

Economic Growth and Welfare Systems

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Endogenous growth theory



Models

- ▶ **Texts:**

- ▶ **General AK model**

- ▶ **Romer 1986: (Increasing Returns and long run growth, JPE)**


- ▶ **Readings**

- **Romer 1990: (Endogenous Technological Change, JPE)**
- **Barro 1990: (Government Spending in a simple model of Endogenous growth JPE)**
- **Barro 1991: (Economic Growth in a Cross Section of Countries QJE)**
- **Lucas 1988**

From Kaldor to endogenous growth

- ▶ Convergence in growth rates in income levels is one of the major result of the exogenous growth theory (neoclassical)
- ▶ But... There is no evidence of significant convergence in growth rates of per capita income between countries in the world

Endogenous growth theory

- ▶ Technological progress (TP) is endogenous, in a sense that new ideas are embedded in new products which bring about new ideas (and as well new habits)
 - ▶ → endogenous technological change
 - ▶ Romer: endogenizes TP by introducing the search for new ideas by reserachers interested in profiting from their inventions
 - ▶ TP driven by R&D
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The AK model $Y_t = AK_t$

- K stands for the set of capital factors reproducible in the broad sense, also the knowledge, capital goods created by public spending.
- The non-accumulating factors (for example unskilled Labour) are of no importance (so it means that the model is valid only for advanced economies).
- Then $K =$ Human capital and physical capital.
- Suppose that the number of L which is attributable to the L component of Human Capital in K coincides with the labour supply, that is, there is full employment FE.

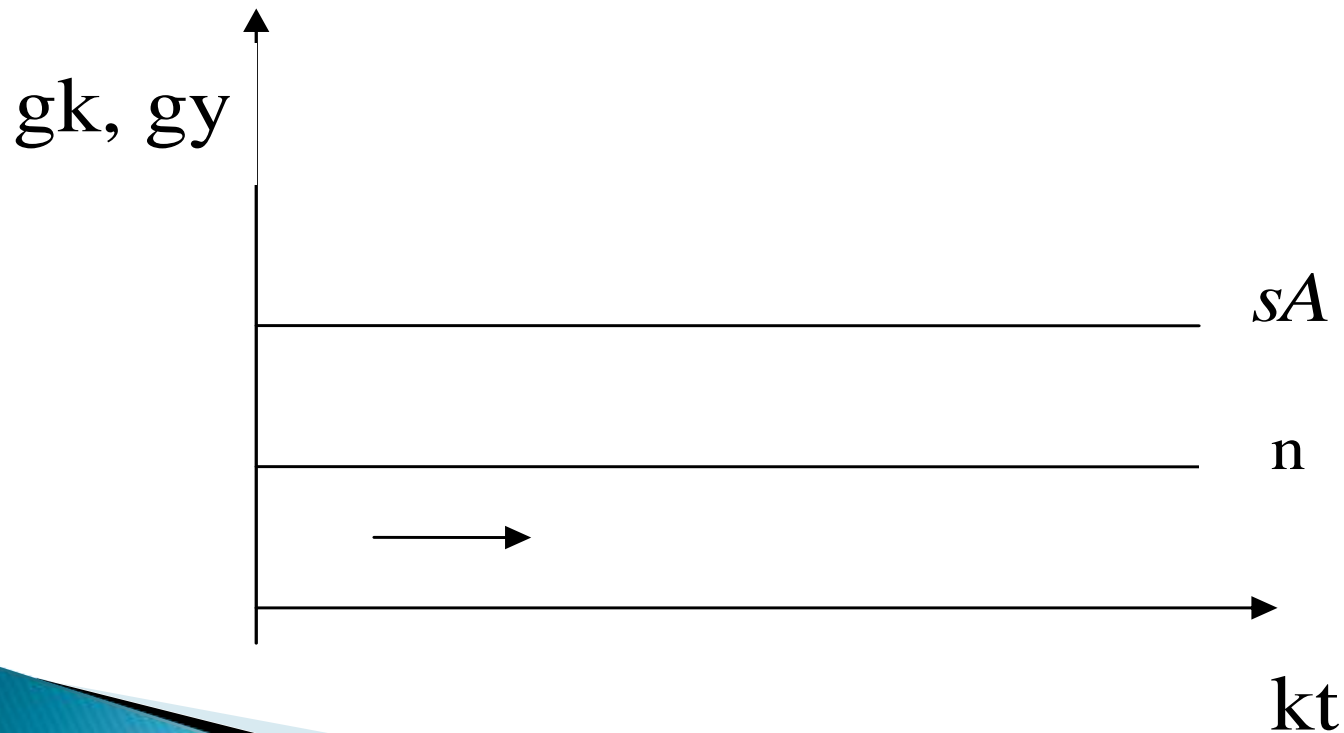
$$y = Ak$$

$$g_y = g_{kt} = g_{Kt} - n = \frac{I_t}{K_t} - n = \frac{sAK_t}{K_t} - n = sA - n$$

Non convergence $sA - n$

- ▶ The growth rate of $Y / L = (sA) - n$.
- ▶ In this case the saving rate affects the rate of growth of long run as opposed to what happens in Solow M.
- ▶ In this case also the returns to scale are still constant (or increasing, if A has a exponent > 1), but the productivity of K is constant, the growth rate is non convergent

Non convergence sA-n graphically



Romer model (general form of increasing returns)

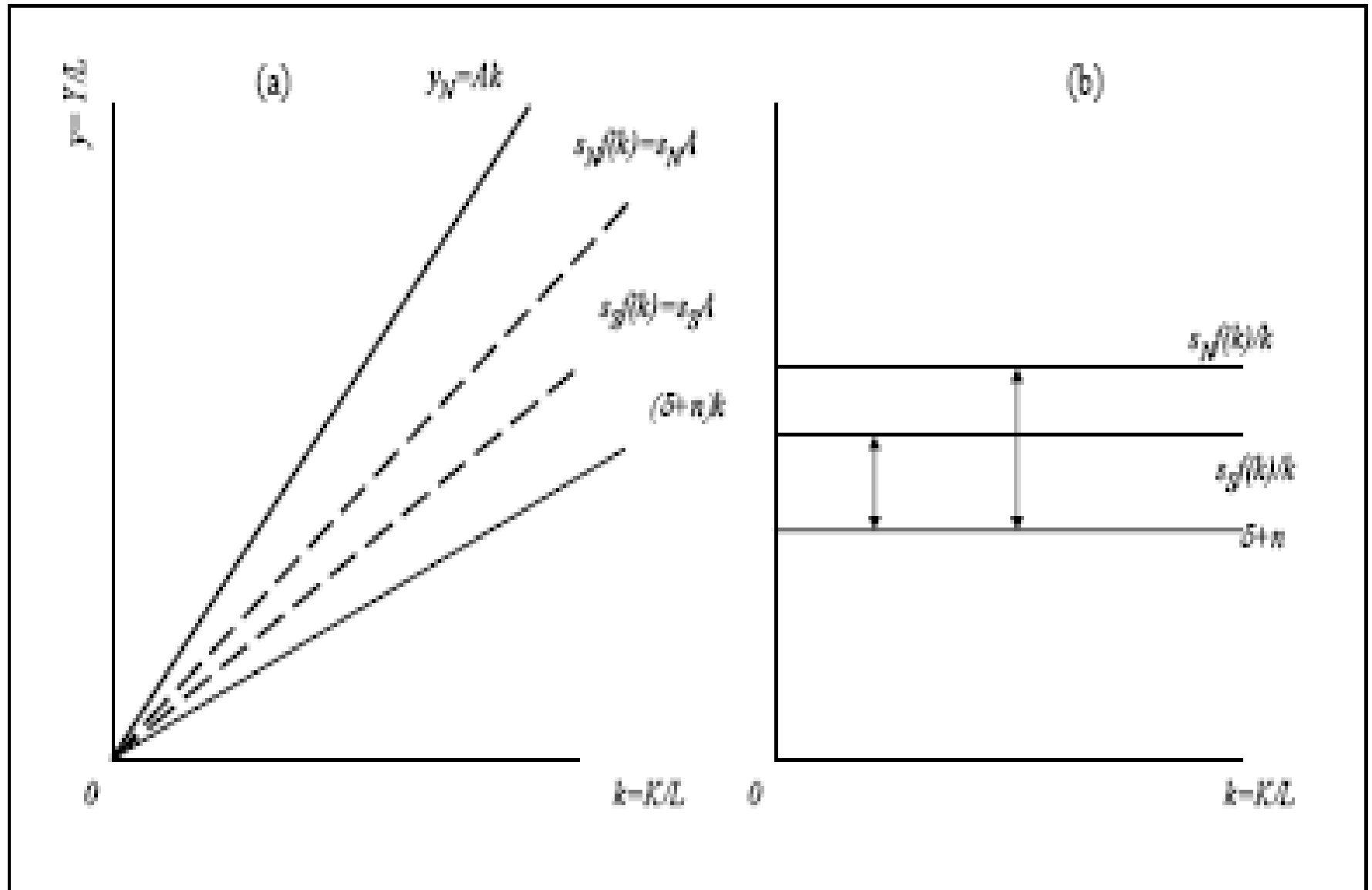
$$Y = K^b L^{1-b} K^d$$

$$d \geq 1$$

K^b Internal to the single firm with constant return

K^d “external” to firms, composite capital good/public good (knowledge) with increasing returns able to compensate the traditional decreasing MPK of physical capital

La crescita capace di autoalimentarsi nei modelli di crescita endogena non implica il raggiungimento di alcun equilibrio di stato stazionario → non sussiste alcun limite *a priori* all'espansione



Consequences

- ▶ Productivity grows at a constant rate, and now it is endogenous in the sense that it depends on **the size of A**, that with various technologies everywhere can be affected by a **country effect**. An increase of s increases the growth rate not only temporarily but also permanently.
- ▶ So countries may grow with different growth rates and there **is no convergence**.
- ▶ Moreover, if $\downarrow K/L$, this does not cause a temporary increase in the rate of growth, but with less “K” (human capital, skills, ideas, physical cap, technology) countries will grow less and **convergence will not occur**.

Romer (R&D)

$$Y = K^\alpha (ALy)^{1-\alpha}$$

Constant return to scale in K and Ly for a given level of technology (A)
Increasing return to scale for all 3 variables (including A, the level of technology)

A, an idea of a new Iphone, will bring about increasing return for K+L+A,
but constant for K+L
(the same new idea will be used for many possible combinations of K and L for a country to create millions of Iphone having therefore increasing returns)

K and L as in the Solow model :

$$\dot{K} = S_K Y - dK$$

$$\frac{\dot{L}}{L} = n$$

Difference Solow # Romer

- ▶ The new equation of TP in Romer
- ▶ In Solow, A grows exogenously at constant rate
- ▶ In Romer A is endogenous
- ▶ A is the stock of Knowledge, the number of new ideas invented so far
- ▶ $\dot{A} = \bar{\delta} L_A$ is the number of new ideas produced at any given point in time, the growth of the stock A .

L_A is the number of researcher s

$\bar{\delta}$ is the rate at which they discover new ideas

A is endogenous

If the invention in the past raises productivity of researcher today

→

$\bar{\delta}$ is an increasing function in A (it increases when A increases)

Alternatively, initially is easier to discover (obvious) ideas, and then is more and more difficult

$\bar{\delta}$ is a decreasing function in A (it decreases when A increases)

$$\bar{\delta} = \delta A^\phi$$

$$\delta, \phi = \text{const} \tan t$$

$\Phi > 0 \rightarrow$ productivity of research increases with the stock of ideas that have already been discovered

$\Phi < 0 \rightarrow$ productivity declines because “fish become harder to catch over time”

$\Phi = 0$ productivity of research is independent of the stock of Knowledge

!Newton was benefiting from previous research (+spillover) made by Kepler

$\Phi > 0$

The importance of Researchers

- ▶ The average productivity of research depends on the number of Researchers L_A

$$\dot{A} = \delta L_A^\lambda A^\phi$$

$0 < \lambda < 1 \rightarrow L_A \uparrow$ (positive externality but less than one because of possible duplication...)

$\phi < 1$

In this context an individual Researcher worker may have constant return, given δ constant. However the economy as a whole will have increasing returns to scale

$$\text{HP: } L_y + L_A = L \rightarrow L_A \rightarrow \text{R\&D (Sr)}$$

$$S_r = L_A / L$$

KBE: $g_A \rightarrow g_Y$

▶ $G_Y = G_K = G_A$

- ▶ So then the question is, what is the rate of growth of Technological progress along a balanced growth path?

▶ The answer is: $\frac{\dot{A}}{A} = \delta \frac{L_A^\lambda}{A^{1-\phi}}$ and using log and derivative:

Along a balanced growth path A/A is constant. But this will be constant only if numerator and denominator grow at the same rate, so that the difference is equals to zero

$$0 = \lambda \frac{\dot{L}_A}{L_A} - (1 - \phi) \frac{\dot{A}}{A}$$

$$\frac{\dot{A}}{A} = g_A$$

$$\frac{\dot{L}_A}{L_A} = n$$

$$g_A = \frac{\lambda n}{1 - \phi}$$

Along a balanced growth path the growth rate of num of reseracher must be equal to pop growth

Long run growth

- ▶ It is determined by the parameters λ and ϕ for ideas (\rightarrow exponents of L_A and A) and by the rate of growth of researchers (equal to n)

- ▶ If $\lambda = 1$ and $\phi = 0$ from $\dot{A} = \delta L_{A^\lambda} A^\phi$

$$\rightarrow \dot{A} = \delta L_A$$

i.e.:

$$g_A = \frac{\lambda n}{1 - \phi} \Rightarrow n$$

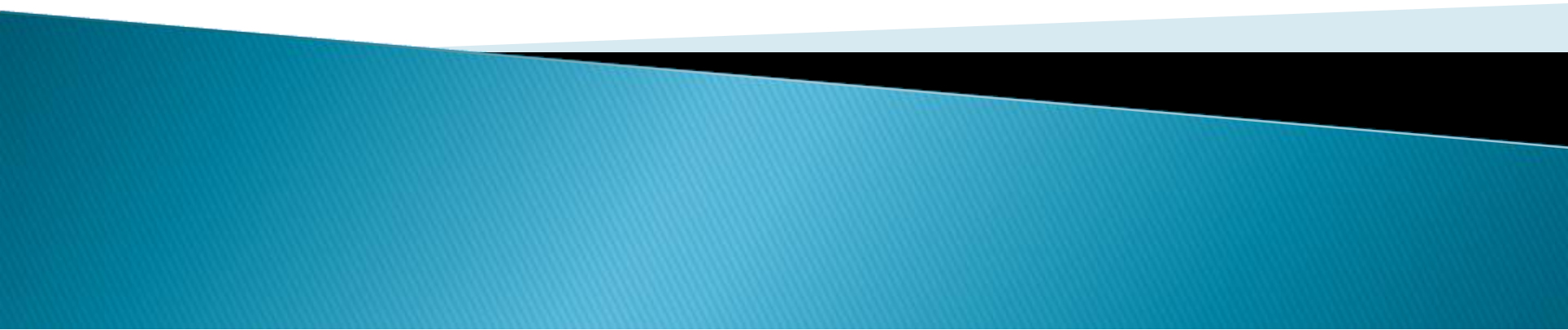
exponential growth

- ▶ In order to generate exponential growth the number of new ideas must be expanding over time.
- ▶ This occurs if the number of reserachers is increasing, for example because of population growth or because states invest more in R&D and new researchers are employed (**see next fig**).
- ▶ More n \rightarrow More researchers \rightarrow more ideas \rightarrow +growth
- ▶ In this model then eco growth is clearly correlated to n

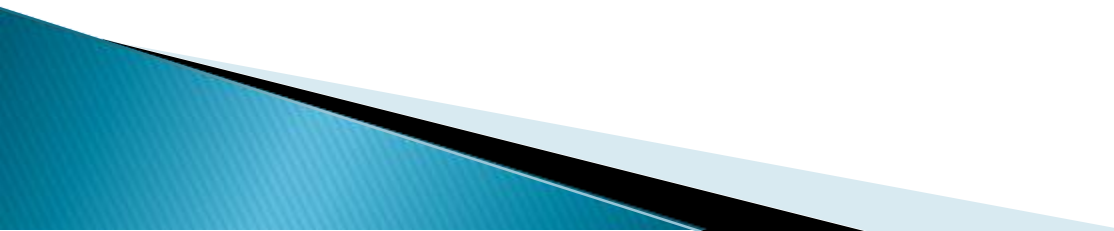
#neoclassical and endogenous growth

- ▶ In Solow a higher n reduce the level of income along a balanced growth path
- ▶ More n means that more K is required in order to keep K/L constant, but K runs in diminishing returns
- ▶ In endogenous growth instead there is no such a diminishing return, and more people generate more ideas and increases growth

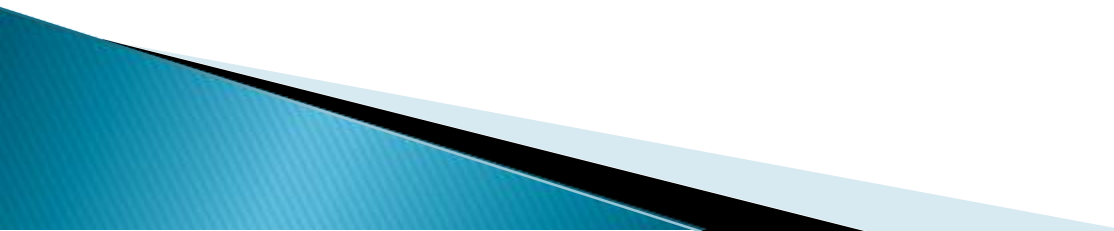
Endogenous growth discussion, critics and comparison with neoclassical growth model



The endogenous growth theory

- ▶ The endogenous growth theory has taken the position of not kaldorian convergence
 - ▶ Seeks to overcome the models of Solow and Swan relying on not established-convergence in reality
 - ▶ However it shares the neoclassical methodology and it takes several postulates, first of all the FE of N – flexibility of p
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Limits and specification of EGT

- ▶ So the main goal of this theory, demonstrating the non-convergence, is demonstrated only by pushing forward the reasons that can give rise to different levels of productivity in different countries.
 - ▶ FE of N – flexibility of p
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Without FE \rightarrow Harrod Domar

- ▶ If one recognizes that there is a reserve of unemployed labour, the explanation of the NON CONVERGENCE is already in the Harrod Domar model and also in the classic model (Marx/Ricardo).
If there is no FE, income per capita of c_1 can continue to grow more than c_2 not only because of productivity but also because income grows faster

Back to Harrod Domar


- ▶ It is sufficient then to explain the different growth rates of y , to consider different rates of s and I . In the model of Domar growth rate of y , $g = s/v$. Given n , the growth rate of y p.capita ($s / v - n$) is determined for every n .
- ▶ It should also be noted that regarding growth differentials in productivity, for economists less tied to the neoclassical school, there was no need to create a "new" growth theory (EGT).
- ▶ It exists already the Kaldor model on technological progress, and also those based on real analysis of diffusion of technological progress differentiated technological gap, etc (Schumpeter).

Endogenous vs exogenous

- ▶ The endogenous growth theory is opposed to the results of the theory of exogenous g as it goes in search of endogenous elements to the economy and therefore the economic analysis that can affect productivity growth differently in different countries.
- ▶ In contrast, growth in the exogenous growth path towards which the economy converges is characterized by a constant rate of productivity growth completely exogenous (and technical progress is not affected by endogenous elements, by contrast is a free-good, “sent by God and accessible to all”)

EGT vs NT

The Fundamental hp of the Neoclassical theory for the convergence are two:

1. PMK decreasing and PF with constant returns to scale.
 2. TP as a free good exogenously given.
- ▶ The Endogenous Growth Theory deals with the problem of non-convergence through two roads:
1. Replaces the first neoclassical hp with that of endogenous TP. Every country has its own
 2. Expand the concept of K, that is a “reproducible factor”, so as to eliminate any factor complementary to it, and then also the cause of its descending MPK (K reproduces itself, so it is not necessarily required $K + L$ to maintain a constant Productivity)
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HP of EGT

- ▶ Each of these 2 hp is able to explain the non-convergence (NC)
- ▶ The TP is not available in all countries = and is not a free good, it basically depends on factors endogenous to the specific country.
- ▶ Therefore, the Advanced Economies will continue to have faster growth because of their acquired skills in terms of TP, and the developing countries to have a slower growth, with the result that in the long run divergence occurs

Capital “self-reproducing”

- ▶ The K unlike the land and the unskilled labour is reproducible in the production process. Together with the TP , K is a force of development
- ▶ The Neoclassical theory has always thought that K can not work alone but needs to be associated with factors not reproducible. Accordingly, the MPK will be decreasing.
- ▶ THE MPK is decreasing as long as the same process that reproduces K is not able to reproduce as well the complementary factors of it (L and T).
- ▶ If everything were reproducible then there is no reason to assume PMK descending.
- ▶ Today it can be assumed that the skilled labour – the human-capital is reproducible.
- ▶ So it can be assumed that both the human and physical capital are reproducible.

Increasing returns

- ▶ Echoing Smith and Kaldor EGT assumes therefore increasing returns to scale achieved through increases endogenous productivity.
- ▶ In the neoclassical framework that does not reconcile with perfect competition and orthodox formalization.

The EGT justifies it introducing externalities' (Ex. Education, Roads, Pollution, INNOVATION, etc).
(vd. Another ppt)

- ▶ The individual firm can still have constant returns but because of the positive effects of spillovers' (.....), the overall economic system will have Increasing returns

Endogenous growth and the absence of convergence

- ▶ The wider the K the greater its productivity growth because of increasing returns of scale or externalities (eg. Learning by doing). Ex. Ideas of laptop, app, apple, etc
- The constancy of the rate of return of factors implied by the endogenous growth leads to the constancy of the ratio $K / Y \rightarrow$ capital accumulation is independent of the quantity of K

Critics

- ▶ How can one justify the lack of unskilled labour?
- ▶ In developing countries this is impossible
- ▶ How can be reconciled the HP of FE?
- ▶ If one would remove it, easily would return to the Harrod–Domar model where the rate of growth of the product (s / v) and the product per capita ($(s / v) - n$) are "endogenous", but not that of output per worker (Y / L), due to the absence of FE

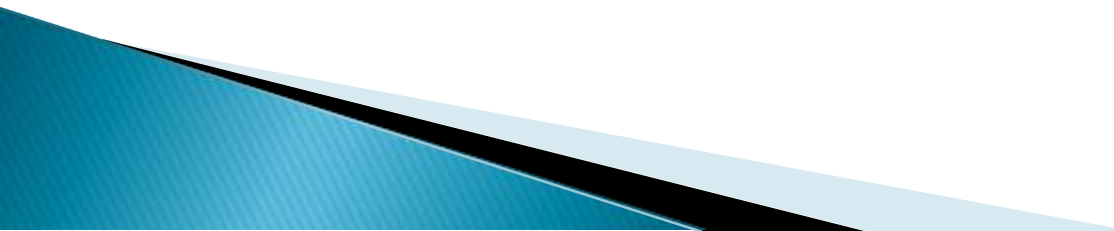
Comparison EGT/Harrod-Domar

- ▶ The EGT model could fit also in LDC if unskilled work would be possible (without FE)
- ▶ In this case, w is not of FE but of subsistence.
- ▶ Is then blocked the possibility of substitution between unskilled labour and other factors based on flex. of prices, and the model operates as if there were a Production Function with fixed coefficients.
- ▶ In this way we would come back to → Harrod Domar.

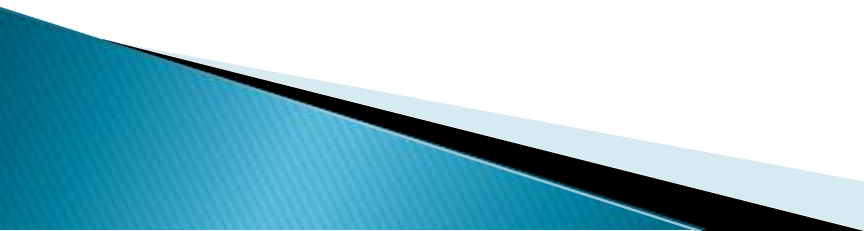
Important observation

- ▶ Of the 2, one must be true:
 1. either the model AK applies only in cases where there is no unskilled L, AE, (but then its application in developing countries is zero), or
 2. if there is skilled and unskilled L, the AK model does not provide a new contribution with respect to HD model.
- ▶ It Remains a model of endogenous growth of Y, and of Y per capita (Y / N) but not of productivity (Y / L)

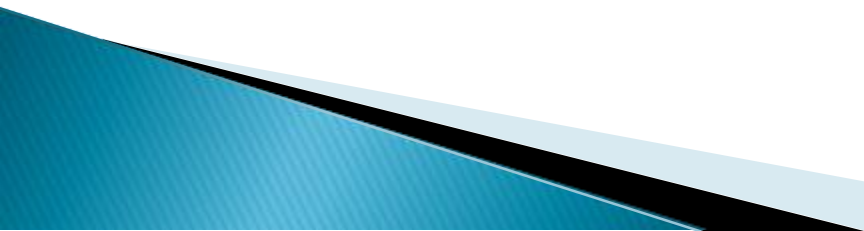
Endogenous growth and divergence

- ▶ A different growth rate of accum. of K , although constant, can increase gaps between the levels of income per capita of different countries,
 - ▶ If they are poor countries without TP they will have lower growth rates.
 - ▶ In many cases, according to the EGT, the future capital stock is a function of the present stock of capital
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The lack of convergence concerns

- ▶ Income levels
 - ▶ the growth rates of y
 - ▶ both
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- ▶ The differences in observed income levels are due to temporary imbalances between the actual investments and required investments (for FE).
 - ▶ If there is absolute convergence gap occurs only during the transition to the SS
 - ▶ The differences in growth rates are consequence of the distance from the SS
- 

The lack of convergence

- ▶ The lack of convergence in income levels is between two countries with different initial conditions.
 - ▶ The divergence can also affect the two countries that share the same initial conditions.
 - ▶ Neoclassicals tend to exclude the association between adverse initial conditions and lower growth rates
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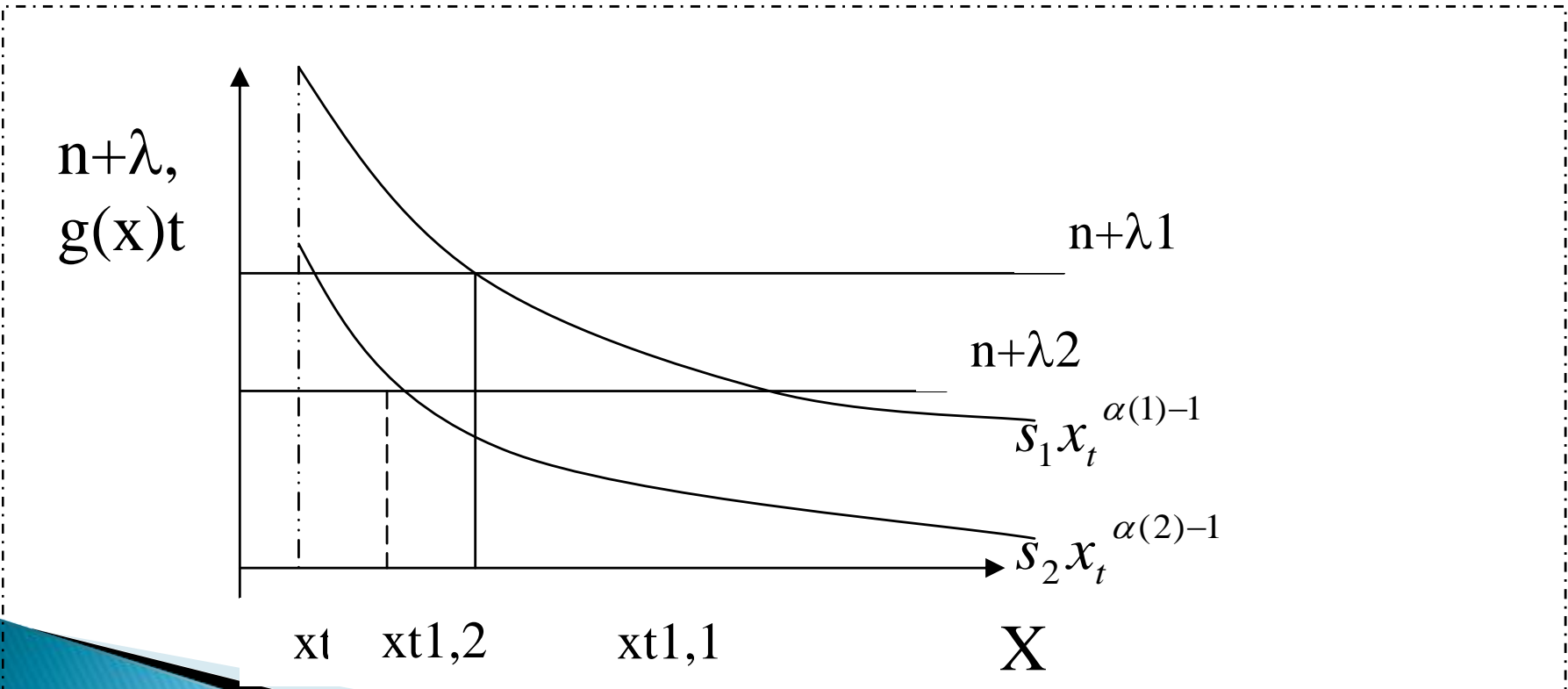
Economic policy

- ▶ each country may have a divergent long-term dynamic compared to other countries.
- ▶ if poorer countries could avoid underinvestment and adopt an appropriate strategy not to suffer from differences in “fundamental parameters“, gap in growth rates between rich and poor could be overcome and the per capita income of the “poor” countries could “converge” to that of the “rich” countries.

Barro equations

- ▶ B. not only focuses on the assessment of conditional convergence. B. admits that countries can differ for both the growth rates of transition (on different SS) and the growth rates of SS. The basic idea is that another variable, economic policy, can support the economic development, or not.

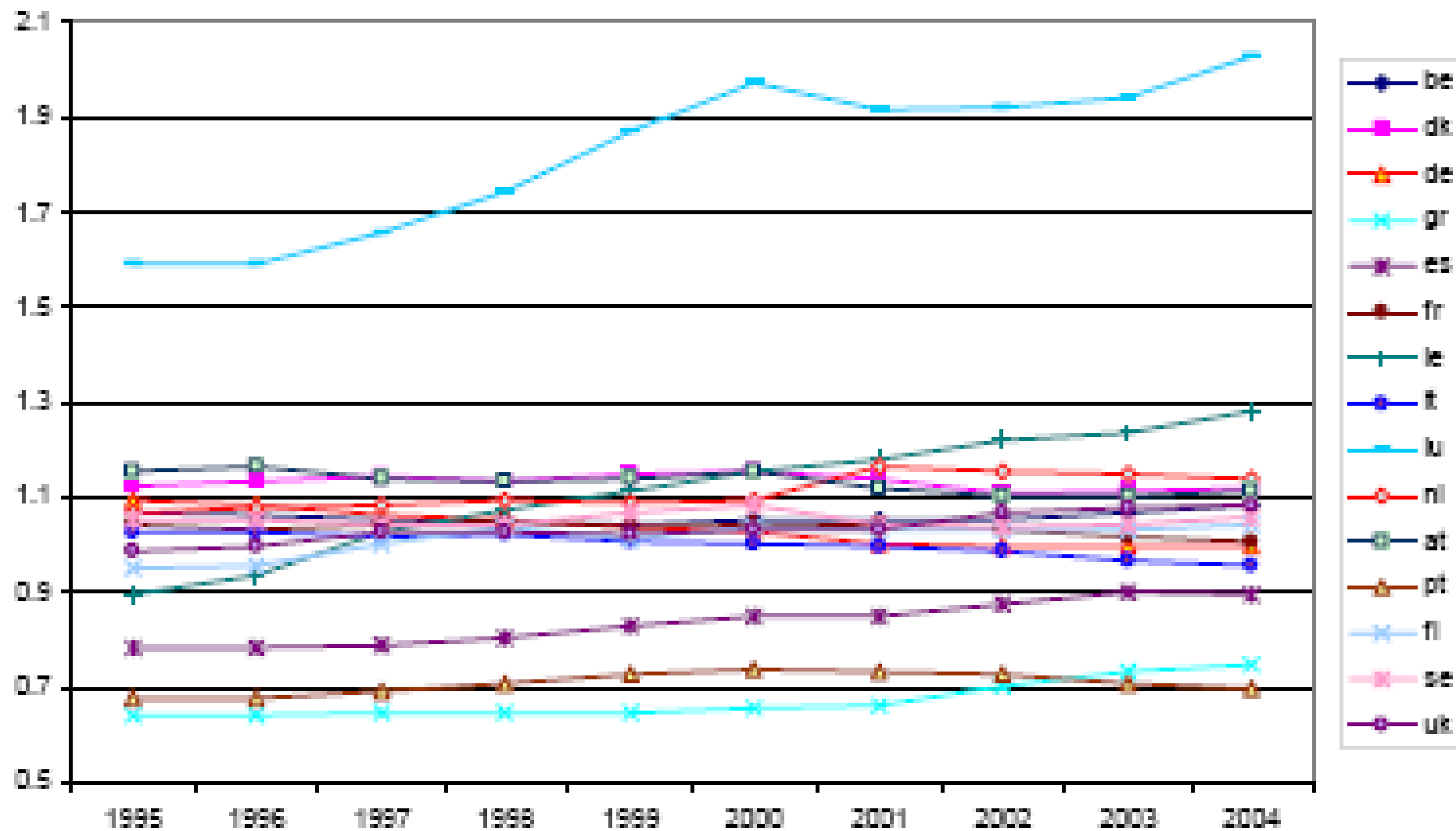
Besides the differences in s_2 (savings) and α (productivity), Barro introduces a third difference, λ , (technical progress), which is assumed to be specific for each country and can be conditioned by their economic policies



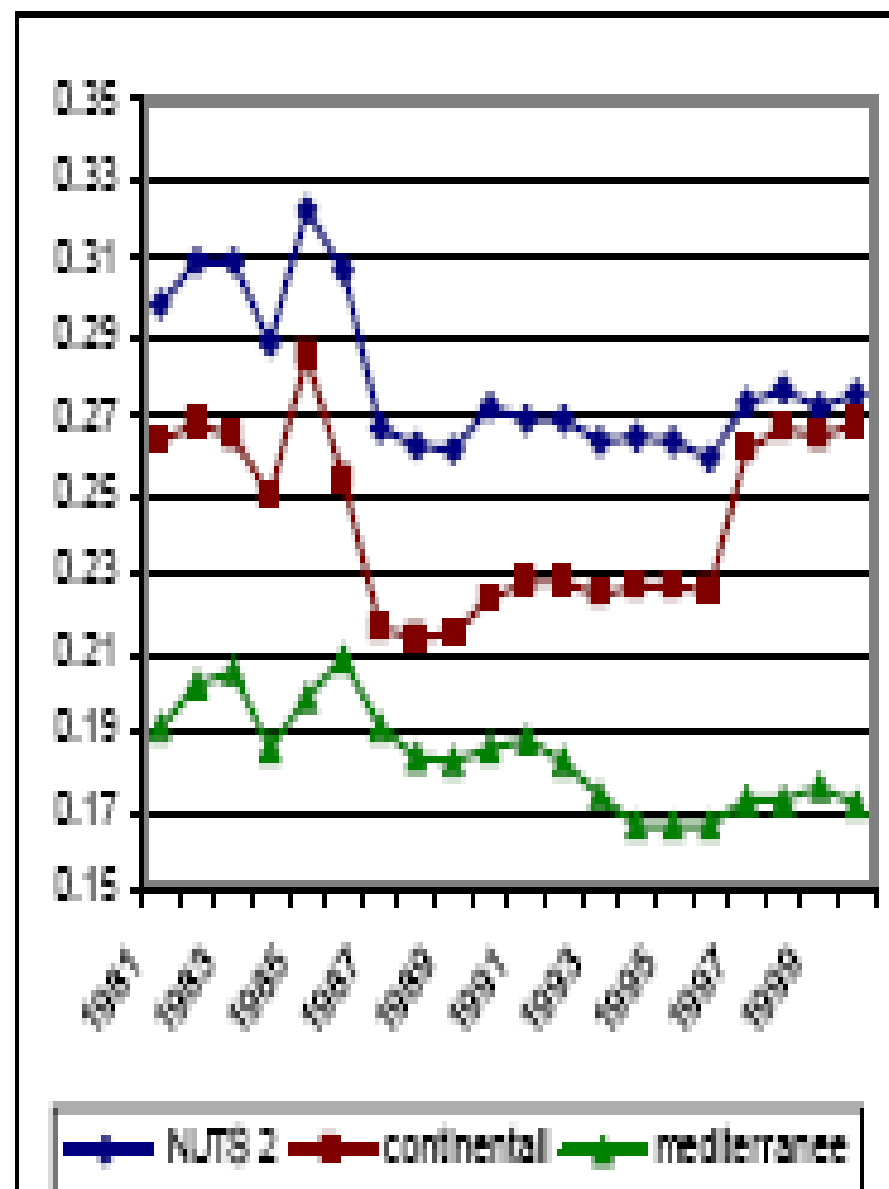
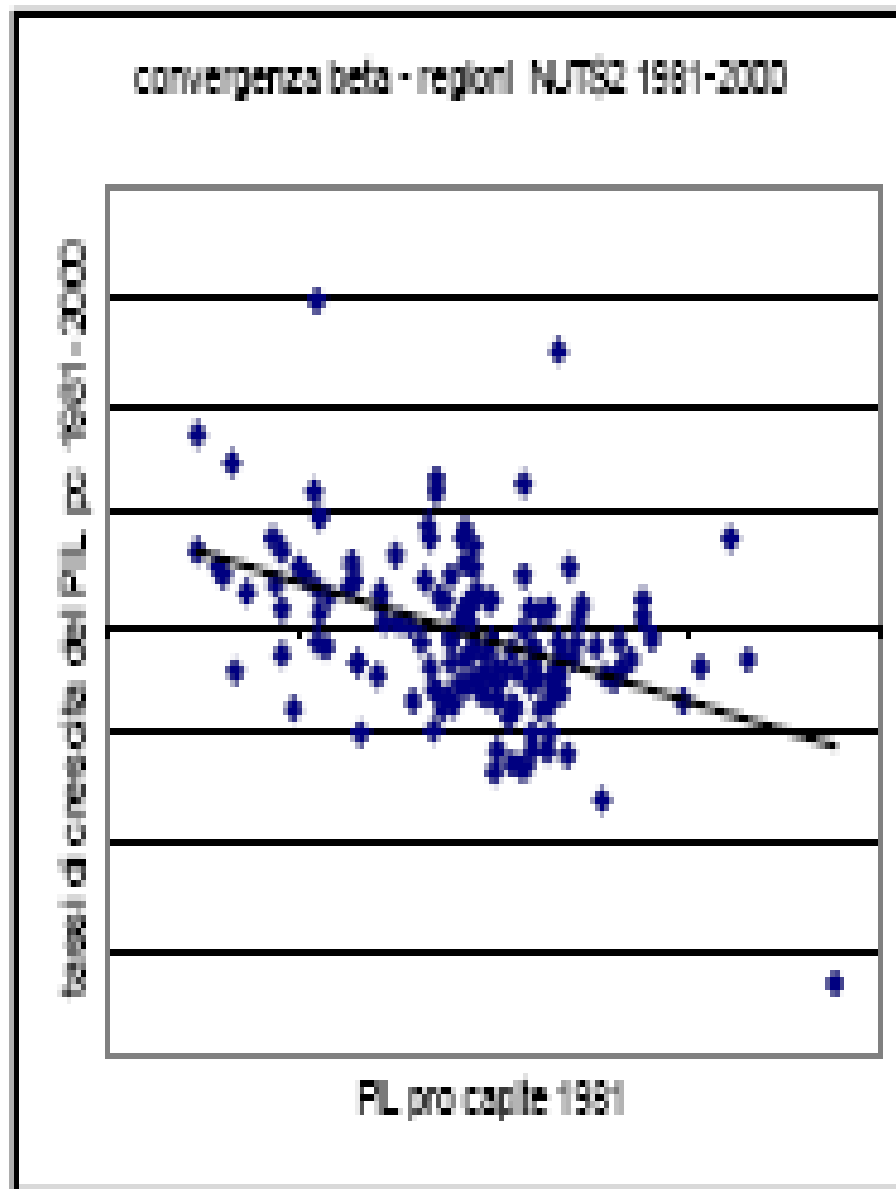
Conclusion (from Barro)

- ▶ The C1 not only maintains a growth rate of transition $>$ of C2 but also converges towards a growth rate of SS bigger.
- ▶ Thus C1 will reach a path of SS $x_1 > x_2$ and also from that point will continue to grow by more

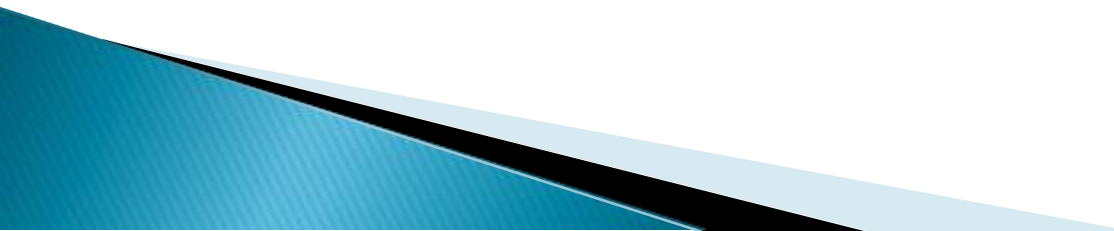
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Convergenza beta e convergenza sigma



Multi determinants

- ▶ Specialization, and cumulative processes
 - ▶ Regional divergence of incomes
 - ▶ Open economy, integration trade and price convergence
 - ▶ polarization between areas: dynamics characterized by concentrations of firms in the sectors ICT
 - ▶ institutions and policies
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Conclusions/observation

- ▶ a plurality of determinants of the trajectories of growth of countries, instead of the stylized model constituted by a single production function, causes the growth process and may culminate in both the convergence and the divergence, rather than in the steady state which is assumed by the Solow model
 - ▶ Crucial role of R&D, HC, education, learning by doing, learning by schooling, training, policies and institutions
 - ▶ As well: in economies with a strong presence of R & D and human capital, high skills represent factors of expansion and allow for the rapid increase in market share, productivity and competitiveness
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