ECON 202: Macroeconomics I
Lecture 18 - Review

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Section 1

Measurement

Measuring GDP

- Nominal GDP calculated as sum of prices times quantities

$$GDP_t^{NOM} = \sum_i p_{it} q_{it}$$

- Only include goods sold to end users to avoid double counting
- Real GDP fixes prices at a particular point in time b

$$GDP_t^{REAL} = \sum_i p_{ib} q_{it}$$

- Chain-weighting (averaging subsequent time periods') reduces substitution bias and better measures new products

Section 2

Finding Equilibrium

The Cookbook to find equilibrium

1. Write down household maximization problem
2. Write down household Lagrangean, take FOCs, solve for Marshallian Demand
$$MRS = MRT$$
3. (If applicable) write down firm's maximization problem. Unless explicitly stated, firm's problem does not have constraint.
4. Write down FOCs, solve for input (a.k.a. factor) demands
$$\text{Marginal Revenue Product} = \text{Marginal Cost}$$
5. Impose market clearing by equating supply and demand

Permanent Income Hypothesis

- In the absence of frictions (e.g. consumers can borrow), fluctuations in consumption will be driven by fluctuations in *permanent* income, not transitory income
- Thus temporary shocks should not affect consumption greatly in the absence of large propagation mechanisms.
- Came from a problem like

$$\max_{c_0, c_1} \ln c_0 + \beta \ln c_1 \qquad s.t. \qquad c_0 + b_1 = y_0$$
$$c_1 = y_1 + (1+r)b_1$$

to yield Euler equation

$$\frac{u'(c_0)}{\beta u'(c_1)} = 1 + r$$

Section 3

Growth

Empirics

1. Growth in per capita output of about 2% per year in the U.S.
2. Poorer countries converge to richer countries on average
3. Savings rate highly correlated with wealth
4. Innovation positively correlated with growth

Solow Growth - Set up

- Output produced with capital and labor according to

$$Y_t = A_t K_t^{\alpha} L_t^{1-\alpha}$$

for Y_t aggregate output (GDP), A_t total factor productivity (TFP), K_t capital, L_t labor, and α the capital share in production

- Capital evolves according to law of motion:

$$K_{t+1} = (1-\delta)K_t + I_t$$

for δ the (constant) depreciation rate of capital and I_t investment

- Agents save a fixed share s of their income so that

$$I_t = sY_t \qquad\qquad C_t = (1-s)Y_t$$

Solow Growth - Dynamics

- Over time, converge to a steady state value of capital, output, and consumption.

$$\bar{K} = \left(\frac{sAL^{1-\alpha}}{\delta}\right)^{\frac{1}{1-\alpha}} \qquad \bar{Y} = A\bar{K}^{\alpha}L^{1-\alpha} \qquad \bar{C} = (1-s)\bar{Y}$$

- If productivity or labor increasing, converge to steady state value of capital etc. *per effective labor unit*

$$\bar{k} = \left(\frac{s}{\delta + g_A + g_L + g_A g_L}\right)^{\frac{1}{1-\alpha}} \qquad \bar{Y} = \bar{k}^{\alpha} \qquad \bar{c} = (1-s)\bar{y}$$

  for g_A growth rate in productivity, g_L growth rate of labor.
- Increases in savings rate will not lead to higher consumption unambiguously: have more stuff but eat less of it. Optimal $s^* = \alpha$
- Only source of long run growth in per capita output: productivity

Neoclassical Growth

- Same premise as Solow, but people choose savings:
- Consumers solve

$$\max_{\{c_t\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t u(c_t) \qquad s.t. \quad Y_t = A_t K_t^{\alpha} L_t^{1\alpha}$$

$$K_{t+1} = (1-\delta)K_t + I_t$$

$$I_t = Y_t - c_t$$

Substitute constraints into each other to get

$$K_{t+1} = (1-\delta)K_t + A_t K_t^{\alpha} L_t^{1-\alpha} - c_t$$

- Get Euler Equation a before.
- Savings rate is

$$s = \frac{\delta\alpha}{\rho+\delta} \Rightarrow \quad s = s^* = \alpha \Leftrightarrow \rho = 0$$

Modern Growth

- Growth only comes from increases in productivity
- This requires innovation/input improvements
- Knowledge is a *public good*
- Thus have strong *intellectual property rights* (patent law)
- Public goods tend to be underprovided relative to social optimum

Section 4

Business Cycles

Economic Fluctuations

- Cycles happen recurrently but not periodically
- Multiple indicators fall at the same time
  - $\Rightarrow$ Output, investment, consumption, wages, etc.
- Investment and other highly income elastic goods fluctuate more over the cycle
- People predict with *leading indicators*, including the yield curve.
- Need propagation mechanism to make small shock large
  - People get poorer so invest less, have less capital, thus less output next period
  - Granularity: shocks to large firms can have aggregate effects
  - Network: shocks to highly connected sectors can have aggregate effects

Real Business Cycles - Firms

Firms solve

$$\max_{L_t, K_t} A_t K_t^{\alpha} L_t^{1-\alpha} - w_t L_t - r_t K_t$$

so that

$$w_t = \underbrace{A_t(1-\alpha)L_t^{-\alpha}K_t^{\alpha}}_{MP_L} \qquad r_t = \underbrace{A_t \alpha L_t^{1-\alpha}K_t^{\alpha-1}}_{MP_K}$$

Real Business Cycles - Households

- Two generations: old and young
- Households solve

$$\max_{c_t^t, c_{t+1}^t, k_{t+1}} \ln c_t^t + \ln c_{t+1}^t \qquad s.t. \quad c_t^t + k_{t+1} = w_t$$
$$c_{t+1}^t = (1-\delta)k_{t+1} + r_{t+1}k_{t+1}$$

- Writing Lagrangean and FOC eventually yields

$$k_{t+1} = \frac{w_t}{2}$$

- Higher $w_t \Rightarrow$ higher $k_{t+1} \Rightarrow$ higher Y_{t+1}

Equilibrium

- Labor market clearing implies $L_t = 1$
- Plug firms' FOC into household maximization problem to get

$$K_{t+1} = \left[\frac{A_t(1-\alpha)K_t^{\alpha}}{2}\right]$$

- If $A_t \uparrow$, $w_t \uparrow$, $K_{t+1} \uparrow$
- Define $I_t = K_{t+1} - (1-\delta)K_t$, $C_t = Y_t - I_t$.
- Plugging in for $Y_t = A_t K_t^{\alpha}$, K_{t+1}, take derivative with respect to A_t to get elasticity:

$$\epsilon_{IA} > 1 > \epsilon_{CA}$$

so investment moves more than consumption through the cycle

Dynamics

1. $A_t \downarrow$ so labor and capital demand falls
2. $w_t \downarrow$ and $r_t \downarrow$
3. $K_{t+1} \downarrow$
4. A_{t+1} rebounds, so labor and capital demand rebound
5. Lower K_{t+1} implies lower marginal product of labor, so wage doesn't rebound all the way
6. Lower K_{t+1} and old labor supply means r_{t+1} jumps above old steady state

Section 5

Labor Markets

Labor Supply

- Labor supply comes from people trading off leisure and consumption
- Two forces when wages rise:
  1. Substitution effect: higher wage makes labor more expensive $\Rightarrow$ work more
  2. Income effect: higher wage means higher income; leisure normal good $\Rightarrow$ work less
- If leisure and consumption substitutes, strong substitution effect $\Rightarrow$ upward-sloping labor supply
- If leisure and consumption complements, weak substitution effect $\Rightarrow$ downward-sloping labor supply (possibly)
- Short run changes in wages do not affect permanent income $\Rightarrow$ small income effect

Size of effects

	Income Effect	Substitution Effect	Slope of Uncompensated Labor Supply
Permanent $w \uparrow$	Large	?	Less positive
Temporary $w \uparrow$	Small	?	More positive
c, l substitutes	?	Large	More positive
c, l complements	?	Small	Less positive

Labor Supply Shifters

- Non-labor income $\uparrow$ shifts labor supply in
- Taxes: unclear as makes people poorer but leisure cheaper
- Population growth: add more supply curves together
- Increased value of leisure (e.g. improved leisure technology)

Laffer Curve: revenue maximizing income tax does not equal 0 or 1.

Unemployment comes from frictions

- Wage stickiness
- Search and matching frictions
  - Individuals need time to find a job
  - Suppose a fraction λ of unemployed U_t find a job each period
  - A fraction δ of employed lose their job each period
  - Yields law of motion

$$U_{t+1} = (1 - \lambda)U_t + \delta E_t$$

  - Divide by L, get

$$u_{t+1} = (1 - \lambda)u_t + \delta(1 - u_t)$$

  - At steady state, natural unemployment rate is

$$u_n = \frac{\delta}{\delta + \lambda} > 0$$

Job Search

- Individuals draw a wage w from a distribution $F(w)$
- Can either accept it and earn that wage for two periods, or reject and search again
- If reject, get unemployment benefit b
- Choose:

$$\max \left\{ \underbrace{w + \beta w}_{\text{Accept}}, \underbrace{b + \beta \mathbb{E}[w']}_{\text{Reject}} \right\}$$

- Leads to reservation rate strategy: accept all wages above some w^*
- $w^* \uparrow$ and so too does unemployment duration if:
  1. Unemployment benefit $b \uparrow$
  2. Expected next period wage offer $\mathbb{E}[w'] \uparrow$
  3. Discount factor $\beta \uparrow$

Section 6

Inflation and Money

Use of money

- Money used to trade for goods and services
- But by holding money, give up on holding high yield bonds
- Thus holding money has carrying cost
  - Forgone interest r
  - Possibility of theft
- But costly to take money out
  - "Shoe-leather cost" γ
  - It's costly to go to ATM or bank.

Quantity Theory of Money

$$M_t V_t = P_t Y_t$$

Baumol-Tobin model of Cash Management

- Need money to make pc purchases in a period
- Go to bank every T periods
- Holding money has carrying cost r
- Have to pay cost γ to go to bank
- Hold $pcT/2$ dollars on average
- Thus choose frequency of going to bank T to minimize total cost:

$$\min_T \frac{1}{2}pcTr + \frac{\gamma}{T}$$

yields

$$T^* = \sqrt{\frac{2\gamma}{pcr}} \qquad \Rightarrow m^D = pcT^*/2 = \overbrace{p\sqrt{\frac{c\gamma^{REAL}}{2r}}}^{p\cdot\Phi(r,c,\gamma)}$$

Cash-in-Advance

- Prices flexible, money supply grows constantly from Fed
- Choose money, bonds, consumption, and labor to maximize utility
- Two constraints:
  1. Cash in Advance (CIA): $p_t c_t \leq m_t$
  2. Budget Constraint (BC):
     $p_t c_t + b_{t+1} + m_{t+1} = m_t + (1 + R_t)b_t + p_t l_t + \tau_t$
- To solve:
  1. Set up Lagrangean
  2. Take first order conditions
  3. Use market clearing $(b_t + 1 = 0, m_t^D = m_t^S)$

Lessons from CIA

1. Growth rate of prices = growth rate of money
2. $(1 + R) = (1 + \pi)(1 + r)$ for R nominal interest rate, π inflation rate, r real interest rate
3. Friedman rule: should set money growth and inflation negative, to have nominal interest rate $= 0$
4. Output negatively related to inflation
5. If prices fully flexible, money market does not affect goods market.
6. However, reverse could be true by changing the real interest rate

IS-LM

- If prices fixed (possibly true in short run), monetary expansions increase output
- Draw curves of output (Y) vs real interest rate (r)
- Investment-Savings (IS) curve downward sloping because if r low, cheaper to borrow and invest, so investment rises and so does output as

$$Y = C + I + G + NX$$

- Liquidity Management (LM) curve upward sloping because as Y increases, demand for money increases for every value of r.
- Where they intersect is economywide general equilibrium
- Increases in money supply shift out LM curve $\Rightarrow$ higher output, lower real interest rate.

Section 7

Uncertainty and Asset Pricing

Expected utility

- Assume people maximize expected utility.
- Define:
  1. Risk averse: $u(E[y]) > E[u(y)]$
  2. Risk neutral: $u(E[y]) = E[u(y)]$
  3. Risk loving: $u(E[y]) < E[u(y)]$
- Risk averse if and only if $u(c)$ concave.

Asset pricing

- If know price of states q_s, can price any asset as weighted combination of q_s
  - An asset that pays x_s in state s for each state s will have price

$$p = \sum_s q_s x_s$$

  - Price of burger + fries = Price burger + price fries
- Risk aversion implies people want to buy insurance
  - $\Rightarrow$ Price of bad states higher than price of good state
- Rate of return (Expected payout/price) higher for risky assets – those that pay out when output already high
- Higher rate of return generally inversely related to price