Lecture 6
Business Cycle Macro and Lucas Critique

Macroeconomics EC2B1

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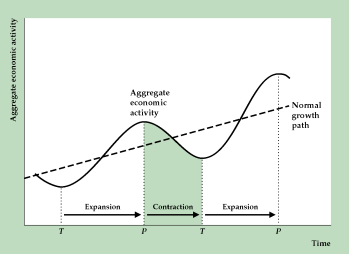
Reminder: business cycles (from EC1B1 notes)

Business Cycles

- Recurrent but not periodic
- Last approximately from 2 to 10 years
- Phases:
  - Expansion phase (trough to peak)
  - Contraction phase (peak to trough)
- "Official" arbiter:
  - Business Cycle Dating Committee of the National Bureau of Economic Research in the US
  - In the UK according to Office of National Statistics: recession is two consecutive quarters of -ve GDP growth



Reminder: business cycles (from EC1B1 notes)

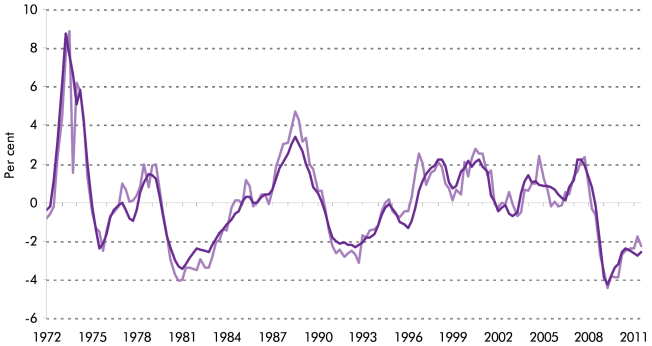
Business Cycles

- Useful to de-trend output and focus on deviations of output from trend
- We think of trend output as "potential output" or the "natural rate of output"
- We define the output gap as percentage deviations of output from potential output

$$\tilde{Y}_t = \frac{Y_t - \bar{Y}_t}{\bar{Y}_t} \approx \log\left(\frac{Y_t}{\bar{Y}_t}\right)$$

Reminder: business cycles (from EC1B1 notes)

UK Deviations of Output from Trend



Percent Deviation of Output from Trend (light line is higher frequency estimate)

Source: Office of Budgetary Responsibility

Plan

1. Brief history of business cycle macro until the 1980s
    - key idea: Lucas critique
2. A two-period Real Business Cycle model = the model from lecture 5
3. The fully-fledged Real Business Cycle model
4. Criticisms of the RBC model

Readings

1. EC1B1 lecture notes, in particular lecture 6
2. Kurlat, chapters 12 and 13
3. Jones, chapter 15 “DSGE Models: the Frontier of Business Cycle Research”
4. NPR Planet Money episode on Bob Lucas and Lucas critique https://www.npr.org/2023/05/17/1176781995/the-man-who-busted-the-inflation-employment-myth
5. Ivan Werning (2023) “Lucas Miracles” https://economics.mit.edu/sites/default/files/inline-files/Translated%20Lucas%20Miracles%20by%20Ivan%20Werning.pdf

A brief history of business cycle macro

A brief history of business cycle macro until the 1980s

As with all attempts to fit complex history into simple narrative, won't do justice

Some key models and ideas you should know:

- 1930s: Keynesian model (Keynesian cross, IS-LM or IS-MP-PC)
- 1970s
  - Lucas critique and importance of microfoundations
  - rational expectations
- 1980s: real business cycle (RBC) model
- (to be continued in later lectures)

1930s: Keynesian model

- Macroeconomics becomes separate field in 1930s, starting with Keynes
- Keynes (1936) "The General Theory of Employment, Interest and Money"
- Keynesian cross and IS-LM model (or its modern incarnation = IS-MP-PC)
- One key policy prescription: countercyclical fiscal policy, i.e. provide fiscal stimulus in recessions
- Most common methodology until 1970s: large-scale macroeconometric models without microfoundations (i.e. no utility or profit maximization)
  - write down big models with many equations like Keynesian consumption function $C = \alpha + \gamma(Y - T)$, Phillips curve, etc
  - estimate these equations using time-series data
  - conduct policy counterfactuals, e.g. monetary & fiscal policy

Aside: Keynesian IS-LM is actually due to Hicks (1937)

MR. KEYNES AND THE "CLASSICS";
A SUGGESTED INTERPRETATION[1]

By J. R. Hicks

I

It will be admitted by the least charitable reader that the entertainment value of Mr. Keynes' *General Theory of Employment* is considerably enhanced by its satiric aspect. But it is also clear that many readers have been left very bewildered by this Dunciad. Even if they are convinced by Mr. Keynes' arguments and humbly acknowledge themselves to have been "classical economists" in the past, they find it hard to remember that they believed in their unregenerate days the things Mr. Keynes says they believed. And there are no doubt others who find their historic doubts a stumbling block, which prevents them from getting as much illumination from the positive theory as they might otherwise have got.

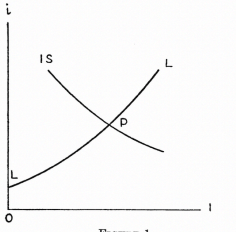


Figure 1

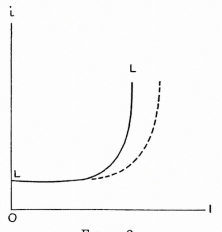


Figure 2

Income and the rate of interest are now determined together at P, the point of intersection of the curves LL and IS. They are determined together; just as price and output are determined together in the modern theory of demand and supply. Indeed, Mr. Keynes' innovation

1970s: Lucas critique and importance of microfoundations

- Critique of 1970s-style macroecometric models without microfoundations
- Lucas (1976) "Econometric Policy Evaluation: A Critique". Idea:
  - you cannot use these macroeconometric models for policy evaluation because the parameters are not policy-invariant
  - i.e. you'd expect these parameters to change when policy changes
  - in a nutshell: behavior changes with the rules of the game. Models must allow for this.
- Lucas aims critique at Phillips curve estimated with historical data & "the inference that permanent inflation will induce a permanent economic high"
- ... but the point is much more general
  - coffee-drinking example in NPR podcast
  - Tom Sargent's (1980) American football example
    https://researchdatabase.minneapolisfed.org/downloads/kh04dp86z

Lucas (1976) lays it out nicely

7. Concluding Remarks

This essay has been devoted to an exposition and elaboration of a single syllogism: given that the structure of an econometric model consists of optimal decision rules of economic agents, and that optimal decision rules vary systematically with changes in the structure of series relevant to the decision maker, it follows that any change in policy will systematically alter the structure of econometric models.

For the question of the short-term forecasting, or tracking ability of econometric models, we have seen that this conclusion is of only occasional significance. For issues involving policy evaluation, in contrast, it is fundamental; for it implies that comparisons of the effects of alternative policy rules using current macroeconometric models are invalid regardless of the performance of these models over the sample period or in ex ante short-term forecasting.

The argument is, in part, destructive: the ability to forecast the consequences of "arbitrary", unannounced sequences of policy decisions, currently claimed (at least implicitly) by the theory of economic policy, appears to be beyond the

Example: our models predict that MPCs not policy-invariant

- Recall microfounded consumption model from Lecture 4
- MPC out of transitory income shock

$$\frac{\partial c_1}{\partial y_1} = \frac{\left(\frac{1}{\beta(1+r)}\right)^{\sigma}(1+r)}{1+\left(\frac{1}{\beta(1+r)}\right)^{\sigma}(1+r)}$$

  where r = interest rate, β = discount factor, σ = IES

- So can write a consumption function

$$c_1 = \gamma y_1 + \ldots, \quad \text{with} \quad \gamma = \frac{\left(\frac{1}{\beta(1+r)}\right)^{\sigma}(1+r)}{1+\left(\frac{1}{\beta(1+r)}\right)^{\sigma}(1+r)}$$

- Example of policy tool: interest rate r
- Clearly when r changes, MPC γ changes $\Rightarrow$ when interest rates change drastically, may no longer want to use historical MPC estimates

Lucas' solution = microfoundations

- Build models of individual behavior starting from policy-invariant primitives
- Which ones? Answer: primitives of classical microeconomics
  - preferences
  - technology
  - resource constraints
- This hopefully looks familiar. Precisely why I always make such a big deal out of spelling out these primitives for each economy we study.
- Preference and technological parameters are sometimes called "structural parameters" where "structural" means "policy-invariant"
  - examples: discount factor β, IES σ
- To think about: how satisfactory is proposed solution in practice?
  - If a model is misspecified, can we treat primitives as policy-invariant?
  - Is a model with a representative household really "microfounded"?

Rational expectations

- Separate idea often mentioned together with Lucas critique, likely because pushed by same economists (Lucas, Sargent & co) around same time
- People often use term “rational expectations revolution”
  - often (not always) they actually mean push for microfoundations
- Lucas critique and microfoundations are really the more fundamental & influential ideas – “microfoundations revolution”?
  - Werning on Lucas: “Lucas was a visionary not for importing rational expectations into [macro], but for understanding that GE theory was the basis for completely refounding macroeconomics.”
  - Blanchard on Lucas https://www.tandfonline.com/doi/full/10.1080/09672567.2022.2137552

    “[What Lucas did] was to define the rules of what a macro model had to be: It had to be dynamic; it had to have general equilibrium; it had to have optimising agents; then it had to have expectations, in that case rational expectations, but that was not essential.”

    “The widely accepted notion was that macro was different from micro because of aggregation, because of complex behaviour, because of all that. You were inspired by theory, but you surely didn’t feel like you actually had to derive things from first principles. And I was always struck by my revered colleague Paul Samuelson, who, when he did micro, did it absolutely rigorously. And when he did macro he just wrote equations down which sounded right, and that was thought to be the only way to go.”

Rational expectations

- While we're at it, let's also define "rational expectations" ... but first need some language
  - stochastic = there is uncertainty, i.e. something is a random variable
  - rational = people and firms maximize some objective function

- **Rational expectations** = people know the correct probability distributions of stochastic economic variables
  - people's subjective probability distributions used to form expectations = objective (actual) probability distributions

Rational expectations

- Example: throwing fair coin
  - rational expectations = people know that Pr(heads) = Pr(tails) = 0.5
  - ... use this to compute expected utility $0.5 \times U(\text{heads}) + 0.5 \times U(\text{tails})$
- Rational expectations = same idea but applied to everything, e.g. you know correct probability distribution of everything in entire economy
  - clearly a very strong assumption
  - but definitely does not say people always get it right or the like (which is what's sometimes stated in cheap criticisms of economics)
  - "rational expectations" does not imply "rationality" or vice versa
  - better word: "model-consistent expectations"
  - much more controversial than Lucas critique which most economists agree with (though not necessarily with the proposed solution)

A Nobel prize for rational expectations & microfoundations

The Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 1995

Robert E. Lucas Jr.

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The Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 1995

Photo from the Nobel Foundation archive.

Robert E. Lucas Jr.

Prize share: 1/1

The Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 1995 was awarded to Robert E. Lucas Jr. "for having developed and applied the hypothesis of rational expectations, and thereby having transformed macroeconomic analysis and deepened our understanding of economic policy"

https://www.nobelprize.org/prizes/economic-sciences/1995/summary/

1980s: the Real Business Cycle (RBC) Model

- Developed in the 1980s, following the "rational expectations revolution"
- The first fully-fledged microfounded business cycle model
- Key paper by Kydland and Prescott (1982)

E C O N O M E T R I C A

VOLUME 50 NOVEMBER, 1982 NUMBER 6

TIME TO BUILD AND AGGREGATE FLUCTUATIONS

BY FINN E. KYDLAND AND EDWARD C. PRESCOTT[1]

The equilibrium growth model is modified and used to explain the cyclical variances of a set of economic time series, the covariances between real output and the other series, and the autocovariance of output. The model is fitted to quarterly data for the post-war U.S.

Why Real Business Cycle Model?

Reminder: “nominal” and “real”

- Nominal: not adjusted for inflation, i.e. money values
- Real: adjusted for inflation, i.e. quantities valued such that they are comparable over time – think “physical” quantities

Why real business cycle model?

- because money and nominal variables play no role in it
- in contrast to Keynesian theories – see next lecture and your EC1B1 and EC1P1 notes

A Nobel prize for the RBC model

The Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 2004

Finn E. Kydland
Edward C. Prescott

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The Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 2004

Photo from the Nobel Foundation archive.
Finn E. Kydland
Prize share: 1/2

Photo from the Nobel Foundation archive.
Edward C. Prescott
Prize share: 1/2

The Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 2004 was awarded jointly to Finn E. Kydland and Edward C. Prescott "for their contributions to dynamic macroeconomics: the time consistency of economic policy and the driving forces behind business cycles"

https://www.nobelprize.org/prizes/economic-sciences/2004/summary/

Reading suggestions for those who like old papers and drama (not examinable)

- Lucas and Sargent (1979) “After Keynesian Macroeconomics”
  https://www.bostonfed.org/-/media/Documents/conference/19/conf19d.pdf
  - don’t miss discussion by Ben Friedman, Lucas & Sargent response
  - 1978 Boston Fed conference “After The Phillips Curve” for which paper was written
    https://www.bostonfed.org/news-and-events/events/economic-research-conference-series/after-the-phillips-curve-persistence-of-high-inflation-and-high-unemployment.aspx
  - ... and Sargent’s recollection of conference here
    http://www.liuyanecon.com/wp-content/uploads/Sargent-2022.pdf
- Summers (1991) “The Scientific Illusion in Empirical Macroeconomics”
  https://www.jstor.org/stable/3440321

A Two-Period RBC Model

Model from lecture 5 = baby RBC model

- Key idea of RBC model: (random) variations in productivity (TFP) as source of business cycles
  - changes in productivity drive output, investment, consumption, ...
- Solow model emphasized TFP as source of growth
- .... now emphasize variations in TFP as source of business cycles
- The model of lecture 5 had exactly these features

Recall: primitives of baby RBC model

- **Preferences:** households have utility function

$$U(C_1) + \beta U(C_2) \quad \text{with} \quad U(C) = \frac{C^{1-\frac{1}{\sigma}} - 1}{1 - \frac{1}{\sigma}}$$

- **Technology:** firms have production function

$$Y_t = A_t K_t, \quad t = 1, 2$$

and capital accumulates according to $K_2 = I_1 + (1 - d)K_1$ with $d = 1$, i.e.

$$K_2 = I_1$$

- **Resource constraints (feasibility):**

goods in period 1: $C_1 + I_1 = Y_1$

goods in period 2: $C_2 = Y_2$

Recall: competitive equilibrium allocation

$$C_1 = \frac{\left(\frac{1}{\beta A_2}\right)^{\sigma} A_2}{1 + \left(\frac{1}{\beta A_2}\right)^{\sigma} A_2} A_1 K_1$$

$$C_2 = \frac{A_2}{1 + \left(\frac{1}{\beta A_2}\right)^{\sigma} A_2} A_1 K_1$$

$$K_2 = I_1 = \frac{1}{1 + \left(\frac{1}{\beta A_2}\right)^{\sigma} A_2} A_1 K_1$$

$$Y_1 = A_1 K_1$$

$$Y_2 = \frac{A_2}{1 + \left(\frac{1}{\beta A_2}\right)^{\sigma} A_2} A_1 K_1$$

$$1 + r_1 = A_2$$

Recall: a recession due to a drop in A_1 and/or A_2

1. When A_1 falls, all of $(C_1, C_2, I_1, Y_1, Y_2)$ fall unambigously
   - C_1 and I_1 both fall because $C_1 + I_1 = Y_1$ and $Y_1 = A_1 K_1$ falls
2. When A_2 falls and $\sigma < 1$, (C_1, C_2, Y_1, Y_2) fall and I_1 rises
   - $C_1 + I_1 = Y_1$ and Y_1 unaffected, $\sigma < 1 \Rightarrow$ income effect dominates
3. When both A_1 and A_2 fall (e.g. $\log A_2 = \rho \log A_1 + \varepsilon_2$), economic effect is combination of effects in cases 1 and 2

Oil shocks as productivity shocks (or gas shocks)

- What on earth is a drop in productivity?
  - do we think people forget how to make stuff? Not really
  - hard to come up with sensible justifications
- One possible justification: oil shocks or energy (gas etc) shocks
- Technology: firms use oil to produce

$$\tilde{Y}_t = \tilde{A}_t K_t^{\alpha} O_t^{1-\alpha}.$$

- Firms maximize output net of oil expenditure

$$Y_t = \max_{O_t} \tilde{A}_t K_t^{\alpha} O_t^{1-\alpha} - p_t O_t \quad \text{where } p_t = \text{oil price}$$

$$\Rightarrow \quad Y_t = A_t K_t \text{ where } A_t = \text{effective productivity} = \alpha \tilde{A}_t^{1/\alpha} \left(\frac{1-\alpha}{p_t} \right)^{(1-\alpha)/\alpha}$$

so an increase in p_t causes a drop in effective productivity

Room for policy in the baby RBC model?

- Suppose we introduce government spending into this model

$$\text{goods in period 1:} \quad C_1 + I_1 + G_1 = Y_1$$
$$\text{goods in period 2:} \quad C_2 = Y_2$$

- Should the government engage in countercyclical fiscal stimulus, i.e. increase G_1 if there is a recession (due to a fall in A_2)?
- Why or why not?
- How does this compare with policy prescriptions of the Keynesian model?
- What about other policies, e.g. investment subsidies, income taxes, ...?
- What about monetary policy?

The Fully-Fledged RBC Model

Primitives of the RBC model

- Relative to baby RBC model: infinite horizon, uncertainty, labor supply
  - a "dynamic stochastic general equilibrium (DSGE) model"
- **Preferences:** households have utility function

$$U(C_0, N_0) + \beta \mathbb{E}[U(C_1, N_1)] + \beta^2 \mathbb{E}[U(C_2, N_2)] + \ldots = \mathbb{E} \sum_{t=0}^{\infty} \beta^t U(C_t, N_t)$$

  Note: expectation $\mathbb{E}[\cdot]$ because C_t and N_t are stochastic (because A_t is)

- **Technology:** firms have production function

$$Y_t = A_t F(K_t, N_t), \quad t = 1, 2, \ldots$$

  where A_t is stochastic (see next slide), capital accumulates according to

$$K_{t+1} = I_t + (1 - d)K_t, \quad 0 < d < 1$$

- **Resource constraints (feasibility):**

$$\text{goods in period t:} \quad C_t + I_t = Y_t, \quad t = 1, 2, \ldots$$

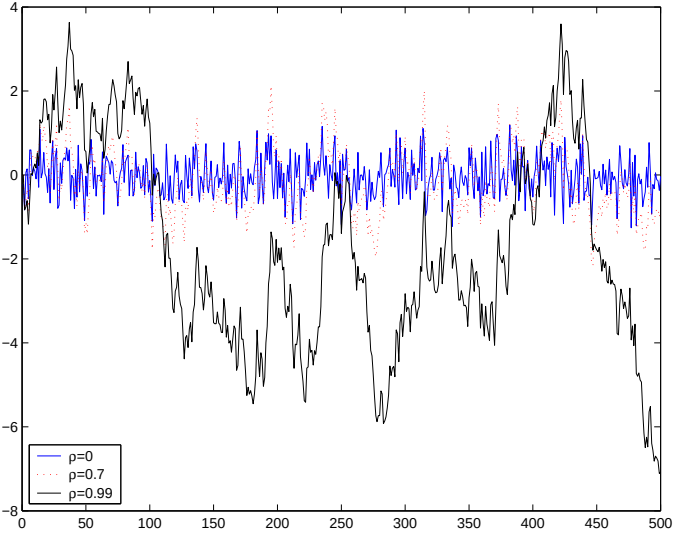
Evolution of the Technology

- A_t changes randomly over time
  - ignore growth and just think of fluctuations around a trend
- Assume A_t follows the process:

$$\log A_t = \rho \log A_{t-1} + \varepsilon_t, \qquad \varepsilon_t \sim \mathcal{N}(0, \sigma^2)$$

  where $\varepsilon_t \sim \mathcal{N}(0, \sigma^2)$ means ε_t is normally distributed w mean 0, var σ^2
- This process is called $AR(1)$ process: "autoregressive of order 1"
- The parameter ρ governs persistence of changes in TFP
  - if $\rho = 1$ they are permanent
  - if $0 < \rho < 1$ they are persistent but eventually die out

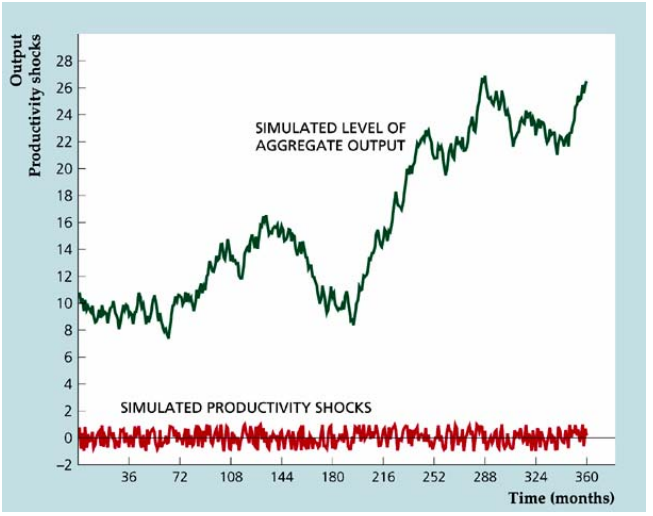
Examples of TFP Processes



Logic of RBC model: response to positive TFP shock

- Static effects of positive TFP shock:
  - implies higher labor productivity, increasing wages
  - substitution effect leads to higher labor supply, thus increasing output
- Dynamic effects of positive TFP shock:
  - part of increased output is consumed, but part is saved
  - the more persistent the shock, the more is saved
  - return to capital $\uparrow \Rightarrow$ investment $\uparrow \Rightarrow$ capital stock $\uparrow$
- So for extended period: greater output due to labor, capital $\uparrow$ (plus TFP $\uparrow$)
  - effects of single shock eventually die out, but they may be long-lived
  - new shocks continually arrive
- Two key features of RBC model
  1. amplification: small shocks generate large cycles
  2. persistence: transitory shocks generate persistent cycles

Small, transitory shocks generate large, persistent cycles



Room for policy in the RBC model?

- No, because 1st welfare theorem holds
- Same logic as in baby RBC model
- In RBC model, business cycles are efficient
  - the optimal response to a changing environment
  - when productivity falls, it's a bad time to produce, so households should work and invest less
  - government intervention can only worsen the allocation
- For more discussion, see Kurlat, chapter 13.5, section "Policy Implications"
- Come back to this at end of lecture

Criticims of the RBC Model

Criticisms of the RBC model

See the good discussion in Kurlat, chapter 13.5, section “Criticisms”

1. Mechanism for generating recessions not plausible (see next slides)

2. Need implausible parameter values, in particular implausibly high labor supply elasticity

3. Model fits cyclical behavior of quantitities but not of prices (real wages and interest rates)

4. Model does not feature any unemployment

5. Inappropriate to treat measured TFP (Solow residuals) as productivity shocks, e.g. due to mismeasured capacity utilization

A hostile description of the RBC model (part 1)

Pretend that the national economy consists of a single person, the "representative agent". This agent owns all the goods, especially all the capital goods, and does all the work in the economy. The agent is greedy for material consumption, and lazy. To consume, which it likes, it must produce, which is a matter of indifference, except that to produce it must work, which it dislikes. If it produces more now than it consumes, it can save the difference as capital goods, which make its future labor more productive. There are also shocks to "technology", i.e., to how effectively it can use capital to turn labor into consumption goods; rather bizarrely, these shocks are both negative and positive, which means that it regularly forgets productive technologies, and not because better replacements have come along.

Source: http://bactra.org/notebooks/dsges.html by Cosma Shalizi (statistician)

A hostile description of the RBC model (part 2)

In addition to being greedy and lazy, the agent is is determined to act now so as to maximize not present utility, but the discounted future stream of utility at all times (since it is also immortal). Fortunately, it is incredibly foresighted, and knows the exact distribution of future shocks to technology. (This distribution is not changed by anything the agent does; or, if you like, it always acts in such a way that its expectations are exactly fulfilled.) Possessing unlimited cognitive resources, it is easy for the agent to solve the resulting dynamic programming problem optimally. This will not lead to a smooth pattern of production, investment and consumption; if, for instance, there is a big negative shock to technology, and shocks are persistent, it becomes rational to slack off now, and enjoy leisure; extra work will be more rewarded later when the agent will have remembered how to do stuff. These fluctuations are, supposedly, the fluctuations of the macroeconomy, the business cycle.

Source: http://bactra.org/notebooks/dsges.html by Cosma Shalizi (statistician)

A hostile description of the RBC model: brief discussion

- To be clear: this description is basically correct
- But it is a bit unfair in that it somewhat misunderstands how economists think about models – see "Modeling in (Macro)economics" in Lecture 1
  - "descriptive realism is not the objective"
  - idea of "crucial" or "critical" assumptions
  - "Do not criticize an economist's model because of its assumptions; ask how the results would be changed if the assumptions that seem problematic were more realistic."
- I nevertheless like and teach this hostile description because
  - it's pretty funny
  - some of these assumptions do turn out to be "crucial" assumptions
  - ... i.e. when assumptions are made more realistic, results change, in particular policy implications

Key takeaways from RBC model (my opinion)

1. RBC model makes one pretty deep point: Just because something fluctuates doesn't mean it's necessarily inefficient
   - forces us to ask harder questions
   - any argument for trying to stabilize the business cycle must first make the case of why such stabilization is desirable
   - an application of what we said in Lecture 2: 1st welfare theorem forces us to think about rationale for policy intervention – what market failures, frictions, externalities are there?

2. Methodologically, RBC model shows how a simple model can generate amplification and persistence