Lezione 1.2
La scienza fra stato e mercato

WORLD*:

1.7 trillion
R&D expenditure

7.8 million researchers

0.1%
world population

218k
GERD per researcher

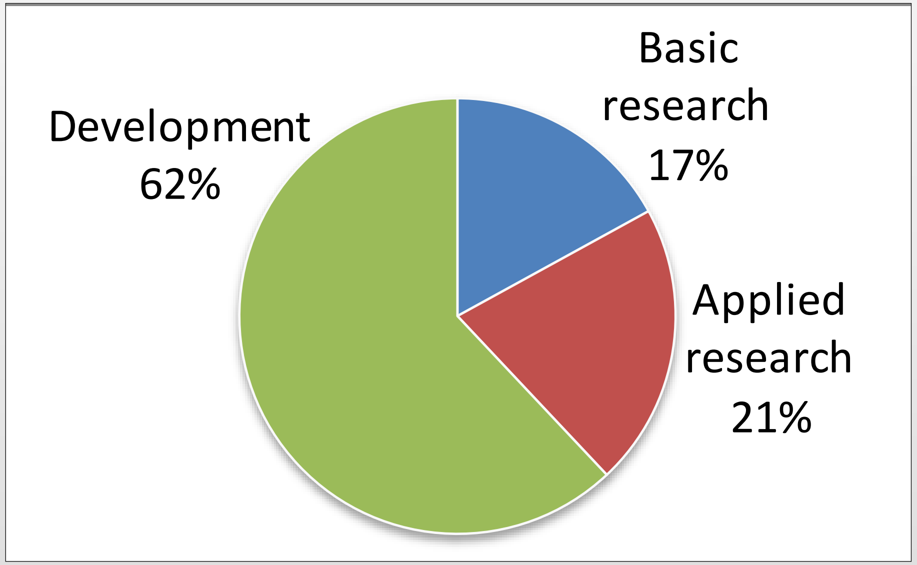
500 billion USD R&D
USA

409 billion USD
China

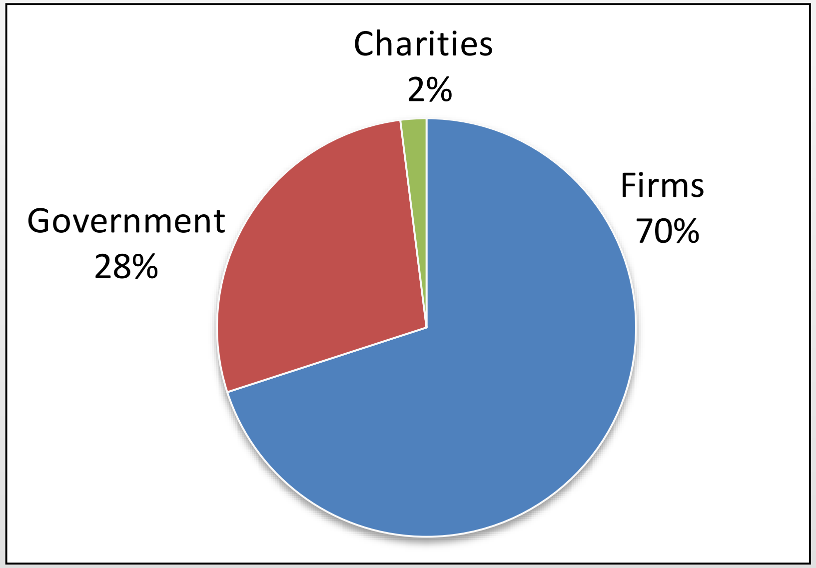
386 billion USD
EU 28 Area

405 billion USD
Rest of the world

OECD AREA:

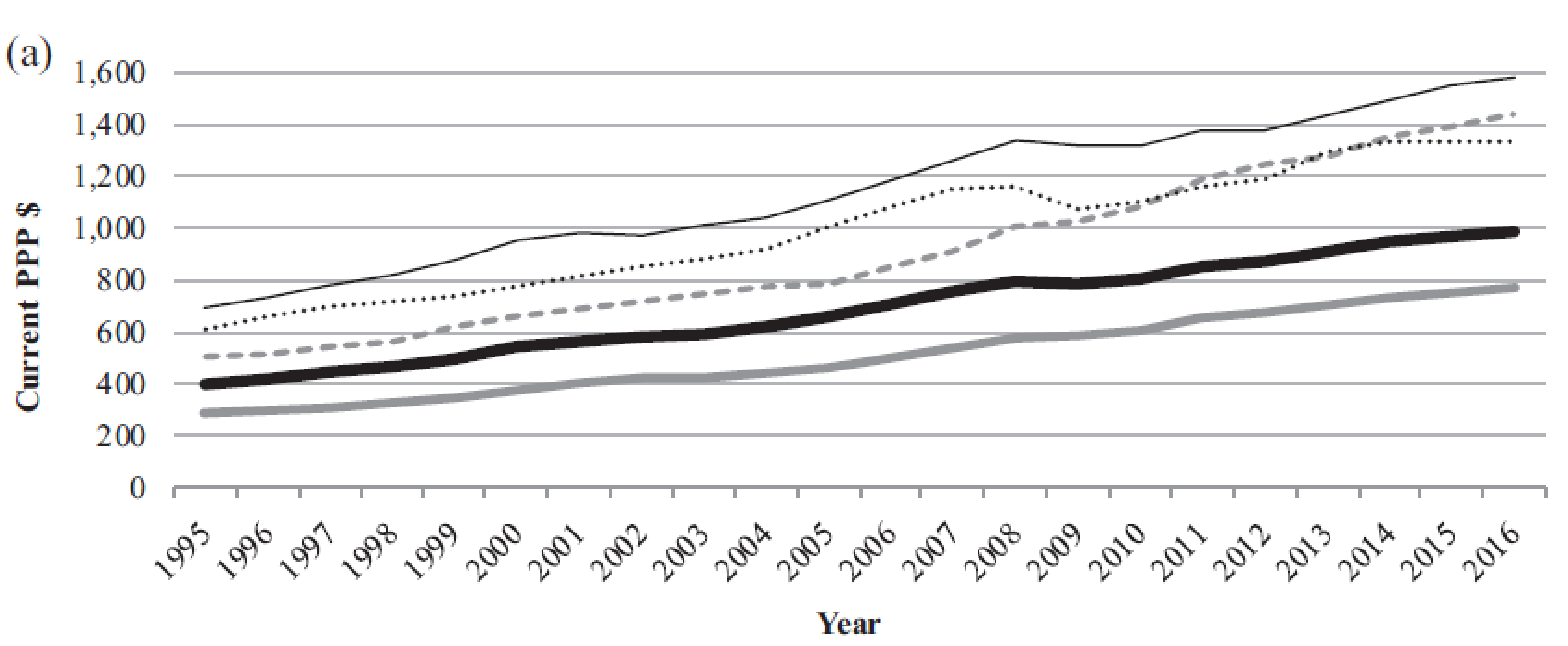


Government funding: USD 315 billion or USD **246 p.c./year to R&D.**

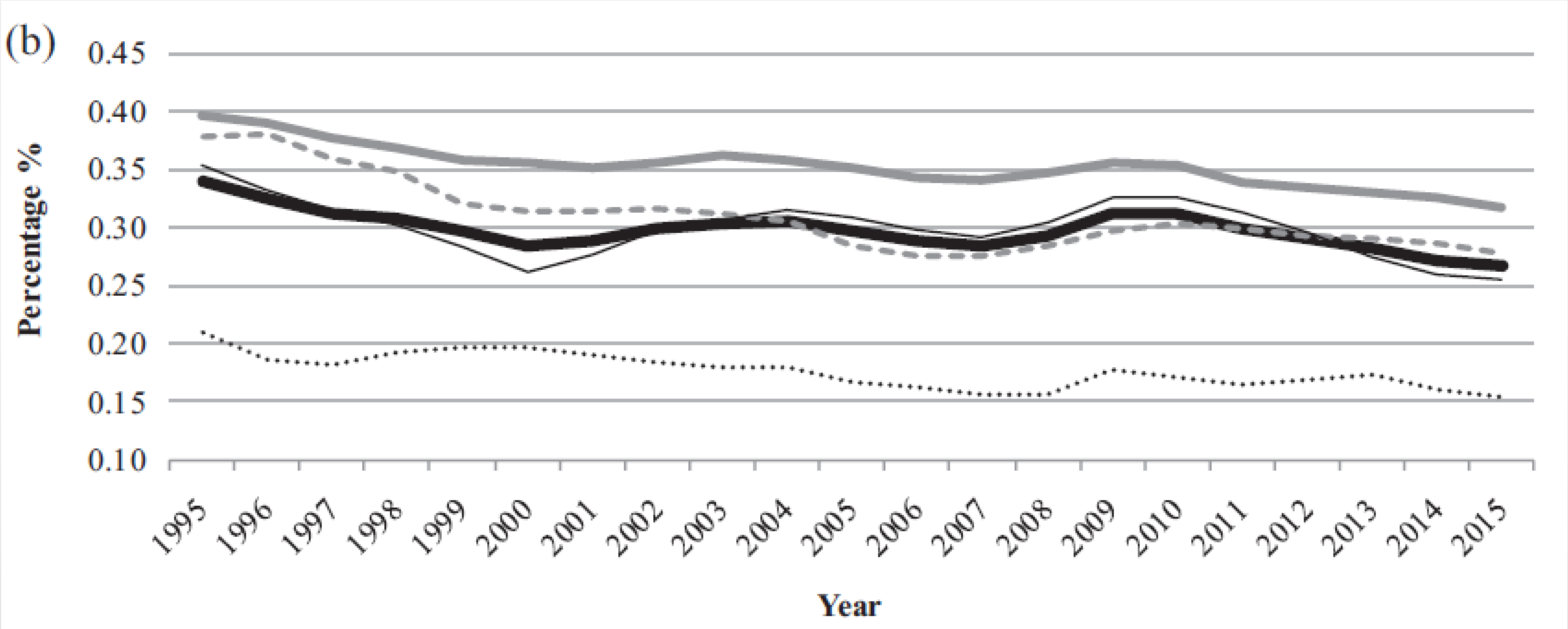


- All values are in current USD.
- **Sources**: UNESCO and OECD 2015-2017 , new edition available

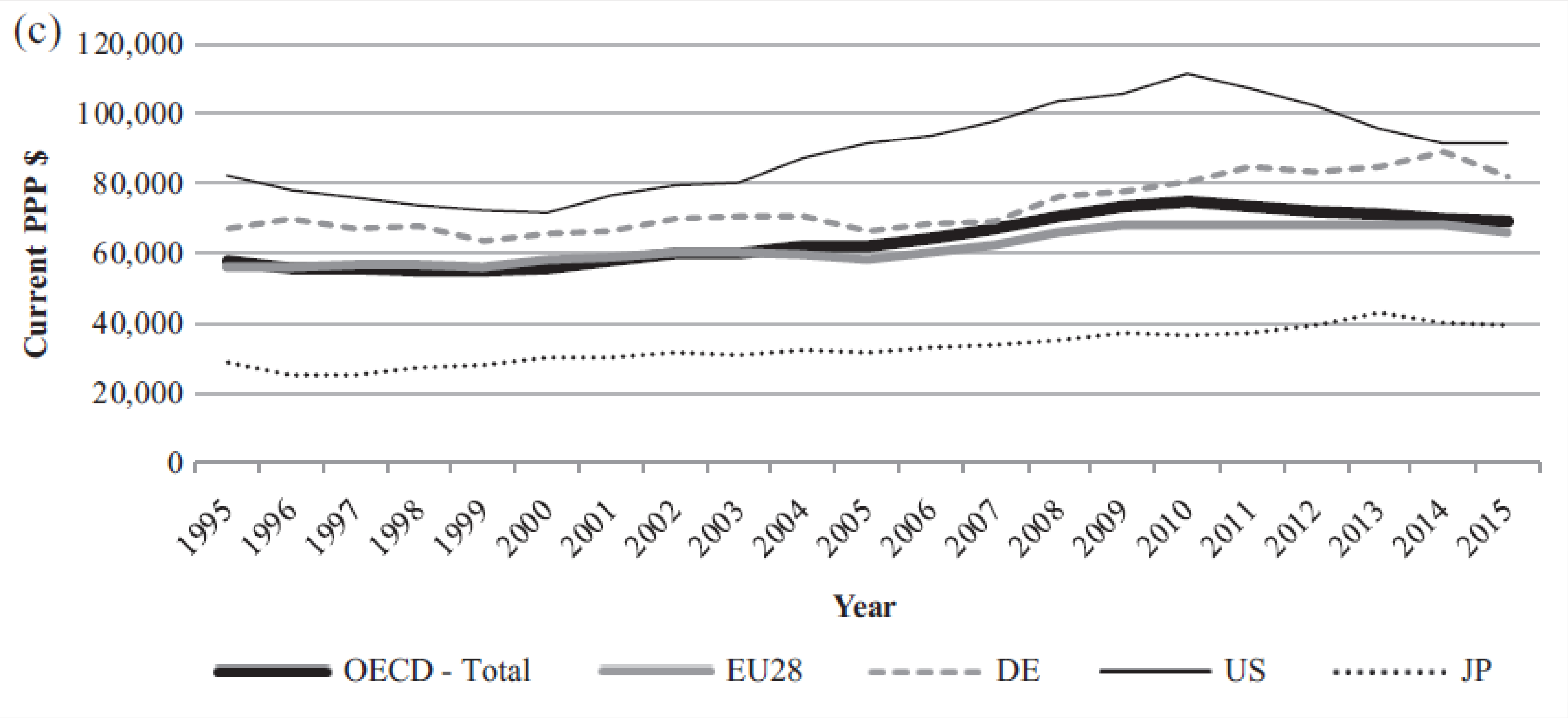
GERD per capita



GERD funded by government



GERD funded by government per researcher

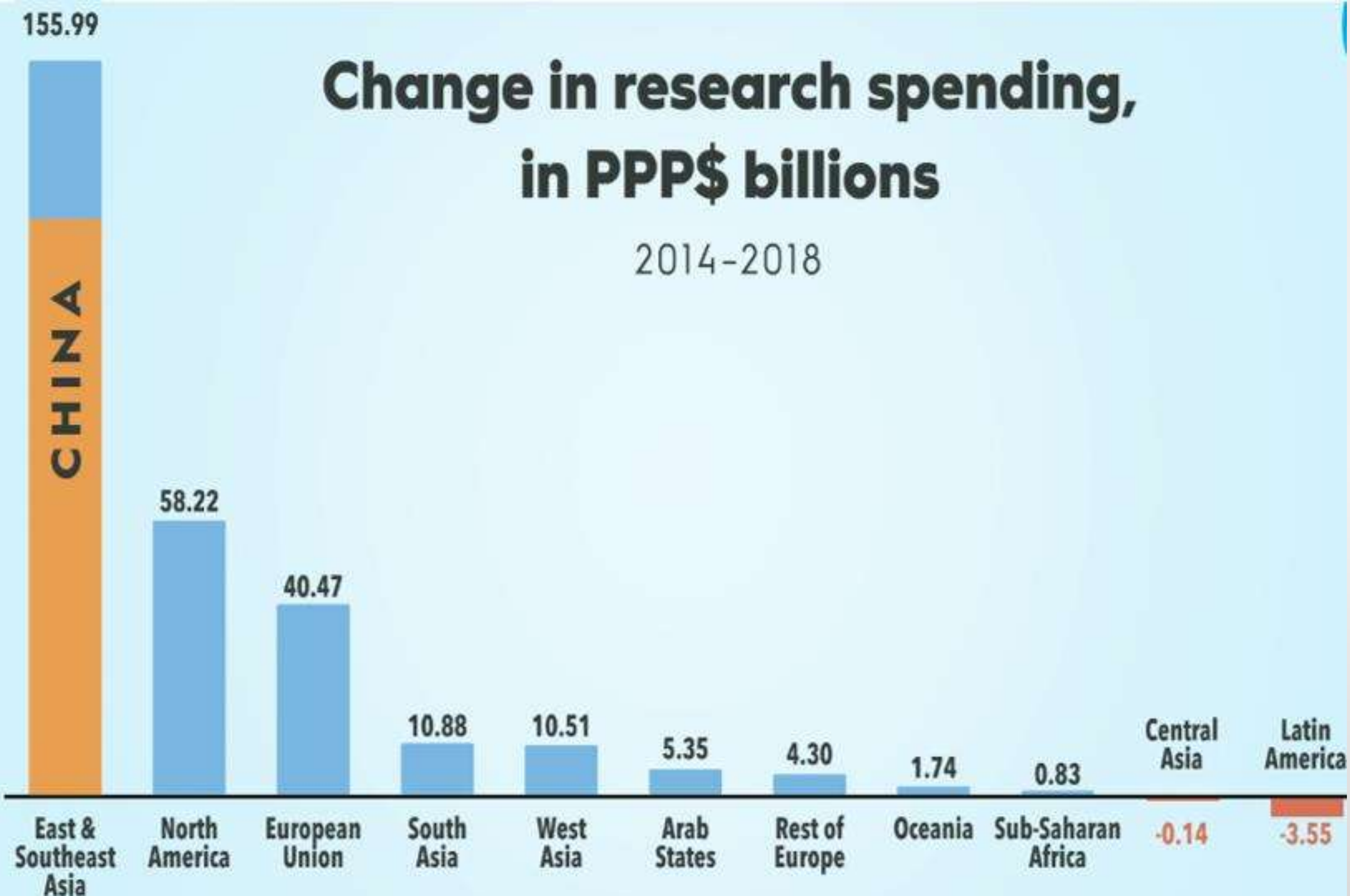


Nuovi dati

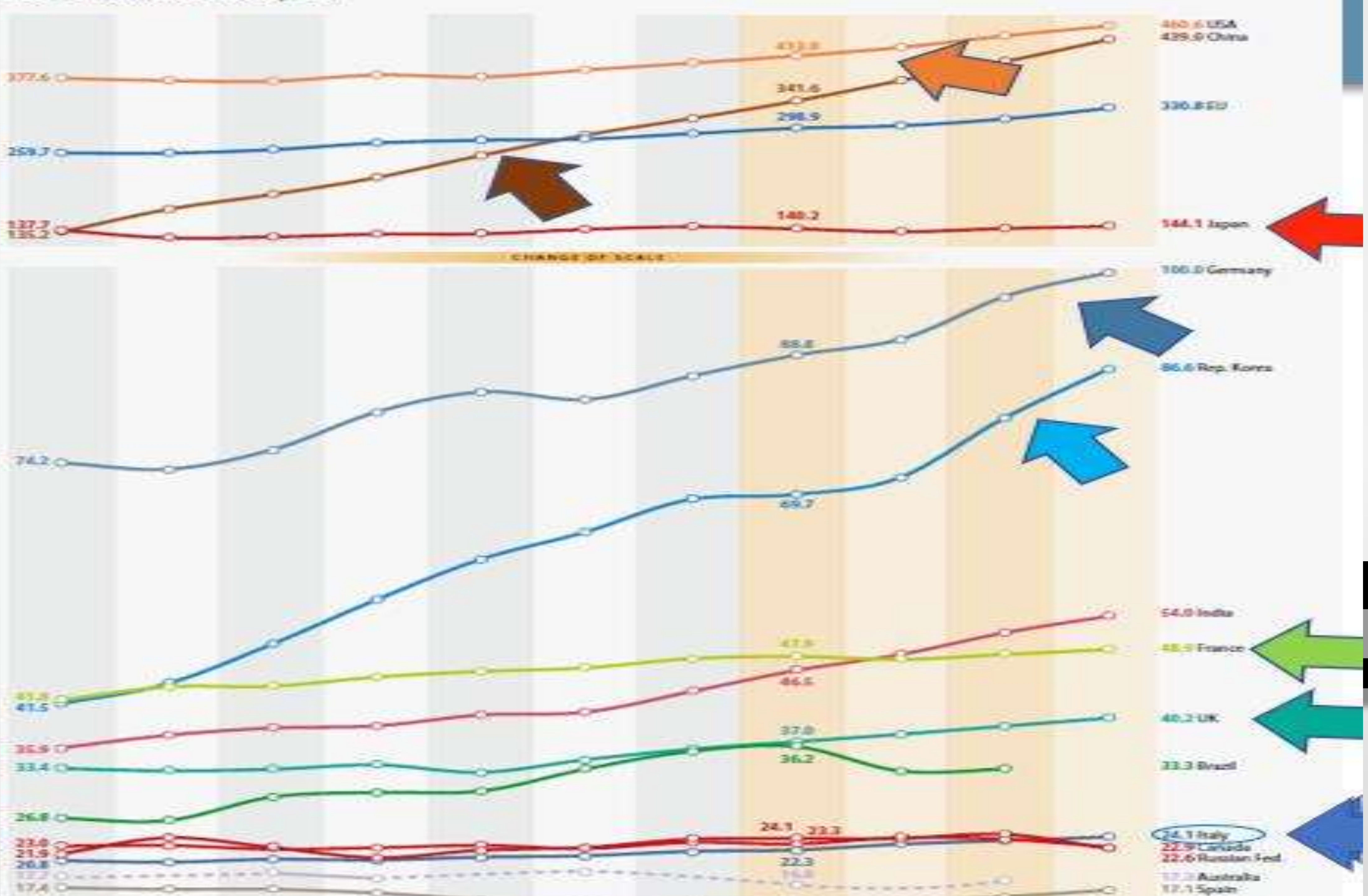
- According to OECD 2022, in 2020 there was a significant jump of **15 % increase of government budget allocations for R&D (GBARD) for the OECD area**
- (followed in 2021 by a limited decrease of 4.4%) compared to 2020)
- The available evidence suggest that such increase was driven by public expenditures on **R&D for health**
- which in any case is the sector where the overall increase of yearly budgets has been highest: **+ 300% in constant PPP dollars between 1991 and 2020**,
- a major driver of the 200% increase of total GBARD.

UNESCO SCIENCE REPORT 2021

https://www.unesco.org/reports/science/2021/sites/default/files/medias/files/2022/05/USR2021_PPT_Brussels.pdf



Change in research spending,
in PPP$ billions
2014–2018
155.99
CHINA
58.22
40.47
10.88
10.51
5.35
4.30
1.74
0.83
Central Asia
-0.14
Latin America
-3.55
East & Southeast Asia
North America
European Union
South Asia
West Asia
Arab States
Rest of Europe
Oceania
Sub-Saharan Africa


439.0 China
330.8 EU
144.1 Japan
CHANGE OF SCALE
100.0 Germany
86.6 Rep. Korea
54.0 India
40.2 UK
33.3 Brazil
24.1 Italy
22.9 Canada
22.6 Russian Fed
17.1 Spain
377.6
259.7
137.7
135.2
74.2
41.5
36.9
33.4
26.8
341.6
298.5
140.2
88.8
69.7
46.5
37.0
36.2
24.1
22.3

- Which projects should take **priority**, given their costs and unknown benefits?

- ***Lobbying for science***: the decision to fund highly expensive RIs is advocated by a coalition of scientists (supported by peer reviews and other experts) to convince policy-makers about the importance of a new project

- Economic analysis of infrastructures projects in other fileds (transport, energy, environment) has been proposed as a way to counterbalance **flawed arguments in investment decisions**

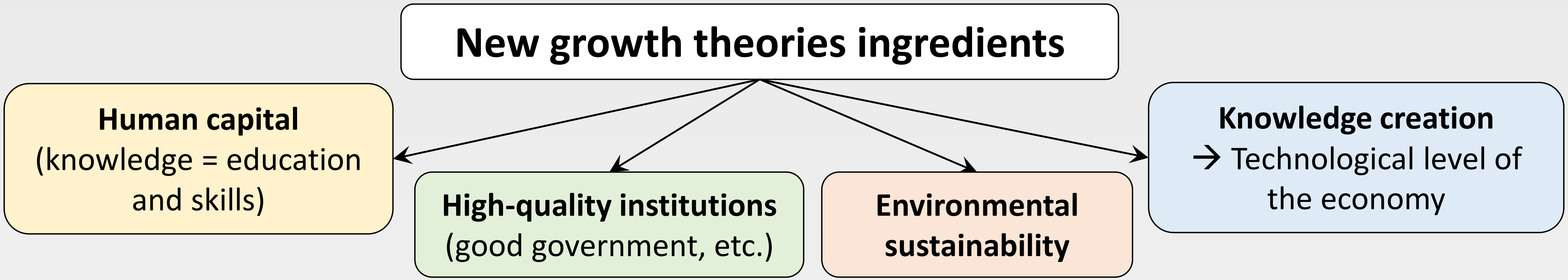
- ***CBA*****:** <u>**intellectual attempt to introduce economic rationality in public policies**</u>
- <u>**Macro vs microeconomics perspective**</u>

Growth theory (1): neoclassical

- Knowledge plays a prominent role in economic growth, as it has been acknowledged by macro-economic growth models which have evolved over time from very simple to more sophisticated specifications.
- Within the framework of neoclassical economics, the Solow–Swan model (1956) attempted to explain long-run economic growth by looking at capital accumulation, labor growth and increases in productivity, referred to as technological progress.
- It assumes a Cobb–Douglas production function where a single output (Y) is produced using two inputs, labor (L) and capital (C):
- $Y=C^{\alpha}(AL)^{1-\alpha}$
- where $0<\alpha<1$ is the elasticity of output with respect to capital and A refers to labor-augmenting technology or “knowledge”.

Growth theory (2): Solow model

- In the Solow-Swan model, the number of workers (i.e. labor) and the level of technology are assumed to grow exogenously.
- For this reason, the model is likely an unsatisfactory tool to explore long-run growth, as it predicted economies without endogenously determined technological change and thus eventually converging to a steady state with zero per capita growth.
- The hypoteses of exogenous factors (unexplained technical progress) determining long-run growth was later on heavily criticized by economists like Paul Romer and Robert Lucas, who developed new models where the key determinants of growth were explicitly accounted for, giving rise to the «Endogenous Growth Theory».



- **Governments** can contribute to growth by:
  - Policy supporting investments
  - Employment
  - Knowledge creation
- Research by private firms produces an **externality** as knowledge
- Once is created can easily s**pill over** (non everything can be keep secret), the returns of R&D expenditures by a firm may be captured by other firms
- Pri**vate investors** would invest in R&D less
- **Governments need to counteract this effect by funding research in areas where the private investors are not willing to invest**

Theory: endogenous growth models (3)

- According to this theory, economic growth is not the result of external forces but rather of endogenous factors. Investment in human capital, innovation, and knowledge are significant determinats of growth and great relevance is attributed to positive externalities and spillover effects.
- Specifically, in the long-run endogenous growth models of Romer (1986) and Lucas (1988) technological change is omitted and growth is assumed to be caused by indefinite investment in human capital which, having spillover effects on the economy, reduces the diminishing return to capital accumulation, leading to economic development.

Growth theory (4)

- The simplest endogenous growth model assumes constant exogenous saving rate and a fixed level of technology: the production function is a special case of a Cobb–Douglas function where the technological progress is modeled with a single parameter (A, the total factor productivity) and constant returns to scale are assumed (α=1):
- Y=AC

Growth theory (5)

- The strong assumption that the production function does not exhibit diminishing returns to scale is used to lead to endogenous growth.
- Various explanations have been given to support this hypotheses, such as positive spillovers from capital investment to the economy as a whole or the possibility of «learning by doing», that is improvements in technology leading to further improvements (Arrow, 1962).

Growth theory (6)

- The presence of technological or knowledge spillovers was explicitly modeled by Griliches (1979) who built a simple model in which the output of one firm depends on its own knowledge investment but also on the knowledge of other firms.
- The model hinges on the economic theory behind endogenous growth models, with two basic ideas underneath the general framework:
- the existence of increasing returns characterizing new knowledge
- and the existence of technological spillovers that arise from the particular properties (non-rivalry and partial-excludability) characterizing knowledge.

Growth theory (7)

- The Griliches (1979) model of within-industry spillovers relies on a two factor Cobb-Douglas production function:
- $Y_i = BX_i^{1-\gamma}K_i^{\gamma}K_a^{\mu}$
- where B is a constant, Y_i is the output of firm *i* which depends on the level of conventional inputs X_i, its specific knowledge capital K_i and the aggregate knowledge in the industry K_a. The coefficients (1 -γ), γ and μ represent the elasticities of output with respect to conventional inputs, own and external R&D capital respectively.

Growth theory (8)

- Taking the log of the Cobb-Douglas production function yields:
- $y_i = b + (1-\gamma)x_i + \gamma k_i + \mu k_a$
- where lower-case letters denote variables' log-tansformation.
- Therefore, the coefficient μ captures the impact of positive knowledge externalities on company *i* performance.

Growth theory (9)

- Such knowledge spillovers can be generated either by other private firms operating in the same (or in a linked) industry
- or by the public sector through organizations like RIs, agencies and State-owned enterprises.
- In the latter case, knowledge externalities may arise because of two mechanisms. A direct channel is public procurement
- In addition, an indirect channel stems from the social value of non-patenting inventions. Indeed, public entities like RIs are not always willing to patent the knowledge they generate, thus allowing private companies to do so, benefiting from the exploitation of the new process/product developed by, or in collaboration with, the RI.

Growth theory (10)

- The Griliches (1979) model accounts for the role of knowledge externalities assuming that the aggregate knowledge in the industry is simply the sum of all specific knowledge of each firm ($K_a = \sum_i K_i$), there is an optimal allocation of resources and all firms face the same relative factor prices. Therefore, aggregating all the individual production functions, yields:
- $\sum_i Yi = B \sum_i X_i^{1-\gamma} K_a^{\mu+\gamma}$
- As it can be noted, the aggregate production function has a higher coefficient of aggregate knowledge capital ($\mu + \gamma$) than the coefficient at the individual level (γ) because, besides the private returns, the aggregate production function takes also into account the spillovers to research and development.

Growth theory (11)

- A crucial implication of the endogenous growth theory is that the long run growth rate of an economy depends on policy measures. All of the policies that support research and development, education, competition, change and innovation will be able to promote growth.
- Public investment in these fields represents an fundamental tool to stimulate both physical and human capital accumulation, particularly infrastructures and employment.
- We can distinguish between alternative forms of policy measures: financial support provided by the State to private companies, direct State intervention by means of SOEs and public organizations, and indirect intervention through public procurement for innovation (PPI)
- Contributions by Romer (1990), Aghion and Howitt (1992) and Grossman and Helpman (1991) also incorporated imperfect markets and R&D in the endogenous growth model.
- Per una semplice introduzione: Musu (2007), Crescita Economica, Il Mulino.

Conceptual framework (Romer 1)

- «Too little human capital is devoted to research
- 1st reason: positive external effects
- An additional design raises the productivity of all future individuals who do research
- But because this benefit is non excludable, it is not reflected at all in the market price for designs

Conceptual framework (Romer 2)

- 2nd reason: research produces an input that is purchased by a sector that engages in monopoly pricing
- The markup of price over marginal cost forces a wedge between the marginal social product of an input used in this sector and its market compensation

Conceptual framework (Romer 3)

- [...] Both of these effects cause human capital to be undercompensated[...]
- the marginal product in the research sector is higher than the wage because the price of the
- patent captures only part of the social value of the patent...
- As a result, in equilibrium, the marginal value of an additional unit of human capital is higher than the market wage»
- (Romer, 'Endogenous technological change.' Journal of Political Economy 1990

Verifiche empiriche (1)

- Georghiou Luc, Guellec D, Ostry J, Revoltella D, Soete L, Veugelers L, 2017, “The economic rationale for public R&I finding and its impact”, European Commission

- -According to Georghiou et al (2017) in a survey of the economic justifications and impact of public funding of R&D activities, an increase of aggregate R&D investment of 0.2% of GDP would create an increase of 1.1% of GDP.
- This would be a rate of return of over 500% per Euro spent, not considering social benefits not accounted for GDP (e.g. life expectancy).
- The empirics of these calculations is however tricky, as the same authors report the traditional result that at firm level the net return would be between 10-30%. The externality, id est the gap between private and social returns, would hence be huge.
- The economic returns to public funding of private R&D has been estimated around 20%. The variability of findings across countries, industries, fields, and time is very large.

Verifiche empiriche (2)

-Gheorghiou et al (2017) suggest that:

public funding of private R&D investment is needed because of five bottlenecks faced by firms:

a) scientific, technological and market risk;
b) high investment, high sunk costs and long time lags before paybacks;
c) inability to fully appropriate the R&D returns;
d) lack of financing;
e) spillovers to other firms.

Verifiche empiriche (3)

- A survey of firms by the European Investment Bank (EIB Investment survey, finds other constraints, particularly general uncertainty, lack of staff with the right skills, business regulations.
- High sunk costs are often needed for market-creating disruptive technologies.
- These arguments have supported the view that government should offer subsidies in different forms to ‘first mover’ companies, usually without much consideration of the distributive impact of this transfer of resources from taxpayers to investors.
- Or perhaps with the belief that in turn taxpayers will benefit at a later stage.

Conclusione: Politiche pubbliche per RDI

- State support to RDI can follow different channels:
- 1) support to private firms R&D, using tools like subsidies and fiscal incentives;
- 2) direct intervention through State-owned enterprises (SOEs);
- 3) direct intervention through the collaboration with and the funding of (*mission-oriented*) public organizations like knowledge agents, such as public agencies, research universities, large research infrastuctures (e.g. CERN, ESA, NASA, EMBL, NIH);
- 4) indirect intervention through public procurement for innovation, which in turn can be managed through SOEs or other public organizations

The RI concept

- RIs are the large scale government response to a market failure
- But also create entirely new investment opportunities
- Hence we need to analyze the social efficiency of such a public intervention
- Applied welfare economics approach
- CBA,the microeconomics of public projects and policies
- Macro and “meso” of R&D empirics well established