julia> Lecture Eight: Economic Models

Course: Computational Bootcamp

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> Most economic models involve an agent or set of agents trying to maximize something
>
> > Individuals maximize their utility
> >
> > Firms maximize their profits
> >
> > Governments maximize welfare
>
> These maximization problems are subject to some constraints
>
> > Budget constraints
> >
> > Incentive compatibility constraints
>
> Whenever you build a model, it is important to know who your agents are and what constraints they face

julia> Dynamic or Static

- Static: Choices today do not affect future pay-offs.
  - What type of cereal brand to buy
  - Labor-leisure choice
- Dynamic: Choices today affect future pay-offs
  - Human capital accumulation such as college
  - Investment choice of a firm
- Static models are simpler. Start simple.
- Dynamic programming will help solve dynamic models

julia> Discrete or Continuous?

- State and control variables can be either:
- Discrete: Finite number of choices:
  - What industry to work in?
  - Whether to go to college?
  - Whether to adopt new technology?
- Continuous: Infinite number of choices.
  - How much to save or invest? What price to set? How many hours to work?
- Not clear which one is simpler, but start simple

julia> Infinite vs. Finite Time?

- Infinite Time: Agents possibly live forever
  - Typically used for firms and government
  - No aging/life-cycle effects
  - Solve with value function iteration or something else
- Finite Time: Agents' decisions end in some terminal period
  - Necessary to study how things evolve over the life-cycle
  - Retirement, human capital accumulation, etc
  - Solve via backward induction from final period

julia> Today: Ben-Porath Model

- What is optimal human capital accumulation over the life-cycle?
- Time invested in human capital accumulation:
  - Increase our wages But decreases time spent working
- Model begins at age 20. Workers retire at age 70.
- Agent has a learning ability a and initial human capital h_0
- In each period, the agent decides how much time to spend learning and working

julia> How to solve this?

- We could start at age 20 and consider all possible HC paths
- Downside: this takes forever
- Even if HC only takes two values, there are 2^50 possible paths (an absolutely *massive* number)
- Better way: Use dynamic programming
  1. Start at age 70. You won't invest in human capital
  2. Then we can solve at age 69
  3. Then go to age 68, ..., repeat until we reach age 20

julia> Formal value function

> Agent with ability a at age t with human capital h chooses investment I in human capital to maximize:

$$V(a,h,t) = \max_I \{u(c) + \beta V(a,h',t+1)\}$$

subject to:

$$c = h(1-I)$$

$$h' = (a(hI)^\kappa + h)\varepsilon$$

$$\log(\varepsilon) \sim N(0,\sigma^2)$$

> Terminal condition:

$$V(\cdot,\cdot,71) = 0$$

julia> Age 70 problem:

$$V(a,h,70) = \max_{I}\{u(c) + \beta V(a,h',71)\}$$

> subject to

$$c = h(1-I)$$

> Plug in the terminal condition:

$$V(a,h,70) = \max_{I}\{u(c)\}$$

> This is maximized by setting $I = 0$!

julia> Age 69 problem:

- Now we know the value at age 70 at all values of a and h on their respective grids
- We can interpolate h and solve:

$$V(a, h, 69) = \max_{I}\{u(c) + \beta V(a, h', 70)\}$$

- Once we solve this, we obtain $V(a, h, 69)$ for all values of a and h
- Repeat again for age 68, then age 67, and so on...
- Finally, we solve at age 20!
- Let's code this up. It's hacking time!

julia> Wrapping up

- In this class, we have learned how to:
  - Do things on a computer that you can't do with pencil and paper.
    - e.g. Approximate and optimize complex functions
- Do these things quickly.
  - Writing good code in Julia, dynamic programming, parallelization
- Things we learned feature heavily in solving economic models
- You will work through many such models in Econ 899 and hopefully your own research

julia> Happy coding!

> Happy coding!

> Lots of additional resources I have found useful are on Kevin's website: https://kevinghunt.github.io/ComputationCamp/index.html#resources

> Good luck with your research and field papers.

> Thank you for your participation!