

Lecture 16

The Real Business Cycle Model

Part 3: Competitive Equilibrium

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Overview

- Recall that in Lecture 13, there is no production in dynamic model.
- The following 5 lectures is for **Real Business Cycle** (RBC) model:
 - Lecture 14: consumer
 - Lecture 15: firm
 - Lecture 16: competitive equilibrium
 - Lecture 17: formal example
 - Lecture 18: application to bring RBC to data

Review: Consumer's Problem

Taken $\{w, w', r, T, T', \pi, \pi'\}$ as given, a representative consumer chooses $\{C', N_S, N'_S\}$ to solve

$$\begin{aligned} \max_{C', N_S, N'_S} \quad & u \left(wN_S + \pi - T + \frac{w'N'_S + \pi' - T' - C'}{1+r} \right), \\ & - v(N_S) + u(C') - v(N'_S) \end{aligned} \quad (1)$$

which we can back out C, S, l, l' .

Review: Firm's Problem

Taken $\{w, w', r\}$ as given, a representative firm chooses $\{N_D, N'_D, K'\}$ to solve

$$\begin{aligned} \max_{N_D, N'_D, K'} \quad & zF(K, N_D) - wN_D - [K' - (1 - \delta)K] \\ & + \frac{z'F(K', N'_D) - w'N'_D + (1 - \delta)K'}{1 + r}, \end{aligned} \quad (2)$$

which we can back out Y, Y', π, π', I

Government Budget Constraint

Government behaves exactly the same in two-period model:

- current budget constraint: $G = T + B$

- future budget constraint: $G' + (1 + r)B = T'$

- lifetime budget constraint: $G + \frac{G'}{1 + r} = T + \frac{T'}{1 + r}$

Taken $\{r\}$ as given, government satisfy lifetime budget constraint by choosing $\{T, T', B\}$.

Market Clear

There are three markets to clear:

- ① labor markets clear at each date determines wage:
 - find w such that $N_S = N_D$
 - find w' such that $N'_S = N'_D$
- ② goods markets clear at each date determines consumption and investment:
 - date 0 (today): $Y = C + I + G$
 - date 1 (tomorrow): $Y' = C' + I' + G'$
- ③ bonds market clears at date 0 determines real interest rate:
 - find r such that $S = B$

Competitive Equilibrium: RBC Model

Given exogenous quantities $\{G, G', z, z', K\}$, a **competitive equilibrium** is a set of

① consumer choices

$$\{C, C', N_S, N'_S, l, l', S\},$$

② firm choices

$$\{Y, Y', \pi, \pi', N_D, N'_D, I, K'\},$$

③ government choices $\{T, T', B\}$,
and

④ prices $\{w, w', r\}$

such that

① consumer solves problems in (1),

② firm solves problems in (2),

③ government balances its budget,
and

④ all three markets clear.

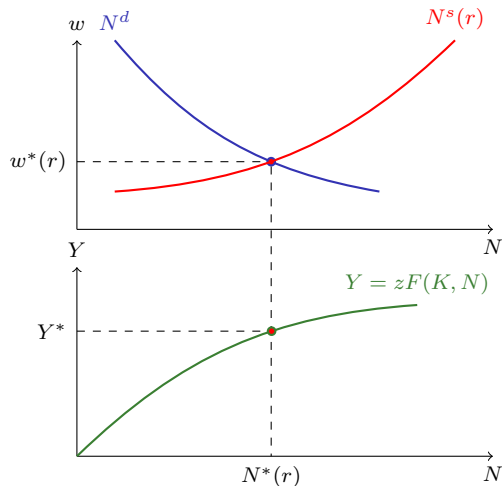
Plan to analyze the Model

In the following slides, we are going to use graphical analysis on **two markets** in **current period**:

- ① **current labor market**: interaction of firm and consumer today
 - similar to static model: **labor supply** and **labor demand** curves
 - what's new: both curves reflect the dynamic tradeoff through interest rate
- ② **current goods market**: interaction of firm, consumer and government today
 - new: construct and analyze **output supply** and **output demand** curves

The Current Labor Market

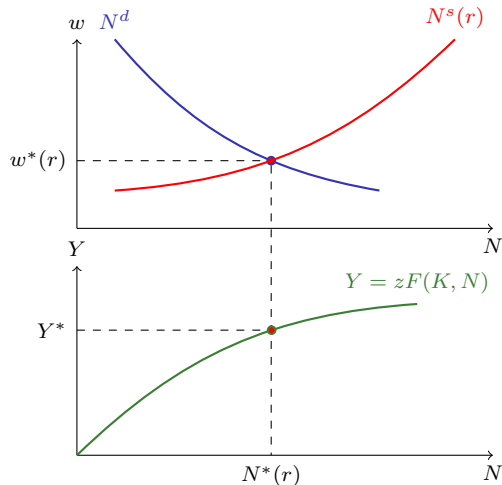
Figure 11.14 Determination of Equilibrium in the Labor Market Given the Real Interest Rate r



- **consumer optimality:** *ceteris paribus*, $N^s \uparrow$ in w
 - **N1:** $\frac{dN^s}{dw} > 0$, substitution dominates income effect
- **firm optimality:** $N^d \downarrow$ in w
 - $MPN = w$, \therefore diminishing MPN
- account for **multiple markets:** intersect at $N^*(r)$
 - note: top figure is given r, π
 - labor mkt clearing w is $w^*(r)$

The Current Labor Market (Cont.)

Figure 11.14 Determination of Equilibrium in the Labor Market Given the Real Interest Rate r



■ r increases?

- **N2** (consumer): $N^s(r) \uparrow$ in r
 $\Rightarrow w \downarrow, N^*(r) \uparrow$

- **firm**: $\because MPN = w$, same

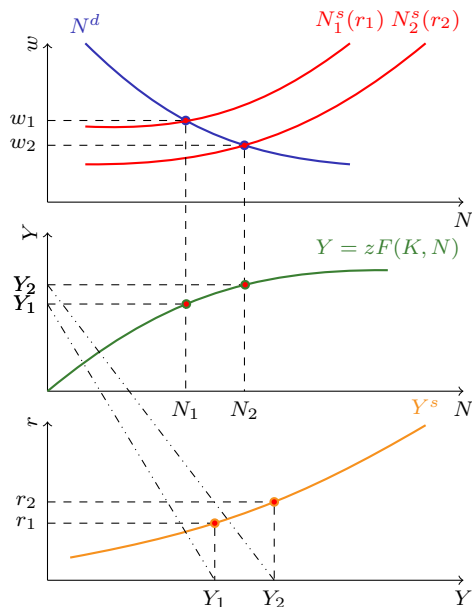
■ consumer wealth increases?

- **N3** (consumer):
 $N^s(r) \downarrow \Rightarrow w \uparrow, N^*(r) \downarrow$

- **firm**: nothing

- Bottom chart: $N^*(r) \rightarrow Y^*(r)$,
output supply!

The Output Supply Curve



Using our insight from labor market, we can repeat our analysis for any real interest rate r

- Top: each r implies a different “labor market equilibrium”, i.e., w & N
- Middle: each $N(r)$ yields production $Y^S(r)$
- Bottom: combined to show $\frac{dY^S}{dr} > 0$

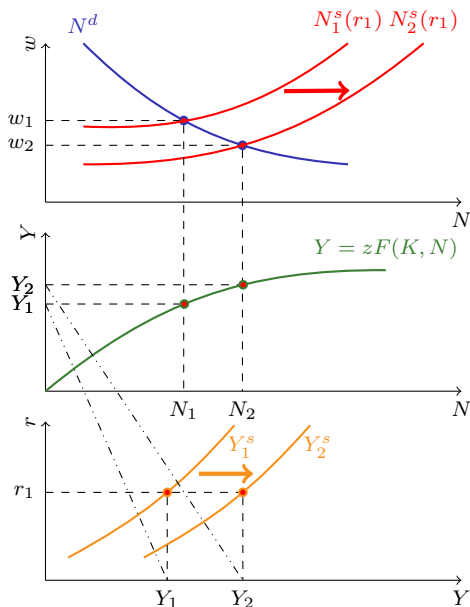
Shifts in the Output Supply Curve

How do changes in exogenous variables shift $Y^S(r)$? Consider 2 cases:

- ① shift in lifetime wealth (for example, by gov't spending or taxation)
- ② change in total factor productivity (TFP) or capital stock
 - recall static model: with K fixed, these have the same effect

In each case, we can start our analysis with the current labor market.

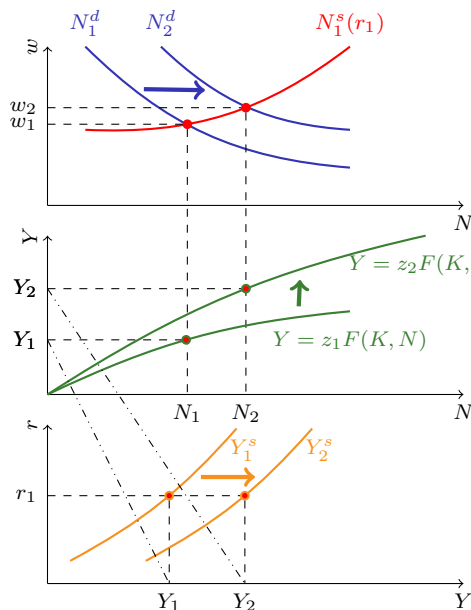
Wealth and Output Supply



Suppose $G \uparrow$ or $G' \uparrow$.

- gov. budget: $T \uparrow$ or $T' \uparrow$
- consumer budget: $we \downarrow$
- **N3:** $dN^S/d(we) < 0$, $N^S(r) \uparrow$
(shift to the right, top panel)
- Middle: $N \uparrow \Rightarrow Y^S \uparrow$
- bottom: combine, get rightward shift in output supply

TFP / Capital and Output Supply



Suppose TFP $z \uparrow$.

■ **firm optimality:**

$$MPN = zD_N F(\cdot) \uparrow \Rightarrow N^d \uparrow$$

■ **Top:** N^d shifts out \Rightarrow
 $w^* \uparrow, N^* \uparrow$

■ **Middle:** production fcn shifts
 up, $\because z \uparrow$

■ **Bottom:** combine, outward shift
 in output supply

Summary: Current Labor Market

We have constructed most of the model!

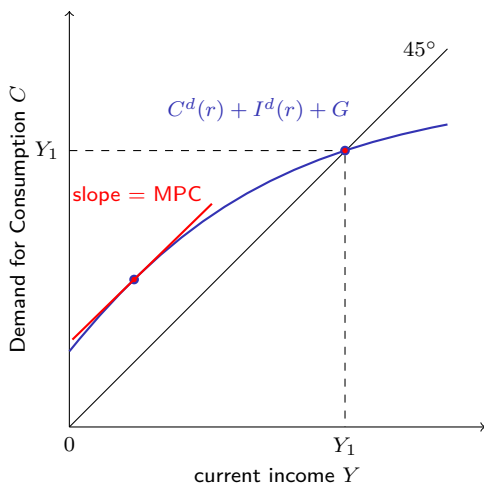
- labor market clearing, *conditional on* the interest rate
- trace through production function to get output supply curve

Now we need to determine the equilibrium interest rate, r^* .

- pair the output supply curve with the **output demand curve**
- who demands goods today, and how much?
 - consumer: consumption $C^d(r, Y)$
 - firm: investment $I^d(r)$
 - government: expenditures G
- use GDP accounting to get aggregate demand for goods

Current Goods Demand

Figure 11.18 The Demand for Current Goods

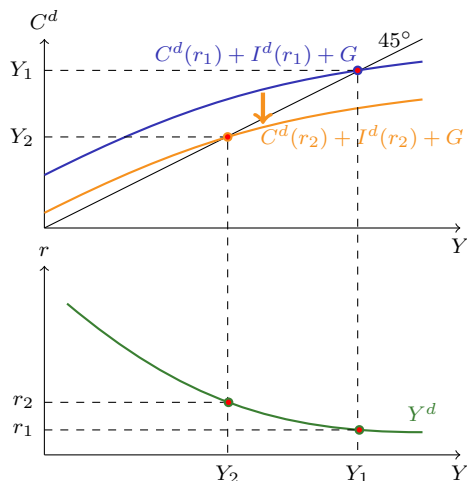


$$D(r, Y) = C^d(r, Y) + I^d(r) + G$$

- plot $D(r, Y)$ on y -axis, Y on x -axis
- C^d depends on wealth: $w e = wN + \pi - T + \frac{w'N' + \pi' - T'}{1+r}$, which depends on income.
- Not true for I and G
 - $MPC < 1$: flatter than 45° line
 - MPC diminishing: concave
 - combine: cross 45° line at $Y^d(r)$

Constructing Output Demand

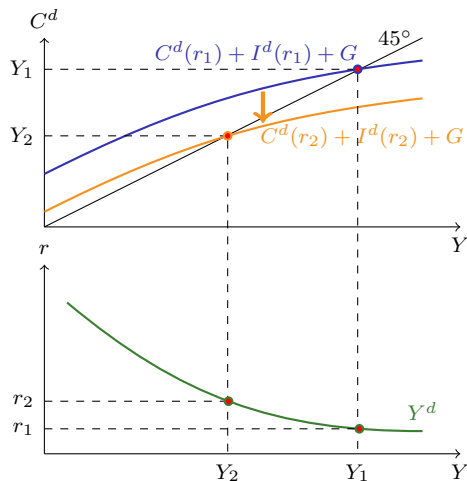
How different r affect output demand?



- **C2 (consumer):** $C^d(r) \downarrow$ if $r \uparrow$ (substitution effect dominates)
- **firm:** optimal investment schedule ($r = MPK' - \delta$), $r \uparrow \Rightarrow MPK' \uparrow \Rightarrow I^d \downarrow$
- **gov:** no change, $\because G$ exogenous
- **Combine:**
 - ① intersection with 45° line is lower

Constructing Output Demand (Cont.)

Combine:



① intersection with $45^\circ \downarrow$

② output demand curve Y^d
downward sloping

$Y^d(r)$ shift to the right if

① present value of taxes $\downarrow \Rightarrow C^d \uparrow$

② future income $\uparrow \Rightarrow C^d \uparrow$

③ future TFP $\uparrow \Rightarrow I^d \uparrow$

④ current capital $\downarrow \Rightarrow I^d \uparrow$

Other changes (e.g., current TFP)
are ambiguous in general!

Competitive Equilibrium

Figure 11.21 The Complete Real Intertemporal Model

