Lecture 2: intro to macrofinance

Ernest Liu and Atif Mian

Overview

Macro: allocation of resouces and implications for aggregate outcomes.

- How to allocate productive resources across firms to maximize output
- How to allocate output across time to maximize present-discounted welfare
- How to allocate output across different agents for consumption
- Role for policy under market imperfections

Finance: a broad set of mechanisms that allocate resources

- corporate and household finance, intermediation

Goal of the course: understanding the role of finance in short- and long-run macro

Overview for today

A toy model where households supply labor & consume, firms use resources to produce

Illustrates many of the key issues in business cycle macro

- demand-driven recession, misallocation
- fiscal policy, heterogeneous MPCs, nominal rigidity, cost of inflation
- role of the Fed, zero lower bound, forward guidance, commitment

Future lectures on short-run topics: how these issues relate to finance

- what causes misallocation: financial frictions on firm side & the bank lending channel
- what causes demand-driven recessions: excess leverage on household balance sheet
- what causes excess leverage: pecuniary externality, behavioral bias, heterogeneous beliefs
- coordination failure, bank runs, and crisis
- interconnectedness: banking and production networks

Real business cycle model without capital

- A representative consumer choosing C_t and L_t, with concave $u(\cdot)$ and convex $v(\cdot)$

$$\max_{C_t, L_t} \mathbb{E}\left[\sum_{t=0}^{\infty} \beta^t \left(u(C_t) - v(L_t)\right)\right] \quad \text{s.t. } C_t = z_t L_t$$

- Representative agent $\implies$ no net saving, essentially repeated static decisions

$$v'(L_t) / u'(C_t) = z_t$$

- Equilibrium interest rate is such that there is no borrowing/saving

$$R_t \mathbb{E}_t\left[\frac{\beta u'(C_{t+1})}{u'(C_t)}\right] = 1$$

- Can add capital to study investment dynamics (saving tech. to smooth over shocks)
- The literature has added bells and whistles along many dimensions

Krugman on RBC

Simple conceptual models can also help convince you NOT to believe in economic ideas. Real business cycle theory says that economic fluctuations are the result of technological shocks, amplified by intertemporal labor substitution. My version: ***think of a farmer who faces sunny and rainy days. On rainy days his labor won't be as productive as on sunny days; this effect on his output is amplified by his rational decision to stay in bed on rainy days and work extra hard when the sun shines****. I think this gets at the essence of the concept; it also makes you wonder, is this really, really what you think happens in recessions?*

A two-period model with nominal rigidity

- Two-period ($t = 0, 1$) endowment economy, with consumption goods L_0 and L_1
- Representative agent with log preferences: $\ln c_0 + \beta \ln c_1$
- Exogenous price level in both periods p_0, p_1 and nominal interest rate $(1 + i)$
- Consumer solves:

$$\max_{c_0, c_1} \quad \ln c_0 + \beta \ln c_1 \qquad \text{s.t. } p_0 c_0 + p_1 c_1 / (1 + i) = p_0 y_0 + p_1 y_1 / (1 + i)$$

- Equilibrium definition: $\{c_0, c_1, y_0, y_1\}$ such that

$$\underbrace{c_t = y_t}_{\text{consumption = quantity sold}} \qquad \leq L_t$$

- Note: market always clears at $t = 1$ ($y_1 = L_1$), but market-clearing at $t = 0$ depends on the real interest rate, as we'll see

Real and nominal rates

- Real interest rate:

$$1 + r = (1 + i) \bigg/ \frac{p_1}{p_0}$$

- Without price stickiness, nominal rate is irrelevant
  - prices adjust, so does the real rate, such that market clears at $t = 0$ and $y_0 = L_0$

- When prices are sticky, real interest rate may not clear the market—a fraction of the endowment is destroyed

- Next: First consider a world without rigidities; solve for the real rate.
  Then show rigidity destroys output

When prices are flexible, nominal rate is irrelevant

- Equilibrium with flex. prices: $\{c_0, c_1, y_0, y_1, r\}$ such that $c_0 = y_0 = L_0$, $c_1 = y_1 = L_1$
- Log preference implies c_0 is $\frac{1}{1+\beta}$ fraction of the (real) present-value of wealth

$$c_0 = \frac{1}{1+\beta}\left(y_0 + \frac{y_1}{1+r}\right)$$

By setting $c_0 = y_0$, we find the real rate that clears the endowment:

$$1 + r = \frac{L_1}{\beta L_0}$$

- Real rate is the opportunity cost of consumption at $t = 0$. When endowment is abundant at $t = 0$, relative cost of consumption is low $\implies$ r is low.

Nominal rigidity & high real rate: demand driven recession

- Now suppose with rigidities and exogenous nominal rate, we have

$$1 + r > L_1 / (\beta L_0)$$

- Consumption at $t = 0$ is

$$\begin{aligned}(1+\beta)\, c_0 &= \underbrace{y_0 + y_1/(1+r)}_{\substack{\text{wealth in terms of} \\ \text{consumption good at } t=0}} \\ &< y_0 + \beta L_0 \leq (1+\beta)\, L_0\end{aligned}$$

- When the real interest rate is too high, market at $t = 0$ does not clear ($c_0 < L_0$)
  - opportunity cost of consumption is too high; present value of future wealth is too low
  - happens when L_0 is high: large endowments require low rates to clear
- **A demand driven recession**

Fiscal policy: MPC and Keynesian fiscal multiplier

$$c_0 = \frac{1}{1+\beta} PV\,(\text{wealth}) = \frac{1}{1+\beta}\left(c_0 + \frac{L_1}{1+r}\right)$$

1. $\frac{1}{1+\beta}$ is the marginal propensity to consume (MPC): if wealth $\nearrow$ by \$1, $c_0 \nearrow$ by $\frac{1}{1+\beta} < 1$
2. Suppose a component of wealth comes from government transfers $\mathcal{T}$ so that wealth $= c_0 + \frac{L_1}{1+r} + \mathcal{T}$. Note

$$dc_0 = \frac{1}{1+\beta}\left(dc_0 + d\mathcal{T}\right)$$

Thus $dc_0/d\mathcal{T} = 1/\beta > 1$: Keynesian fiscal multiplier

- higher wealth $\implies$ more consumption $\implies$ higher income $\implies$ even more consumption

Household balance sheet and heterogeneous MPCs

- Why is there insufficient demand?
  - heightened uncertainty and precautionary savings
  - tightening constraints, poor balance sheet, and debt overhang of the marginal agent
- For unconstrained agents, $c_0 = \frac{1}{1+\beta} PV\,(\text{wealth})$;
  - MPC out of wealth is $\frac{1}{1+\beta}$
- For constrained agents,

$$c_0 = \text{Liquid Wealth} + \text{Borrowing Limit} < \frac{1}{1+\beta} PV\,(\text{wealth})$$

  - MPC out of liquid wealth is 1
- Is fiscal transfer always more effective when given to constrained agents?

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- Is fiscal transfer always more effective when given to constrained agents?

$$dc_0^{uncon} = \frac{1}{1+\beta}\left(dy_0^{uncon} + d\mathcal{T}^{uncon}\right)$$

$$dc_0^{con} = d(\text{liquid wealth+borrowing limit}) + \text{d}\mathcal{T}^{con}$$

Supply-side inefficiencies

Now interpret endowments as exogenous labor supply L_0 and L_1

- A continuum of monopolistic firms $\nu \in [0, 1]$ produce consumption goods $c_t(\nu) = \ell_t(\nu)$
- Consumer's preference is CES across varieties:

$$C_t = \left(\int_0^1 c_t(\nu)^{\frac{\sigma-1}{\sigma}} \, d\nu \right)^{\frac{\sigma}{\sigma-1}} \tag{1}$$

- In a flexible-price equilibrium, where monopolistic producers set prices:
  - by symmetry, $p_t(\nu)$ is independent of ν, and consumption/output is constant across varieties

$$c_t(\nu) = \ell_t(\nu) = L_t$$

When prices are sticky

- Suppose prices are exogenously given
- Let $P_t \equiv \left[\int_0^1 p_t(\nu)^{1-\sigma}\, d\nu\right]^{\frac{1}{1-\sigma}}$ denote the price index
  - CES price indices have the property that $P_t C_t = \int_0^1 p_t(\nu)\, c_t(\nu)\, d\nu$

Similar to our previous model,

- Flex. price equilibrium features $C_0 = L_0$, $C_1 = L_1$, and $1 + r = \frac{L_1}{\beta L_0}$
- Price stickiness & high real rate $\implies$ a demand-driven recession
  - period $t = 0$ may not feature full employment $\int_0^1 \ell_0(\nu)\, d\nu < L_0$

Price dispersion generates allocative inefficiency

Now suppose the Fed picks the nominal rate i to ensure full employment, but prices $p_t(\nu)$ are exogenous and heterogeneous.

- Let $P_t \equiv \left[\int_0^1 p_t(\nu)^{1-\sigma}\, d\nu\right]^{\frac{1}{1-\sigma}}$ again be the price index
- Consumer optimization implies

$$c_t(\nu) = \ell_t(\nu) = \left(p_t(\nu)/P_t\right)^{-\sigma} C_t$$

$$\implies \ell_t(\nu) = \frac{p_t(\nu)^{-\sigma}}{\int p_t(\nu)^{-\sigma}\,\mathrm{d}\nu} L$$

- Consumption aggregate is

$$C_t = \left[\int_0^1 \ell_t(v)^{\frac{\sigma-1}{\sigma}}\, d\nu\right]^{\frac{\sigma}{\sigma-1}} \neq \int_0^1 \ell_t(v)\, d\nu = L_t$$

- Price dispersion leads to heterogeneous labor allocation across varieties

A digression: generalized means

- Generalized mean with exponent s is $M_s \equiv \left[\int_0^1 \ell_t(v)^s \, d\nu\right]^{1/s}$.
  - $C_t = \left[\int_0^1 \ell_t(v)^{\frac{\sigma-1}{\sigma}} \, d\nu\right]^{\frac{\sigma}{\sigma-1}}$ is a generalized mean over $\ell_t(\nu)$ with exponent $\frac{\sigma-1}{\sigma}$.
- M_1 is arithmetic mean, M_{-1} is harmonic mean, $\lim_{s\to 0} M_s$ is geometric mean.

Theorem. **(Generalized mean inequality)** Suppose $\ell_t(\nu) > 0$. If $p < q$ then $M_p \leq M_q$.

- $C_t = M_{\frac{\sigma-1}{\sigma}} \leq \int_0^1 \ell_t(\nu) \, d\nu = M_1 = L_t$.
- Equality only when $\ell_t(\nu) = L_t$ for all ν. C_t/L_t is decreasing in the dispersion of $\ell_t(\nu)$.

Misallocation

- Price dispersion creates a new source of inefficiency: misallocation of labor
  - even with full employment, it may be the case that $C_t < L_t$
  - consumption index below potential: MPL unequal across firms
- Lognormal and CES: closed form solution
  - If $p_t(\nu)$ is log-normally distributed with variance V, then

$$C_t = \exp\left(-\frac{\sigma V}{2}\right) L_t$$

- Relative to homogeneous prices, price dispersion lowers effective productivity
  - productivity $\searrow$ in dispersion of prices V and elasticity of substitution σ
  - more misallocation under either cases
- Bottom line: price dispersion is bad. It is a main source of inefficiency due to inflation in standard, infinite-horizon models

- Misallocation could arise from price dispersion relative to social production costs
  - staggered price-setting (standard New Keynesian), heterogeneous market power
  - financial frictions & firm balance sheet channel
- Debt overhang on household, firm, or banking side: too little precaution pre-crisis
  - pecuniary externality; calls for macro-prudential policies
  - collective moral hazard
  - heterogeneous belifes; behavioral agents
- Why do crisis occur? Fundamental v.s. coordination
- Interconnections & networks
- Recession or stagnation? Low interest rate, debt, and long run growth
- Open economy issues

Back to New Keynesian: role of monetary policy

Setup

- Prices at $t = 1$ (long run) are exogenously given at $p_1 = 1$, $w_1 = \frac{\sigma-1}{\sigma}$
- Firms enter $t = 0$ with prices $\bar{p}_0 = 1$
  - but a fraction θ of firms can change prices, denoted as p_0
- Central bank chooses nominal rate i between $t = 0$ and $t = 1$

Natural rate of interest

- The **natural rate of interest** ("r-star"): the real rate at which the economy's output is at it's full potential, without misallocation or demand-driven recession

$$\beta L_0 = \frac{L_1}{1 + r^*}$$

- $r > r^*$ causes output to be below potential
  - unemployment and demand-driven recession when all prices are fixed
  - misallocation when only some firms can adjust prices
- $r < r^*$ causes consumption rationing when prices are all fixed
  - not possible when prices can adjust: P_0 always increases such that $1 + r = \frac{(1+i)}{P_1/P_0} \geq 1 + r^*$
  - with endogenous labor supply, low interest rates cause output to be above the potential level

Indeterminacy

Recall consumer optimization implies $\beta P_0 C_0 = \frac{P_1 C_1}{1+i}$

Suppose central bank sets nominal rate $i = r^*$.

- When prices at $t = 1$ are fixed, the unique equilibrium is $p_0 = \bar{p}_0 = 1, w_0 = \frac{\sigma - 1}{\sigma}$
  - Output is at potential, efficient level
- However, when prices at $t = 1$ are fully flexible (but only fraction θ of firms can change p_0), this is only one of the infinitely many equilibria!
- Substitute $1 + i = L_1 / (\beta L_0)$ and $C_1 = L_1$, we get

$$C_0 = \frac{P_1}{P_0} L_0$$

  - For any P_1, there exists a p_0 that is consistent with equilibrium

A forward-looking interest rate rule

- Suppose the Fed sets $1 + i = (1 + r^*)\, P_1/P_0$
  - A forward-looking rule that incorporates expected inflation

- Recall $\beta P_0 C_0 = \frac{P_1 C_1}{1+i}$ and $1 + r^* = L_1/(\beta L_0)$; plugging in, we get

$$C_0 = L_0$$

  Thus the interest rate rule stabilizes output; the unique equilibrium price is $p_0 = 1$.

- "Divine coincidence": stable output and no inflation

A three-period New Keynesian model

- Setup: three periods and exogenous labor supply L_0, L_1, L_2
- Continuum of firms but first consider exogenous and homogeneous prices $p_t(\nu) = 1 \ \forall t$
- Rep. consumer with log preference: $\ln c_0 + \beta \ln c_1 + \beta^2 \ln c_2$
- The Fed sets nominal rates $(1 + i_1)$ and $(1 + i_2)$, which consumer takes as given
- Natural real rates r_1^* and r_2^* ensure full employment in all periods. Log-preference implies:

$$c_0 = \frac{1}{1+\beta+\beta^2}\left(L_0 + \frac{L_1}{1+r_1^*} + \frac{L_2}{(1+r_1^*)(1+r_2^*)}\right)$$

$$c_1 = \frac{1}{1+\beta}\left(L_1 + \frac{L_2}{(1+r_2^*)}\right)$$

The real rates that clear markets $(c_0 = L_0,\ c_1 = L_1)$ are

$$1 + r_1^* = \frac{L_1}{\beta L_0}, \qquad 1 + r_2^* = \frac{L_2}{\beta L_1}$$

Liquidity Trap & Zero Lower Bound

- Suppose $\beta L_0 > L_1 = L_2 = 1$. Real rates that clear the market in each period is

$$1 + r_1^* = \frac{L_1}{\beta L_0} < 1, \qquad 1 + r_2^* = 1/\beta > 1$$

- Given zero lower bound on nominal interest rates & price stickiness ($p_t = 1 \forall t$), the real rate r_1 cannot fall below zero $\implies$ a demand-driven recession, just as before

What should the Fed do?

- The Fed could set $i_1 = 0$ (lower bound), $i_2 = 1/\beta - 1$ (natural rate)
  - Exogenous prices and no inflation $\implies$ real $=$ nominal rate
  - Recession at $t = 0$, full employment in $t = 1, 2$
  - Consumption at $t = 0$ solves $c_0 = \frac{1}{1+\beta+\beta^2}[c_0 + L_1 + \beta L_2]$, thus

$$c_0 = 1/\beta < L_0$$

Forward Guidance

- The Fed could actually do better; consider choosing $i_1 = 0$ and $1 + i_2 < 1 + r_2^* = 1/\beta$.
  - Recall we have chosen $L_1 = L_2 = 1$ for numerical simplicity
  - $1 + i_2 < 1/\beta$ generates a consumption boom at $t = 1$
- At $t = 1$, consumer would like to consume $\frac{1}{1+\beta}\left[L_1 + \frac{L_2}{1+i_2}\right] > 1 = L_1$
  - There is rationing on the consumption side but full employment at $t = 1, 2$
- At $t = 0$, consumer would like to consume $\frac{1}{1+\beta+\beta^2}\left[c_0 + L_1 + \frac{L_2}{1+i_2}\right]$
  - This is greater than $\frac{1}{1+\beta+\beta^2}\left[c_0 + L_1 + \frac{L_2}{1+r_2^*}\right]$
  - Low nominal rate i_2 stimulates demand at $t = 0$, by raising the present value of wealth!

Can raise c_0 but only up to a point (ZLB in the future, $i_2 \geq 0$, may also bind)

- Forward guidance can be very powerful with a long horizon (see Werning 2012)

Forward Guidance

- No cost of forward guidance with exogenous labor supply: consumption rationing, but no inefficient output boom
  - In richer models, cost of forward guidance is to overheat the economy in the future, with high inflation and inefficient output boom. Commitment issues?
- In July 2012 Mario Draghi said "within our mandate, the ECB is ready to do whatever it takes to preserve the euro. And believe me, it will be enough."

Summary of key ideas

- The toy model illustrates many of the key mechanisms in business cycle macro
  - demand-driven recession, role of the Fed, zero lower bound, forward guidance, commitment
  - fiscal policy, heterogeneous MPCs, nominal rigidity, cost of inflation, misallocation