Advanced Macroeconomics II

Handout 1 - Course Intro, Version Control, Best Practices

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January 9, 2023

A bit about me

- Assistant Professor at Western since 2020
  - Before researcher as University of Oslo
- PhD at Minnesota
- Work on "modern macro" (Minnesota style)
  - We (minnesotans) have a very broad definition of macro...

A bit about my work

- Papers on many topics:
  - Tasks and occupations, wealth taxes, concentration, self-employment

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  - Tasks and occupations, wealth taxes, concentration, self-employment
- One unifying theme: **Heterogeneity**
- Modern macro is all about (cross-sectional) heterogeneity
  - Workers vary in skills, investors in rate of return, entrepreneurs in productivity, markets in concentration, consumers in wealth and income
  - List goes on: age, marital status, health, race, gender, human capital
- The line between modern macro and micro is blurry:
  - Macro models need to capture a lot of micro-behavior
  - Empirical backing for model assumptions from data

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- Should capital be taxed? What is the optimal value of τ_k?

$$c + a^{'} = a + (1 - \tau_k)\, ra + wn$$

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- $\tau_k > 0$ optimal if agents face **idiosyncratic labor income risk** (Aiyagari, 1995; Imrohoroglu, 1998; Boar & Midrigan, 2020)
  - Result maintained after adding life cycle and other taxes (Conesa, Kitao & Krueger, 2009; Many others)

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  - This is true even if agents are heterogeneous: labor income, life cycle, retirement, mortality risk, bequest motives

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- They are equivalent! Replace τ_k for $\tau_a = r\tau_k$
  - This is true even if agents are heterogeneous: labor income, life cycle, retirement, mortality risk, bequest motives
- Equivalence breaks if agents have **heterogeneous returns**!
  - Wealth taxes favors agents with high r (leading to efficiency gains...)

A bit about my work: Wealth taxation (3/4)

Lesson:

- Different forms of heterogeneity have different effects
- Ask: what is the relevant form of heterogeneity
  - relevant theoretically
  - relevant empirically

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Why heterogeneous returns?

- Theoretically interesting (break equivalence of taxes)
- Empirically relevant
  - Necessary to capture fat tail of income/wealth distribution (Work of Benhabib, Bisin and coauthors; Akira-Toda, 2019)
  - Direct empirical evidence: Norway (Fagereng, Guiso, Malacrino & Pistaferri, 2020) US (Smith, Yagan, Zidar & Swick, 2020)

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Two tasks:

1. Establish conceptual result (this time it was easy)
2. Show result is quantitatively relevant

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Quantitative methods in modern macro

- Heterogeneous agent models required for validation
- In my paper I include and match moments for:
  - Life cycle: work, retirement, mortality risk, bequests
  - Source of income (entrepreneurial activity, savings, labor)
    - Labor income risk
    - Heterogeneous returns
- Individual problem has 6 states variables (11 million combinations)

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- Why is self-employment so much higher in developing countries? (JME)
  - Who are the self-employed? Why does it matter?
  - Look at the self-employed across the earnings distribution

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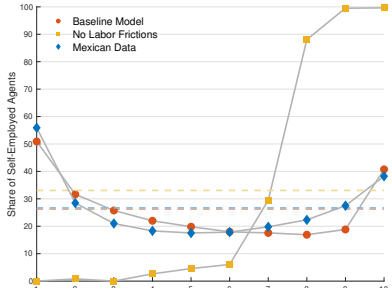
1. Look at pattern in micro-data
2. Contrast model result
3. Understand mechanisms



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1. Quickly implement and test research ideas
   - Most ideas are bad... you need a way to check

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What I get out of the course:

1. I am going to learn Julia with you
2. Hopefully convert some of you to the true faith

(Tentative) Course outline

1. Basic tools (version control + coding best practices + basic code)

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2. The Neo-Classical growth model

- Most tools can be learned here
- Starting point for many models

2.1 Value function iteration (and how to speed it)
2.2 Continuous choice / First order conditions
2.3 The endogenous grid method
2.4 Shocks and expectations

(Tentative) Course outline

1. Basic tools (version control + coding best practices + basic code)
2. The Neo-Classical growth model
3. Adding distortions
   - 3.1 (k,K) models
   - 3.2 Sovereign default models

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1. Basic tools (version control + coding best practices + basic code)
2. The Neo-Classical growth model
3. Adding distortions
4. Heterogeneity
   - 4.1 The Bewley/Hugget/Aiyagari/Imrohoroglu model
   - 4.2 The stationary distribution
   - 4.3 The life cycle heterogeneous agent model

(Tentative) Course outline

1. Basic tools (version control + coding best practices + basic code)
2. The Neo-Classical growth model
3. Adding distortions
4. Heterogeneity
5. Extensions
   - 5.1 Discrete choice (Occupational choice problems/Retirement)
   - 5.2 Transition out of steady state

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1. Basic tools (version control + coding best practices + basic code)
2. The Neo-Classical growth model
3. Adding distortions
4. Heterogeneity
5. Extensions
6. Some topics
   - 6.1 Cross-Sectional moments for macroeconomics
   - 6.2 Modeling at the frontier

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1. Basic tools (version control + coding best practices + basic code)
2. The Neo-Classical growth model
3. Adding distortions
4. Heterogeneity
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6. Some topics
7. Search Models (just the basics)
   - 7.1 The McCall model
   - 7.2 The DMP model
   - 7.3 Directed Search

Course mechanics

- Weekly topic covered in live (video) lecture
  - 3 hours with break in the middle
- Weekly problem set
  - Problem sets to be done individually
  - Submit solution via a public (github) repository
  - Readme file, ready-to-execute file, pdf if necessary
- All grade comes from problem sets
  - You get to drop two

Version Control: Git

Slides by Dominic Smith

What is version control?

- Software that keep track of changes to files
- Store history of all changes done to code/figures/output
- The language that lets you keep track of this changes is called **Git**
- We will only deal with the (very) basics of version control
  - Basic Git commands
- All projects benefit from version control. We will use it in all assignments.

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- You always need backups of your code and results
- You often need to share your code with others and collaborate
- Git is better than alternatives:
  - Renaming files or creating new folders

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- When collaborating

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  - Link your local repository to an online repository (github, bitbucket)
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- Online repository is also a backup for your code

Version control in this course

- All assignments should be available on a git repository
- You must create the repository and maintain it
- Upload problem sets to the repository
- Problem sets are individual, but if you choose to collaborate do it with Git (and let me know)

Install Git (if you don't have it)

- Go to https://git-scm.com/
  - Can use getting started tutorial there
  - Atlassian also has useful information: https://www.atlassian.com/git/tutorials
  - Github also has tutorials
- GIT comes with a GUI (graphical user interface) and command line
  - Things are faster with command line

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Now you can always go back to this exact version of your files

What to do now?

Assume we just committed files

1. Modify some number of files, potentially adding new ones
2. **git add** any new files
3. **git commit –a -m** “Message to remember what you modified”

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You want it to be clear which code fixed bug and which added feature

- Use messages to inform of what happened
  - **git commit -a - m “added program to fix bug”**
  - **git commit -a - m “changed program to add new feature”**

Help! I'm stuck in VI/VIM

If you don't type **–m** after git commit you get in trouble!

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- These are archaic and moody editors...

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Here is what to do:

1. Type ESC then :qw and hit return
2. You'll need to commit again
3. Alternatively you can learn VIM, but that is a lot of work

“Advanced” commands

- **git clone**: Useful to start a new project using an old repository, also good to link to an online repository
- **git pull/push**: Useful to communicate with your online repository, pull a new version from it, push a new version to it
- **git branch**: Creates a copy of your repository and tracks changes to it separately
  - Type **git branch Branch_Name** to create branch
  - Type **git checkout Branch_Name** to move to the branch
  - This is the most useful command to keep track of alternative versions of your code
- **git merge**: Merges two branches, useful when done experimenting
- **git reset –hard HEAD**: Returns your repository to its last commit, useful for undoing catastrophic mistakes

Best Practices

1. Breaking up code
2. Readme files
3. Start small
4. Time your code
5. No parallelization

Breaking up code (1/5)

Having all your code in the same script is a bad idea

- Worse: It looks like a good idea at the time
- Your future self will regret it
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Why break scripts up?

- Easy to edit (less lines/script, know what is in script)
- Easy to track changes (most scripts left untouched)
- Easy to reuse (across projects, across model versions)

Breaking up code: Three ways to do it (2/5)

1. Load lines of code from another script
2. Functions
3. Modules

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1. Load lines of code from another script
   - Useful for portions of code that are repeated often
   - Also useful for separating portions of code that are different
     - Solving model vs Graphing solution vs Saving results
   - No need to pass variables
   - Uses same workspace as the "main" script
2. Functions
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Breaking up code: Three ways to do it (2/5)

1. Load lines of code from another script
2. Functions
   - Useful for portions of code that (kind of) repeat themselves... Perform the same tasks but use different variables
   - Need to have (more) defined inputs/outputs (private scope)
3. Modules

Breaking up code: Three ways to do it (2/5)

1. Load lines of code from another script
2. Functions
3. Modules
   - Basically groups of functions

Breaking up code: Breaking up is so hard to do (3/5)

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  - My wealth taxation code has 7 modules
  - Module on model solution has 7500+ lines, 51 functions

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- But they grow so fast!
  - My wealth taxation code has 7 modules
  - Module on model solution has 7500+ lines, 51 functions
- Not ex-ante clear where one module should end or another start
- Not always clear where to place functions

Breaking up code: Too much of a good thing (4/5)

Careful with repetition, breaking up code incorporates overhead

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- Assign consumption for (say) 20 million agents.
- Two options
  1. c[i] = Y(a[i],n[i]), where Y(x,z) = (1+r)*x+w*z is a function
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- First option makes it easy to change income
  - Only have to do it in one place (function definition)
- Second option avoids calling function Y millions of times...

Breaking up code: Rules of Thumb (5/5)

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  - Parameter values
  - Initialization (set up grids, transition matrices, etc)
  - Model Solution
  - Model Simulation
  - Model Results (compute stats, save results)
  - Graphs

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  - Graphs
- Functions for:
  - Everything that you write three times!

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Readme files

- Always have one!
  - I learned this one the hard way... So much code I have no idea what it does
- Easy to do:
  - "The code in this folder solves X model."

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Bonus: You often know the answer in smaller models

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- Poor man's timing:
  - Matlab's tic-toc or Julia's @time or package "TimerOutputs"
  - Use often, "no" overhead, fast iteration
- Rich man's timing:
  - Profile (both Matlab and Julia)
  - Use sparingly, less manageable as code grows

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Message applies to other forms of code optimization:

- First have your code working, then make it fast

Julia/Matlab

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Key: You won't get to choose Matlab if you are doing large scale models

Installation

Matlab

- https://wts.uwo.ca/sitelicense/matlab/

Julia

- https://juliacomputing.com/products/juliapro.html
  - Choose current stable release
  - This should be bundled with Atom, the editor we will use
- Install plots package: import Pkg; Pkg.add("Plots")

Resources

- Julia's manual (actually very readable):
  https://docs.julialang.org/en/v1/
- Best allies: Google + StackOverflow + JuliaDiscourse
- QuantEcon: https://julia.quantecon.org
- Share what you find!

Appendix

Appendix Slides

- Nothing yet...