# The Economics of European Regions: Theory, Empirics, and Policy

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- Solow model with poverty trap or better **multiple equilibria** (but why only two?)
  - ☑ **endogenous investment rate**
  - ☑ **endogenous growth rate of population/employment**
  - ☑ **increasing returns to scale (change in output composition)**
  - ➪ **endogenous level of human capital**
- Solow and **limited technological spillovers**
- Solow with open economy and **factor reallocation** across regions
- Solow with open economy, factor reallocation across countries, and limited technological spillover
- Solow with **two sectors** and factor reallocation across regions (core-periphery, i.e. North-South model)
- Solow with **many intermediate goods**

# Human capital versus GDP per worker in European regions

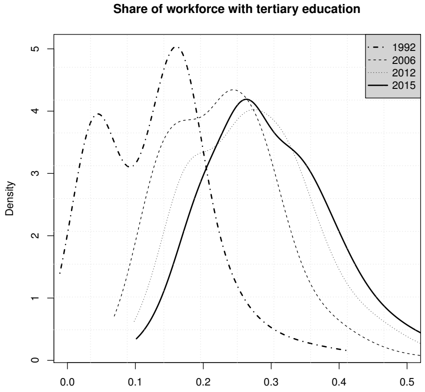



Figure: The share of employment with tertiary education in European regions in 2015

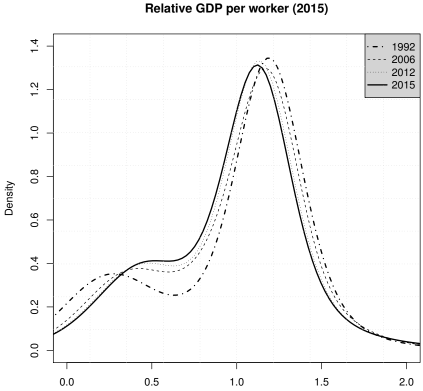



Figure: Relative GDP per worker in 2015

# Main issues about human capital

Main issues:

- How is possible to measure it
- How human capital is accumulated
- How is possible to favour the accumulation of human capital?

# Measurement of human capital: Mincer approach

- The human capital should be a measure of the **services** supplied by labour force to production, i.e. the **abilities** embodied in workforce
- The ability of individual $i$ at period $t$, $h_{i,t}$, can be the result of **years of education**, $s_i$, times the return on education, $\sigma$, **experience** $x_{i,t}$, other factors, as **family background** and genetic characteristics $h_{i,0}$ and other unobservable individual characteristics $\eta_i$, i.e.:

$$h_{i,t} \sim h_{i,0} \exp\left(\sigma s_i + x_{i,t} + \eta_i\right); \tag{1}$$

this is the base of **Mincer equation**. Taking the sum for all $N$ individuals we get the aggregate stock of human capital:

$$H_t = \sum_i^N h_{i,t}, \tag{2}$$

and dividing by $N$ we get an index of average human capital $h_t$:

$$h_t = H_t/N. \tag{3}$$

# Measurement of human capital: formal education

- Also limiting our attention to formal education, we have to elaborate a synthetic index for workers with different levels of education.
- **Returns to education** is a solution adopted in literature, i.e.:

$$h = \left[ \exp(\sum_i^N \sum_j^J \sigma_j s_{i,j}) \right]^{1/N}, \qquad (4)$$

where $\sigma_j$ is the return on level of education $j$ (e.g. primary education for $j = 1$ ) and $s_{i,j}$ the years of education of type $j$ of individual $i$.
- It is possible to directly use the **shares of workforce** with different levels of education, i.e.

$$h = \exp(\sum_j^J \sigma_j \text{share}_j), \qquad (5)$$

where $\text{share}_j$ is the share of workers with the level of education $j$ on total workforce.

# Tertiary education versus human capital index

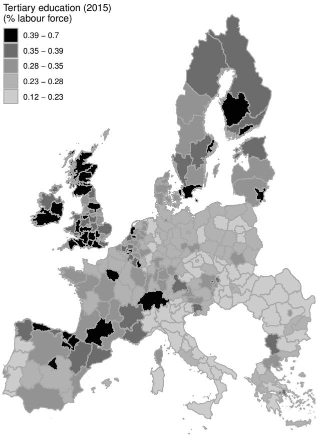



Figure: Share of workforce with tertiary education in 2015

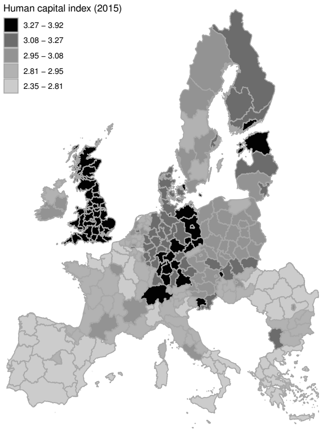
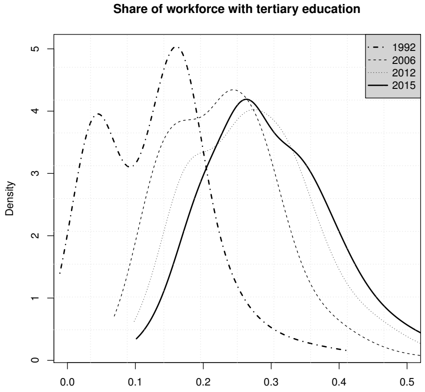



Figure: Human capital index based on formal education in 2015

# Tertiary education versus human capital index

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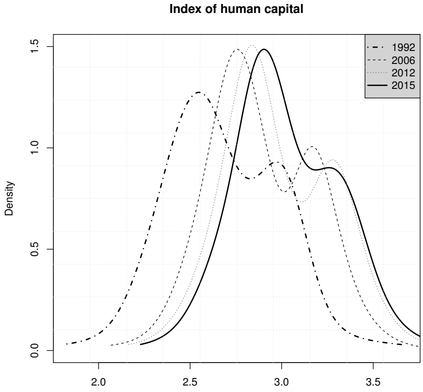


Figure: Human capital index based on formal education in 2015

# Measurement of human capital: wages

- **Wages** can be the other way to calculate human capital when you assume that factors are paid to their **marginal return**. Assume that wage of individual $i$ is given by:

$$w_i = \frac{\partial Y_i}{\partial H_i} \times h_i \tag{6}$$

The efficient allocation of human capital in competitive markets requires that:

$$\frac{\partial Y_i}{\partial H_i} = w^H \forall i, \tag{7}$$

i.e. each unit of human capital should receive the same return. Then

$$w_i = w^H \times h_i, \tag{8}$$

i.e. the distribution of wages reflects the distribution of human capital.

# The theory of accumulation of human capital

Remind standard Solow model:

$$\dot{k} = sf(k,h) - (\delta + g_A + n)\,k, \tag{9}$$

where

$$k \equiv \frac{K}{AL}\ ,\ f \equiv F\left(\frac{K}{AL}, h\right) \equiv f\,(k,h) \text{ and } f_k > 0, f_{kk} < 0 \tag{10}$$

and $s$ and $n$ are the exogenous saving/investment rate and growth rate of employment, $h$ the level of human capital, $\delta$ the depreciation rate of physical capital, and $g_A$ the growth rate of technological change.

Differences in the level of GDP per worker due to differences in human capital

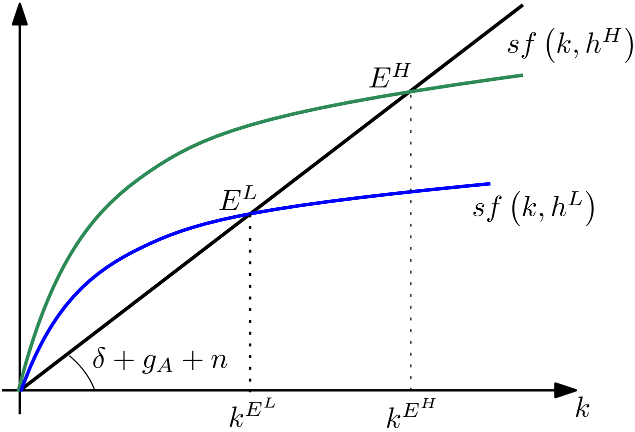


Figure:

$\Rightarrow$ **Now we want to formulate a theory of the level (dynamics) of** $h$

Suppose that the accumulation of human capital can be expressed as:

$$\dot{h} = \Phi\left(h, y, s_h y, CN\right) - \delta_h, \tag{11}$$

with $\Phi_h > 0$, $\Phi_y > 0$, and $\Phi_{s_h} > 0$.

Why these explanatory variable?

- $h$: **spillover effects** deriving from living in a "skilled" environment (Lucas, Durlauf, Brock and Durlauf, etc.)
- $y$: **learning by doing** (Arrow and Lucas)
- $s_h$: **financial investment in education/human capital** (Lucas, Galor and Zeira)
- $CN$ other determinants related to **cultural norms** (gender discrimination, etc.) (Weil)
- $\delta_h$: depreciation of human capital due to various factors, among which the most important is the technological progress

**Assumption**: $\Phi(.)$ is homogeneous of degree one in the first three arguments
Example:

$$\Phi(h, y, s_h y, CN) = h^{\beta} y^{\gamma} s_h^{1-\beta-\gamma} \quad (12)$$

Then:

$$\dot{h} = h\Phi\left(1, \frac{y}{h}, \frac{s_h y}{h}, CN\right) - \delta_h h = h\Phi\left(1, \frac{f(k,h)}{h}, \frac{s_h f(k,h)}{h}, CN\right) - h\delta_h \quad (13)$$

from which:

$$\frac{\dot{h}}{h} = \Phi\left(1, \frac{f(k,h)}{h}, \frac{s_h f(k,h)}{h}, CN\right) - \delta_h \quad (14)$$

$\Rightarrow$ the dynamics of $doth/h$ crucially depends on the **average product of human capital** $f(k,h)/h$.

Two possibilities:

- If we consider technology where average product of human capital is bounded from below, i.e. it cannot go under a certain threshold then the accumulation of human capital **alone** can generate long-run growth (Lucas, Glaser, etc.) and differences in human capital generates differences in growth rates.
- If we take the usual Cobb-Douglas production function $y = k^{\alpha} h^{1-\alpha}$ then $f(k, h)/h$ is decreasing in $h$ and converging to zero. Then we have to consider the **joint dynamics** of $k$ and $h$ to understand the overall dynamics and the level of equilibrium of income.

To study the joint dynamics of $k$ and $h$ consider the special case of Codd-Douglas production function. Then:

$$\frac{\dot{k}}{k} = s\frac{f(k)}{k} - (\delta + n + g_A) = s\left(\frac{k}{h}\right)^{\alpha-1} - (\delta + n + g_A) \tag{15}$$

and

$$\frac{\dot{h}}{h} = \Phi\left(1, \left(\frac{k}{h}\right)^{1-\alpha}, s_h\left(\frac{k}{h}\right)^{1-\alpha}, CN\right) - \delta_h \tag{16}$$

$\Rightarrow$ the crucial variable for the dynamics is the dynamics of the ratio $k/h$.

$$\begin{aligned}
\frac{\dot{\overline{k/h}}}{k/h} &= \frac{\dot{k}}{k} - \frac{\dot{h}}{h} = && (17)\\
&= s\left(\frac{k}{h}\right)^{\alpha-1} - (\delta + n + g_A) + && (18)\\
&- \left[\Phi\left(1, \left(\frac{k}{h}\right)^{1-\alpha}, s_h\left(\frac{k}{h}\right)^{1-\alpha}, CN\right) - \delta_h\right] && (19)
\end{aligned}$$

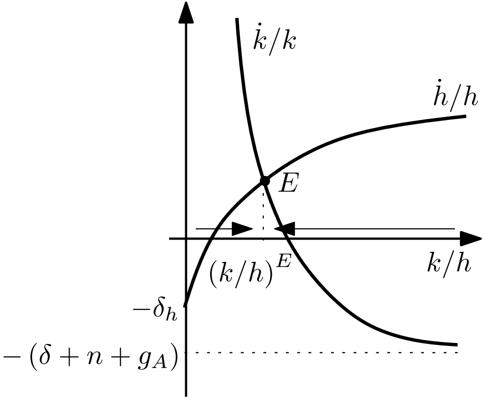


Figure: Dinamics of model with physical and human capital

An increase in $(k/h)^E$ can be the result of:

- an increase in $s$
- a decrease in $n$
- a decrease in $s_h$
- an increase in $\delta_h$
- an increase in $\alpha$

# References


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