

# **Economics and Policy of Innovation**

Academic year 2015/2016

Lecture 14: April 18<sup>th</sup>, 2016

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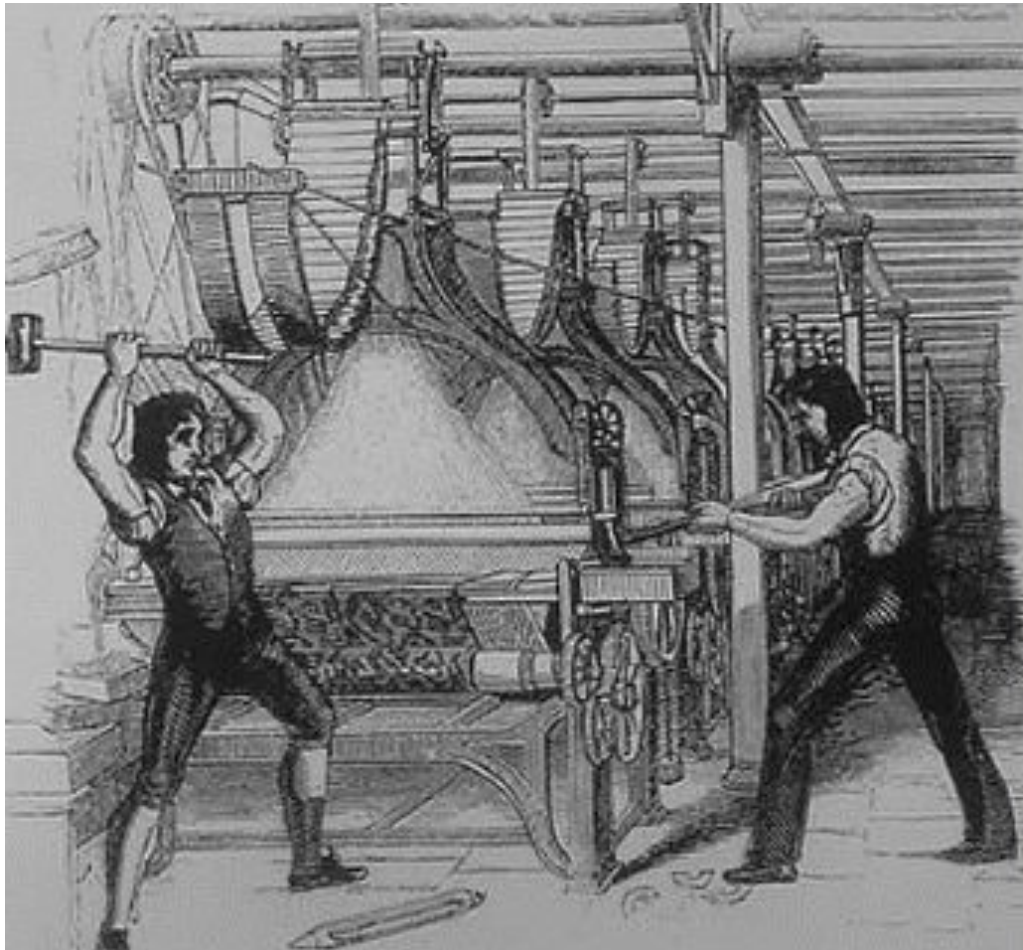
DEAMS – University of Trieste

# Exam only for **course participants**

- Date: May 16<sup>th</sup>, 2016
- Time: during class hours (starting at 2pm)
- Location: Aula Mappa Antiche, via Tigor
- Type of exam: written, closed book
- 24 questions (covering ALL chapters):
  - 21 multiple choice (mark: 0 if wrong, 1 if correct)
  - 3 multiple choice + short written explanation of the answer (mark: 0 if wrong, 1 to 3 if correct, depending on the open answer)
- Students with a positive mark (>18) can decide whether to increase it with oral examination

Innovation  
and Economic Growth  
(Chapter 18)

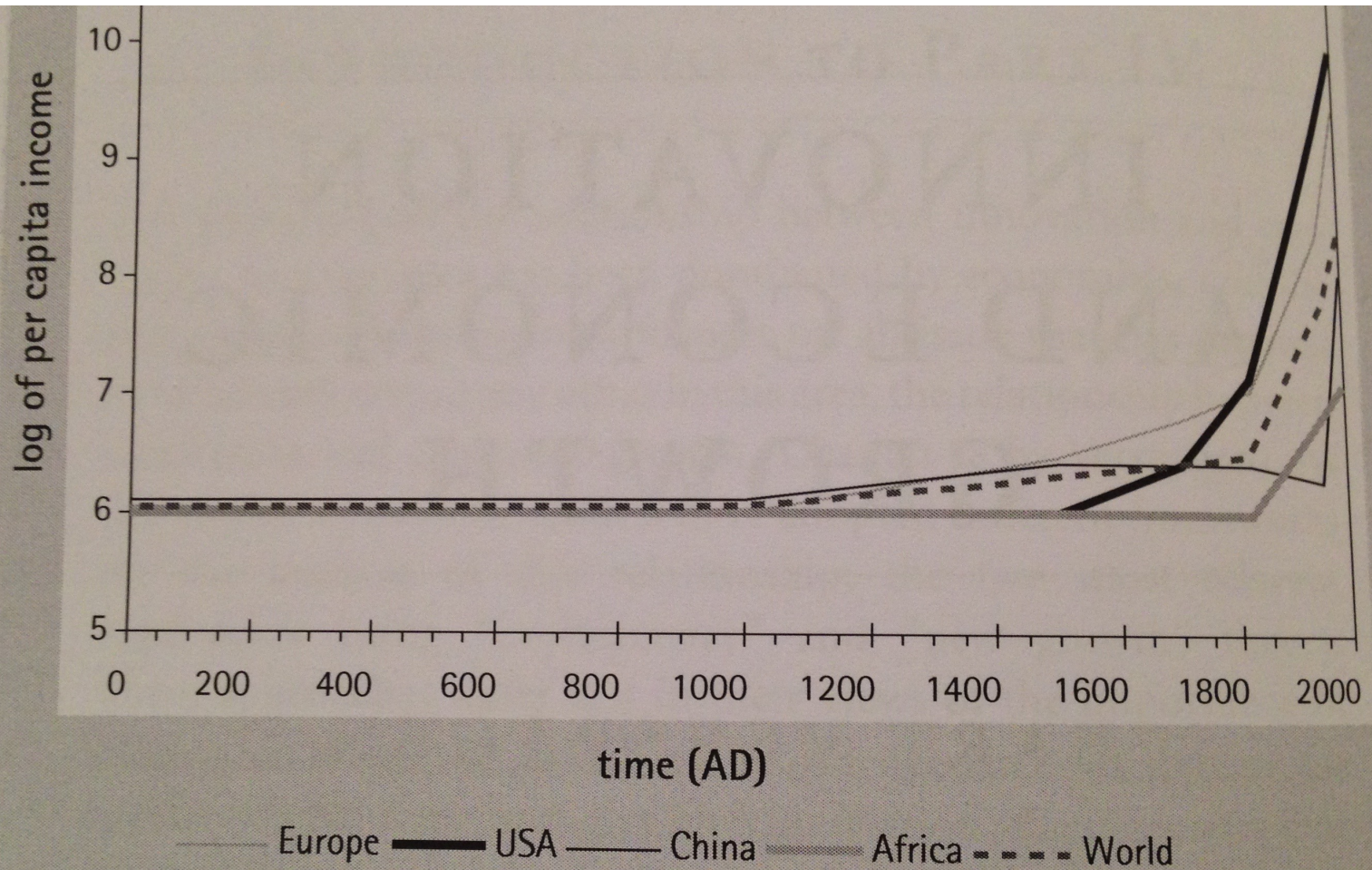
- What is Economic Growth, in your perception & knowledge?
- Why should it be linked to Technology & Innovation?



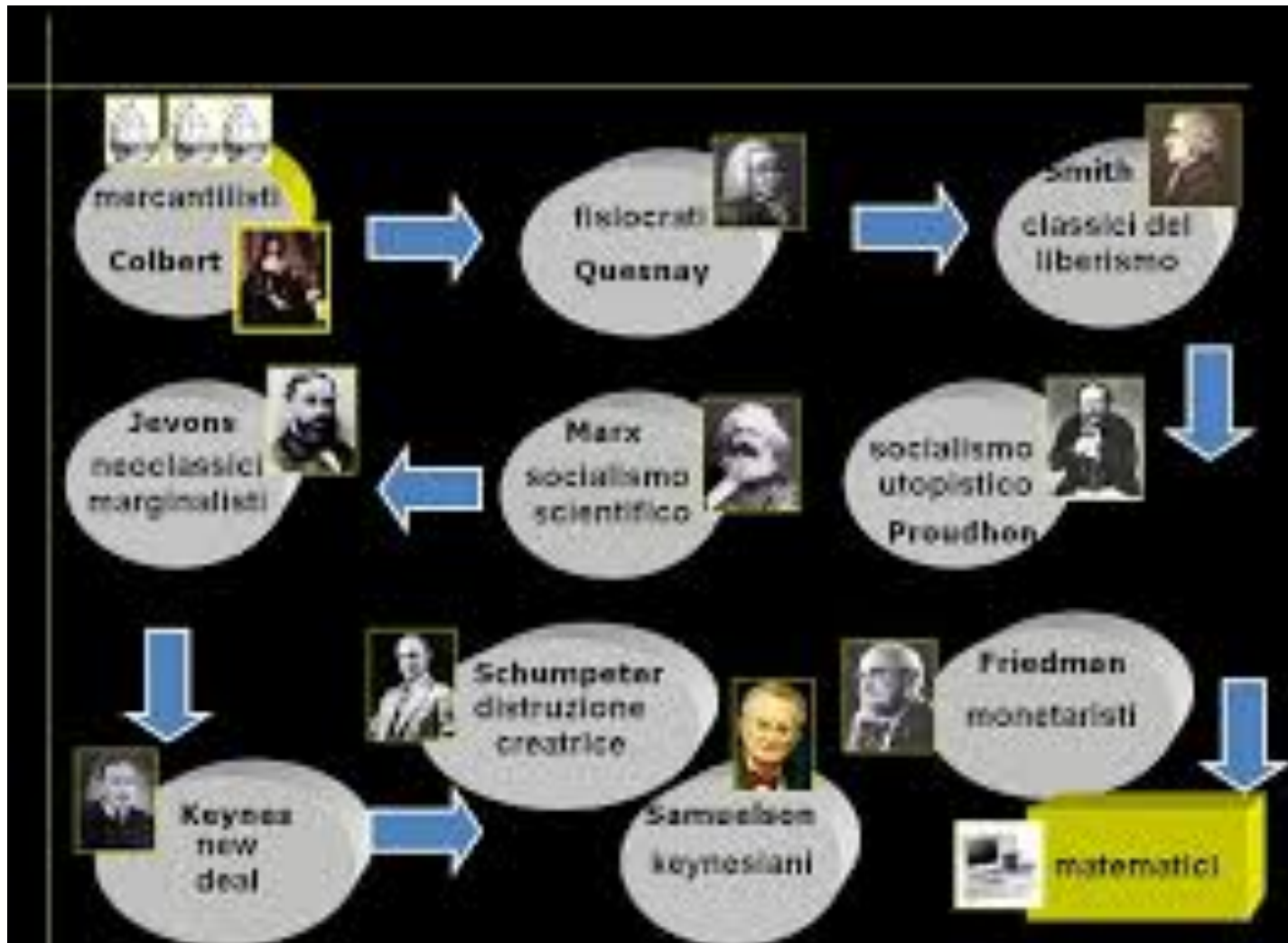
# Economic Growth

- Throughout history, growth has been measured in very different ways.
- Reasonably, a real increase in economic growth (e.g. income per capita) has happened only after Industrial Revolution:
  - Figure 18.1;
  - Recall lectures 3 & 4;
  - It means Technology has had a key role.

# Figure 18.1



# Schools of economic thought



# Economic Growth (2)

- Technology and growth were at the core of **Classical** economists (see again lectures 3 & 4).
- **Smith: *division of labour*** → increased productivity (this is a micro-level, firm perspective)
- But also: “it is the power of exchanging that gives occasion to the division of labour”
- Macro-level perspective: extent of the market → ***division of labour***
- Larger markets increase the incentive to specialise AND to invest in machineries (new Technologies)



# Economic Growth (3)

- **Marx:** *“The technical subordination of the workman to the uniform motion of the instruments of labour, and the peculiar composition of the body of workpeople, consisting as it does of individuals of both sexes and of all ages, give rise to a barrack discipline, which is elaborated into a complete system in the factory, and which fully develops the before mentioned labour of overlooking, thereby dividing the workpeople into operatives and overlookers, into private soldiers and sergeants of an industrial army”.*



# Economic Growth (4)

- Precisely because Technology has to do with the relation between the single workers and the whole factory system, it is a **social relation**.
- In periods of accumulation, economic growth can appear also as a decrease in the length of the working day for the ‘average worker’. However, this growth is *“constantly interrupted by the technical progress that at one time virtually supplies the place of new workmen, at another, actually displaces old ones. [...] The workpeople are thus continually both repelled and attracted, hustled from pillar to post, while, at the same time, constant changes take place in the sex, age, and skill of the levies”* (Marx, The Capital, I-15).

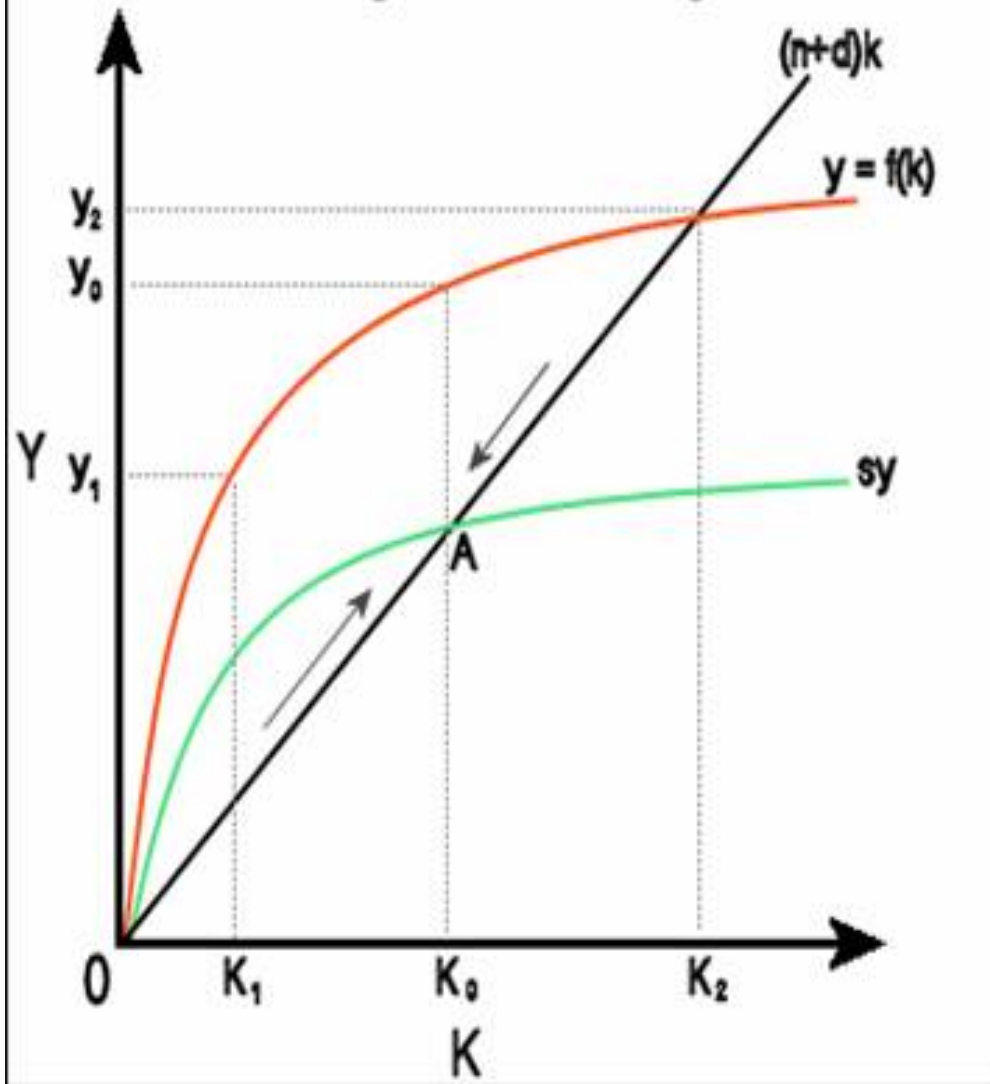
# Economic Growth (5)

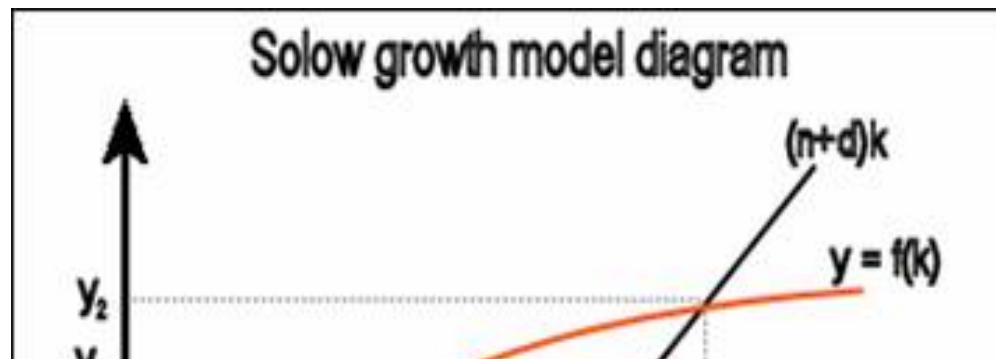
- In other words, for Classical economists **Technology** regards the way capital and labour are related to each other, but...
- It is capital accumulation that deserves a continuous change in technology, to use more intensively the workforce → in accumulation (growth) periods, more workers are employed and the working day might also be shortened.
- However, old workers might be pushed out of the system and new ones introduced, simply because these are more in line with the new technological needs → social impact also in growth periods.

# Economic Growth (6)

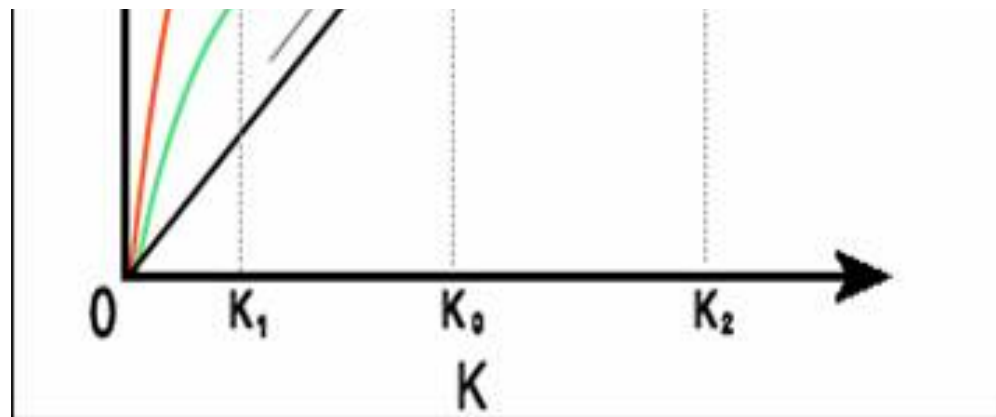
- When **neo-classical** economists started being the mainstream in economics (second half of XIX century, see again lecture 3), Technology almost disappeared from the explanation of economic growth.
- It was re-introduced by Solow in his 1956 work (see section 18.2, page 489):
  - Technology as an “exogenous factor” ...
  - ... measured by the “residual”, that is the part of the economic growth equation that cannot be explained,
  - and improves the productivity of both capital and labour.

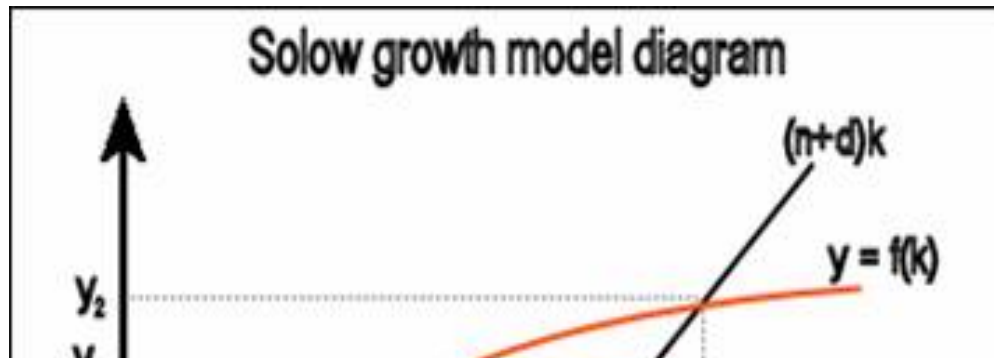
Solow growth model diagram



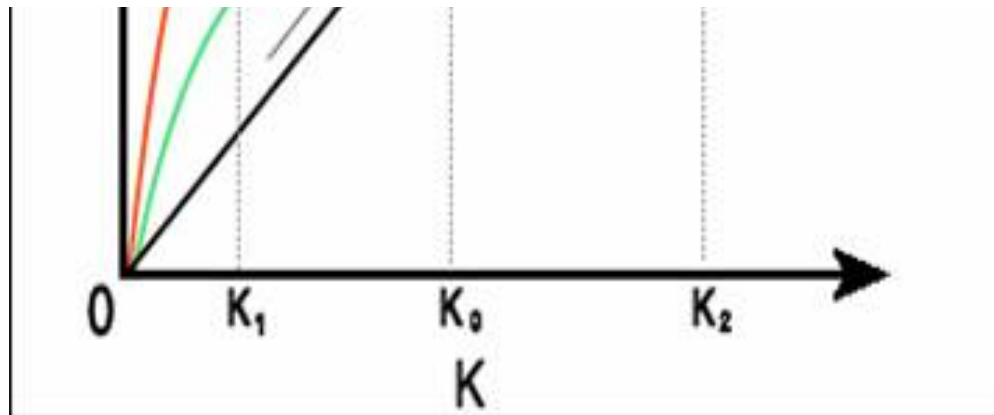


$$Y = AK^a L^{1-a}$$





$$Y = AK^a L^{1-a}$$





# Economic Growth (7)

Many assumptions behind this model:

1. Markets are “in equilibrium” and perfectly competitive (this will be criticised by evolutionary economists, again see table in lecture 3).
2. Economies of scale are insignificant (a vision that had been already challenged by Schumpeter Mark II).
3. Capital and Labour can be perfectly substituted by each other (there is no more the subordination of Labour to Capital as in Marx).

## Main differences, from lecture 3:

Neo-classical	Evolutionary
The equilibrium of the economic system	<b>No</b> equilibrium in the economic system
Technology as <b>information</b>	Technology as <b>knowledge</b>
Firms are studied out of history and context	Firms in <b>history</b> and in a specific context
Public intervention: only <b>patent system and R&amp;D subsidies</b>	<b>Innovation systems</b> including public institutions and firms

# The neo-classical theory of production

- Relationships between inputs and outputs in the productive unit → the firm as an abstract entity
- Assumptions about the firm:
  - it produces one homogeneous product
  - it has perfect information on inputs and outputs
  - it is a price-taker
  - it is owner-managed ('owner-entrepreneur')
  - demand and supply in the relevant market are in equilibrium
  - its production technique is a particular combination of inputs
  - its only objective is profit maximisation
- Analytical form of such assumptions:
  - the production function  $Q = f(K, L)$

# Economic Growth (8)

Other assumption:

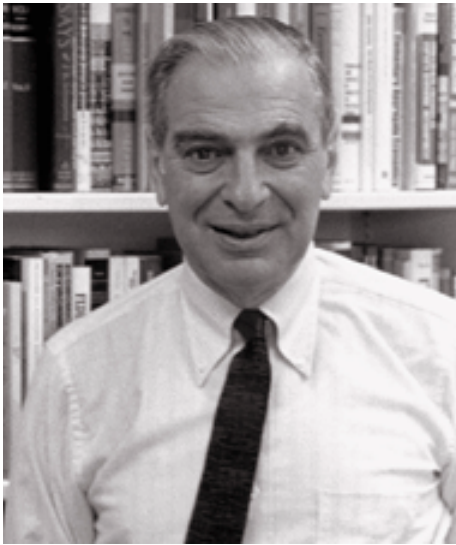
4. Simplistic view of Technology as a “public good”  
→ after the first innovations are introduced, other firms can copy and replicate them almost freely → existence of **spillovers** in the economy.
5. As a consequence, poor countries should **catch-up** → it has not happened!

This assumption is mainly criticised by “post-Keynesian” models → Kaldor, 1957 (page 490): knowledge is not a public good, and “spillovers” do not exist.

# Alternative models of endogenous technological change

- In other words, from the 1950s, the two main schools of economic thought (Neoclassical and Post-Keynesian) have started to include in their models the role of Technology (which was key in alternative views, like the ones by Smith, Marx and Schumpeter).
- Over the years, models on both sides have started being more and more complex, also thanks to the growing availability of data → growth is more and more coincident with the productivity of economic factors (mainly labour).

# What are the factors that make labour more efficient?



Kenneth Arrow,  
1962

(page 491)

Learning: due to spillovers, knowledge increases with the overall investment occurred in the economy. Physical investment generates new machine and new knowledge

➔ Increases returns **external** to the firm

# R&D and productivity

- Starting in the 1970s, the Neoclassical model has been developed or criticised with more empirical work.
- Griliches (1979 and 1984, see page 491) made the first estimations on the impact of R&D investment on the growth of GDP.
- The neoclassical production function includes now a “knowledge stock” measure, that is the cumulative measure of past R&D investment.

## R&D and productivity (2)

- As in the previous neoclassical models, Knowledge (K) is included in the model together with Capital (C) and Labour (E).

$$\ln(VA/E) = \alpha + \beta \ln(K/E) + \gamma \ln(C/E) + \lambda \ln(E) + \eta_t + v_{it}$$

- K is the depreciated cumulative measure of R&D investments.

$$K_t = K_{t-1} \cdot (1 - \delta_g) + R\&D_t$$



# Evolutionary approaches (18.3.2)

- Less formal, more qualitative (thus complex).
- Rationality is bounded, and firms can just follow their own *routines*.
- Past history is crucial in the evolutionary view, but the future cannot be predicted (like the *owl of Athena* in Hegel's words).
- Few formal growth models exist in the evolutionary tradition (the most important is by Nelson & Winter, 1982).

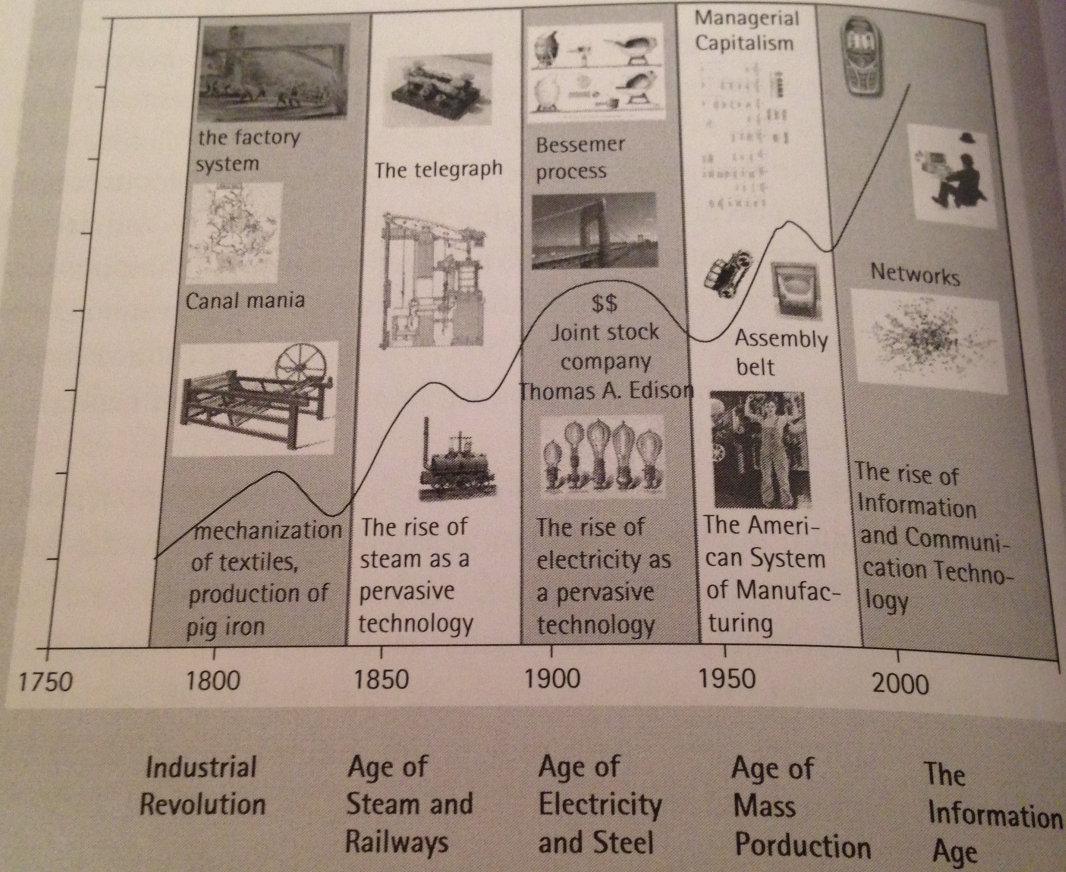


Figure 18.2 Approximate chronology of technological revolutions, based on Freeman and Soete (1997) (dates are approximate)

# What are the factors that make labour more efficient? (2)



Robert Lucas

Human capital accumulation: the contribution of labour to output is affected by the average skill across all workers. Technological progress will still be considered **exogenous**.

# What are the factors that make labour more efficient? (3)



Paul Romer,  
1986 and 1990  
(page 501)

Research and development: technological advance has its origins in a sector which produces productivity-raising ideas (R&D sector). Amount of resources devoted to R&D becomes crucial.

In Romer's model, technology is still a (partly) public good; also spillovers still do exist → make it possible the endogenous growth.

# Current models of endogenous technological change

- Currently, the most dominant theory is the Endogenous Growth one (as in Aghion and Howitt, 1998), which makes use of rational expectations and well-behaved production function.
- Such a theory neglects the main tenets of the scholars of innovation, such as radical uncertainty, heterogeneity, cognitive limitations, and organizational routines (e.g. in Dosi, 1988).
- Thus evolutionary economists go on criticising this type of models, through empirical quantitative and qualitative analyses.