpha N_t^{1-\alpha}$
• Output used for consumption or investment $C_t + l_t = Y_t$
• Capital accumulation follows $K_{t+1} = (1 - \delta)K_t + l_t$
• Aggregate TFP follows $Z_{t+1} = \rho Z_t + \varepsilon_{t+1}$, where $\varepsilon_{t+1} \sim N(0, \sigma^2)$
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Endowments

• Household endowed with one unit of time each period: $N_t \in [0, 1]$
• Household endowed with $K_0$ units of capital in $t = 0$
Equilibrium

**Definition:** Given $K_0$ and $z_0$, a sequential markets competitive equilibrium is a list of stochastic processes for $C_t, K_{t+1}, N_t, w_t, r_t$, and $Z_t$ such that
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1. **Household optimization:** Taking the processes for $w_t$ and $r_t$ as given, the household solves

$$
\max_{C_t, N_t, K_{t+1}} \mathbb{E} \left[ \sum_{t=0}^{\infty} \beta^t \left( \frac{C_t^{1-\gamma} - 1}{1 - \gamma} - \chi \frac{N_t^{1+\frac{1}{\eta}}}{1 + \frac{1}{\eta}} \right) \right]
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such that $C_t + (K_{t+1} - (1 - \delta)K_t) = w_tN_t + r_tK_t$ for all $t$.
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2. **Firm optimization**: Taking the processes for $w_t, r_t,$ and $Z_t$ as given, the firm solves

   $$\max_{K_t, N_t} e^{Z_t} K_t^\alpha N_t^{1-\alpha} - r_tK_t - w_tN_t$$
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3. **Market clearing + consistency:** For all $t$, $Z_{t+1} = \rho Z_t + \varepsilon_{t+1}$
**Equilibrium Characterization**

**Definition:** Given $K_0$ and $z_0$, a *sequential markets competitive equilibrium* is a list of stochastic processes for $C_t, K_{t+1}, N_t, w_t, r_t,$ and $Z_t$ such that
Equilibrium Characterization

**Definition:** Given \( K_0 \) and \( z_0 \), a sequential markets competitive equilibrium is a list of stochastic processes for \( C_t, K_{t+1}, N_t, w_t, r_t, \) and \( Z_t \) such that

1. **Household optimization:**

\[
w_t C_t^{-\gamma} = \chi N_t^{\frac{1}{\eta}}
\]
\[
C_t^{-\gamma} = \beta E_t [C_{t+1}^{-\gamma} (1 - \delta + r_{t+1})]
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2. **Firm optimization:**
   
   $r_t = \alpha e^{Z_t} K_t^{\alpha-1} N_t^{1-\alpha}$
   
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Steady State

**Definition:** A non-stochastic steady state sequential markets competitive equilibrium is a list \(C^*, K^*, N^*, w^*, r^*\) such that if \(\sigma = 0\) and \(K_0 = K^*\), then \(C_t = C^*, K_{t+1} = K^*, N_t = N^*, w_t = w^*,\) and \(r_t = r^*\) for all \(t\) is a sequential markets competitive equilibrium.
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1. Useful in **calibrating parameters of the model** (steady state $\approx$ long run average)

2. Useful in **solving the model** using perturbation methods
   - Approximates solution using Taylor expansion around steady state
   - See my website for **Dynare** code to solve RBC model (you should know how to do this!)
Calibration

**Calibration** is parameterizing the model to match salient features of the data.
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1. Choose some parameters to match steady state aggregates to long-run average in data
   - Choose $\delta$ to match $\mathbb{E}[\frac{L_t}{K_t}] = 10\%$ annual
   - Choose $\alpha$ to match $\mathbb{E}[\frac{w_t N_t}{Y_t}] = \frac{2}{3}$
   - Choose $\beta$ to match $\mathbb{E}[r_t - \delta] = 4\%$ annual

\[
\Delta_t = \log(Y_t) - \log(K_t) - (\delta) \log(N_t)
\]
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   - Choose $\beta$ to match $\mathbb{E}[r_t - \delta] = 4\%$ annual

2. Choose other parameters to match a priori evidence
   - Choose $\sigma$ to set EIS = 1
   - Choose $\eta$ to set Frisch = $\frac{1}{2}$ (more on this next slide)
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   - Choose $\sigma$ to set EIS = 1
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3. Estimate process for TFP from measured Solow residuals
   \[ Z_t = \log(Y_t) - \alpha \log(K_t) - (1 - \alpha) \log(N_t) \]
Indivisible Labor and the Frisch Elasticity

• Calibration of $\eta = \frac{1}{2}$ based on micro-level estimates
• Rogerson (1988) showed that micro-level $\neq$ macro-level
Indivisible Labor and the Frisch Elasticity

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- Rogerson (1988) showed that micro-level $\neq$ macro-level
  - Households $i \in [0, 1]$ with flow utility $\log(c_{it}) - \chi \frac{n_{it}^{1+\xi}}{1+\xi}$, where $\xi = \frac{1}{\eta}$
  - Can only work $n_{it} = 0$ or $n_{it} = 1$ (all extensive margin)
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  - Households choose probability of working $p_{it}$
    - Ex-ante utility is $\log(c_{it}) - \chi(p_{it} \times 1 + (1 - p_{it}) \times 0)$
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  - In symmetric equilibrium, $c_{it} = C_t$, $p_{it} = N_t$, and everyone’s utility is $\log(C_t) - \chi N_t$
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    - In symmetric equilibrium, $c_{it} = C_t$, $p_{it} = N_t$, and everyone's utility is
      $$\log(C_t) - \chi N_t$$
  - Even if micro-level $\eta \to 0$, macro-level $\eta \to \infty$!
Impulse Response Analysis

- An **impulse response function** traces out how a one-time shock affects dynamics of the economy

\[ \mathbb{E}[Y_{t+s}|\varepsilon_t = \sigma, K_t, z_t] - \mathbb{E}[Y_{t+s}|\varepsilon_t = 0, K_t, z_t] \]

- In principle, depends on \( K_t, z_t \), and size of the shock
- But in linear models, does not

- Clear and simple way to understand economic mechanisms in model
Impulse Response to TFP Shock, $\eta = \frac{1}{2}$
Impulse Response to TFP Shock, $\eta \to \infty$
Cyclical Fluctuations with Hodrick-Prescott Filter
Cyclical Fluctuations with Hodrick-Prescott Filter
Cyclical Fluctuations with Hodrick-Prescott Filter
## Business Cycle Statistics in the Data

<table>
<thead>
<tr>
<th>Volatilities (rel. to $\sigma(y_t)$)</th>
<th>$\sigma(y_t)$</th>
<th>$\sigma(c_t)$</th>
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Takeaways From Topic 0

• Benchmark representative agent approach to studying aggregate fluctuations
  • Methodology: model specification, equilibrium, calibration, impulse response analysis, business cycle statistics
  • Economic forces: consumption smoothing, labor supply
Takeaways From Topic 0

- Benchmark representative agent approach to studying aggregate fluctuations
  - **Methodology**: model specification, equilibrium, calibration, impulse response analysis, business cycle statistics
  - **Economic forces**: consumption smoothing, labor supply
- Micro data cannot be used to calibrate representative agent
  - Representative agent may look very different from micro agents
Takeaways From Topic 0

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  • **Methodology**: model specification, equilibrium, calibration, impulse response analysis, business cycle statistics
  • **Economic forces**: consumption smoothing, labor supply

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  • Representative agent may look very different from micro agents

• Need to build models with explicit micro heterogeneity and aggregation
  • To use micro data, need micro agents
  • Micro data is the ONLY data we have on individual decision making