Business Cycles

Part 3: The Real Business Cycle Model
Lecture 6: Effects of shocks, taking the model to the data, criticism of the RBC model

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Outline

Part 1: Introduction

Part 2: Microeconomic Foundations

Part 3: The Real Business Cycle Model

- Lecture 5: The real business cycle model
- Lecture 6: Effects of shocks, taking the model to the data, criticism of the RBC model

Part 4: The New Keynesian Model

Part 5: Financial Crises

Learning Objective of Today‘s Lecture

1. Study different sources of economic fluctuations in the real business cycle model / neoclassical model.
2. Understanding to which extent the model is in line with the data.
3. Going through some criticism of the real business cycle model.

Literature

Required reading:

- Textbook chapter 19

Optional reading:

- Textbook chapters 20-22: datafit, nominal variables, criticism

Equilibrium Conditions

- In equilibrium, the following conditions must hold:

$$C_t = C^d(Y_t - G_t, Y_{t+1} - G_{t+1}, r_t)$$

$$N_t = N^s(w_t, \theta_t)$$

$$N_t = N^d(w_t, A_t, K_t)$$

$$I_t = I^d(r_t, A_{t+1}, K_t)$$

$$Y_t = A_t F(K_t, N_t)$$

$$Y_t = C_t + I_t + G_t$$

$$M_t = P_t M^d(r_t + \pi^e_{t+1}, Y_t)$$

- Exogenous variables: $A_t, A_{t+1}, G_t, G_{t+1}, K_t, \theta_t, M_t, \pi^e_{t+1}$.
- Endogenous: C_t, N_t, I_t, Y_t, w_t, r_t, P_t
- Y_{t+1} treated as exogenous

Formal Analysis

- IS-curve

$$Y_t = \underbrace{C^d(Y_t - G_t, Y_{t+1} - G_{t+1}, r_t) + I^d(r_t, A_{t+1}, K_t) + G_t}_{Y_t^d}$$

  - r_t, Y_t pairs for which aggregate income equals desired spending.

- Y^s curve:

$$\left.\begin{aligned} N_t &= N^s(w_t, \theta_t) \\ N_t &= N^d(w_t, A_t, K_t) \end{aligned}\right\} N_t$$
$$Y_t = A_t F(K_t, N_t)$$

  - N_t from labor supply and demand → via production function find Y_t.
  - Y_t pins down the position of the Y^s curve, which is vertical (independent of r_t) .

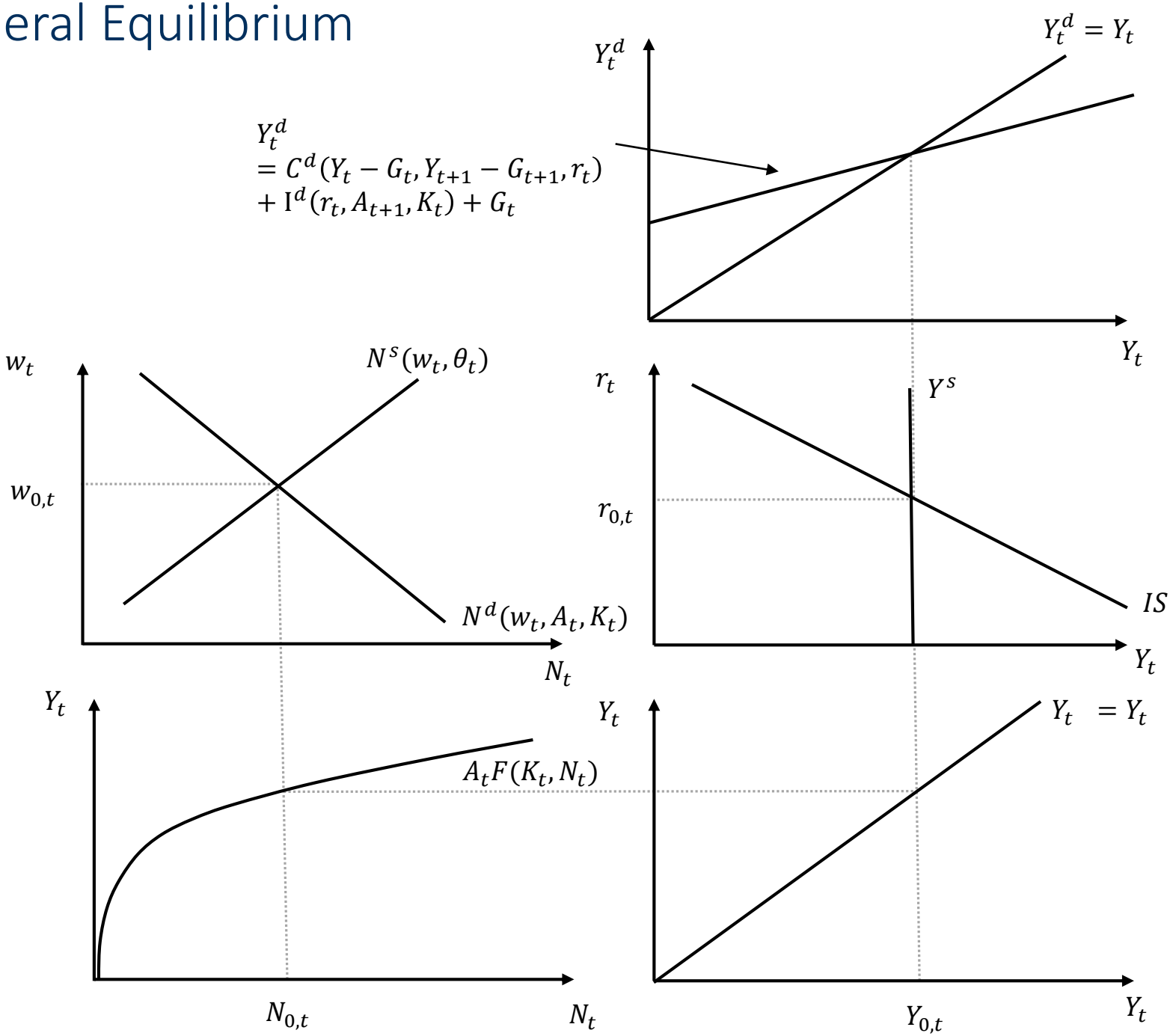
- General equilibrium: Intersection of IS and Y^s curve pins down r_t.

- Nominal variables: Once we know the equilibrium values of real variables, the money market and the Fisher equation yield equilibrium values for P_t and i_t.

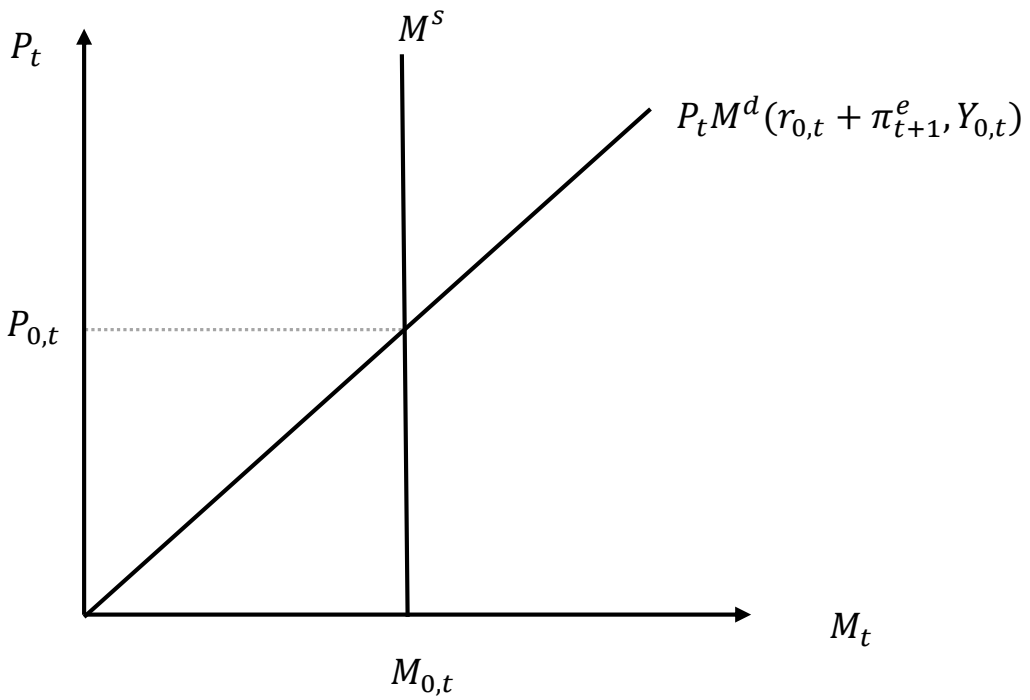
$$M_t = P_t M^d(r_t + \pi_{t+1}^e, Y_t)$$
$$i_t = r_t + \pi_{t+1}^e$$

General Equilibrium

$$Y_t^d = C^d(Y_t - G_t, Y_{t+1} - G_{t+1}, r_t) + \mathrm{I}^d(r_t, A_{t+1}, K_t) + G_t$$



The Nominal Side



Changes in exogenous variables

- Refer to changes in exogenous variables as "macroeconomic shocks".
- Use the model to understand how the endogenous variables react to shocks, i.e. how shocks are transmitted through the economy.
- Shocks are sources of business cycle fluctations.
- Categories of shocks:
  - Shocks that only affect the Y^s equation are s*upply shocks:* A_t, θ_t
  - Shocks that only affect the IS equation are *demand shocks* : G_t, G_{t+1}, A_{t+1}
  - Nominal shocks: M_t, π^e_{t+1}
  - Extra role of K_t: Affects desired investment (demand) and output (supply). We will assume that K_t is constant, but focus on business cycle fluctuations.
  - Y_{t+1} is "pseudo-exogenous": treat as invariant to variable t changes → demand shock affecting the IS-equation (assume that it is not affected by I_t, which impacts K_{t+1}; medium run assumption: treat capital stock as roughly constant).

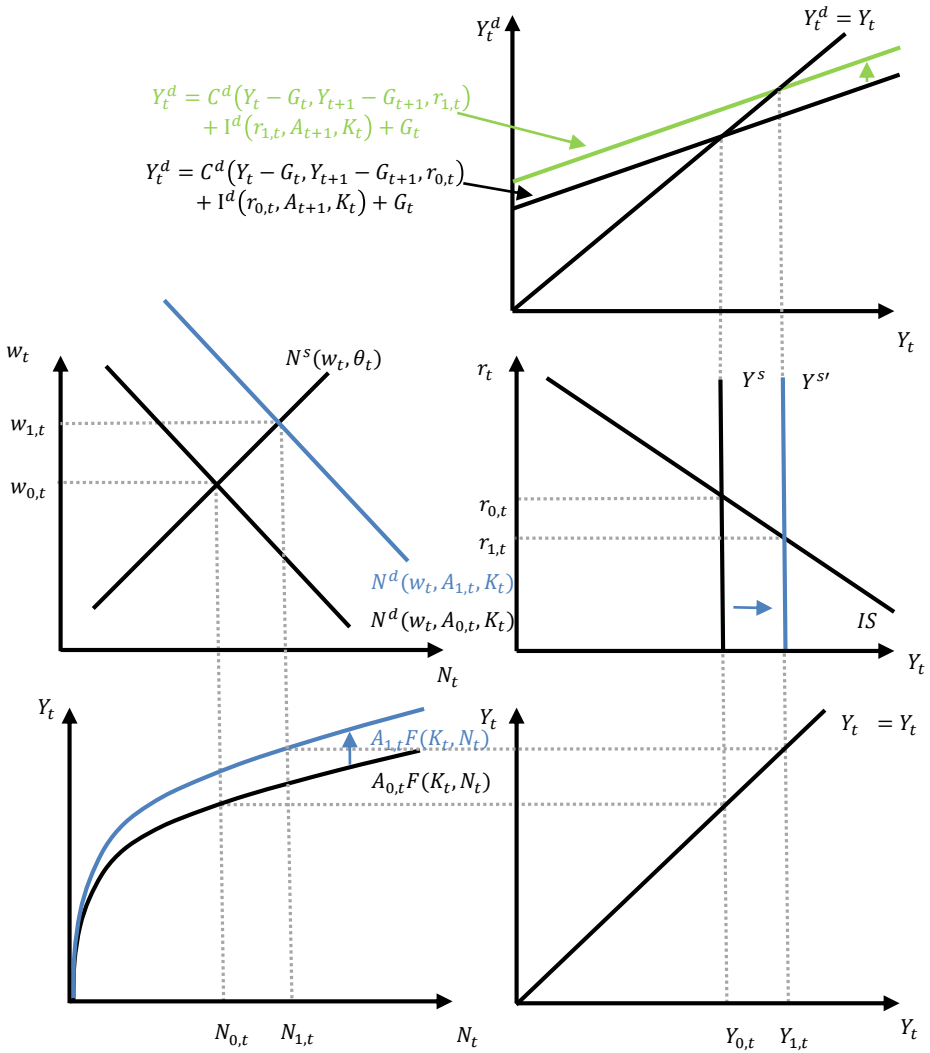
Productivity shock: increase in A_t

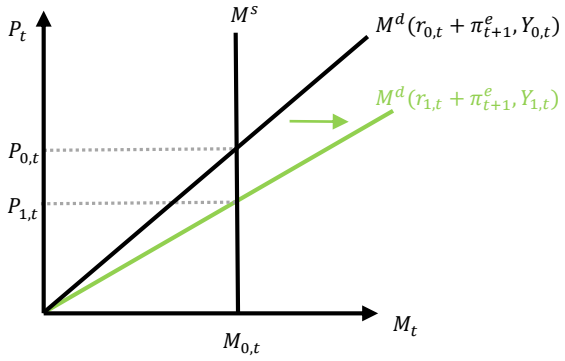
- Affects supply side:

$$N_t = N^s(w_t, \theta_t)$$
$$N_t = N^d(w_t, A_t, K_t)$$
$$Y_t = A_t F(K_t, N_t)$$

- A_t increases N^d, which in equilibrium increases N_t, w_t.
- Exogenous increase in A_t and endogenous increase in N_t, increase Y_t
- Y^s curve shifts to the right, IS-curve does not change → r_t must fall in equilibrium.
- This induces households to consume more and firms to invest more.
- Decrease in r_t lowers via the Fisher equation the nominal interest rate.
- Money demand increases → P_t falls.

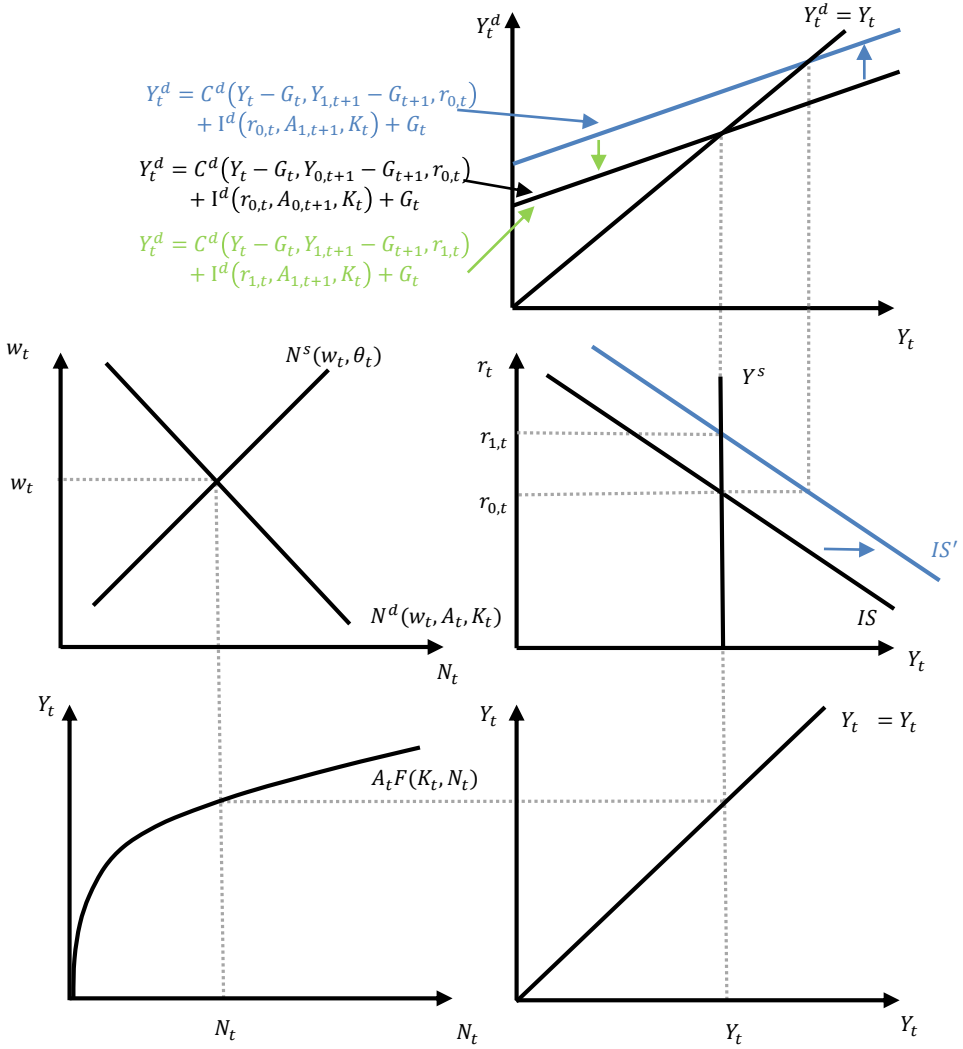
Productivity shock: increase in A_t





Expected future productivity shock: Increase in A_{t+1}

- Higher expected future productivity: *News* shock
- We could think of an increase in A_{t+1} as representing a wave of optimism (or "animal spirits")
- Increases desired investment: $I_t = I^d(r_t, A_{t+1}, K_t)$
- Increases desired consumption: $\mathrm{Y_{t+1}} = A_{t+1}F(K_{t+1}, N_{t+1})$ increases and thus also $C_t = C^d(Y_t - G_t, Y_{t+1} - G_{t+1}, r_t)$
- IS-curve shifts to the right for a given interest rate.
- No change in the Y^s curve as production only depends on the current level of production. Hence, Y_t constant.
- In equilibrium r_t must increase in order to effectively bring desired spending back to its initial level. $C_t + I_t$ must be unchanged (otherwise markets would not clear: $Y_t = C_t + I_t + G_t$)
- Higher r_t reduces money demand and increases the price level. Nominal interest rate increases via Fisher equation.


Y_t^d
$Y_t^d = Y_t$
$Y_t^d = C^d(Y_t - G_t, Y_{1,t+1} - G_{t+1}, r_{0,t}) + I^d(r_{0,t}, A_{1,t+1}, K_t) + G_t$
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IS'
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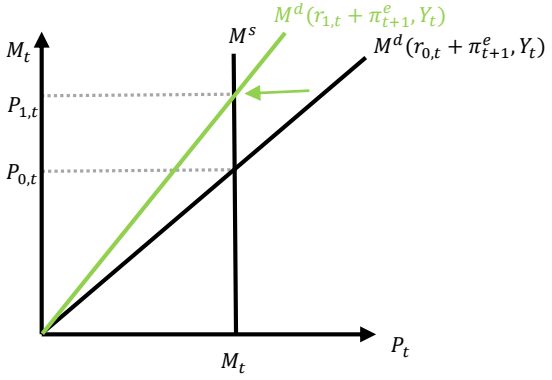
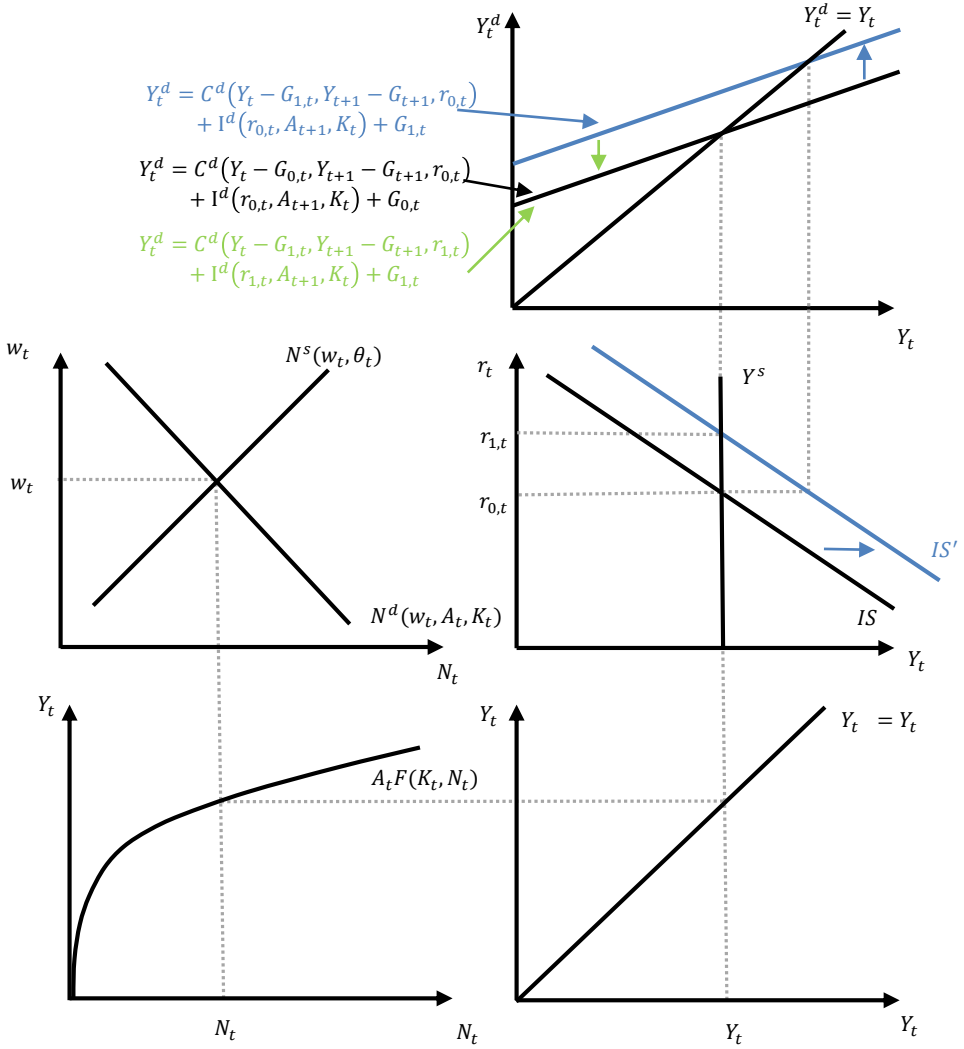

$M^d(r_{1,t} + \pi^e_{t+1}, Y_t)$
M^s
$M^d(r_{0,t} + \pi^e_{t+1}, Y_t)$
M_t
$P_{1,t}$
$P_{0,t}$
P_t
M_t

Government spending shock: Increase in G_t

- Ricardian equivalence applies. Whether financed via T_t or B_t does not matter. If financed via B_t, taxes will go up in $t+1$ and affect lifetime income in the same way as if T_t goes up.
- Desired spending increases by 1 directly, but desired consumption decreases by $-MPC$. Overall effect: $1 - MPC > 0$.

$$Y_t^d = C^d(Y_t - G_t, Y_{t+1} - G_{t+1}, r_t) + I^d(r_t, A_{t+1}, K_t) + G_t$$

- For a given interest rate r_t, the IS-curve shifts to the right.
- No effect on Y^s, i.e. Y_t does not change.
- In equilibrium r_t must increase to reduce investment and consumption such that $Y_t = Y_t^d$
- → Crowding out of private consumption and investment. Government spending multiplier is zero as output does not change.
- Nominal variables: Higher r_t reduces money demand and increases the price level. Nominal interest rate increases via Fisher equation.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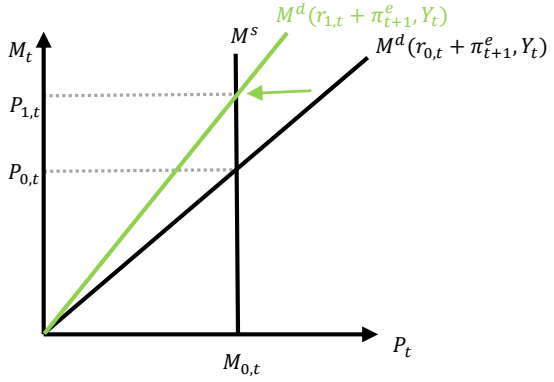
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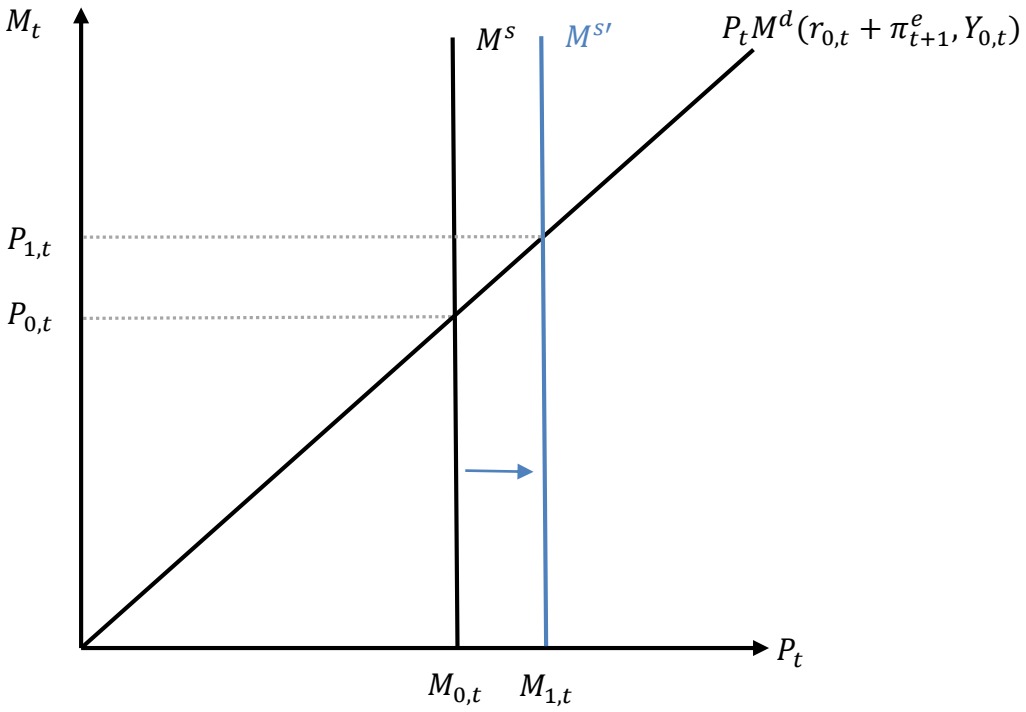
M_t
$P_{1,t}$
$P_{0,t}$
P_t
$M_{0,t}$

Monetary Policy Shock: Increase in M_t

- No effect on real variables because M_t does not show up in the real block of equlibrium relationships. "Money is neutral"
- Does not affect real variables, but only the price level:

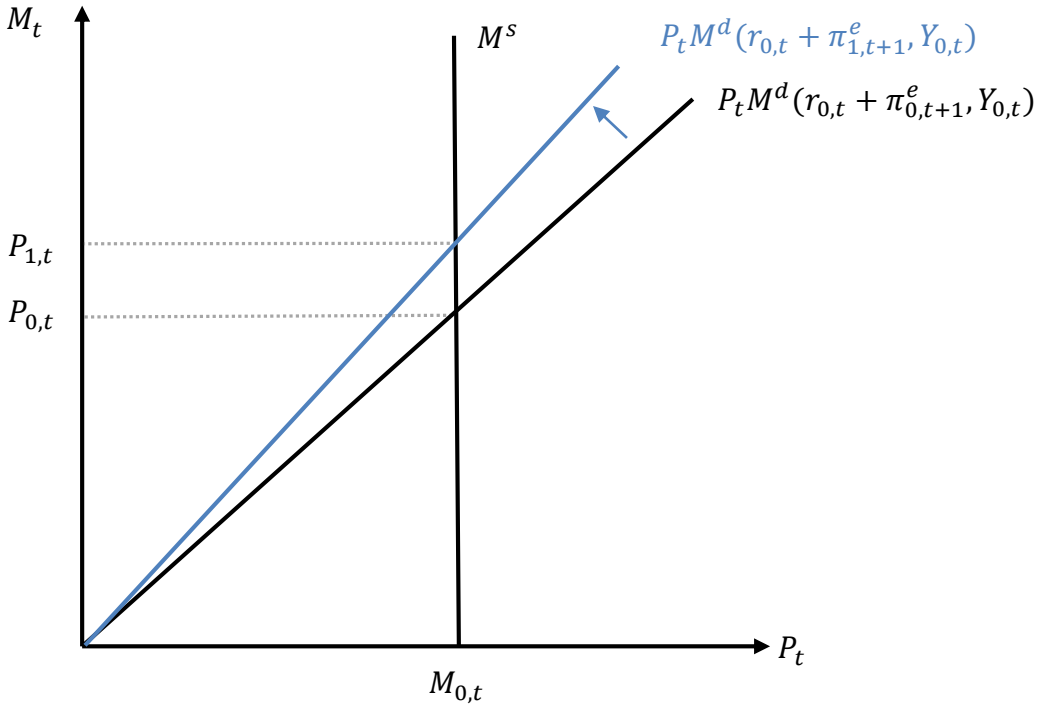
$$M_t = P_t M^d(r_t + \pi^e_{t+1}, Y_t)$$



Increase in expected future inflation

- Increases the nominal interest rate. Money demand goes down, price level goes up→ self-fulfilment

$$M_t = P_t M^d(r_t + \pi^e_{t+1}, Y_t)$$



- Example of forward guidance or generally unconventional monetary policy measures with the goal to affect inflation expectations and the price level.

Real Shocks Affect Nominal Variables

- Increase in A_t: lowers r_t and raises Y_t, both of which pivot money demand to the right, and hence lower P_t
- Increase in θ_t: raises r_t and lowers Y_t, both of which pivot money demand to the left, and hence raise P_t
- Positive "demand" shocks (increases in A_{t+1}, G_t, or a decrease in G_{t+1}): raise r_t, no effect on Y_t. Hence, money demand shifts left, and price level rises.
- Increase in π^e_{t+1}: i_t rises by same amount. Money demand pivots in, so price level raises. "Self-fulfilling" inflation.

Qualitative Effects

	Exogenous Shock				
Variable	$\uparrow A_t$	$\uparrow A_{t+1}$	$\uparrow G_t$	$\uparrow M_t$	$\uparrow \pi^e_{t+1}$
Y_t	+	0	0	0	0
C_t	+	?	-	0	0
I_t	+	?	-	0	0
N_t	+	0	0	0	0
w_t	+	0	0	0	0
r_t	-	+	+	0	0
i_t	-	+	+	0	+
P_t	-	+	+	+	+

Summary of key features of the RBC model

The neoclassical model offers a supply-driven theory of economic fluctuations.

- Because the Y^s curve is vertical, only supply shocks (changes in A_t or θ_t) can result in movements in output and labor market variables.
- Demand shocks (changes in A_{t+1}, G_t, or G_{t+1}) only affect the composition of output between consumption and investment, not the level of output. Instead prices adjust to make sure that aggregate demand remains constant. The real interest rate is a key price in the model which adjusts to shocks to force aggregate expenditure to equal aggregate production.
- Different assumptions on labor supply could generate an upward-sloping Y^s curve, but plausible parameterizations would generate a nearly vertical Y^s curve, wherein supply shocks would account for the vast majority of output and labor market fluctuations.
- There is no effect of nominal variables on real variables.

Summary of key features of the RBC model

The model is useful for

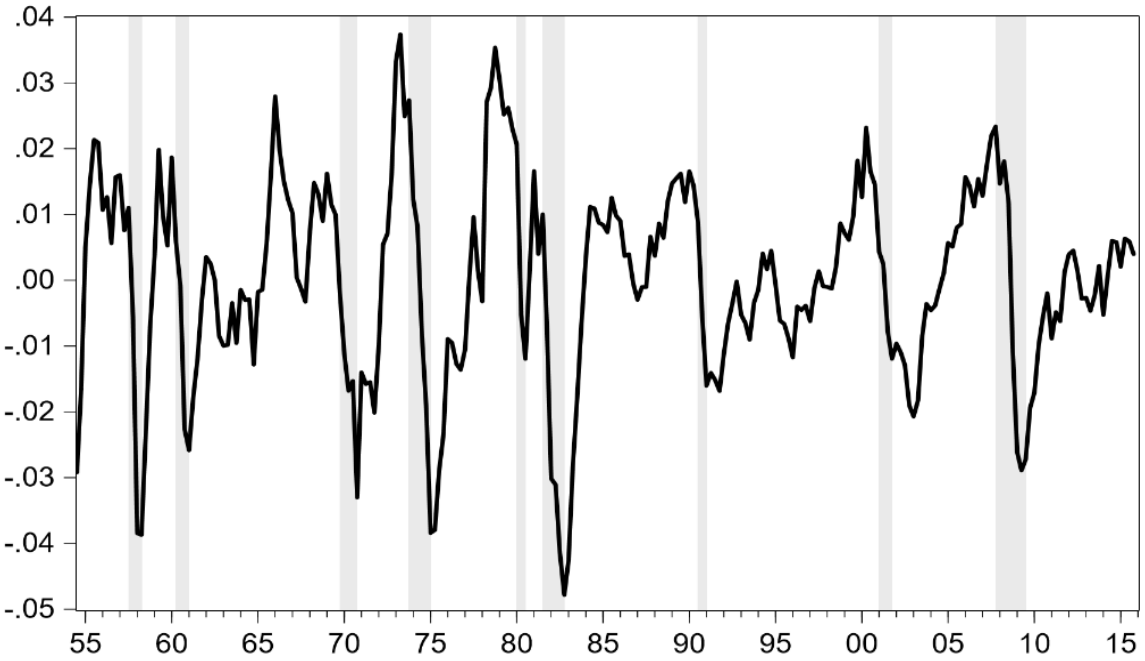
- Studying business cycle caused by supply shocks.
- Having an efficient benchmark allocation that policy in more realistic models should aim at.
- Describing the medium run in which prices have fully adjusted to changes in demand and supply determines output.
- Analyzing the effects of monetary policy in the medium run: money neutrality.

Taking the model to the data

- Moving away from long-run growth we need to eliminate the growth trend in the data to evaluate the model.
- Decompose real GDP into ist trend and cyclical component.

$$\ln Y_t = \ln Y_t^{\tau} + \ln Y_t^{c}$$

- Many ways to measure the trend. Once we have the trend the cyclical component is: $\ln Y_t^{c} = \ln Y_t - \ln Y_t^{\tau}$.
- We use the so-called HP filter to measure the trend.



Evaluating the model

- Usually evaluate whether the standard deviations of model variables and their correlations with output (procyclical, countercyclical, acyclical) are in line with the cyclical component of macro data.
- Cannot do this as we only have a qualitative model, but not a quantitative one.
- Nevertheless, can compare signs of correlations:

Variable	Corr w/ Y_t in Data	Corr conditional on A_t	Corr conditional on θ_t
C_t	0.88	+	+
I_t	0.91	+	+
N_t	0.87	+	+
w_t	0.20	+	-
r_t	0.10	-	-
P_t	-0.46	-	-

- Model quite good, when business cycles are primarly driven by A_t.
- Problems with r_t vanish if A_t shocks are persistent: A_{t+1} also increases. A_t increases output and reduces r_t via Y^s curve, A_{t+1} increases r_t via IS curve.

Is there evidence for changes in A_t in the data?

- Growth accounting: Back out A_t from the data based on a Cobb-Douglas production function:

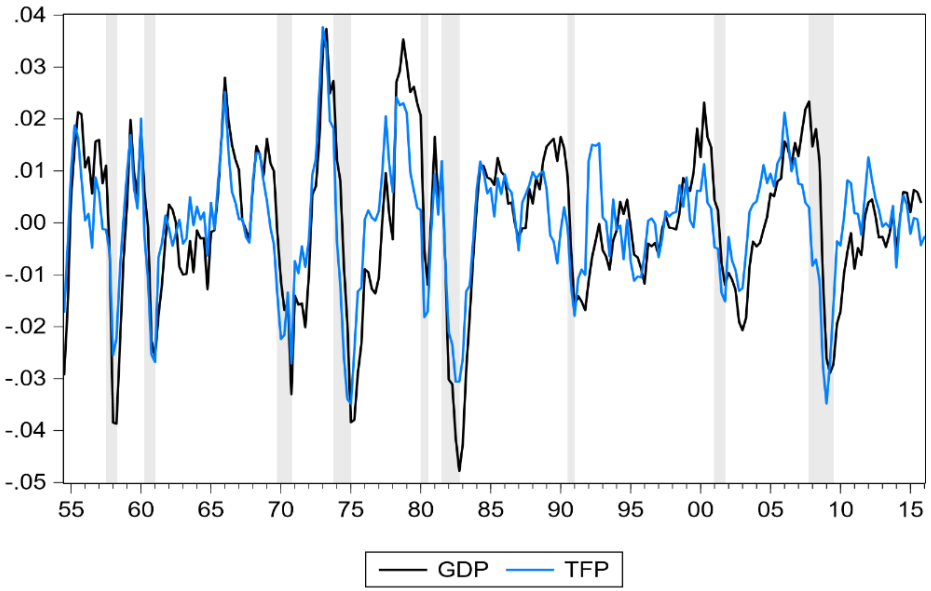
$$Y_t = A_t K_t^{\alpha} L_t^{1-\alpha}$$

- Take natural logs and re-arrange:

$$\ln A_t = \ln Y_t - \alpha \ln K_t - (1-\alpha) \ln L_t$$

- Set $\alpha = 0.3$ based on emprical data; use empirical data for Y_t, K_t and L_t.
- Empirical measure of A_t is called total factor productivity (TFP) since it is that part of output which cannot be explained by the factors capital and labor. Also called Solow residual.

Figure 17.3: Cyclical Components of Real GDP and TFP



Criticism

- For the RBC model to generate the qualitatively right co-movements among aggeregate variables, it needs to be driven by persistent changes in productivity (A_t and A_{t+1} move jointly). We see this in the data. But measurement issues (variable capital utilization) might change this conclusion.
- What are productivity shocks? What are negative productivity shocks?
- Monetary neutrality does not hold in the short run.
- No role for demand shocks in determining output. Not a good assumption for short-run analysis.
- Equilibrium is efficient, no role for activist policy. Recessions caused by A_t are efficient. Policy actions would make things worse.
- No heterogeneity of agents.

Summary

- Because the Y^S curve is vertical, only supply shocks (changes in A_t or θ_t) can result in movements in output and labor market variables.
- Demand shocks (changes in A_{t+1}, G_t, or G_{t+1}) only affect the composition of output between consumption and investment, not the level of output. Instead prices adjust to make sure that aggregate demand remains constant. The real interest rate is a key price in the model which adjusts to shocks to force aggregate expenditure to equal aggregate production.
- There is no effect of nominal variables on real variables. Money neutrality.
- Model too simple for short-run analysis. No role for policy.
- Still an important benchmark model that improved a lot on previous models (microeconomiic decision-making, dynamic and forward-looking behavior) that provides a good characterization of data over longer time horizons.
- Adding nominal stickyness leads to the New Keynesian model which provides a more realistic description of short-run dynamics and creates a role for activist stabilization policy.