Advanced Macroeconomics II
The RBC model with Capital

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Part of these slides are based on Jordi Galí slides for Macroeconomia Avanzada II.
Outline

- Real business cycle model with capital
- Matching real world data (calibration)
- Evaluation of the RBC approach: the debate over RBC theory

Part of these slides are based on Jordi Galì slides for Macroeconomia Avanzada II.
**TRADITIONAL BUSINESS CYCLE THEORY:** output trend $\tilde{Y}_t$ evolves smoothly over time, $\tilde{Y}_t = a + bt$. Cycles are viewed as deviation from trends, i.e. $Y_t - \tilde{Y}_t$

**RBC THEORY:** cycles can be explained also assuming that $\tilde{Y}_t$ evolves according to a random walk, i.e., $\tilde{Y}_t = b + \tilde{Y}_{t-1} + u_t$. In this case much of the movements in $Y_t$ are due to movements in $\tilde{Y}_t$ and rather then to trend deviations $Y_t - \tilde{Y}_t$
The Lucas Research Program (LRP)

- Macroeconomists should build so-called structural models, i.e. models that are based on microeconomics foundations, maximizing households and firms, flexible prices/wages, market clearing, etc.

- The LRP is the logical outcome of the Rational Expectations Revolution of the 1970s.

- Kydland & Prescott (1982) accepted the challenge posed by Lucas: they built the first Real Business Cycle (RBC) model.
Basic RBC model

- Outline of the RBC methodology:

a discrete-time stochastic model of the economy populated by maximizing households and firms

MAIN SOURCE OF FLUCTUATIONS:

- The erratic nature of technological progress
MAIN RESULT AND FIRST INTUITION

- There is only one final good in the economy which is produced according to a constant return to scale (CRS) production function

\[ Y_t = A_t F(K_t, N_t) \]

where \( \ln(A_t/A) = a_t \) is an exogenous process of technological progress (or total factor productivity TFP), which evolves according to:

\[ \ln(A_t/A) = \rho_a \ln(A_t/A) + \varepsilon_{a,t}, \quad \varepsilon_{a,t} \sim WN(0, \sigma_a^2) \quad i.i.d. \]

- A positive shock to the TFP shifts firms’ labor demand and the AS curve

- Movements in employment and economic activity are seen as the efficient responses of a perfectly competitive economy to a productivity shock. \( \Rightarrow \) Movements from a Walrasian equilibrium to another one.
POSITIVE TECHNOLOGY SHOCK

Labor Demand

\[ W/P \]

\[ L^S(W/P) \]

\[ W/P_1 \]

\[ L_1 \]

\[ L_2 \]

Production Function

\[ Y = F(L) \]

\[ Y \]

\[ \bar{Y}_1 \]

\[ \bar{Y}_2 \]

\[ W/P_2 \]
MAIN FEATURES of RBC MODELS

- All prices are flexible, both in the long-run and in the short-run. All markets (of inputs and output) are Walrasian.

- Rational expectations (RE)

- Money short-run and long run neutrality → classical dichotomy

- Fluctuations of all variables (output, consumption, employment, investment...) are the optimal responses to exogenous changes in the economic environment (technology shocks, government spending shocks)

- Shocks are not always desirable. But once they occur, fluctuations in output, employment, consumption and other variables are the optimal responses to them!!
HOUSEHOLDS

- Intertemporal Utility function

\[ E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, N_t) \]

with \( \beta \equiv \frac{1}{1+\rho} \in [0, 1] \), \( U_c > 0 \), \( U_n < 0 \), \( U_{cc} \leq 0 \), and \( U_{nn} \leq 0 \)

- Households’ budget constraint

\[ C_t + I_t + B_t = w_t N_t + R^k_t K_t + (1 + r_{t-1}) B_{t-1} + D_t \]

- Law of motion of capital

\[ K_{t+1} = (1 - \delta) K_t + I_t \]
FIRMS
There is only one final good in the economy which is produced according to a constant return to scale (CRS) production function:

\[ Y_t = A_t F (K_t, N_t) \]

\( K_t \) is a predetermined capital stock. \( N_t \) is the labor input. \( \ln \left( \frac{A_t}{A} \right) = a_t \) is an exogenous process of technological progress (or total factor productivity TFP), which evolves according to:

\[
\log \left( \frac{A_t}{A} \right) = \rho_a \log \left( \frac{A_{t-1}}{A} \right) + \varepsilon_{a,t}, \quad \varepsilon_{a,t} \sim WN \left( 0, \sigma_a^2 \right) \quad i.i.d.
\]
HOW TO SOLVE THE MODEL - SEVEN STEPS

1. Find all the first order necessary conditions
2. Calculate the economy steady state
3. Log-linearize the model around the steady state
4. Solve for the recursive law of motion
5. Calibrate the model and calculate the IRFs in response to different shocks
6. Calculate the moments: correlations, and standard deviations for the different variables both for the artificial economy and for the actual economy.
7. Compare how well the model economy matches the actual economy’s characteristics
STEP 1
Solve the Lagrangian

\[
\max_{\{C_t, N_t, K_{t+1}, B_t\}} E_0 \sum_{t=0}^{\infty} \beta^t \begin{cases} \\
U(C_t, N_t) + \lambda_t \left[ w_t N_t + R_t^k K_t + (1 + r_{t-1}) B_{t-1} + D_t \\
- C_t - B_t - (K_{t+1} - (1 - \delta) K_t) + \gamma_t \right] \end{cases}
\]

Focs:

\[
\begin{align*}
C_t & : \ U_c(t) = \lambda_t \\
N_t & : \ U_n(t) = -\lambda_t w_t \\
K_{t+1} & : \ \lambda_t = \beta \left( 1 - \delta + R_t^{k+1} \right) E_t \lambda_{t+1} \\
B_t & : \ \lambda_t = \beta (1 + r_t) E_t \lambda_{t+1}
\end{align*}
\]
STEP 1 - Household Problem

- Combining the three Focs:

\[
\text{Lab. supply: } w_t = - \frac{U_n}{U_C} \tag{1}
\]

and

\[
Euler \text{ eq. for } C_t: \quad U_C(t) = \beta E_t \left[ (1 + r_t) U_C(t + 1) \right] \tag{2}
\]

and

\[
Euler \text{ eq. for } K_{t+1}: \quad U_C(t) = \beta E_t \left[ (1 - \delta + R^k_{t+1}) U_C(t + 1) \right] \tag{3}
\]

where \( r_t = R^k_{t+1} - \delta \) and \( \beta = \frac{1}{1 + \rho} \).
STEP 1 - Household Problem

- Example

\[ U(C_t, N_t) = \frac{C_t^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\phi}}{1+\phi} \]

- Focs imply:

\[ w_t = C_t^\sigma N_t^\phi \]

\[ 1 = \beta (1 + r_t) E_t \left\{ (C_{t+1}/C_t)^{-\sigma} \right\} \]

\[ 1 = \beta E_t \left\{ (C_{t+1}/C_t)^{-\sigma} (1 - \delta + R_{t+1}^k) \right\} \]
**STEP 1 - Firms Problem**

Competitive firms solve their profit maximization problem, taking all prices $w_t$ and $r_t$ as given,

$$\max_{\{N_t, K_t\}} \Pi = Y_t - w_t N_t - R_t^k K_t$$

s.t.

$$Y_t = A_t F(K_t, N_t)$$
STEP 1 - Firms Problem

- First order conditions of the firms’ problem are:

\[ w_t = A_t F_N (K_t, N_t) \]
\[ R_t^k = A_t F_k (K_t, N_t) \]

- Example (Cobb-Douglas)

\[ Y_t = A_t K_t^\alpha N_t^{1-\alpha} \]

- Optimality conditions

\[ R_t^k = \alpha A_t (K_t / N_t)^{-\alpha} \]
\[ w_t = (1 - \alpha) A_t (K_t / N_t)^\alpha \]
NOTICE: CRS production function implies zero profits

\[ A_t \gamma K_t, \gamma N_t = \gamma A_t \gamma (K_t, N_t) \]

- This implies that

\[ F(K_t, N_t) = F_k(K_t, N_t) K_t + F_N(K_t, N_t) N_t \]

\[ = \alpha K_t^{\alpha-1} N_t^{1-\alpha} K_t + (1 - \alpha) K_t^\alpha N_t^{-\alpha} N_t \]

\[ = \alpha F(K_t, N_t) + (1 - \alpha) F(K_t, N_t) = F(K_t, N_t) \]

- Firms profits are:

\[ \Pi_t = A_t F(K_t, N_t) - w_t N_t - R_t^k K_t \]

\[ = A_t \left[ F_k(K_t, N_t) K_t + F_N(K_t, N_t) N_t \right] + \]

\[ - A_t F_N(K_t, N_t) N_t - A_t F_k(K_t, N_t) K_t \]

\[ = 0 \]

- Profits are always equal to zero!
THE PLANNER PROBLEM

- RBC models do not consider any distortion or market imperfection, therefore the welfare theorems apply to these models:
  1. the competitive equilibrium is pareto-optimal
  2. a pareto-optimal allocation can be decentralized as a competitive equilibrium

- *Try to solve the social planner problem and to verify the competitive equilibrium and the social planner equilibrium are identical and admit a unique solution!*
Equilibrium

- **Good Market**
  \[ Y_t = C_t + I_t \]  (4)
  \[ K_{t+1} = (1 - \delta)K_t + I_t = (1 - \delta)K_t + A_t K_t^\alpha N_t^{1-\alpha} - C_t \]  (5)

- **Labor Market**
  \[ C_t^\sigma N_t^{\phi} = (1 - \alpha)A_t (K_t / N_t)^\alpha \]  (6)

- **Assets markets**
  \[ B_t = 0 \]  (7)
  \[ 1 = \beta E_t \left\{ (C_{t+1} / C_t)^{-\sigma} (1 - \delta + \alpha A_{t+1} (K_{t+1} / N_{t+1})^{-(1-\alpha)}) \right\} \]  (8)
  \[ 1 = \beta(1 + r_t) E_t \left\{ (C_{t+1} / C_t)^{-\sigma} \right\} \]  (9)

- **Technilogy**
  \[ Y_t = A_t K_t^\alpha N_t^{1-\alpha} \]  (10)
STEP 2 - Steady state
Definition: equilibrium with $A_t = A$, $C_t = C$, $K_t = K$, $N_t = N$,...

Equation (8) evaluated in SS implies:

$$
(K/N)^{(1-\alpha)} = \frac{\alpha A}{\rho + \delta}
$$

(11)

Notice: since $Y = AN^{1-\alpha}K^\alpha \implies$ Labor productivity is

$$
Y/N = A(K/N)^\alpha = \left(\frac{\alpha A}{\rho + \delta}\right)^{\frac{\alpha}{1-\alpha}}
$$

(12)

Equation (5) evaluated in SS implies: (divided by $N$),

$$
C/N = A\left(\frac{\alpha A}{\rho + \delta}\right)^{\frac{\alpha}{1-\alpha}} - \delta\left(\frac{\alpha A}{\rho + \delta}\right)^{\frac{1}{1-\alpha}}
$$

(13)
**STEP 2 - Steady state**

Equation (6) evaluated in SS implies (multiplying both LHS and RHS by $N^\sigma$):

$$N^{\sigma+\varphi} = (1 - \alpha) (C/N)^{-\sigma} A (K/N)^\alpha$$

**Notice:** once we assign a value to $A$ and to the parameters, it is possible to find $N$ and then to find also the value of $C$, $K$, $Y$, ... In particular notice that

$$K = \left( \frac{K}{N} \right) N, \quad I = \delta K$$

$$C = \left( \frac{C}{N} \right) N, \quad Y = \left( \frac{Y}{N} \right) N$$

$$w = (1 - \alpha) A (K/N)^\alpha$$

From Euler we also know that

$$1 + r = \frac{1}{\beta} = 1 + \rho, \quad R^K - \delta = r$$
**STEP 3 - Log-linearization around the steady state**

- Replace the dynamic non linear equations with dynamic linear equations
- Equations are linear in percentage deviations from the steady state

Define $\hat{x}_t = \log \left( \frac{X_t}{\bar{X}} \right)$, i.e. the log-deviations of $X_t$ from its steady state $\bar{X}$. Thus $100^* \hat{x}_t$ is approximately the percentage deviation of $X_t$ from its steady state. Take the first order approximation of $X_t$ around $X_t = \bar{X}$ (meaning around $\hat{x}_t = 0$)

\[
X_t = \bar{X}e^{\hat{x}_t} \approx \bar{X}e^{\hat{x}_t} \bigg|_{\hat{x}_t=0} + \bar{X}e^{\hat{x}_t} \bigg|_{\hat{x}_t=0} (\hat{x}_t - 0) \\
\approx \bar{X} (1 + \hat{x}_t)
\]

notice that it implies that $X_t - \bar{X} = \bar{X} \hat{x}_t$

**EXAMPLE 1:** $Y_t = f \left( X_t \right)$:

\[
Y (1 + \hat{y}_t) = f (X) + f_x (X) (X - X_t)
\]

using that $X_t - \bar{X} = \bar{X} \hat{x}_t$ and simplifying

\[
\hat{y}_t = \frac{f_x (X)}{Y} \bar{X} \hat{x}_t
\]
EXAMPLE 2
Similarly: If $Z_t = f(X_t, Y_t)$:

$$f(X_t, Y_t) = f(X, Y) \left( 1 + \frac{f_x(X, Y)}{f(X, Y)} X \cdot \hat{x}_t + \frac{f_y(X, Y)}{f(X, Y)} Y \hat{y}_t \right)$$

and

$$\hat{Z}_t = \frac{f_x(X, Y)}{f(X, Y)} X \hat{x}_t + \frac{f_y(X, Y)}{f(X, Y)} Y \hat{y}_t$$
Example with exact Solution (Long and Plosser, JPE 1983)

- Depreciation of capital ($\delta = 1$) + log-utility in consumption ($\sigma = 1$).

- Equilibrium

\[(1 - \alpha)(Y_t / N_t) = C_t N_t^\phi\]

\[1 = \alpha \beta E_t \left\{ (C_t / C_{t+1}) \left( Y_{t+1} / K_{t+1} \right) \right\}\]

\[K_{t+1} + C_t = Y_t\]

- Conjecture:

\[K_{t+1} = \lambda Y_t\]

\[C_t = (1 - \lambda) Y_t\]
Example with exact Solution (Long and Plosser, JPE 1983)

- Steady state:

\[(1 - \alpha)(Y/N) = CN^\varphi\]

\[1 = \alpha \beta \{(Y/K)\} \implies \frac{K}{Y} = \alpha \beta\]

\[\frac{K}{Y} = 1 - \frac{C}{Y}\]

- Steady state of the conjecture:

\[\frac{K}{Y} = \lambda\]

\[\frac{C}{Y} = (1 - \lambda)\]

- thus

\[\lambda = \alpha \beta\]

- and

\[N_t = \left((1 - \alpha)(Y_t/C_t)\right)^{\frac{1}{1+\varphi}} \implies N_t = \left(\frac{1 - \alpha}{1 - \alpha \beta}\right)^{\frac{1}{1+\varphi}}\]
Example with exact Solution (Long and Plosser, JPE 1983)

- Dynamics (log-deviations from the steady state):
  - Dynamics of Capital in log-terms
    
    \[
    k_t = \log \lambda + y_{t-1} = \log \lambda + (1 - \alpha) n + \alpha k_{t-1} + a_{t-1}
    \]

- In log-deviation from the steady state:
  
  \[
  \hat{k}_t = \hat{y}_{t-1} = \alpha \hat{k}_{t-1} + a_{t-1}
  \]

- Production function and consumption
  
  \[
  \hat{y}_t = \alpha \hat{k}_t + a_t \\
  = \alpha \hat{y}_{t-1} + a_t
  \]

  \[
  \hat{c}_t = \hat{y}_t \\
  = \alpha \hat{c}_{t-1} + a_t
  \]

Discussion:
- "intrinsic persistence"
- drawback: constant employment, volatility ,...
STEP 3 - GENERAL CASE. Model log-linearization

- **Good Market**

\[ \alpha \beta \hat{k}_{t+1} = \alpha \hat{k}_t + (1 - (1 - \delta) \beta) ((1 - \alpha) \hat{n}_t + a_t) + (1 - \beta + \beta \delta (1 - \alpha)) \hat{c}_t \]

- **Labor Market**

\[ \sigma \hat{c}_t + (\alpha + \varphi) \hat{n}_t = a_t + \alpha \hat{k}_t \]

- **Capital**

\[ \sigma \hat{c}_t = \sigma E_t \{ \hat{c}_{t+1} \} + (1 - (1 - \delta) \beta) \left( (1 - \alpha) (\hat{k}_{t+1} - E_t \{ \hat{n}_{t+1} \}) - \rho_a a_t \right) \]

**Matrix Form**

\[
\begin{bmatrix}
\hat{c}_t \\
\hat{n}_t \\
\hat{k}_t
\end{bmatrix}
= \tilde{A}
\begin{bmatrix}
E_t \{ \hat{c}_{t+1} \} \\
E_t \{ \hat{n}_{t+1} \} \\
\hat{k}_{t+1}
\end{bmatrix}
+ \tilde{B} a_t
\]
STEP 4 - Solving the model

- Dynamic System

\[ y_t = AE_t\{y_{t+1}\} + Bz_t \]

\[ z_t = Rz_{t-1} + \varepsilon_t \]

\[ y_t = [x'_t, k'_t]' : \text{ vector } (n \times 1) \text{ of endogenous variables} \]

\[ x_t : \text{ vector } (n_x \times 1) \text{ of endogenous variables } \text{non predeterminates} \]

\[ k_t : \text{ vector } (n_k \times 1) \text{ of endogenous variables } \text{predeterminates} \]

\[ z_t : \text{ vector } (n_z \times 1) \text{ of exogenous variables} \]

\[ \varepsilon_t : \text{ vector } (n_z \times 1) \text{ white noise process } (0,\Omega) \]

- Form of the solution ("state-space representation"):

\[ s_t = Cs_{t-1} + D\varepsilon_t \]

\[ x_t = Ms_t \]

on \( s_t = [k'_t, z'_t]' \) is a vector of "state variables"
STEP 4 - Solving the RBC model for the recursive law of motion (state-space representation).

State variables:

\[
\begin{align*}
\hat{k}_t &= \psi_{kk} \hat{k}_{t-1} + \psi_{ka} a_{t-1} \\
\hat{a}_t &= \rho_a a_{t-1} + \varepsilon_t^a 
\end{align*}
\]

other endogenous variables:

\[
\hat{x}_t = \psi_{xk} \hat{k}_t + \psi_{xa} a_t
\]
STEP 5 - Calibracion

[β]: $\beta R = 1$
S&P500 = 6.5% $\implies \beta = (1 + (0.065/4))^{-1} \approx 0.985$

[δ]: $0.10/4 = 0.025$.

[α]: $w = (1 - \alpha)(Y/N)$ $\implies \alpha = 1 - S_{n,t}$ on $S_{n,t} \equiv \frac{W_t N_t}{Y_t} \approx 2/3$
$\implies \alpha = 1/3$

[σ]: $(1 - \alpha)\frac{Y_t}{N_t} = C_t^\sigma N_t^\varphi$ ... $\implies$ balanced growth $\sigma = 1$

[φ]: $w_t = \sigma c_t + \varphi n_t$ ... $n_t = \varphi^{-1} w_t - \sigma \varphi^{-1} c_t$
$\implies \varphi^{-1} :$ Frisch Elasticity of Labor Supply $\sim 4$ (controversial)

King-Rebelo: $U(C, L) = \frac{C_t^{1-\sigma}}{1-\sigma} + \theta \frac{L_t^{1-\eta}}{1-\eta}$ with restriction on $N_t + L_t = 1$
Elasticity $= \frac{L}{\eta N} = \frac{0.8}{(1)(0.2)} = 4$

[$\rho_a, \sigma_a^2$]:
$a_t = y_t - \alpha k_t - (1 - \alpha) n_t$
Estimation AR(1): $\rho_a = 0.979, \sigma_a^2 = (0.007)^2$
STEP 5: IRFs to a positive technology shock
STEP 5: IRFs to a positive technology shock

- A technology shock determines a shift in labor demand.
- Part of the increase in labor demand is accommodated by an increase in labor supply by agents.
- Real wage increases. The effect on the real wage is stronger the lower is the elasticity of labor supply. In the extreme case of fixed labor supply all the increase in labor demand would translate into an increase in the real wage.
- Hours increase. As a consequence the marginal product of capital increases, determining a positive response of investment. Both the increase in hours and the stock of capital contributes to the increase in output.
- Households postpone consumption because the interest rate is expected to be falling in the future. For this reason consumption is characterized by a hump shaped response.
Persistence of a technology shock

\( \rho_a = 0 \) (solid line) vs. \( \rho_a = 0.97 \) (dashed line)
The variables inherit the dynamic properties of the shock. Since with $\rho_a = 0$ technology is higher just for a single period, the marginal products of factors are higher just in the first period, when the shock hits the economy. The household works and save more just in that period. In the second period the effects of shock disappear and variables return quickly to initial level. With $\rho_a = 0.97$, the shock is persistent and therefore the effects on the variables become more persistent over time.

Weakness of basic RBC model:

- the lack of endogenous persistence. Transitory shocks have just a transitory effect on output. Persistent effects on output can be obtained uniquely by imposing a highly persistent shock.
### Table 1

**Business Cycle Statistics for the U.S. Economy**

<table>
<thead>
<tr>
<th></th>
<th>Standard Deviation</th>
<th>Relative Standard Deviation</th>
<th>First Order Autocorrelation</th>
<th>Contemporaneous Correlation with Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y$</td>
<td>1.81</td>
<td>1.00</td>
<td>0.84</td>
<td>1.00</td>
</tr>
<tr>
<td>$C$</td>
<td>1.35</td>
<td>0.74</td>
<td>0.80</td>
<td>0.88</td>
</tr>
<tr>
<td>$I$</td>
<td>5.30</td>
<td>2.93</td>
<td>0.87</td>
<td>0.80</td>
</tr>
<tr>
<td>$N$</td>
<td>1.79</td>
<td>0.99</td>
<td>0.88</td>
<td>0.88</td>
</tr>
<tr>
<td>$Y/N$</td>
<td>1.02</td>
<td>0.56</td>
<td>0.74</td>
<td>0.55</td>
</tr>
<tr>
<td>$w$</td>
<td>0.68</td>
<td>0.38</td>
<td>0.66</td>
<td>0.12</td>
</tr>
<tr>
<td>$r$</td>
<td>0.30</td>
<td>0.16</td>
<td>0.60</td>
<td>-0.35</td>
</tr>
<tr>
<td>$A$</td>
<td>0.98</td>
<td>0.54</td>
<td>0.74</td>
<td>0.78</td>
</tr>
</tbody>
</table>
STEP 6-7 - second moments RBC model (King and Rebelo 1999)

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>1.39</td>
<td>1.00</td>
<td>0.72</td>
<td>1.00</td>
</tr>
<tr>
<td>C</td>
<td>0.61</td>
<td>0.44</td>
<td>0.79</td>
<td>0.94</td>
</tr>
<tr>
<td>I</td>
<td>4.09</td>
<td>2.95</td>
<td>0.71</td>
<td>0.99</td>
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<tr>
<td>N</td>
<td>0.67</td>
<td>0.48</td>
<td>0.71</td>
<td>0.97</td>
</tr>
<tr>
<td>Y/N</td>
<td>0.75</td>
<td>0.54</td>
<td>0.76</td>
<td>0.98</td>
</tr>
<tr>
<td>w</td>
<td>0.75</td>
<td>0.54</td>
<td>0.76</td>
<td>0.98</td>
</tr>
<tr>
<td>r</td>
<td>0.05</td>
<td>0.04</td>
<td>0.71</td>
<td>0.95</td>
</tr>
<tr>
<td>A</td>
<td>0.94</td>
<td>0.68</td>
<td>0.72</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Note: All variables have been logged (with the exception of the real interest rate) and detrended with the HP filter.
STEP 6-7 - second moments and comparisons with the data

King and Rebelo 1999, provides you with summary statistics. Compare them with those in the data. In particular we notice that:

- output volatility is quite lower but similar to that in the data.
- consumption volatility is lower than that in the data.
- investment are much more volatile than output as found in the data.
- volatility of labor is too low wrt to the data.
- there is too much comovements of variables with output.
- real wage is procyclical while it is almost acyclical in the data.
- real rate is procyclical while is countercyclical in the data.
STEP 6-7 - comparisons with the data (King and Rebelo 1999)
STEP 6-7 - comparisons with the data (King and Rebelo 1999)
Some questions

- In RBC setup labor market is Walrasian and therefore involuntary unemployment is absent. The question is: Do changes in employment always reflect voluntary changes in employment?

- Is the economy hit by large and exogenous productivity shocks in the short run? In other word, are technology shocks the main sources of economic fluctuations?

- Is money really neutral in the short run?

- Are wages and price fully flexible in the short run?
SHORTCOMINGS LABOR MARKET

- **Intertemporal substitution of labor supply:** households reallocate labor over time in response to changes in \( w_t \) versus \( w_{t+1} \).

- in RBC models: technology shocks cause fluctuations in the intertemporal relative wage and then workers responds adjusting their labor supply \( \Rightarrow \) employment and output fluctuate.

- Contrary to RBC results, empirical evidence suggests that the long-run labor supply is independent of real wages.

**CRITICS:**
- labor supply does not depend that much on the intertemporal real wage;
- high unemployment is mainly involuntary.
Solow residual and technology shocks

- TFP is

\[ TFP = \frac{\Delta A}{A} = \frac{\Delta Y}{Y} - \alpha \frac{\Delta K}{K} - (1 - \alpha) \frac{\Delta N}{N} \]

- the Solow residual should be highly correlated with output
Criticism

- Solow residual and technology shocks
- Need for highly persistent technological shocks: why? and above all: what are they?
- Solow residual is highly correlated with output
RBC View:

- RBC theory argue that the strong correlation between output growth and Solow residuals is the evidence that productivity shocks are an important source of economic fluctuations.

Critics:

- Are economic fluctuations really caused by productivity shocks?

Expansions arise because of increases in productivity!

... **What does that mean about recessions?** *(Summers 1986)*

- Does it mean that recessions are periods of technical regress!
- Less implausible if supply shock considered more broadly (OPEC, strikes etc.)
Are wages and prices flexible?

- RBC theory assumes that wages and prices are completely flexible, so markets always clear.
- RBC proponents argue that the degree of price stickiness occurring in the real world is not important for understanding economic fluctuations.
- They also assume flexible prices to be consistent with microeconomic theory.

Critics:

- Wage and price stickiness explains involuntary unemployment and the non-neutrality of money.
SUMMING UP

- Empirical significance of intertemporal labor substitution mechanism is doubtful.
- RBC theory implies that recessions are periods of technical regress!
- Money is neutral so does not explain positive correlation between prices and output; and that this can be rectified by endogenizing the money supply.
- Wage and price rigidity can help to explain involuntary unemployment and non-neutrality of money.