Where are we heading to?

In the first 6 lectures we learnt how to think in terms of a model where all agents are optimizing and solving for the (general) equilibrium. All variables were real variables. In lecture 7 we introduced a central bank to our "real" model so that we can discuss money supply/demand and inflation.

Now we are going to build on what we have learnt, and in this lecture, examine the Real Business Cycle (RBC) model (reading: Williamson, chapter 11, pp. 403-413) and ask how well it fits the data. The following two to three weeks will then be spent analyzing the Keynesian IS-LM/AS-AD model (reading: Williamson, chapter 12), and asking how well it fits the data.

One age-old (normative) question: **should governments intervene to smooth out business cycles?**

Answer: it's not obvious.

Suggested reading for those interested in reading up on the history of economic thought: "New Ideas from Dead Economists" by Todd Buchholz
If you're interested in the history of money in the US, try "A Nation of Counterfeiters" by Stephen Mihm, 2007

Before we can ask which model performs relatively better when compared to data, we need to know what the data says.

But before we go into the data, some history:
- 1936: publication of Keynes "General Theory of Employment, Interest, and Money"; he was greatly influenced by the Great Depression
- by 1960s, Keynesian thought dominated; most economists believed that Keynesian business cycle models captured behavior of economy in short-run (Keynes

famous saying: "In the long run we're dead"); idea was that prices and wages could be sticky, so there is a role for monetary and fiscal policy in stabilizing economy in short run, in particular fiscal policy was a good way to "fine-tune" economy

- 1960s: emergence of "monetarists" (Milton Friedman) who believe that monetary policy was more effective as a tool for stabilization than fiscal policy, but they were skeptical of ability of governments to "fine-tune" the economy;
- early 1970s: rational expectations revolution (Robert E. Lucas, Thomas Sargent, Edmund Phelps): principles coming out of this RE revolution were: (1) macro models should be based on micro foundations, i.e., descriptions of preferences, endowments, technology and the optimizing behavior of all agents; and (2) equilibrium models are the best way to study macro phenomena.
- from then on, we never looked back. Essentially two schools of thought now: **Neo-Classical** and **New Keynesian**
- another revolution in the future?

What are business cycles?
Reading: Chapter 3, Williamson

Macro data are time series data; collected quarterly, monthly, yearly
(For example, Penn World Tables)

Look at real GDP time series,
for example figures 1.1-1.4, 3.2, where
(i) growth/trend component
(ii) fluctuations around trend

In practice, a Hodrick Prescott filter (HP filter) is used to separate the trend component from the business cycle component. Note that the trend component need not be linear!
- these fluctuations around trend are business cycles (see figures 1.3 and 1.4)

See figure 3.1: amplitude, peak, trough

As 2 major abnormal events took place in the first half of the 20th century (Great Depression and WWII), we will focus on the post WWII period. These 2 events are considered "abnormal" because they are associated with very large and long variations of GDP, negative in the case of the Great Depression, and positive in the case of WWII.

Observations about business cycles 1: GDP Fluctuations

- deviations from trend are persistent (if GDP dips below (above) trend, tends to stay below (above) trend)
- no regularity in amplitude (maximum deviation from trend) of fluctuations around trend
- no regularity in frequency of fluctuations around trend; length of time between peaks and troughs varies considerably

Hence, all business cycles are different

Observations about business cycles 2: Comovements of GDP and other macro variables

But if we look at how other macroeconomic variables vary with real GDP, we get a different picture. In fact, we then observe that there is a pattern in business cycles, and this is the pattern we will test our models against. But what is this pattern?

To be able to answer this question, we need to define a few (statistical) terms. Like we did for real GDP, we can "detrend" a time series for a macroeconomic variable. So for all detrended time series:

Definition 1 *Definition: A variable is said to be* **procyclical (countercyclical)** *if its deviations from trend are positively (negatively) correlated with the deviations from trend of real GDP. If, on the contrary, a variable's deviations from trend are not correlated with the deviations from trend of real GDP we say that this variable is* **acyclical**.

Definition 2 *If a macroeconomic variable x tends to aid in predicting the future path of another variable y, we say that x is a* **leading variable** *and y is a* **lagging variable**. *If both variables move at the same time, we say they are* **coincident**.

To measure the variability of a variable, we will use the standard deviation of its percentage deviation from trend.

Some business cycle facts

	Cyclicality	Lead/Lag	see figure:
Consumption (real)	Procyclical	Coincident	3.9
Investment (real)	Procyclical	Coincident	3.10
Price level (nominal)	Countercyclical?	Coincident?	3.12
Money supply (nominal)	Procyclical	Leading	3.13
Employment (real)	Procyclical	Lagging	3.14
Real wage	Procyclical	?	–
Av. labour productivity (real)	Procyclical	Coincident	3.15

Observe: investment is very, very volatile, even though it makes up a small percentage of real GNP/GDP

Observe: nominal money supply is a leading variable. Suggestive?

From data cited in another paper (Kydland and Prescott (1991)), using Citicorp's Citibase data bank, quarterly real GNP measured from 1954-1989, GNP volatility is 1.72% std dev from trend, and

Components of real GNP	Mean (% of GNP)	Volatility (% std dev from trend)
Consumption Expenditures	63.55	1.25
- nondurables and services	54.79	0.84
- durables	8.76	4.99
Investment Expenditures	15.85	8.3
Government Expenditures	20.13	2.07
Net Exports	0.47	5.53 (exports) 4.92 (imports)

Market Clearing Models of Business Cycles
Reading: Chapter 11, Williamson

Rational Expectations Revolution

Robert E. Lucas, Thomas Sargent, Neil Wallace, Robert Barro, among others, in early 1970s

1. macroeconomic models should be based on microeconomic principles; describe preferences, endowments, technology; optimizing behavior of agents;

2. equilibrium models

Note: different models give different predictions.

Economists generally agree that prices are flexible in the long run. But short run? Therein lies the controversy. Should fiscal and monetary policy be used to stabilize the economy or to achieve certain targets?

- Neoclassical economists believe that prices adjust quickly, and markets function best without interference through legislation; Adam Smith's idea of the "invisible hand"

> It is not from the benevolence of the butcher, the brewer, or the baker, that we expect our dinner, but from their regard to their own interest. We address ourselves, not to their humanity but to their self-love, and never talk to them of our own necessities but of their advantages.
> (The Wealth of Nations, Book 1 Chapter II)

- New Keynesians believe that prices are sticky; role for government, so "active intervention"

Question: Guess whether Williamson is Neoclassical or New Keynesian?
Comment: rational bubbles

Model : A Real Business Cycles Model

Finn Kydland and Edward Prescott asked whether a standard (Neo-Classical) Growth model subject to productivity shocks can replicate business cycles. In the Model

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

where $z_t = (1 + g_z)\, z_{t-1} + \varepsilon_t$ and ε_t is the potential TFP shock hitting the economy at time t. So their question is, is it possible that Business Cycles are driven by the ε_t shocks?

Looking at Solow residual and GDP deviations from trend, seems like a good idea (See figure 11.1)

$$\begin{aligned} Y_t &= z_t F(K_t, N_t), \text{ so} \\ \ln Y_t &= \ln z_t + \ln F(K_t, N_t). \end{aligned}$$

A Real Business Cycles Model (cont.)

If $F(K_t, N_t) = K_t^{\alpha} N_t^{1-\alpha}$, then get

$$\ln z_t = \ln Y_t - \alpha \ln K_t - (1-\alpha) \ln N_t.$$

It turns out that a very good representation of the time series for z is such that $\varepsilon_t = 0.95\varepsilon_{t-1} + \eta_t$, where η_t is a shock which is random every period and on average is zero, so that at time $t-1$ the expectation of what ε_t will be is 0.95 times what it is at time $t-1$. Hence, when a shock hits the economy, it is expected to be persistent, but its effects will eventually vanish.

TFP shocks in the RBC model

Suppose there is a persistent increase in current and future TFP, so $z_1 \nearrow$, $z_2 \nearrow$, $z_3 \nearrow$, $z_4 \nearrow$,..., but future TFP increases are expected to get smaller and smaller.

Change in TFP today is η_1, and $E_1(\Delta z_2) = 0.95\eta_1$, $E_1(\Delta z_3) = 0.95^2\eta_1$, $etc.$

Finn Kydland and Ed Prescott asked whether a standard growth model subject to random productivity shocks can replicate business cycles.

(See figure 11.1) Doesn't it look like a very good question to ask?

We'll study a version of the RBC model, which includes money

Suppose there is a persistent increase in current and all future TFP, so $z_1 \nearrow$, $z_2 \nearrow$, $z_3 \nearrow$, $z_4 \nearrow$,..., (see "figure 11.2")

Increase in z_1 means $\nearrow$ in MPL so N_1^d shifts right to $\widetilde{N}_1^d$, because more labour is demanded at every wage rate. But increases in future TFP also imply that wages in the future $\nearrow$, so lifetime wealth $\nearrow$, and you choose to work less at every wage rate, so $N_1^S\left(r_1^*\right)$ shifts to the left to $\widehat{N}_1^S\left(r_1^*\right)$. It turns out that the leftward shift of labour supply curve today is smaller than the rightward shift of labour demand curve, so overall current employment rises in the labour market. This thus causes Y_1^s to shift to the right to $\widetilde{Y}_1^s$.

But increases in future z imply that for the representative firm, future $MPK \nearrow$, so $I_1 \nearrow$, so investment component of Y_1^d rises.

And for the representative consumer, increases in future TFP also imply that wages in the future $\nearrow$, so lifetime wealth $\nearrow$, so $C_1 \nearrow$. Hence, consumption component of Y_1^d increases.

Hence, Y_1^d shifts to the right to $\widetilde{Y}_1^d$.

Rightward shifts of both Y^d and Y^s imply that aggregate output has risen unambiguously

Shift of Y_1^s is likely to be larger than shift of Y_1^d, because the former is the direct effect of increasing $TFPs$ whereas latter is a response to an anticipated effect of higher $TFPs$. Further, the representative consumer knows that a bad shock can hit the economy later on, so the wealth effect (in affecting labour supply and consumption today) is small.

Hence, at the original real rate of interest r_1^*, output supplied exceeds output demand. To boost demand, interest rates are going to fall to encourage consumer to consume more today because $(1 + r)$ is the price of consumption today relative to consumption tomorrow, so a fall in interest rate today makes consumption today relatively cheaper, so consumption today rises. At the same time, as interest rate falls, I_1 increases because the interest rate is the rate of return on alternative asset to the representative firm, bonds, so a fall in interest rate makes investing more attractive relative to bonds. Hence, there is a movement downwards along the $\widetilde{Y}_1^d$ from point A.

At the same time, as interest rate falls, the representative consumer works less, since the price of leisure today is less expensive relative to the price of leisure tomorrow, which is $w_1(1 + r)/w_2$, and this substitution effect dominates, so $\widehat{N}_1^S\left(r_1^*\right)$ starts to shift to the left, and thus causes a movement down the $\widetilde{Y}_1^s$ curve from point B.

Equilibrium is restored in the goods market when the real interest rate has fallen enough to equate output supplied with output demanded at $\left(\widetilde{Y}_1^*, \widetilde{r}_1^*\right)$. In the labour market, data suggests that the real interest rate effect on labour supply is smaller than the change in labour demanded, so overall, current employment rises from N_1^* to $\widetilde{N}_1^*$, and real wage rate today rises to $\widetilde{w}_1^*$.

Further, since $Y_1^* \nearrow$ to $\widetilde{Y}_1^*$ and $r_1^* \downarrow$ to $\widetilde{r}_1^*$, money demand increases, at every price level, from $P_1 L\left(Y_1^*, r_1^*\right)$ to $P_1 L\left(\widetilde{Y}_1^*, \widetilde{r}_1^*\right)$. Equilibrium in the money market is restored at a lower price $\widetilde{P}_1^*$

What happens to C_1?

- rises due to $\downarrow$ in r_1
- rises because $\nearrow$ in current income
- rises because $\nearrow$ in future periods' income

Overall: $C_1 \nearrow$

What happens to I_1?:

- rises because $\nearrow$ in future $TFPs$

- rises because $\downarrow$ in r_1

Overall: $I_1 \nearrow$

Since in equilibrium $Y_1 \nearrow$ and $N_1 \nearrow$, what can you say about Y/N, average labor productivity?

Kydland and Prescott's model show that $\frac{Y_1}{N_1} \nearrow$

How does the model compare with data? Qualitatively: well. See table 11.1

Quantitatively, the model fares well also. Simulating an artificial economy Cooley and Hansen (1995) obtain that the **volatility**, in % Std Dev/trend, for the model and the US data compare in the following fashion:

Variable	**Model**	**US data**
Output	1.69	1.72
Consumption (non-durables)	0.42	0.86
Investment	5.83	8.24
Hours	1.35	1.59
Price level	0.42	0.88
Inflation	0.26	0.57

Conclusion: model with persistent shocks fares very well when compared to data. Just can't replicate procyclicality of money supply

What about Money Supply?

1. Nominal money supply is procyclical
2. Nominal money supply tends to lead real GDP

RBC model above doesn't have these 2 features. Remedy?
Endogenous money (money supply responds to conditions in economy, not fixed)

1. Money supply taken as exogenous. But can always make money supply endogenous. If we assume that central bank cares about stabilizing price level, then above predicts a fall in price level. How to stabilize prices? Increase money supply. Now we have procyclicality of money supply

("figure 11.4")

2. seems like a real problem. From data, nominal money supply appears to lead real GDP. Economists like Friedman take it to mean a causality (QTM, Quantity Theory of Money: $MV = PY$). Changing M changes PY if V constant). But distinction between causality and statistical causality (correlation between current M and future Y) Do M changes cause Y changes?

Example
- of birds flying south in winter

How does nominal money supply lead real GDP?

1. If central bank knows TFP is going to change in the future, then to stabilize prices it can increase money supply now, so nominal money supply leads real GDP

2. banking sector tends to lead other sector because it's very responsive, so any anticipation that future Y is going to change will lead to more activity today, for example, more lending/borrowing. Depending on which measure of money supply you use, there can be more activity.

Implications of RBC Model

No role for government stabilization policy because:
- all markets clear
- money is neutral

In *RBC* model above, business cycles are optimal responses of economy to fluctuations to *TFP*, and nothing should be done about them.

But this does not mean that there is no role for government to play

Critique of RBC Model

Is Solow residual the best way to measure *TFP*? Measurement error?

Labor hoarding (underutilization of labor) and underutilization of capital during recessions?

What are these technology shocks? Are they really exogenous or is there something else that drives these shocks that are not modeled in the RBC literature?

Note: We are not going to analyze Keynesian coordination failure model nor the segmented markets model in this course.