Introduction and intertemporal choices

John Kramer – University of Copenhagen

May 2024

UNIVERSITY OF COPENHAGEN

Course admin

Lectures every week

- Tuesdays 1000h-1300h
- Cancelled lectures will be recorded
- Office hours on lecture days from 1400h-1500h

Problem sets

- Exercise classes every week
- Preparation for these will greatly help with the exam

Assignments

- Pass 2/3 to take the exam

Exam

- Closed book, 3h

What is macroeconomics?

Aggregate quantities

- GDP (growth & fluctuations)
- Inflation
- Unemployment
- ...

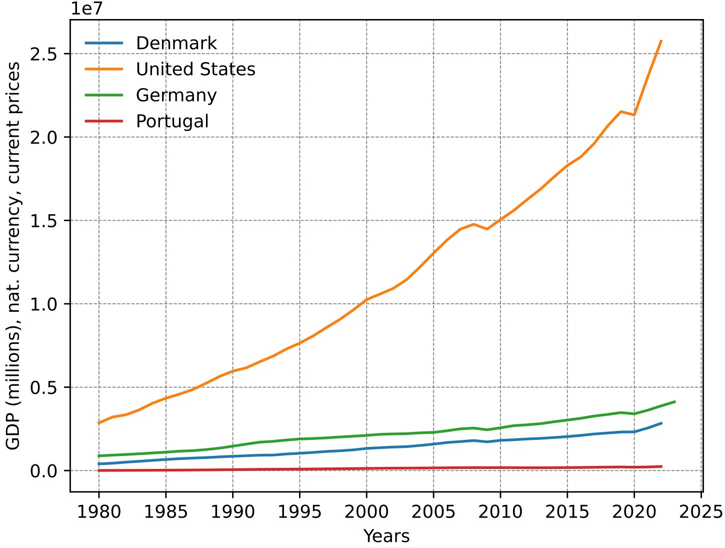
Society-wide phenomena

- Inequality
- Political changes

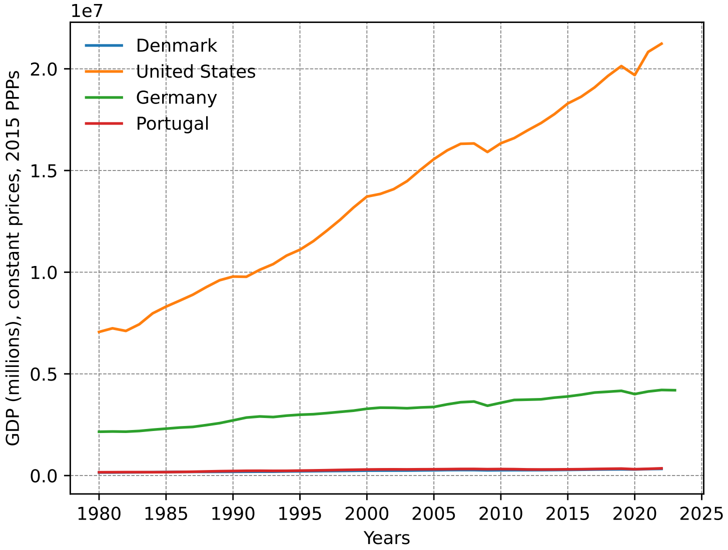
Public policy

- Pension systems
- Unemployment insurance

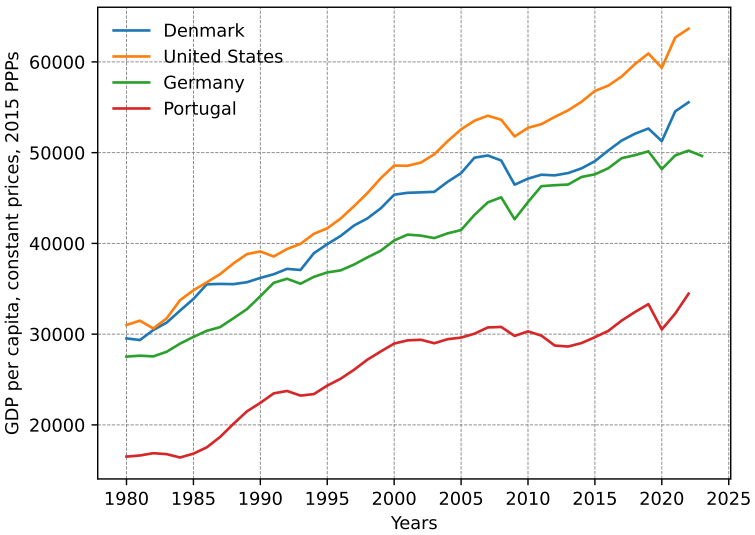
GDP across countries



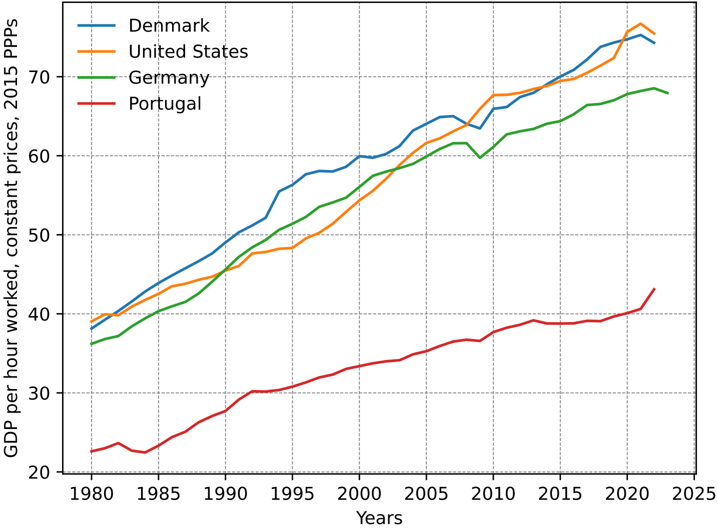
GDP across countries



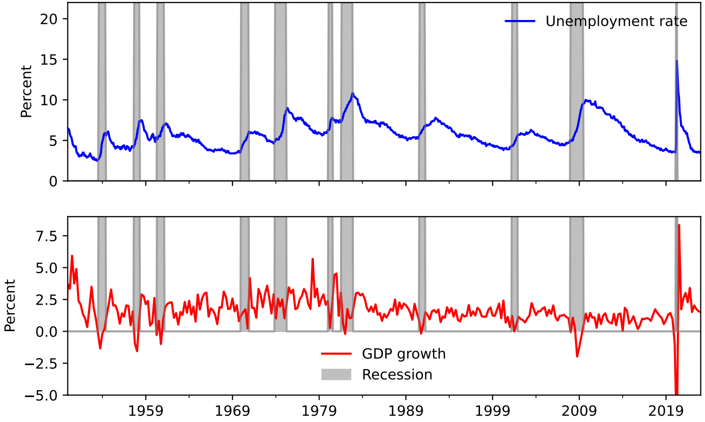
GDP across countries



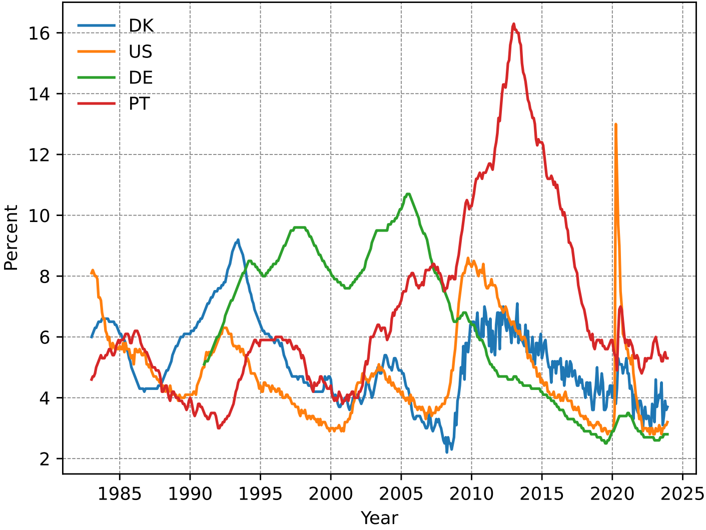
GDP across countries



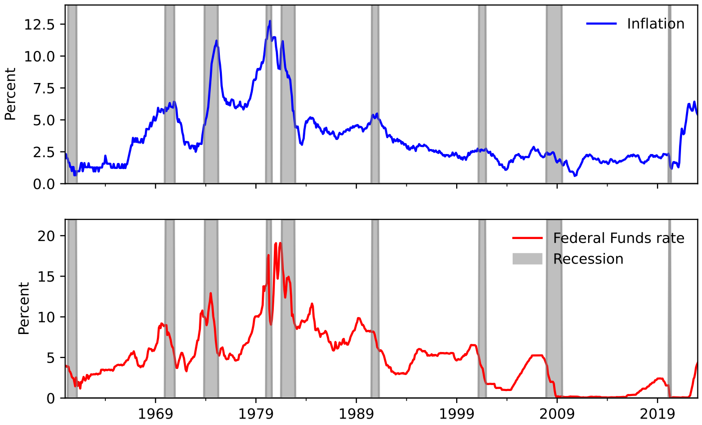
Unemployment and GDP growth in the US



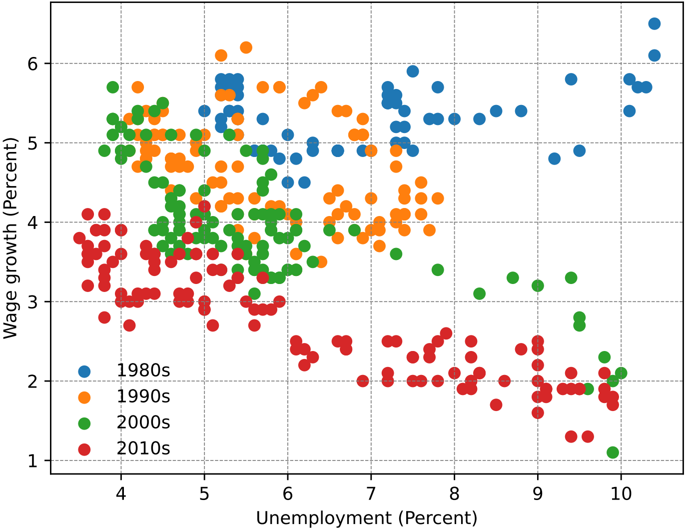
Unemployment in Europe



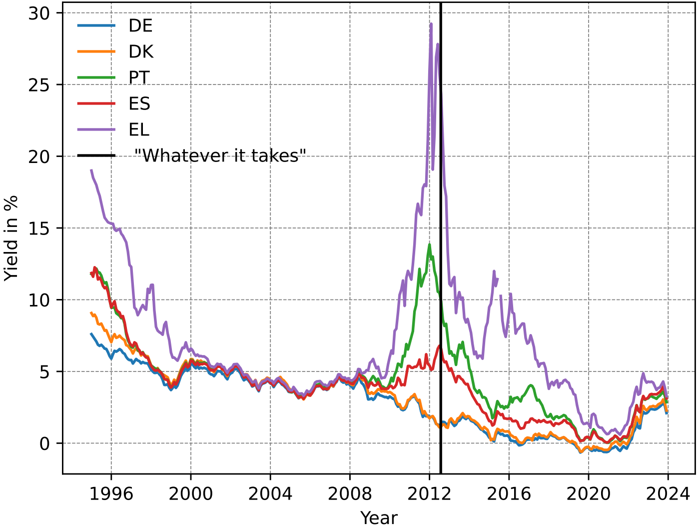
Inflation and interest rates in the US



The US Phillips Curve



The words of a European central banker



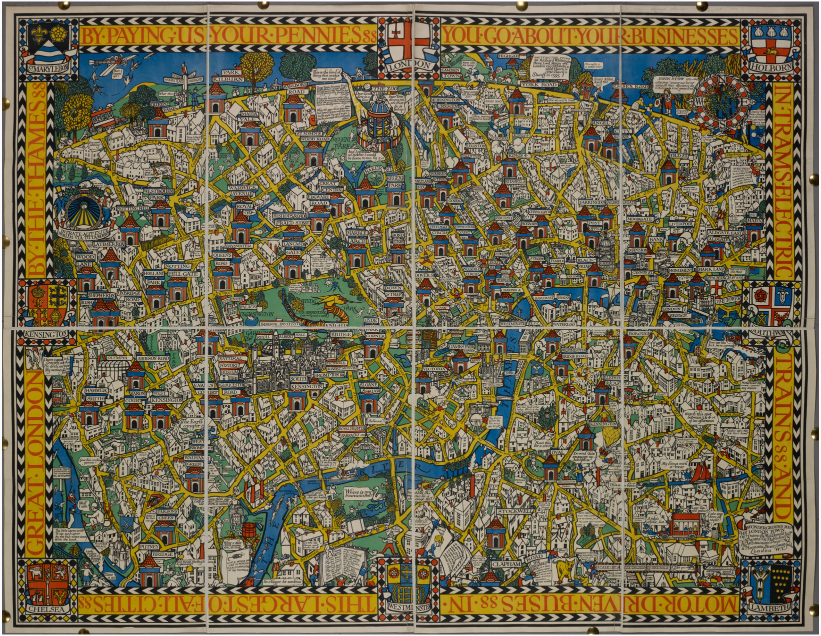
Macroeconomic questions

Very rare to get experiments at the aggregate level (in advance)

- How much more do people work if their wages rise?
- What happens to German GDP if natural gas from a large supplier disappears?
- What happens if European countries form a currency union without a fiscal union?
- What happens to inflation if the ECB raises interest rates? (And why?)

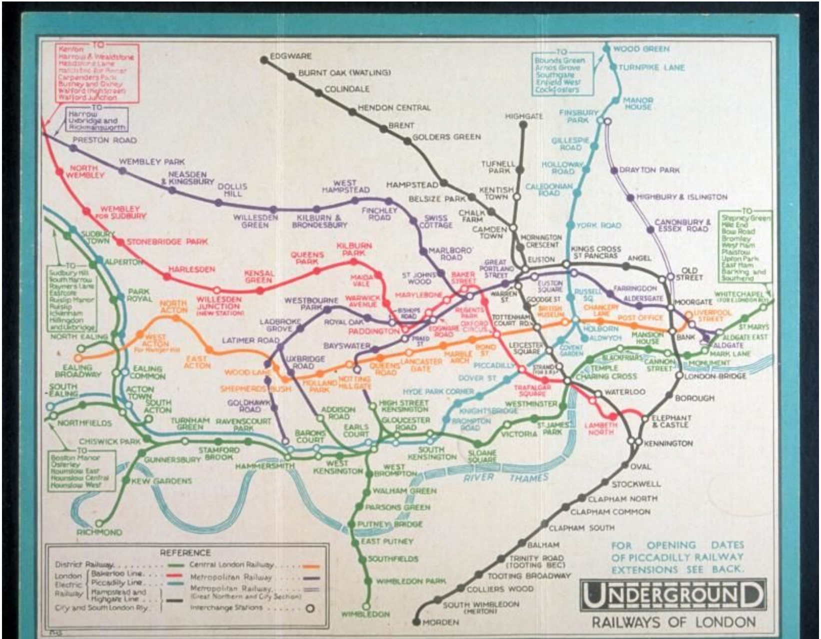
Empirics alone are not enough

- Need frameworks to analyze the present and predict the future
- Absent an event having happened before

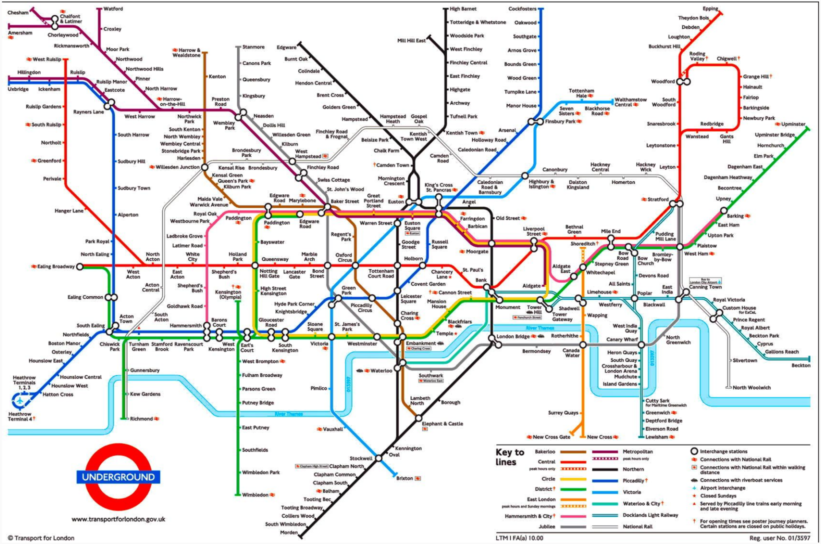


BY·PAYING·US·YOUR·PENNIES ss
YOU·GO·ABOUT·YOUR·BUSINESSES
IN·TRAMS·ELECTRIC
TRAINS ss AND
MOTOR·DRIVEN·BUSES ss IN
THIS·LARGEST·OF·ALL·CITIES ss
GREAT·LONDON
BY·THE·THAMES ss
ST MARYLEBONE
LONDON
HOLBORN
KENSINGTON
SOUTHWARK
CHELSEA
WESTMINSTER
LAMBETH

A map of ? Video




UNDERGROUND
REFERENCE
DISTRICT RAILWAY
CENTRAL LONDON RLY
BAKERLOO LINE
METROPOLITAN RLY
PICCADILLY LINE
INTERCHANGE STATIONS
UNDER CONSTRUCTION
OLD STREET
MOORGATE
LIVERPOOL STREET
ELEPHANT & CASTLE
KENNINGTON
OVAL
STOCKWELL
CLAPHAM NORTH
CLAPHAM COMMON
CLAPHAM SOUTH
BALHAM
TOOTING BROADWAY
COLLIERS WOOD
SOUTH WIMBLEDON
MORDEN
WIMBLEDON
EDGWARE
COCKFOSTERS
SOUTHGATE


Chesham
Chalfont & Latimer
Watford
Croxley
Amersham
Chorleywood
Rickmansworth
Moor Park
Northwood
Northwood Hills
Pinner
North Harrow
Harrow-on-the-Hill
West Ruislip
Hillingdon
Ruislip
Ruislip Manor
Eastcote
Uxbridge
Ickenham
Ruislip Gardens
Rayners Lane
West Harrow
South Ruislip
South Harrow
Northolt
Greenford
Sudbury Hill
Perivale
Sudbury Town
Hanger Lane
Alperton
Park Royal
North Ealing
Ealing Broadway
Ealing Common
South Ealing
Northfields
Boston Manor
Osterley
Hounslow East
Hounslow Central
Hounslow West
Hatton Cross
Heathrow Terminals 1,2,3
Heathrow Terminal 4
Harrow & Wealdstone
Kenton
Preston Road
Northwick Park
South Kenton
North Wembley
Wembley Central
Stonebridge Park
Harlesden
Willesden Junction
Stanmore
Canons Park
Queensbury
Kingsbury
Wembley Park
Neasden
Dollis Hill
Willesden Green
Kilburn
West Hampstead
Brondesbury Park
Kensal Rise
Brondesbury
Kensal Green
Queen's Park
Kilburn Park
Maida Vale
Warwick Avenue
Royal Oak
Westbourne Park
Ladbroke Grove
Latimer Road
North Acton
West Acton
East Acton
White City
Acton Central
Acton Town
South Acton
Chiswick Park
Turnham Green
Stamford Brook
Ravenscourt Park
Hammersmith
Goldhawk Road
Shepherd's Bush
Holland Park
Kensington (Olympia)
Barons Court
West Kensington
Earl's Court
Gunnersbury
Kew Gardens
Richmond
Edgware
Burnt Oak
Colindale
Hendon Central
Brent Cross
Golders Green
Hampstead
Finchley Road & Frognal
Finchley Road
Swiss Cottage
St. John's Wood
Hampstead Heath
Gospel Oak
Belsize Park
Chalk Farm
Kentish Town West
Camden Town
Camden Road
Mornington Crescent
Paddington
Edgware Road
Marylebone
Baker Street
Great Portland Street
Regent's Park
Bayswater
Queensway
Notting Hill Gate
Lancaster Gate
Marble Arch
Bond Street
Oxford Circus
High Street Kensington
Hyde Park Corner
Knightsbridge
Gloucester Road
South Kensington
Sloane Square
Green Park
Piccadilly Circus
St. James's Park
Victoria
Westminster
West Brompton
Fulham Broadway
Parsons Green
Putney Bridge
East Putney
Southfields
Wimbledon Park
Wimbledon
Pimlico
Vauxhall
Stockwell
Clapham North
Clapham Common
Clapham South
Balham
Tooting Bec
Tooting Broadway
Colliers Wood
South Wimbledon
Morden
Brixton
Kennington
Oval
Mill Hill East
High Barnet
Totteridge & Whetstone
Woodside Park
West Finchley
Finchley Central
East Finchley
Highgate
Archway
Tufnell Park
Kentish Town
Cockfosters
Oakwood
Southgate
Arnos Grove
Bounds Green
Wood Green
Turnpike Lane
Manor House
Finsbury Park
Arsenal
Holloway Road
Caledonian Road
Tottenham Hale
Seven Sisters
Blackhorse Road
Walthamstow Central
King's Cross St. Pancras
Euston
Euston Square
Warren Street
Goodge Street
Russell Square
Tottenham Court Road
Holborn
Covent Garden
Leicester Square
Charing Cross
Embankment
Temple
Blackfriars
Mansion House
Cannon Street
Chancery Lane
St. Paul's
Bank
Monument
Moorgate
Barbican
Farringdon
Angel
Old Street
Liverpool Street
Aldgate
Aldgate East
Tower Hill
Tower Gateway
Waterloo
Southwark
Lambeth North
Elephant & Castle
Borough
London Bridge
Bermondsey
Canada Water
Rotherhithe
Surrey Quays
New Cross Gate
New Cross
Shoreditch
Whitechapel
Shadwell
Wapping
Stepney Green
Mile End
Bethnal Green
Bow Road
Bow Church
Bromley-by-Bow
Devons Road
All Saints
Limehouse
Westferry
Poplar
Blackwall
East India
West India Quay
Canary Wharf
Heron Quays
South Quay
Crossharbour & London Arena
Mudchute
Island Gardens
Cutty Sark for Maritime Greenwich
Greenwich
Deptford Bridge
Elverson Road
Lewisham
North Greenwich
Canning Town
Royal Victoria
Custom House for ExCeL
Prince Regent
Royal Albert
Beckton Park
Cyprus
Gallions Reach
Beckton
Silvertown
North Woolwich
Highbury & Islington
Canonbury
Dalston Kingsland
Hackney Central
Hackney Wick
Homerton
Caledonian Road & Barnsbury
Stratford
Pudding Mill Lane
West Ham
Plaistow
Upton Park
East Ham
Barking
Upney
Becontree
Dagenham Heathway
Dagenham East
Elm Park
Hornchurch
Upminster Bridge
Upminster
Leyton
Leytonstone
Wanstead
Redbridge
Gants Hill
Snaresbrook
South Woodford
Woodford
Epping
Theydon Bois
Debden
Loughton
Buckhurst Hill
Roding Valley
Chigwell
Grange Hill
Hainault
Fairlop
Barkingside
Newbury Park
River Thames
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National Rail
Interchange stations
Connections with National Rail
Connections with National Rail within walking distance
Connections with riverboat services
Airport interchange
Closed Sundays
Served by Piccadilly line trains early morning and late evening
For opening times see poster journey planners. Certain stations are closed on public holidays.
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Understanding/explaining macroeconomic phenomena formally

Models

- Simplified description of the world
- Useful analytical tools

Advantages

- All assumptions clearly stated
- Rigorous representation of the world
- Focus on the most important aspects
- Counterfactuals can easily be understood

Disadvantages

- Simplifications

Main steps from previous courses

Mathematical formalism

- Explain macroeconomic phenomena using common language
- Learn new analytical tools
- Individual optimization

Microfoundations

- Models are built from the ground up
- Consistent at micro- and marco-level
- Can be compared to micro-data

$\Longrightarrow$ we get the answers right for the right reasons

Main models to be covered

Long-run models

- Ramsey model (aka the neoclassical growth model)
- Overlapping generations model (OLG)

Business cycles

- The real business cycle (RBC) model
    - Open Economy Macro (at the end)
- Diamond-Mortenssen-Pissarides (DMP) model of the labor market
- Nominal rigidities
- The New Keynesian (NK) model of central banking

Ramsey model

Frank Ramsey

- English mathematical genius, died early in 1930
- Publishes 'A mathematical theory of saving' in 1928

The model

- Ramsey's theory + Solow model form the neoclassical growth model
- Savings an endogenous object (exogenous in Solow)
- Expectations matter for consumption

Relevance

- Foundation for modern macroeconomics
- What should the role of governments be? What drives growth? What is the role of fiscal policy?

Overlapping generations model

Peter A. Diamond (student of Solow at MIT)

- Nobel Prize winner in 2010 (for something else)

The model

- Different generations modelled explicitly (heterogeneity)

Relevance

- Social security and pension system design
- Design of educational systems
- Financing of public debt

The RBC model

Finn Kydland (NO) & Edward Prescott (US) (Carnegie Mellon)

- Nobel Prize winners in 2004

The model

- Neo-classical growth model with short-run disturbances
- Business cycles are the result of supply shocks

Relevance

- Economic stabilization policies

The DMP model

Peter Diamond, Dale Mortensen, and Christopher Pissarides

- Nobel Prize winners in 2010

The model

- Moving away from perfectly competitive labor markets
- Search frictions result in involuntary unemployment and wage inequality

Relevance

- Design of unemployment insurance schemes

Nominal rigidities and the New Keynesian model

New Keynesian Economics

- No Nobel Prize winners yet

The model

- Moving away from perfect towards monopolistic competition
- Incorporating rigid prices into the RBC model
- Money is no longer neutral, monetary policy matters

Relevance

- Monetary policy
- Interest rates
- Inflation

Monetary policy making

Torsten Persson (SE) & Guido Tabellini (IT)

- Not Nobel Prize winners yet

The model

- Game theoretical framework of society
- Expectations, reputation and credibility matter
- Allows prescriptions on optimal policy

Relevance

- Institutional design of monetary policy institutions

Brief history of macroeconomic thought

Keynes' General Theory of empl., interest & money

Beginning of modern macroeconomic theory

- Response to Great Depression
- Attempting to formulate policy responses for the future

Major innovation

- Business cycles are demand driven
- Analytical thinking, but without formalizing in mathematical terms
- Brings together real and nominal quantities for the first time
- Markets may not clear automatically
- Involuntary unemployment

Neoclassical-Keynesian synthesis

Formalization of Keynes' ideas

- Hicks (Nobel 1972) IS-LM
- Samuelson (Nobel 1970) built MIT economics

Major innovation

- Keynes is relevant for the short-run, classical theory is a long-run concept
- Turning Keynes' writings into policy prescriptions
- IS-LM model
- Inclusion of the labor market into the model ($\implies$ Phillips curve)

(Not really a synthesis at all)

Monetarism

Milton Friedman (University of Chicago)

- Nobel Laureate of 1976

Major innovation

- "Inflation is always and everywhere a monetary phenomenon" (Friedman & Schwartz, 1963)
- Monetary policy can have unintended consequences
- Depression was caused by lack of money supply
- Permanent income hypothesis
- Endogeneity of inflation expectations

The new-classical counter revolution

Fresh water economics

- Lucas (Nobel 1995), Sargeant (Nobel 2011), Wallace
- Kydland, Prescott (both Nobel 2004)

Major innovation

- Flexible prices, even in the short-run, Walrasian market clearing
- Rational expectations under uncertainty
- Policy ineffectiveness proposition
- Microfoundations, stochastic modelling of agents, optimization
- Business cycles are supply-driven

The New Keynesian reconstruction

Salt water economics

- Blanchard, Akerloff, Yellen, Rotemberg, Kiyotaki
- Woodford, Gali

Major innovation

- Acceptance of rational expectations and microfoundations
- Monopolistic competition
- Rigid prices
- Short run fluctuations caused by supply and demand

Modern macroeconomics

Heterogeneity

- Increased computing power allows for more heterogeneity
- Inequality

Data

- Computing power allows for bigger datasets to discipline more complicated models

Non full information rational expectations (FIRE) models

- Behavioral biases, etc

Climate economics

- Synthesis with environmental economics

Microfoundations

Microfoundations

Macroeconomic phenomena have to make microeconomic sense

- No more ad-hoc assumptions about macroeconomic relationships
- Optimizing agents make *rational* decisions
- Utility functions and discounting of future consumption
- Aggregate up across individuals

Intertemporal consumption & savings choices (simple)

Assumptions

- Time is discrete (i.e., not continuous)
- There is a representative agent
- The economy ends in T=1 (i.e., two periods = $\{0, 1\}$)
- Agents discount the future at rate β
- The agent can save in bonds (a_1) which pay interest rate $R(= 1 + r)$
- Each period, agents receive an endowment y_t, **which is know**
- The utility function is given by $u(c_t)$

No general equilibrium yet

- Assume R is given exogenously ("Partial equilibrium")

Solving a two-period consumption/savings problem

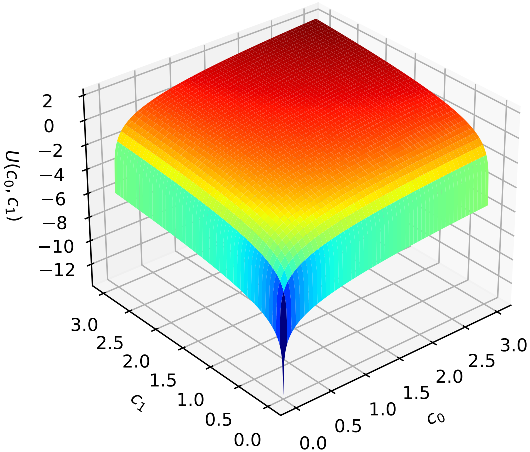
Maximization problem

$$
\begin{aligned}
\max_{c_0, c_1} \quad & U = u(c_0) + \beta u(c_1) \\
\text{subject to} \quad & c_0 + a_1 = y_0 \\
& c_1 = y_1 + (1 + r) a_1
\end{aligned}
$$

- Budget constraints are "dynamic" $\implies$ influence each other
- Solution: combine and substitute

$$
c_0 = y_0 - \frac{c_1 - y_0}{1 + r}
$$

Preferences – graphical



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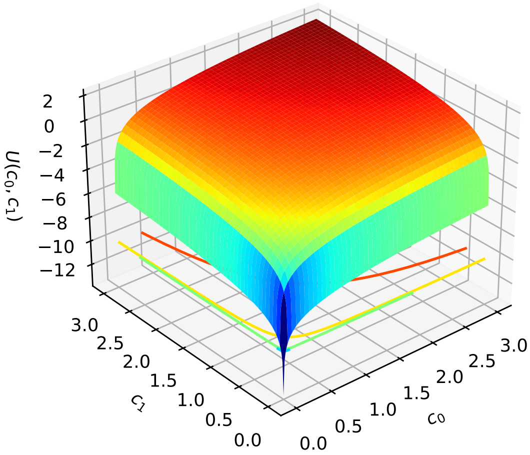
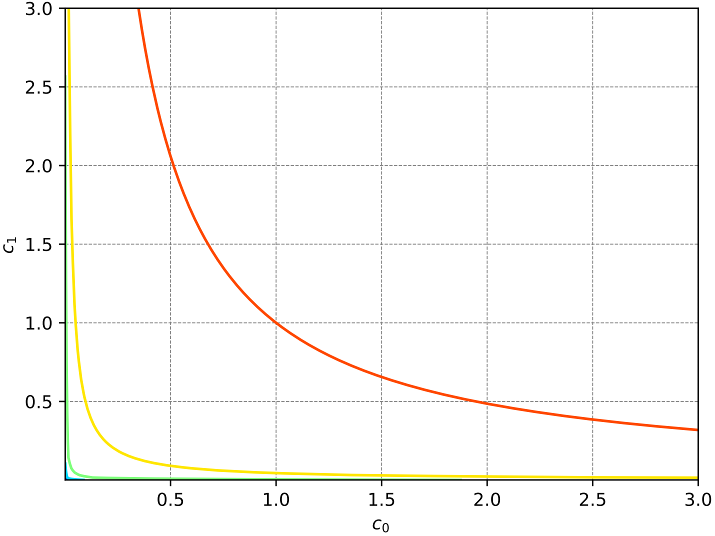
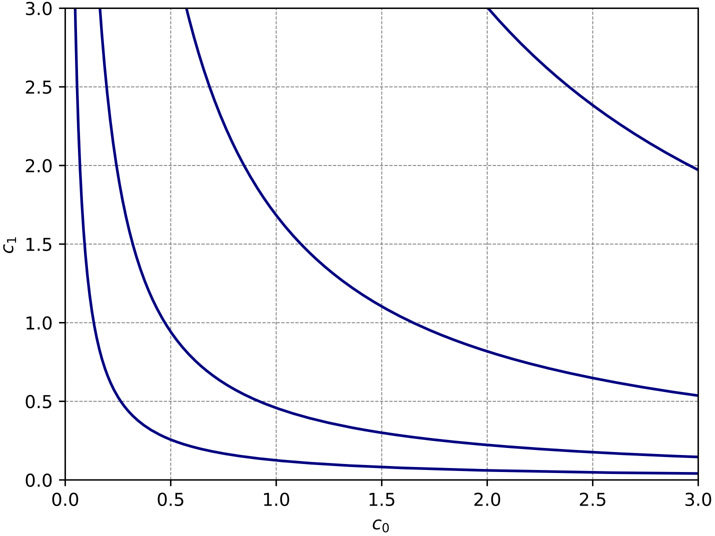


Preferences – graphical



Preferences – graphical



Constrained optimization

Maximization problem

$$\max_{c_0, c_1} \quad U = u(c_0) + \beta u(c_1)$$

$$\text{subject to} \quad c_0 + a_1 = y_0$$

$$c_1 = y_0 + (1+r)a_1$$

$$\downarrow$$

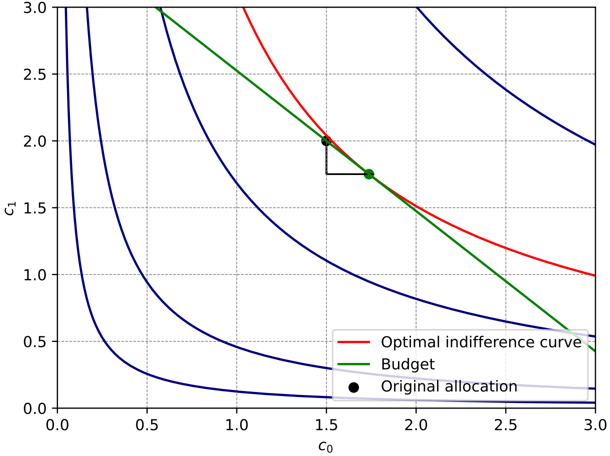
$$\max_{c_1} \quad U = u(y_0 - \frac{c_1 - y_0}{1+r}) + \beta u(c_1)$$

First order condition for optimality

$$\beta u'(c_1) = \frac{1}{1+r} u' \underbrace{\left(y_0 - \frac{c_1 - y_0}{1+r} \right)}_{c_0}$$

$$\underbrace{u'(c_0) = \beta(1+r)u'(c_1)}_{\text{Euler equation}} \text{ and } \underbrace{c_1 = y_1 + (1+r)(y_0 - c_0)}_{\text{Budget constraint}}$$

Solution – Graphical (increasing consumption path)



- Agents borrow to smooth consumption

Intuition

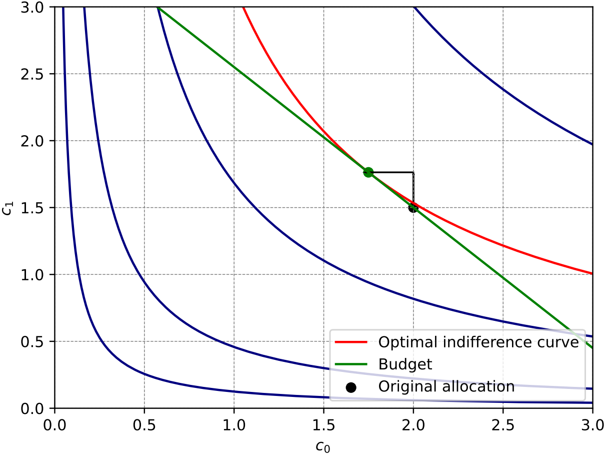
Euler equation

$$u'(c_0) = \beta(1+r)u'(c_1) \iff \frac{u'(c_0)}{\beta u'(c_1)} = (1+r)$$

Tradeoff between marginal utility today and tomorrow is governed by

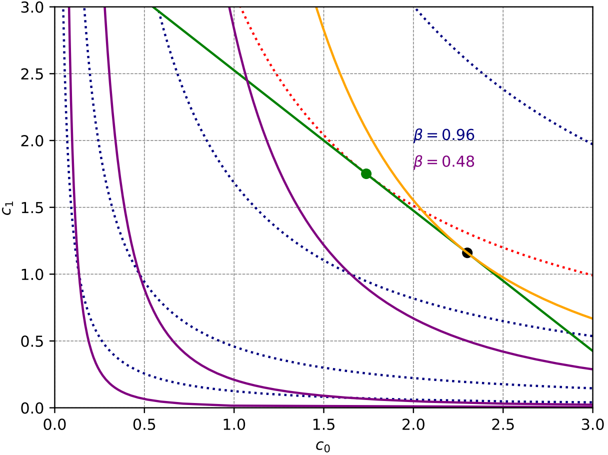
- Endowment path y_t
- Patience β
- Shape of the utility function
- Interest rate r

Solution – Graphical (decreasing consumption path)



- In the face of decreasing endowments, the agent saves

Patience vs impatience – $u'(c_0) = \beta(1 + r)u'(c_1)$



- Impatient consumers allocate to consumption today c_0

Utility function

Crucial assumptions

- Continuously differentiable and displays positive but decreasing marginal returns: $\lim_{c\to\infty} u'(c) = 0$
- Consumption is essential: $\lim_{c\to 0} u'(c) = \infty$

The workhorse – Constant Relative Risk Aversion (CRRA)

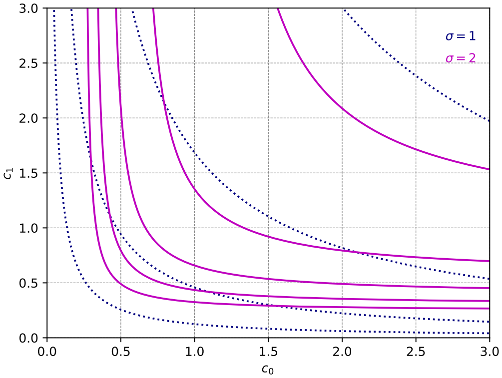
$$u(c) = \frac{c^{1-\sigma} - 1}{1-\sigma}; \quad \sigma > 0; \sigma \neq 1$$

- σ is called the coefficient of relative risk aversion
- $1/\sigma$ is the intertemporal elasticity of substitution between two periods ($\sigma \to \infty \implies$ Leontief across periods)
- As $\sigma \to 1$, one can show that $u(c) = \ln(c)$

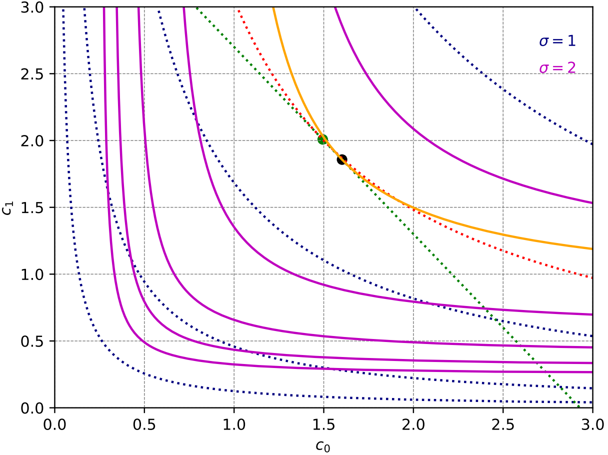
Euler equation

$$c_0^{-\sigma} = \beta(1+r)c_1^{-\sigma} \iff \left(\frac{c_0}{c_1}\right)^{-\sigma} = \beta(1+r)$$

- Differences between c_0 and c_1 become more costly as σ rises

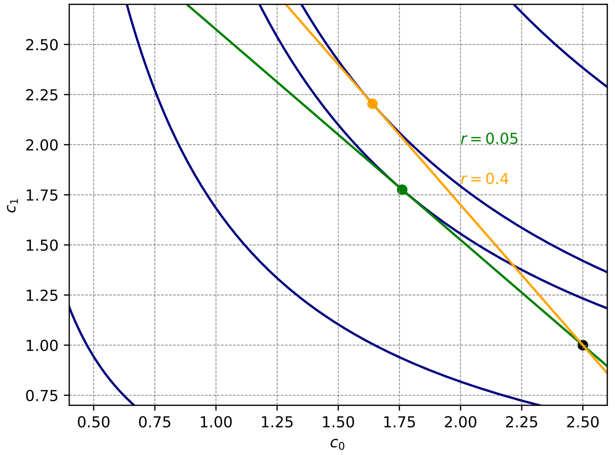


Risk aversion – $u'(c_0) = \beta(1+r)u'(c_1)$



- Risk aversion makes agents smooth more $\implies$ stay away from the edges

Interest rates – $u'(c_0) = \beta(1+r)u'(c_1)$



- Higher interest rates lead to more consumption tomorrow

Income and substitution effects

Remember micro: effect of price changes can be decomposed!

- Interest rate r is the relative price of period 1 utility vs period 0 utility

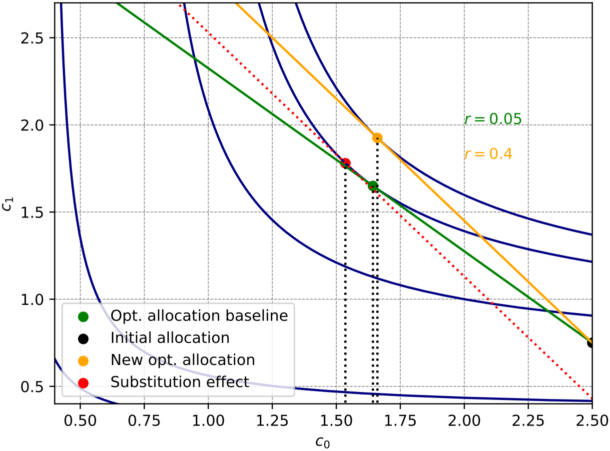
Substitution effect

- If relative prices had been the same initially, what bundle would give initial utility level?
- This effect becomes strongest with $\sigma \to 0$, as agents consumer all in one of the periods (corner solutions)

Income effect

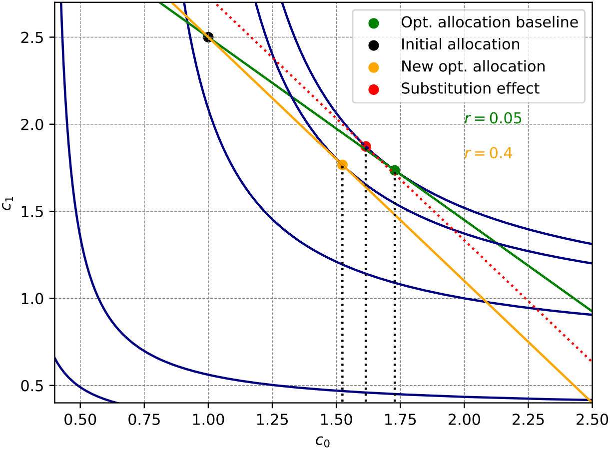
- How does having a changed budget affect the bundle?

Interest rates – $u'(c_0) = \beta(1+r)u'(c_1)$



- Substitution and income effect can go into opposite directions

Interest rates – $u'(c_0) = \beta(1+r)u'(c_1)$



- Substitution and income effect can go in the same direction

Income and substitution effect

Period 0 consumption as a function of parameters

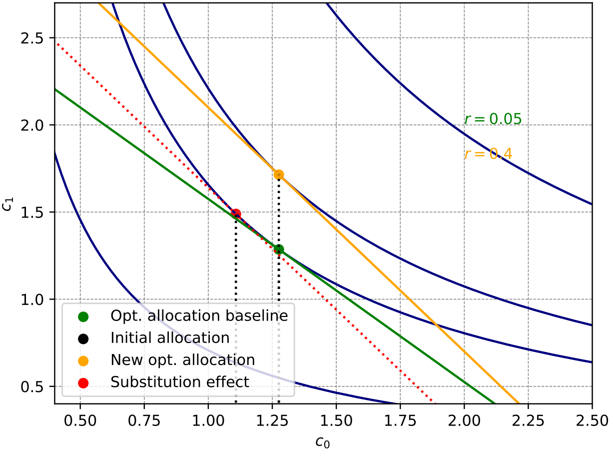
$$c_0^{-\sigma} = \beta(1+r)c_1^{-\sigma} \text{ and } c_1 = y_1 + (1+r)(y_0 - c_0)$$

$$\implies c_0\left(1 + \frac{(\beta(1+r))^{\frac{1}{\sigma}}}{1+r}\right) = \frac{y_1}{1+r} + y_0$$

Effects of interest rate changes

- Wealth effect (goes to 0 as $y_1 \to 0$)
- Income effect
- Substitution effect (goes to 0 as $\sigma \to \infty$)

Interest rates – $u'(c_0) = \beta(1+r)u'(c_1)$



- With log-utility and $y_1 = 0$ (no wealth effect), the effects cancel