The full RBC model. Empirical evaluation
Lecture 13 (updated version), ECON 4310

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Today’s lecture

- Add labor to the stochastic model
- Discuss effects of stochasticity
- Log-linearized model
- Calibration (repetition from Lecture 12)
- Simulation and evaluation
Consider an economy with

- An infinite horizon
- A representative agent with time separable utility, assumed to also be separable in consumption and labor supply
- The agent can invest in real capital and supply labor
- Due to labor lotteries, we assume that utility is linear in labor supply $n_t$
- Production is Cobb-Douglas and the representative firm is a price-taking profit maximizer
- Factor markets are perfect
- There is no government (easy to add) and the economy is closed
- Productivity follows an exogenous stochastic process
Due to the second welfare theorem, we know that the competitive equilibrium is equivalent to the solution to the social planner’s problem. It is given by:

$$\max_{\{c_t, n_t, k_{t+1}\}} \sum_{t=0}^{\infty} E_0 \beta^t [u(c_t) - Dn_t]$$

s.t.

$$c_t + k_{t+1} = A_t k_t^\alpha n_t^{1-\alpha} + (1 - \delta) k_t$$

$$A_t = Ae^{zt}$$

$$z_t = \rho z_{t-1} + \varepsilon_t$$

$$c_t \geq 0$$

$$k_{t+1} \geq 0$$

$$0 \leq n_t \leq 1$$

with $k_0 > 0$ given. Can as before simplify by ignoring the conditions on $n$, $c$ and $k$ under ‘normal’ assumptions.
We will use this model to study *business cycles*. So we take a model originally developed as a growth model, feed it with shocks to productivity, and see how well it does in creating business cycles. Implications:

- Business cycles are the product of rational agents responding to changes in productivity
- Monetary policy (money) has no/little importance in business cycles
To solve the problem, insert for $c_t$ in the utility function using the resource constraint. The first-order conditions with respect to $k_1$ and $n_0$ are now:

$$u'(A_0 k_0^\alpha n_0^{1-\alpha} + (1 - \delta)k_0 - k_1) = \beta E_0 \left[(1 + r_1)u'(A_1 k_1^\alpha n_1^{1-\alpha} + (1 - \delta)k_1 - k_2)\right]$$

$$\omega_0 u'(A_0 k_0^\alpha n_0^{1-\alpha} + (1 - \delta)k_0 - k_1) = D$$

where I have defined

$$w_t = (1 - \alpha)A_t k_t^\alpha n_t^{-\alpha}$$

$$r_{t+1} = \alpha A_t k_t^{\alpha-1} n_t^{1-\alpha} - \delta$$
Simplify the first-order condition for $k_{t+1}$ by re-introducing $c_t$ as defined by the resource constraint. That gives the familiar expressions for the Euler equation and the intratemporal condition:

$$u'(c_0) = \beta E_0 [(1 + r_1)u'(c_1)]$$
$$w_0 u'(c_0) = D$$

These two conditions, together with the resource constraint and the definition of $w_t$ and $r_{t+1}$:

$$c_t + k_{t+1} = A_t k_t^\alpha n_t^{1-\alpha} + (1 - \delta)k_t$$
$$w_t = (1 - \alpha)A_t k_t^\alpha n_t^{-\alpha}$$
$$r_{t+1} = \alpha A_t k_t^{\alpha-1} n_t^{1-\alpha} - \delta$$

is what we need to describe optimum.
Often it is easier to work with more variables and simpler equations. Let us re-introduce output $y_t$ and investment $i_t$ to instead write equilibrium conditions as:

$$E_0 \left[ \beta t u'(c_t) \right] = E_0 \left[ (1 + r_{t+1}) \beta u'(c_{t+1}) \right]$$

$$E_0 \left[ w_t u'(c_t) \right] = D$$

$$c_t + i_t = y_t$$

$$A_t k_t^{\alpha} n_t^{1-\alpha} = y_t$$

$$(1 - \delta)k_t + i_t = k_{t+1}$$

$$w_t = (1 - \alpha) A_t k_t^{\alpha} n_t^{\alpha - 1}$$

$$r_{t+1} = \alpha A_t k_t^{\alpha - 1} n_t^{1 - \alpha} - \delta$$

These are the conditions we will linearize in a minute.
The effect of stochasticity

- We get stochasticity since $A_t$ is a random variable
- This creates more ‘action’ in our model since technology never falls to rest at its steady state value
- Optimum conditions must therefore hold *in expectations*
Take the Euler equation. For $t = 0$ it states:

$$1 = E_0 \left[ (1 + r_1) \frac{\beta u'(c_1)}{u'(c_0)} \right]$$

$$= E_0 [1 + r_1] E_0 \left[ \frac{\beta u'(c_1)}{u'(c_0)} \right] + \text{cov}(1 + r_1, \frac{\beta u'(c_1)}{u'(c_0)})$$

- The first term is the equivalent to what we have in a deterministic case
- The second term is introduced because of the risk involved in investing in capital when technology is stochastic
The effect of stochasticity III

The covariance is negative if $u(c)$ is concave, since higher future return then reduces the future marginal utility of consumption.

The effect of making technology stochastic is then, all else equal, less investment in capital.

But this is a second-order moment effect. When we linearize the model around steady state, it will not matter.

(But there might be cases where this is an important effect)
Stochasticity

The effect of stochasticity IV

It is the same thing for the intratemporal optimality condition:

\[ D = E_0 \left[ w_t \beta^t u'(c_t) \right] \]

\[ = E_0 \left[ w_t \right] E_0 \left[ \beta^t u'(c_t) \right] + \text{cov}(w_t, \beta^t u'(c_t)) \]

Here we also have a ‘risk’ element to labor supply decisions – but it will not have an impact on our first-order approximations around the steady state.
The effect of stochasticity V

- So risk elements are ignored in a first-order linear approximation.
- But we keep the expectations terms, so our model becomes *forward-looking*.
- For the investment decision, it means that agents will expect the rate of return to increase also tomorrow, if a persistent technology shock hits the economy today.
- For consumption and labor supply, it means that one will anticipate future income and marginal utilities when deciding what the optimal levels are.
We know what the non-stochastic steady state looks like. No growth, so $c_t = c_{t+1}$ and $k_{t+1} = k_t$. Gives:

\[
1 = \beta (1 + r^*)
\]
\[
D = w^* u'(c^*)
\]
\[
c^* = A^* k^*^{\alpha} n^*^{1-\alpha} - \delta k^*
\]
\[
w^* = (1 - \alpha) A^* k^*^{\alpha} n^*^{-\alpha}
\]
\[
r^* = \alpha A^* k^*^{\alpha-1} n^*^{1-\alpha} - \delta
\]
Then we need to derive the linearized conditions. The only change compared to Lecture 11, is that now we must take into account that $n_t$ is not fixed. In addition I have introduced $r_{t+1}$ and $w_t$ as variables. We keep on letting $\hat{x}_t$ be a variable’s percentage deviation from steady state:

$$\hat{x}_t = \frac{x_t - x^*}{x^*}$$
Linearized equilibrium conditions II

Start with Euler equation. As last time:

\[ u'(c_t) \approx u'(c^*) [1 - \sigma \hat{c}_t] \]

where \( \sigma = -c^* u''(c^*)/u'(c^*) \) is the coefficient of relative risk aversion. Then we have

\[ \beta E_t[(1 + r_{t+1})u'(c_{t+1})] \approx \beta (1 + r^*) u'(c^*) + \beta u'(c^*) E_t(r_{t+1} - r^*) + \beta (1 + r^*) u''(c^*) E_t(c_{t+1} - c^*) \]

Use \( \beta(1 + r^*) = 1 \) to get

\[ \beta E_t[(1 + r_{t+1})u'(c_{t+1})] \approx u'(c^*) (1 + \beta r^* E_t \hat{r}_{t+1} - \sigma E_t \hat{c}_{t+1}) \]

Euler equation is then:

\[ \hat{c}_t = E_t \hat{c}_{t+1} - \frac{\beta r^*}{\sigma} E_t \hat{r}_{t+1} \]
The intratemporal optimality condition

\[ D = w_t u'(c_t) \]

is easy to linearize. We use

\[
  w_t u'(c_t) \approx w^* u'(c^*) + u'(c^*)(w_t - w^*) + w^* u''(c^*)(c_t - c^*)
\]

\[ \Rightarrow w_t u'(c_t) \approx D(1 + \hat{w}_t - \sigma \hat{c}_t) \]

The intratemporal optimality condition is then in linearized form just

\[ \sigma \hat{c}_t = \hat{w}_t \]
Linearizing $c_t + i_t = y_t$ is somewhat trivial; it is in linearized form:

$$\hat{y}_t = \frac{c^*}{y^*} \hat{c}_t + (1 - \frac{c^*}{y^*}) \hat{i}_t$$

Similarly for the law of motion for capital; it is straightforward to linearize

$$k_{t+1} = (1 - \delta) k_t + i_t$$

to get

$$\hat{k}_{t+1} = (1 - \delta) \hat{k}_t + \delta \hat{i}_t$$
Next we do the production function. We see that
\[ A_t k_t^\alpha n_t^{1-\alpha} \approx y^* + y^* \hat{A}_t + \alpha y^* \hat{k}_t + (1 - \alpha) y^* \hat{n}_t \]
After approximating \( \hat{A}_t \) by \( \log A_t - \log A^* = z_t \) we get the linearized condition
\[ \hat{y}_t = z_t + \alpha \hat{k}_t + (1 - \alpha) \hat{n}_t \]
The two last equations we need to linearize are those for \( w_t \) and \( r_{t+1} \). For the wage equation we use

\[
 w_t = (1 - \alpha) A_t k_t^\alpha n_t^{-\alpha} \approx w^* + w^* \hat{A}_t + \alpha w^* \hat{k}_t - \alpha w^* \hat{n}_t
\]

and again, we use \( \hat{A}_t \approx z_t \) so

\[
 \hat{w}_t = z_t + \alpha (\hat{k}_t - \hat{n}_t)
\]
For the return on capital:

\[ r_t = \alpha A_t k_t^{1-\alpha} n_t^{1-\alpha} - \delta \approx r^* + (r^* + \delta) \hat{A}_t - (1 - \alpha)(r^* + \delta) \hat{k}_t + (1 - \alpha)(r^* + \delta) \hat{n}_t \]

and again, we use \( \hat{A}_t \approx z_t \) so

\[ \hat{r}_t = \frac{r^* + \delta}{r^*} \left( z_t - (1 - \alpha)(\hat{k}_t - \hat{n}_t) \right) \]
Linearization

Linearized equilibrium conditions VIII

The full set of linearized equilibrium conditions is:

\[
\hat{c}_t = E_t \hat{c}_{t+1} - \frac{\beta r^*}{\sigma} E_t \hat{r}_{t+1}
\]

\[
\sigma \hat{c}_t = \hat{w}_t
\]

\[
\hat{y}_t = \frac{c^*}{y^*} \hat{c}_t + (1 - \frac{c^*}{y^*}) \hat{i}_t
\]

\[
\hat{k}_{t+1} = (1 - \delta) \hat{k}_t + \delta \hat{i}_t
\]

\[
\hat{y}_t = z_t + \alpha \hat{k}_t + (1 - \alpha) \hat{n}_t
\]

\[
\hat{w}_t = z_t + \alpha (\hat{k}_t - \hat{n}_t)
\]

\[
\hat{r}_t = \frac{r^* + \delta}{r^*} \left( z_t - (1 - \alpha)(\hat{k}_t - \hat{n}_t) \right)
\]

together with the process for \( z_t \):

\[
z_t = \rho z_{t-1} + \varepsilon_t
\]
Before we can simulate the model, we need to calibrate the model – i.e. assign parameter values based on moments we want to match. As in Lecture 12, if we want to ensure a capital share equal to 1/3, an investment to capital ratio of 2.5%, a real interest rate of 1% and $n = 1/3$ in our model we just choose:

- $\alpha = 1/3$
- $\delta = 0.025$
- $\beta = 1/1.01$
- $D = 8/3$

This calibration was based on assuming log utility, i.e. it holds for $\sigma = 1$, so let us set keep that. Empirical estimates of the CRRA are often very dispersed, and consensus seems to be $\sigma \in (0, 5)$, but also higher values are used.
There are two other parameters we need to find values for as well. Remember, technology depends on $z_t$, which is an AR(1) process

$$z_t = \rho z_{t-1} + \varepsilon$$

where $\varepsilon$ is $N(0, \sigma^2\varepsilon)$. Must pin down $\rho$ and $\sigma^2\varepsilon$. How to choose?

- Find ‘productivity’ as the Solow residual: $Z_t = \log A_t = \log Y_t - \alpha \log K_t - (1 - \alpha) \log N_t$ (possibly also controlling for a linear trend)
- Estimate $\rho$ from regressing $Z_t = \rho Z_{t-1} + e_t$
- Estimate $\sigma^2\varepsilon$ based on the residual sum of squares from the regression

We follow Krueger in setting $\rho = 0.95$ and $\sigma\varepsilon = 0.007$. 
The set of linearized equations can be used to solve for the solution, given some realization of \(\{z_t\}\). Normally we have:

\[
\text{Linearized model } \Rightarrow \text{ Computer } \Rightarrow \text{ Solution}
\]
A program that makes simulation of forward-looking models very accessible is **Dynare**. See [www.dynare.org](http://www.dynare.org) for more information. To simulate a model with Dynare you need access to Matlab. A standard simulation exercise can be performed by completing five simple steps:

1. Define endogenous variables (including exogenous stochastic shocks, such as $A_t$)
2. Define parameters and assign parameter values
3. Define innovations and their standard deviations
4. Write down the linearized equations
5. Initiate simulation

We will not require you to use Dynare yourselves, but it is useful to know it for those who wish to do more macro later.
The following code simulates our model:

```plaintext
// VARIABLES
var y, c, i, n, k, z, r, w;

// PARAMETERS
parameters beta, rstar, sigma, cystar, delta, alpha, rho;

rstar = 0.01;
cystar = 0.75;
alpha = 1/3;
rho = 0.95;
sigma = 1;
delta = (1-cystar)/10.4;
beta = 1/(1+rstar);

// SHOCKS
varexo epsilon;

shocks;
var epsilon; stderr 0.007;
end;

(Continued on next slide)
Simulation IV

(Continued from last slide)

```
// MODEL
model (linear);
c = c(+1) - (beta*rstar/sigma)*r(+1);
sigma*c = w;
y = cystar*c + (1-cystar)*i;
k = (1-delta)*k(-1) + delta*i;
y = z + alpha*k(-1) + (1-alpha)*n;
w = z + alpha*(k(-1)-n);
r = (rstar+delta)/rstar*(z - (1-alpha)*(k(-1)-n));
z = rho*z(-1) + epsilon;
end;
stoch_simul(irf=20,periods=200);
```

Note:

- Dynare treats variables such as $x(+1)$ as $E_t x_{t+1}$
- Pre-determined variables (such as $k_t$) must be refered to as $k(-1)$ for the same reason
Impulse-responses

What is the effect of a one percentage point shock to technology?
Impulse-responses II

- Investment becomes very volatile
- Employment goes up to take advantage of the temporarily higher wages
- Output increases by twice as much (in percentage points) as technology. \( \Rightarrow \) The shock is propagated by the endogenous responses (labor supply and investment)
Impulse-responses III
Importance of labor supply response

Remember: We use a labor lottery to justify linear disutility of labor supply. How would it change our impulse-response plot if we assume divisible labor instead? If period $t$ utility is

$$u(c_t, h_t) = \log c_t - \phi \frac{h_t^{1+\theta}}{1 + \theta}$$

The new intratemporal optimality condition is

$$\phi h_t^\theta = w_t c_t$$

Linearized around steady state that gives:

$$\hat{c}_t + \phi \theta \hat{h}_t = \hat{w}_t$$

We can therefore replace $\hat{c}_t = \hat{w}_t$ with this equation to get a model with divisible labor.
As seen in Lecture 12, to calibrate the model to have $h^* = 1/3$ we now need to choose $\phi = 24$ if $\theta = 2$ (the latter follows from micro estimates). Impulse-response function for the new model:
Importance of labor supply response III

- Investment remains volatile
- But employment barely goes up
- Output increases only due to technology (in the short run). ⇒ To get propagation in the first years, we need employment to respond more forcefully!
And again: Both models (indivisible and divisible labor) are calibrated to match the same moments, so it is not the case that calibrating a model just gives us what we want. The difference lies in the substitution effects!
Evaluation of the model

Return to model with labor lottery. It is finally time to see how well the model does in ‘explaining’ business cycles. What we do is to

- Simulate the model for $T$ periods (I chose $T = 5000$). This can be done with the Dynare code we have looked at
- Find the cyclical components using the HP-filter (idea: treat simulated data in the same way as real data)
- Compute standard deviations and cross-correlations, just like the table in Kydland and Prescott (1990)
- Compare your table with what is found for actual data
- If the match: Hurra!
- If not: Identifies areas where the model should be improved
Evaluation of the model II

HP-filtered data:
### Evaluation of the model III

**Table:** Correlation table for simulated data

<table>
<thead>
<tr>
<th>Variable</th>
<th>Volatility</th>
<th>$y_{t-4}$</th>
<th>$y_{t-3}$</th>
<th>$y_{t-2}$</th>
<th>$y_{t-1}$</th>
<th>$y_t$</th>
<th>$y_{t+1}$</th>
<th>$y_{t+2}$</th>
<th>$y_{t+3}$</th>
<th>$y_{t+4}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y$</td>
<td>1.937</td>
<td>0.092</td>
<td>0.279</td>
<td>0.495</td>
<td>0.737</td>
<td>1.000</td>
<td>0.737</td>
<td>0.495</td>
<td>0.279</td>
<td>0.092</td>
</tr>
<tr>
<td>$c$</td>
<td>0.536</td>
<td>0.432</td>
<td>0.565</td>
<td>0.688</td>
<td>0.790</td>
<td>0.860</td>
<td>0.528</td>
<td>0.243</td>
<td>0.008</td>
<td>-0.176</td>
</tr>
<tr>
<td>$i$</td>
<td>6.418</td>
<td>0.004</td>
<td>0.195</td>
<td>0.426</td>
<td>0.692</td>
<td>0.992</td>
<td>0.758</td>
<td>0.537</td>
<td>0.334</td>
<td>0.156</td>
</tr>
<tr>
<td>$n$</td>
<td>1.501</td>
<td>-0.035</td>
<td>0.158</td>
<td>0.394</td>
<td>0.670</td>
<td>0.983</td>
<td>0.763</td>
<td>0.552</td>
<td>0.357</td>
<td>0.182</td>
</tr>
<tr>
<td>$w$</td>
<td>0.536</td>
<td>0.432</td>
<td>0.565</td>
<td>0.688</td>
<td>0.790</td>
<td>0.860</td>
<td>0.528</td>
<td>0.243</td>
<td>0.008</td>
<td>-0.176</td>
</tr>
<tr>
<td>$r$</td>
<td>6.727</td>
<td>-0.096</td>
<td>0.098</td>
<td>0.340</td>
<td>0.629</td>
<td>0.964</td>
<td>0.766</td>
<td>0.573</td>
<td>0.390</td>
<td>0.223</td>
</tr>
<tr>
<td>$z$</td>
<td>0.942</td>
<td>0.097</td>
<td>0.283</td>
<td>0.499</td>
<td>0.739</td>
<td>1.000</td>
<td>0.736</td>
<td>0.493</td>
<td>0.276</td>
<td>0.089</td>
</tr>
</tbody>
</table>

**Table:** Correlation table from Kydland and Prescott (1990)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Volatility</th>
<th>$y_{t-4}$</th>
<th>$y_{t-3}$</th>
<th>$y_{t-2}$</th>
<th>$y_{t-1}$</th>
<th>$y_t$</th>
<th>$y_{t+1}$</th>
<th>$y_{t+2}$</th>
<th>$y_{t+3}$</th>
<th>$y_{t+4}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y$</td>
<td>1.71</td>
<td>0.15</td>
<td>0.38</td>
<td>0.63</td>
<td>0.85</td>
<td>1.00</td>
<td>0.85</td>
<td>0.63</td>
<td>0.38</td>
<td>0.15</td>
</tr>
<tr>
<td>$c$</td>
<td>0.84</td>
<td>0.06</td>
<td>0.27</td>
<td>0.46</td>
<td>0.63</td>
<td>0.76</td>
<td>0.77</td>
<td>0.67</td>
<td>0.53</td>
<td>0.38</td>
</tr>
<tr>
<td>$i$</td>
<td>5.38</td>
<td>0.08</td>
<td>0.35</td>
<td>0.60</td>
<td>0.81</td>
<td>0.90</td>
<td>0.83</td>
<td>0.64</td>
<td>0.44</td>
<td>0.25</td>
</tr>
<tr>
<td>$n$</td>
<td>1.47</td>
<td>0.38</td>
<td>0.59</td>
<td>0.75</td>
<td>0.86</td>
<td>0.86</td>
<td>0.69</td>
<td>0.44</td>
<td>0.12</td>
<td>0.05</td>
</tr>
<tr>
<td>$w$</td>
<td>1.58</td>
<td>0.40</td>
<td>0.62</td>
<td>0.80</td>
<td>0.90</td>
<td>0.88</td>
<td>0.68</td>
<td>0.42</td>
<td>0.18</td>
<td>-0.02</td>
</tr>
<tr>
<td>$r$</td>
<td>2.93</td>
<td>-0.19</td>
<td>0.02</td>
<td>0.30</td>
<td>0.60</td>
<td>0.84</td>
<td>0.79</td>
<td>0.63</td>
<td>0.44</td>
<td>0.24</td>
</tr>
</tbody>
</table>

Based on using real GNP as $y$, consumption of nondurables and services as $c$, fixed investments as $i$, hours from Household Survey as $n$, labor income as $w$, capital income as $r$.
Evaluation of the model IV

Comparing the tables we see that we are doing (surprisingly?) well.

- First four volatilities are almost the same for our model as in the data
- Autocorrelation structure for output is not bad
- Consumption follows output as in the data, but it does not have the same tendency for almost leading the cycle
- Investment looks OK
- Employment does not lag the cycle as in the data
- Factor prices are somewhat more far off

Our results are similar to what Kydland and Prescott (1982) [Time to Build and Aggregate Fluctuations, Econometrica] found.
Evaluation of the model V

We have at least two dimensions where we should improve:

- Need to make factor prices, and especially $r$ much less volatile
  - Tobin's $Q$?
- Generally speaking we see that correlations with $y(t + i)$ and $y(t - i)$ are generally higher in the data. Indicates that we might have too little internal persistence.
  - Habit formation in consumption?
  - Sticky prices and wages?
Today’s state-of-the-art New Keynesian DSGE models are basically just extended RBC models. Standard features of these models (as e.g. Smets and Wouters, 2007) are

- Sticky prices
- Sticky wages
- Costly capital adjustment (Tobin’s Q)
- Habit formation
- Variable capital utilization
- Collateral constraints ⇒ Financial accelerator (not in Smets and Wouters)

You learn about how to include sticky prices in ECON4325 (next spring)
Evaluation of the model VI

- The more involved New Keynesian DSGE models usually ‘fit the data’ much better than simple RBC models.
- But they are often criticized by RBC theorists as being too ‘ad hoc’. Problem is that they include features that are not necessarily structural.
RBC models describe business fluctuations as

- Driven by technology shocks in a perfectly competitive environment
- Since the representative agent maximizes utility and there are no externalities, there are no efficiency losses
- Business cycles are therefore the product of an economy’s optimal response to temporary technology shocks
- Any stabilization policy will either be (at best) ineffective or harmful
The RBC methodology involves:

- Macroeconomics should always involve *microfounded general equilibrium models* with *rational expectations*. Family of such models: DSGE.
- One should take the quantitative implications of a model seriously.
A controversial question is the role of monetary policy for business cycle fluctuations

- Monetary policy is irrelevant in RBC models since prices are flexible
- So-called New Keynesian DSGE models therefore modify the RBC framework to allow for imperfect price flexibility. This makes monetary policy play a role
Objections to RBC models

- Weak statistics/econometrics foundation of the empirical evaluation
  - Answer: All models are wrong, but some are useful
  - Not necessarily a sufficient reply
- What are technology shocks? Is it realistic to expect technology to be hit by new shocks every period?
- How do you explain the Great Depression? Or today’s Great Recession?
- Do we have technological decline?
- There is some empirical evidence supporting that monetary shocks can play a role: Should make prices less flexible?
- Gali (1999): Technology shocks seem to reduce hours worked, not increase them as in RBC models
Objections to RBC models II

We can focus more at the technology shock. One important selling point for RBC models is that they generate persistent business cycles. But this hinges critically on the value of $\rho$, the autoregressive parameter of the technology shock. In our calibration it is set to 0.95. Look at impact on output if we reduce $\rho$ to 0.5:
Objections to RBC models III

This means that the persistence of our RBC model relies heavily on the high persistence of our poorly measured productivity shock. Not satisfactory.
This ends the RBC part of the course. You have been through:

- Using the basic Ramsey model with and without uncertainty
- Including labor supply and why we use labor lotteries
- Linearizing the equilibrium conditions
- Understanding what a solution to the model is
- Calibrating a model
- How an RBC model is evaluated
- Some discussion on the RBC approach

Next week: Consumption asset pricing.