

# Growth & Rates

a macro economic approach

Theories & Facts

2020-2021



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# History of economic growth : No or few Growth before the industrial revolution

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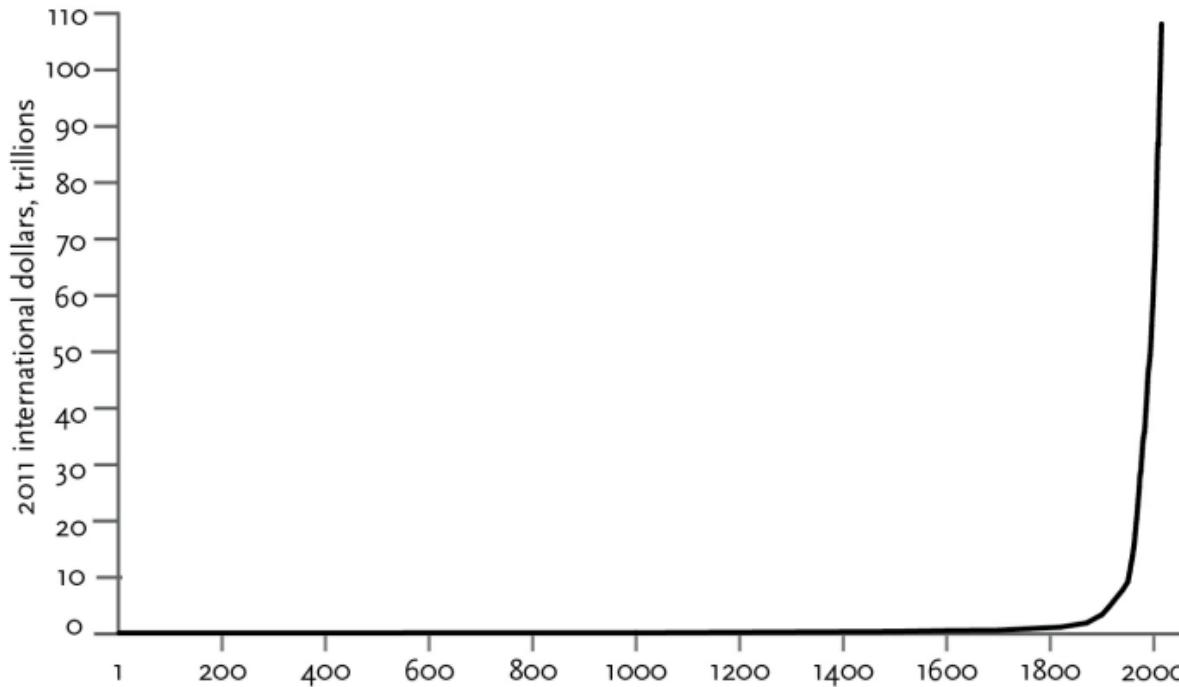


Figure 8-1: Gross World Product, 1–2015

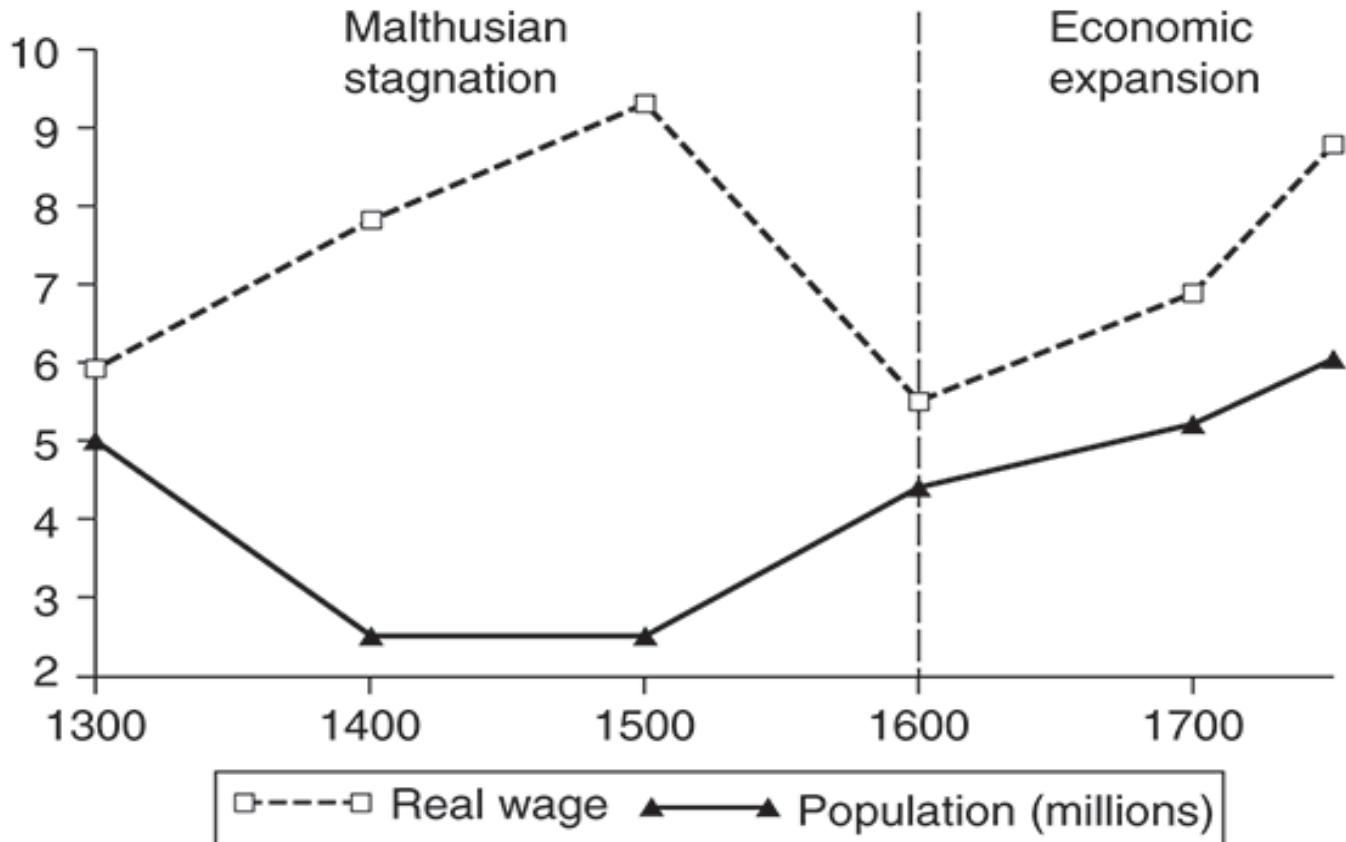
**Source:** *Our World in Data*, Roser 2016c, based on data from the World Bank and from Angus Maddison and Maddison Project 2014.

# No growth but why ? The Malthusian trap

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Before the industrial revolution very few productivity growth when the population increased the real wage decreased



**Population and the real wage in England, 1300–1750.**

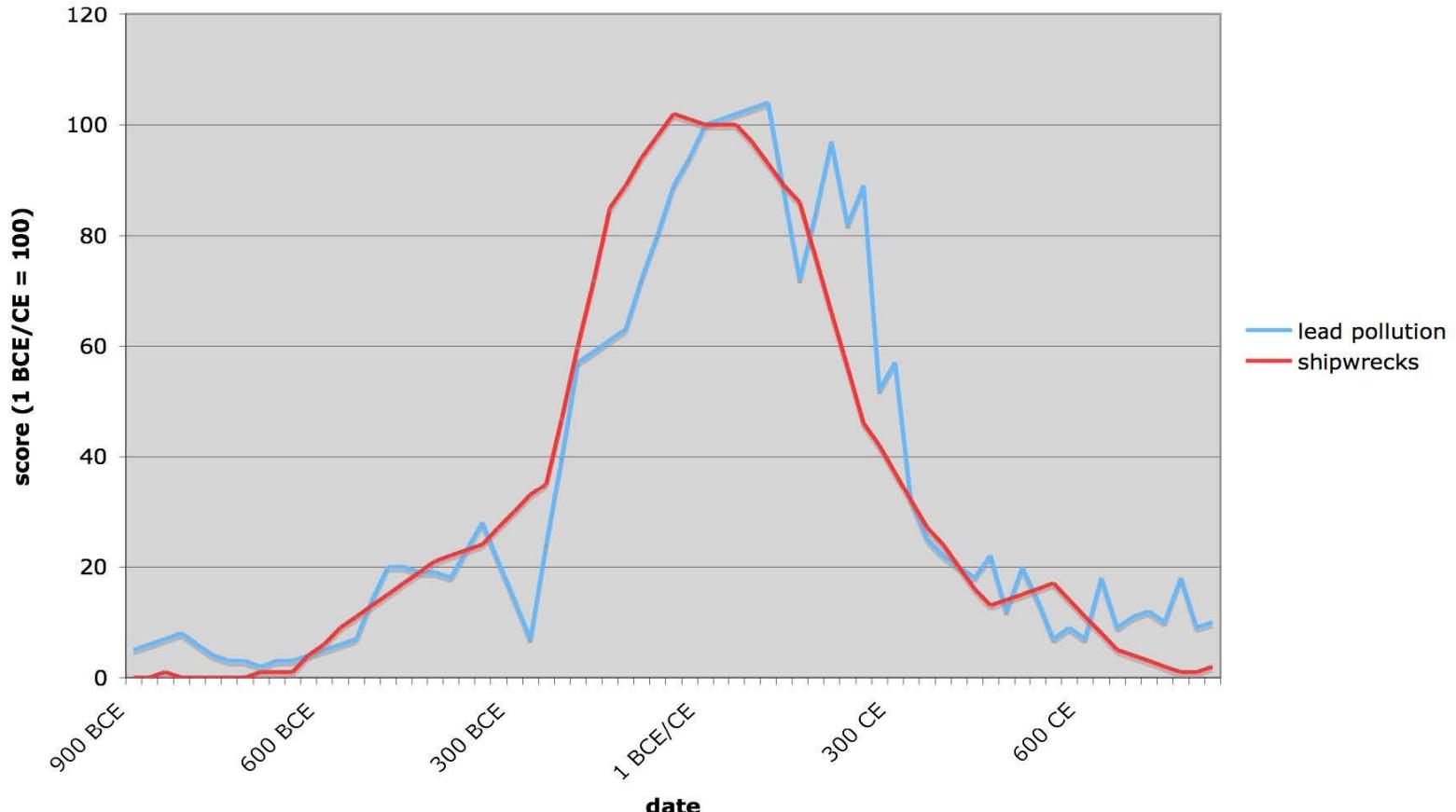
# The roman economic crisis (with proxy)

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Before the industrial revolution only extensive growth could occur with few productivity gain

**lead pollution and Mediterranean shipwrecks, 900 BCE-800 CE**



Ian Morris, Why the west rules, for now (2010)

# Great Divergence and Great Convergence

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- After the Industrial revolution a Great Divergence occurred between the Western World and the “Tiers Monde”.
- Since 1990 a Great Convergence is occurring with the rise of the GDP per capita of China and India

*Robert Baldwin The Great Convergence: Information Technology and the New Globalization The Belknap Press*

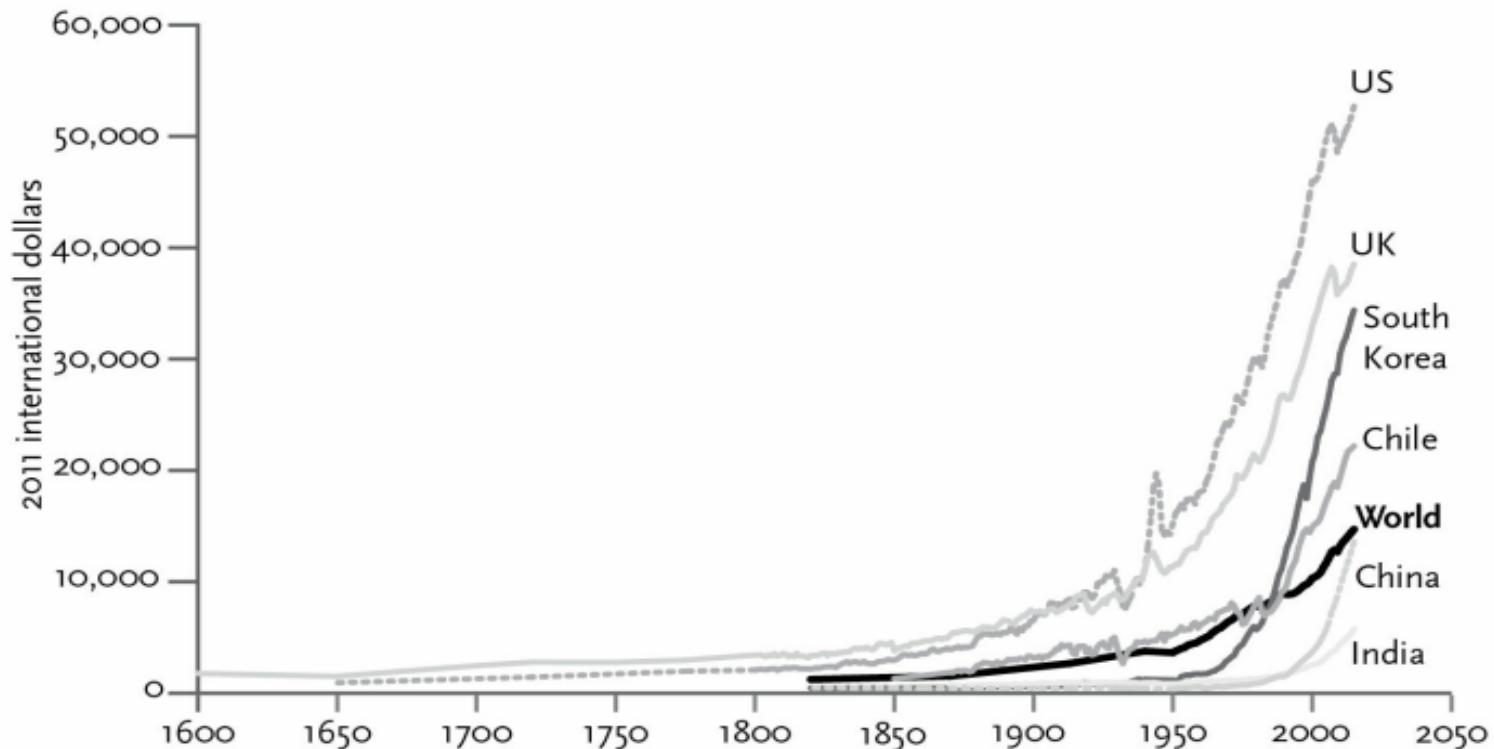


Figure 8-2: GDP per capita, 1600–2015

**Source:** *Our World in Data*, Roser 2016c, based on data from the World Bank and from Maddison Project 2014.

# Growth modelization : Classical growth equation Cobb Douglas

## The malediction of growth : The law of Diminishing Returns

$$Y = AK^\alpha L^{1-\alpha} \text{ Cobb Douglas Production Function Stock equation with } 0 < \alpha < 1$$

*Robert Solow : A contribution to the Theory of economic growth*

- $\alpha + (1 - \alpha) = 1$  constant return to scale ie  $f(\lambda K, \lambda L) = \lambda f(K, L)$
- For  $L = cst$   $\alpha < 1$  decreasing return to scale of  $L$  (Law of Diminishing Returns) ie  $f(\lambda K) < \lambda f(K)$
- For  $K = cst$   $1 + \alpha < 1$  decreasing return to scale of  $K$  (Law of Diminishing Returns) ie  $f(\lambda L) < \lambda f(L)$

*Y : GDP    L : Labor Input    K : Capital Input    A : Total Factor Productivity (statistical residue)*

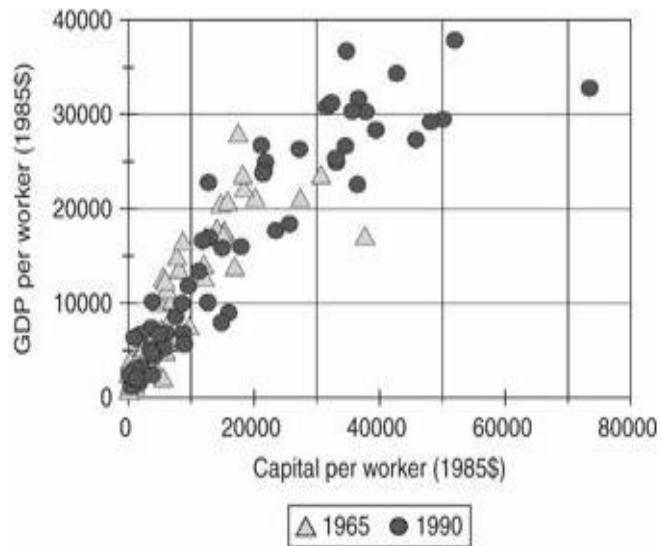
*NB : All value as stocks not flows (rate of growth)*

*Elasticity : The % increase of dependent variable resulting to 1 % increase of independent variable*

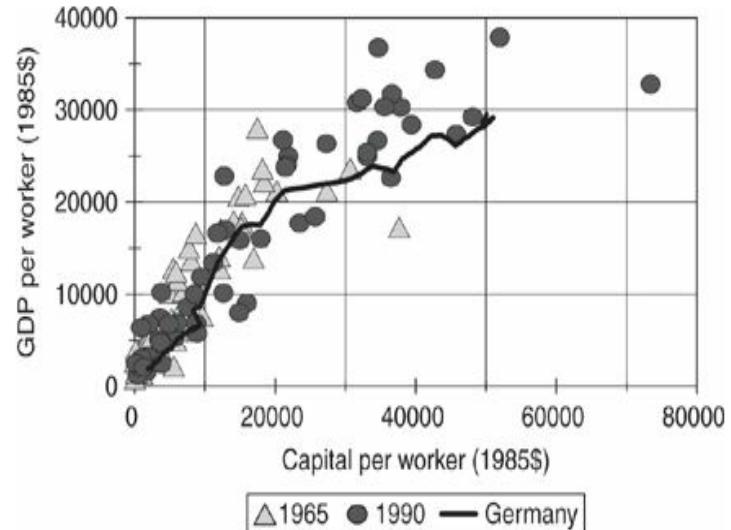
*Capital elasticity :  $\alpha = (dY/Y)/(dK/K) = 0,3$     Labor elasticity :  $1-\alpha = (dY/Y)/(dL/L) = 0,7$*

# The malediction of growth

**Law of diminishing returns is confirmed by the stats**



8. World production function



11. German growth trajectory

# From stock to rate of growth : Linearization of the Cobb Douglas equation

Cobb-Douglas equation a stock equation  $Y(t) = A(t)K^\alpha(t)L^{1-\alpha}(t)$

- $Y$  = total production (the real value of all goods and services produced in a year)
- $L$  = Labor input (the total number of person-hours worked in a year). L may be adjusted to the Labor Productivity for e.g. taking into account educational level of working age population
- $K$  = capital input (the monetary worth of all machinery, equipment, and buildings). K may be adjusted to the Capital Productivity e.g. taking into account computer capacity and memory in Computer Investment
- $A$  = Total Factor Productivity i.e. statistical residue. Called improperly technical progress. Capability to mix the K & L input, may be institutional factors (rule of law, organization...) / anthropological and sociological factor.....mainly not catch by the accounting i.e. qualitative factor vs quantitative one
- $\alpha$  and  $1 - \alpha$  are the output elasticities of labor and capital, with  $\alpha = 0.3$

Flow Equation ie rate of growth (%) :  $\ln[Y(t)] = \ln[A(t)] + \alpha \ln[K(t)] + (1 - \alpha) \ln[L(t)]$

$$\frac{1}{Y} \frac{dY}{dt} = \frac{1}{A} \frac{dA}{dt} + \alpha \frac{1}{K} \frac{dK}{dt} + (1 - \alpha) \frac{1}{L} \frac{dL}{dt}$$

$$\frac{\Delta Y}{Y} = \frac{\Delta A}{A} + \alpha \frac{\Delta K}{K} + (1 - \alpha) \frac{\Delta L}{L}$$

This model is oversimplified but is easy to test with historical statistics in order to understand the impact of the different growth factors. Let remind that advanced growth modelization use more sophisticated model (Romer Endogenous Growth).

# Cobb Douglas equation : the 3 factors of growth

GDP Growth

$$\frac{\Delta Y}{Y} = \frac{\Delta A}{A} + \alpha \frac{\Delta K}{K} + (1 - \alpha) \frac{\Delta L}{L}$$

$$\frac{\Delta A}{A}$$

- Growth of total factor productivity : 50% of GDP during the « Trentes glorieuses » in France.*  
TFP falters after 1974 in Western Europe /USA and after 1980 in Japan > beginning of the Great Recession and Stagflation.
- Few TFP in emerging countries (China, India...) extensive vs intensive but growth subject to Law of Diminishing Returns

$$\frac{\Delta L}{L}$$

- Demographic dividend (no old people, few very young > increase of growth / too many old people , no more young > decrease of growth)
- China /Turkey demographic dividend is faltering.
- In 1963 end of baby boom in USA/UE. In 1980 end of demographic dividend in Japan > pressure on growth

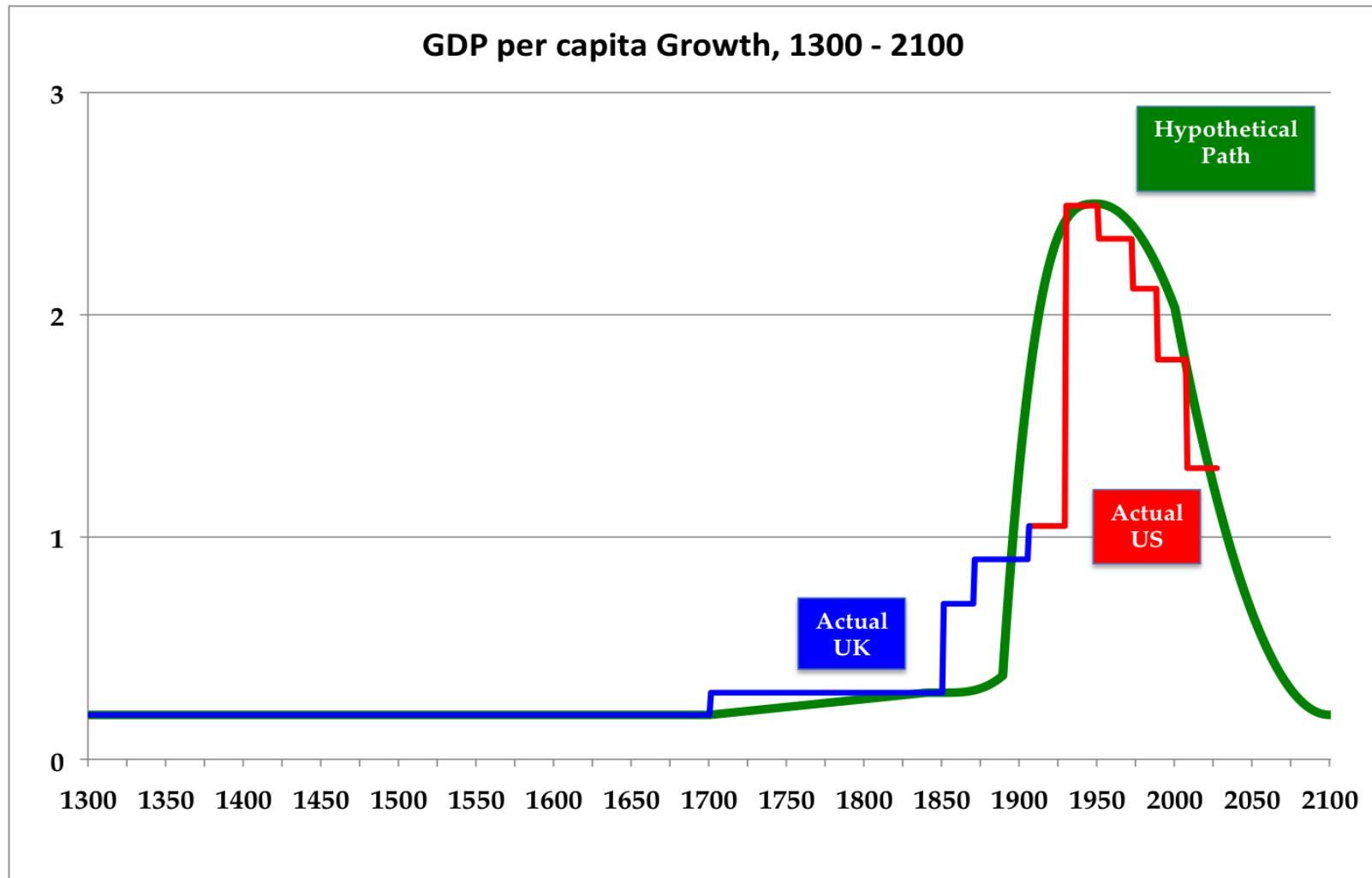
$$\frac{\Delta K}{K}$$

- Southern Europe decline (Italy, France, Greece) : Structural decline of the capital profitability > decline of I > no capital growth > youth unemployment
- Emerging countries growth is mainly driven by capital accumulation e.g. China growth was mainly driven by investment as  $I = 50\%$  of GDP ie extensive growth subject to Law of Diminishing Returns if TFP structurally weak

# Structural crisis of the Western economy : the slowdown of per capita growth

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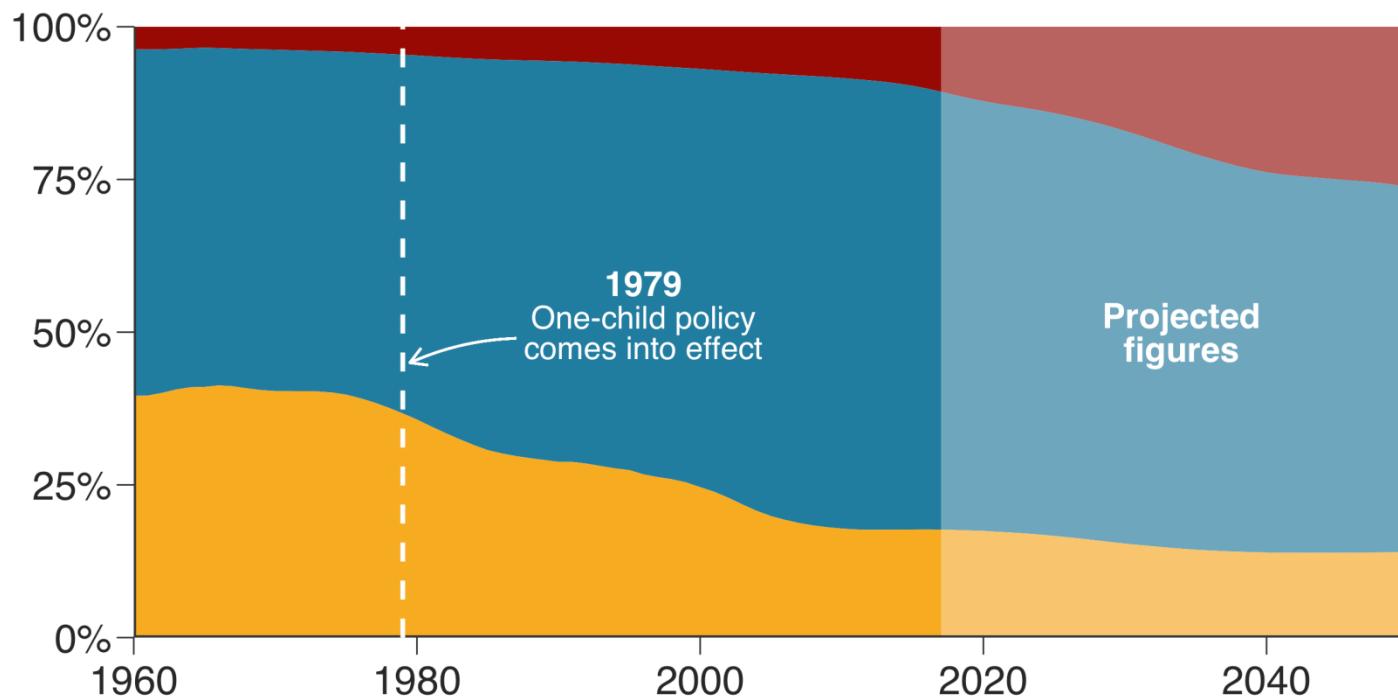
Robert J. Gordon, Northwestern

# The demographic driver of growth : China's demographic dividend

## Breakdown of China's population by age group

Proportion of total population (1960-2050)

■ 0-14 years ■ 15-64 ■ 65+



Source: The World Bank

BBC

# GDP & TFP Growth : « Les trentes glorieuses » and the slowdown of developed economies

	GDP per capita Growth			TFP Growth		
	1950-1973	1973-1987	Var	1950-1973	1973-1987	Var

	1950-1973	1973-1987	Var	1950-1973	1973-1987	Var
France	4.0	1.8	-2.2	4.9	2.3	-2.6
Germany	4.9	2.1	-2.8	5.6	1.9	-3.7
Japan	8.0	3.1	-4.9	6.4	1.7	-4.7
UK	2.5	1.8	-0.7	2.3	1.7	-0.6
USA	2.2	1.6	-0.6	2.6	0.6	-2.0
Mean	4.3	2.1	-2.2	4.4	1.6	-2.8

Angus Maddison, Dynamic in Capitalist Development 1991

## GDP & TFP Growth : China growth

China TFP is slowing the growth is driven by capital accumulation and will be subject if unchanged to the law of diminishing returns

**Table 12-3** Average Annual Rate of Growth of Output per Worker and Technological Progress in China, 1978–2011

Period	Rate of Growth of Output (%)	Rate of Growth of Output per Worker (%)	Rate of Technological Progress (%)
1978–1995	10.1	7.4	7.9
1996–2011	9.8	8.8	5.9
Source: Penn World Table version 8.1.			

# The slowdown of US Total Factor Productivity growth since 1970

Etats-Unis : croissance moyenne de la productivité globale des facteurs et du PIB volume (en %)

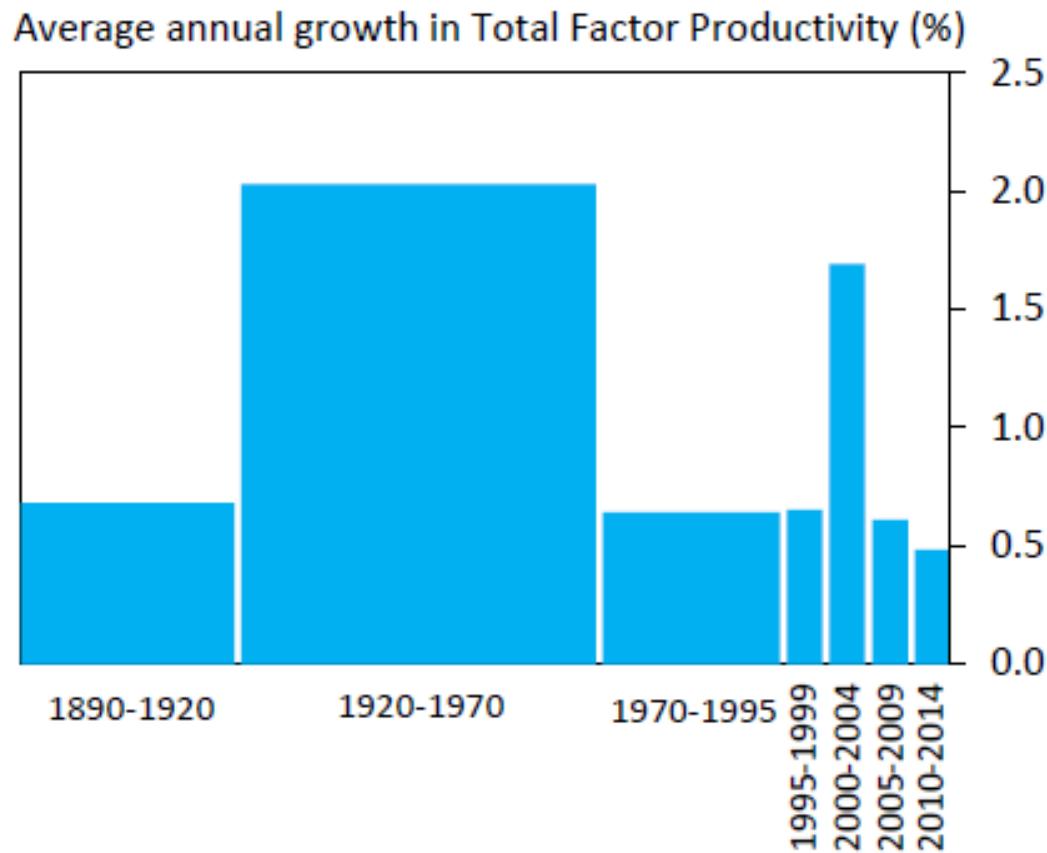
	Productivité globale des facteurs	PIB volume
1960-1969	2,39	4,51
1970-1979	0,66	3,24
1980-1989	1,06	3,14
1990-1999	1,49	3,25
2000-2013	0,78	1,94
2007-2013	0,63	1,10

# The slowdown of French Total Factor Productivity growth since 1970

	Productivité globale des facteurs	PIB volume
1960-1969	3,57	5,91
1970-1979	2,15	4,15
1980-1989	1,29	2,30
1990-1999	0,97	1,86
2000-2013	0,11	1,24
2007-2013	-0,38	0,43

Sources : Datastream, OCDE, NATIXIS

# The structural decline slowdown of US TFP



Source: [Gordon \(2014\)](#)

Robert Gordon : *The Rise and Fall of American Growth : The U.S. Standard of Living since the Civil War*, [Princeton University Press](#), 2016

# Why the Total Factor Productivity is declining ?

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**Robert Solow Computer productivity paradox (1987) :**

**"You can see the computer age everywhere but in the productivity statistics."**

2 explanations :

1. Measurement problem : The GDP deflator is not able to catch the increase of quality of the technological products (*Boskin*). Partially true but not sufficient to explain the huge disappearance of the TFP.
2. The technological progress doesn't impact the productivity (Robert Gordon)

What will happen in the future ?

Pessimistic argument 1: Most employment growth will occur in low productivity sectors

Pessimistic argument 2: The low hanging fruit has already been picked

Optimistic argument :

Recent productivity weakness is a sign of growing pains and will abate (*Brynjolfsson & McAfee The second Machine Age*). As in the previous technological revolution the technology take time to diffuse and to impact the productive sector as it was the case during the Electrification Era 1890-1940.

Will see !!!!

*Bank of England Secular drivers of the global real interest rate Lukasz Rachel & Thomas D Smith Staff Working Paper n° 571 Dec 2015*

# Neo-classical optimization model : Perfect competition hypothesis

- A large number of buyers and sellers
- All goods and services are infinitesimal on the market (market is atomic)
- Perfect information
- Homogeneous products
- Perfect factor mobility / No barriers to entry or exit / No externalities
- Zero transaction costs / Well defined property rights / anti-competitive regulation
- Rational buyers & profit maximization sellers
- Non-increasing returns to scale and no network effects ie decreasing return to scale
- So Every participant is **PRICE TAKER** ie each participant can hire or fire a worker at the wage market rate & each participant can buy and sell goods and services at the market price. That market price adjusts automatically and then is not sticky (Walrasian market vs marshallian market).

*Wikipedia Perfect competition*

# Economics as convex optimization : The Neo Classical optimization model

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## The producers will maximize their production function $Y = f(K, L)$

Perfect competition & Profitability function is continuous and concave then maximization of the Profit function:

$$\pi(K, L) = pY - wL - cK$$

$$\pi(K, L) \text{ with } K = cst \text{ max if } \frac{d\pi}{dL} = p \frac{dY}{dL} - w = 0 \quad \text{then} \quad \frac{dY}{dL} = \frac{w}{p} \quad \text{Marginal Product of Labor}$$

- At equilibrium  $\frac{dY}{dL}$  Marginal Product of Labor (MPL) is equal to  $\frac{w}{p}$  Real Wage. Perfect competition : the Real Wage is settled by the market. Firms and Labor are Price Takers.
- Then if the  $MPL > \frac{w}{p}$  Profit Maximization Firms will hire a unit of L on the Perfect Labor market until  $MPL = \frac{w}{p}$
- Then if the  $MPL < \frac{w}{p}$  Profit Maximization Firms will fire a unit of L on the Perfect Labor market until  $MPL = \frac{w}{p}$

$$\pi(K, L) \text{ with } L = cst \text{ max if } \frac{d\pi}{dK} = p \frac{dY}{dK} - c = 0 \quad \text{then} \quad \frac{dY}{dK} = \frac{c}{p} \quad \text{Marginal Product of Capital}$$

- At equilibrium  $\frac{dY}{dK}$  Marginal Product of Capital (MPK) is equal to  $\frac{c}{p}$  Real Cost of Capital (Weighted average of Equity and rates) for long period without equity market the Real Rate  $\frac{r}{p}$  is a good proxy of  $\frac{c}{p}$ .
- Then if the  $MPK > \frac{c}{p}$  Profit Maximization Firms will add a unit of K on the Perfect Goods market until  $MPK = \frac{c}{p}$
- Then if the  $MPK < \frac{c}{p}$  Profit Maximization Firms will shed a unit of K on the Perfect Goods market until  $MPK = \frac{c}{p}$

# Economics as convex optimization : The Cobb Douglas model

© Sébastien Jallat



$$Y = AK^\alpha L^{1-\alpha}$$

$$\pi = pY - wL - cK \text{ if } K = \text{cst} \max \text{ if } \frac{d\pi}{dL} = p \frac{dY}{dL} - w = 0 \quad \frac{d\pi}{dL} = p(1-\alpha)A(K/L)^\alpha - w = 0$$

$$\frac{dY}{dL} = (1-\alpha)A(K/L)^\alpha = \frac{w}{p} \quad \text{with} \quad \frac{d^2Y}{dL^2} = -\alpha(1-\alpha)AK^\alpha L^{-\alpha-1} < 0 \quad \text{i.e. law of diminishing return}$$

- Real wage is proportional to A and K. At equilibrium, increasing the capital stock (K) and the TFP (A) will increase the productivity of labor hence the labor demand from firm then the employment level and the real wage.
- Real wage is inversely proportional to the stock of Labor. Increasing the real wage will decrease the demand of L and increase the demand of K (substitution of L by K / Supply > Demand of Labor).

$$\pi = pY - cK - wL \text{ if } L = \text{cst} \max \text{ if } \frac{d\pi}{dK} = p \frac{dY}{dK} - c = 0 \quad \frac{d\pi}{dK} = p\alpha A(L/K)^{1-\alpha} - c = 0$$

$$\frac{dY}{dK} = \alpha A(L/K)^{1-\alpha} = \frac{c}{p} \quad \text{with} \quad \frac{d^2Y}{dK^2} = (\alpha - 1)\alpha AK^{\alpha-2}L^{1-\alpha} < 0 \quad \text{i.e. law of diminishing return}$$

- Cost of capital is proportional to A and L. At equilibrium iIncreasing the Labor stock (L) and the TFP (A) will increase the productivity of capital hence the Investment demand from firm then the cost of capital.
- Cost of capital is inversely proportional to the stock of capital. Increasing the cost of capital will decrease the demand of K and increase the demand of L (substitution of K by L / Supply > Demand of Capital)

# Neo classical formulation linking growth to real interest rate in the Solow model

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

Alternative production function : Endogenous growth theory where the productivity factor A is linked to the Labor factor L.

$$r = \frac{\alpha Y}{K} \text{ and Solow model } \frac{K}{Y} = \frac{s}{n+g+\delta} \text{ then } r = \alpha \left( \frac{n+g+\delta}{s} \right)$$

**r** : gross physical marginal product of capital and long run real rate

**s**: saving rate

**g**: Rate of growth of labor productivity

**n** : Rate of growth of employment

**δ** : Rate of depreciation

At equilibrium in the long run the real rate r has to be consistent with the long term growth (zero output gap) and inflation anticipation.

*Dean Baker, J Bradford Delong, Paul R. Krugman Asset returns and economic Growth Brookings Papers on Economics Activity*

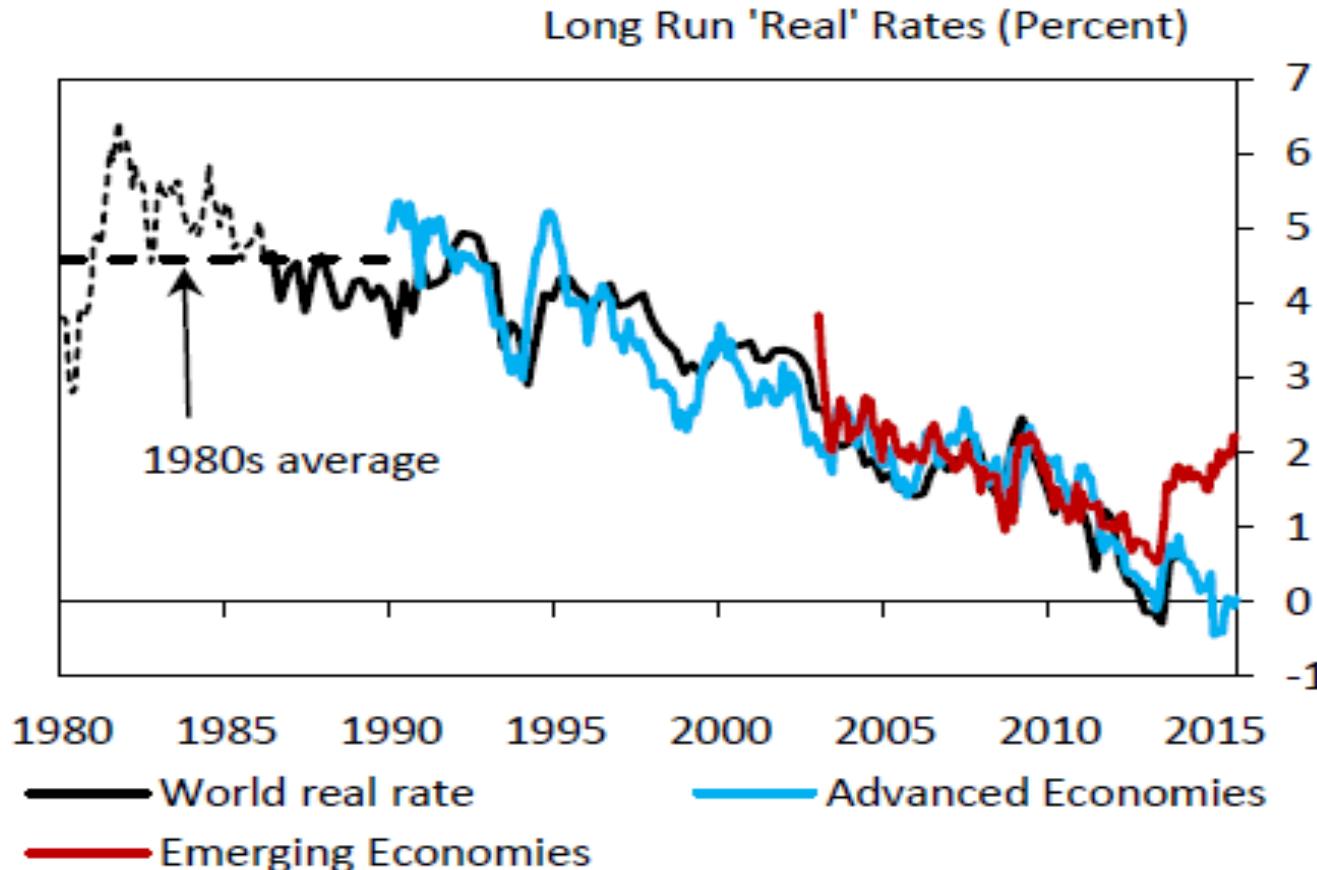
# Secular stagnation hypothesis : is the neo classical rate model prediction validate?

© INED Jérôme Fourquet

Why the real and nominal interest Rate are so low ? (Sept 2019 10Y Bund -0,61%) :

1. Proximal cause : Quantitative Easing ie strong increase of the Money Supply by The Central banks
2. Distal cause : the slowdown of productivity & growth.

Secular stagnation hypothesis ? Then Monetary expansion is the consequence of the structural economic slowdown



Bank of England Secular drivers of the global real interest rate Lukasz Rachel & Thomas D Smith Staff Working Paper n° 571 Dec 2015

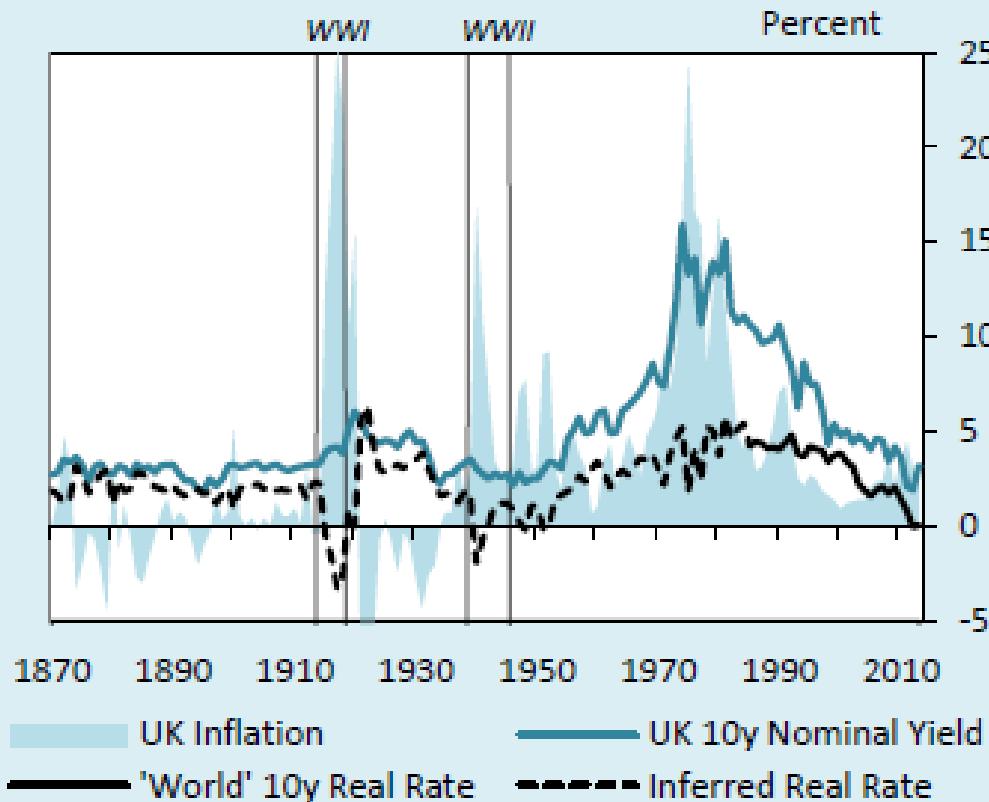
# Secular stagnation hypothesis : is the neo classical rate model prediction validate?

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- Since the beginning of the XX century real interest rates are correlated with the long term growth
- Before the XX century no clear correlation as the money and financial market was rigid (Gold standard)

**Chart A1.A: A long-run estimate of the 'world' real interest rate based on UK data**

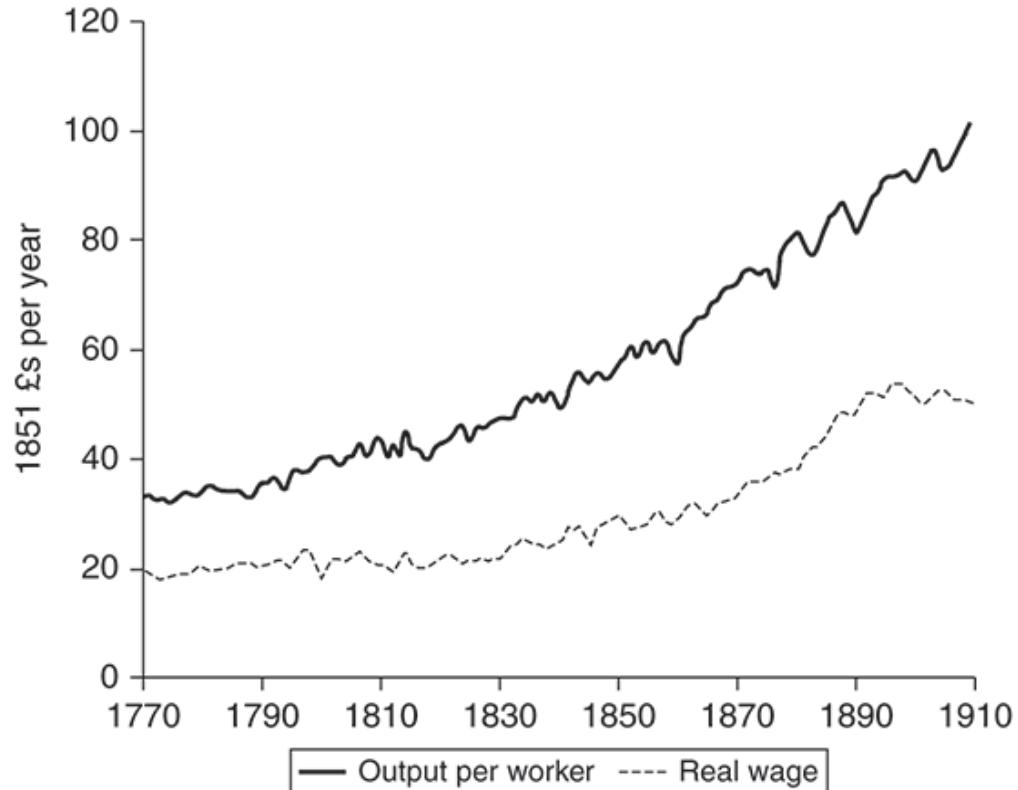


Sources: [King & Low, 2014](#), Consensus Economics, IMF, DataStream and Authors' calculations

# Neo classical wage model prediction is validate: Karl Marx is wrong !

© Thibaut

Long term period wages are increasing with the labor productivity **but** stasis could occur as between 1770 to 1830



GDP per worker versus the average real wage.

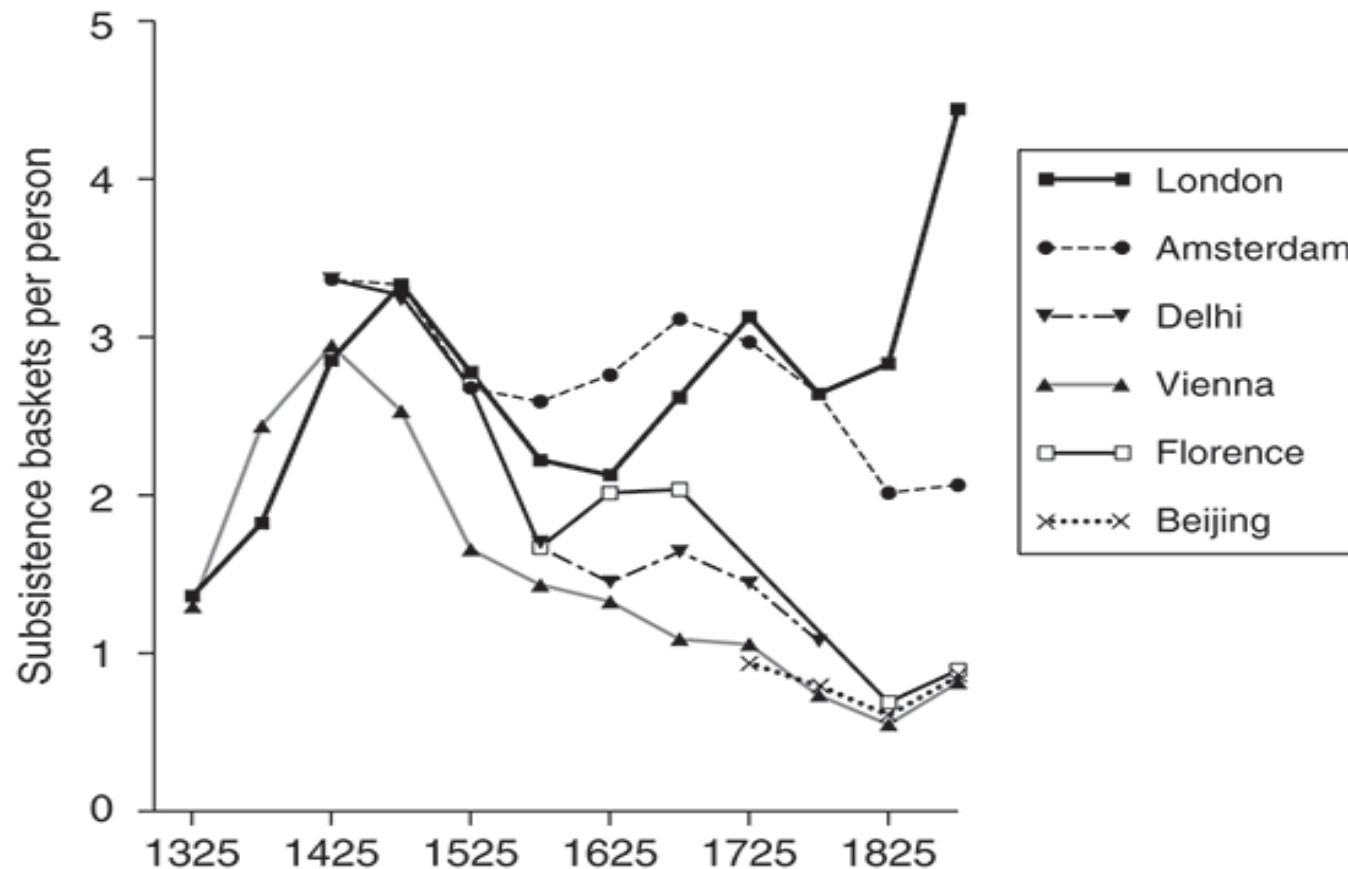
# Living standard : How could we calculate the cost of subsistence in order to evaluate the historical standard of living

<b>Basket</b>		
	<b>Respectability: quantity per person per year</b>	<b>Bare bones subsistence: quantity per person per year</b>
Oatmeal/grain		170 kg
Bread	182 kg	
Beans/peas	34 kg	20 kg
Meat	26 kg	5 kg
Butter/oil	5.2 kg	3 kg
Cheese	5.2 kg	
Eggs	5.2 kg	
Beer	182 litres	
Soap	2.6 kg	1.3 kg
Linen/cotton	5 metres	3 metres
Candles	2.6 kg	1.3 kg
Lamp oil	2.6 litres	1.3 litres
Fuel	5.0 MBTU	2.0 MBTU

# Living standard : A big disparity of historical relative wages could appear between different economies

© Théo Labeyrie 

With the industrial revolution take off in England the Great Divergence appears with a wide wage discrepancies between countries at different stage of their economic development.



**Wages relative to the cost of subsistence around the world.**

# Living standard : But before the Industrial Revolution European standard of living were quite low 1

© Theo Jolabert

Just a reminder : A man need 2500 cal/ day a woman 200 cal/day, a man working in the field could need up to 3 000 cal/day.

Before industrial revolution up to 20/30% of population could not work more than 3 hours due to the lack of energy available in their diet!!!!!!

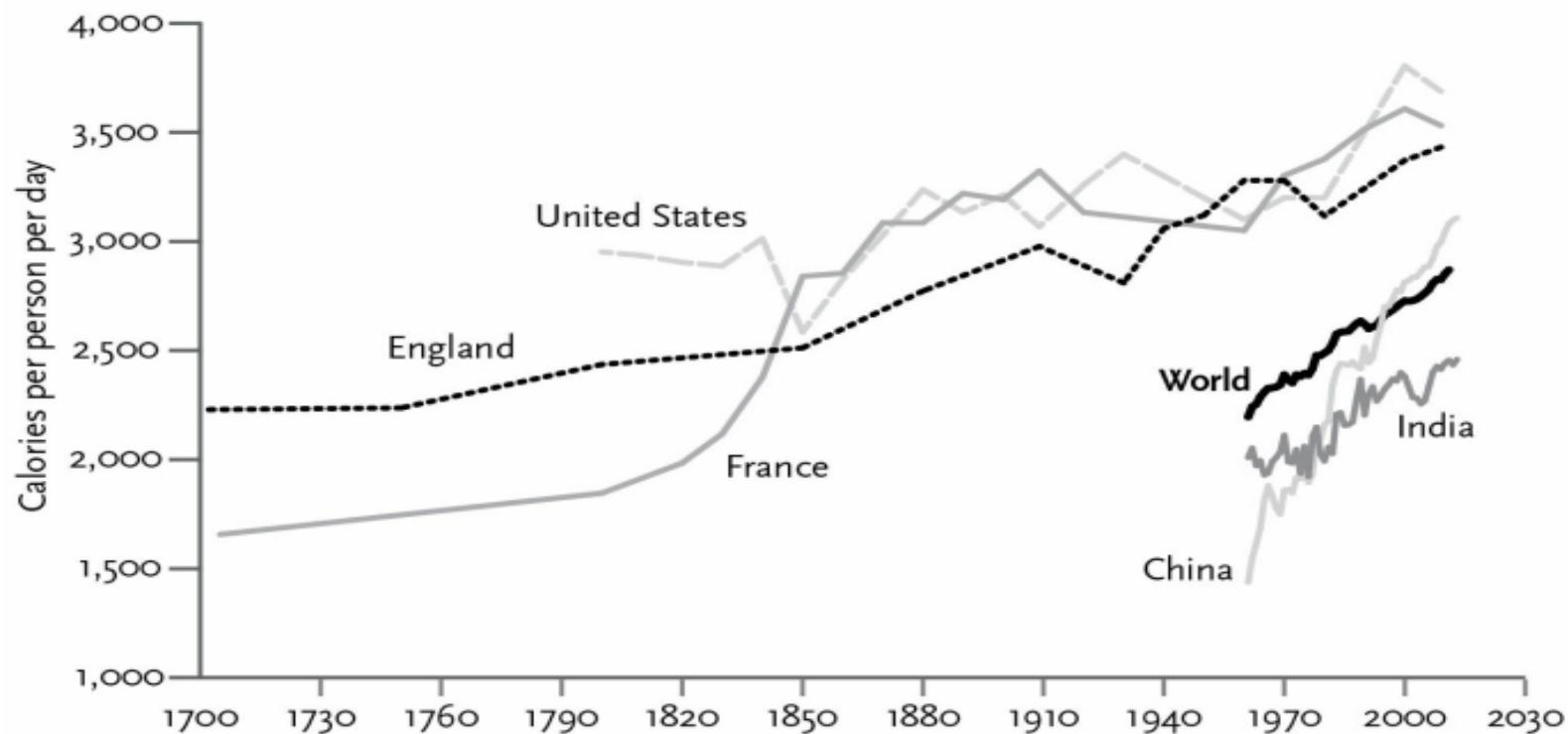
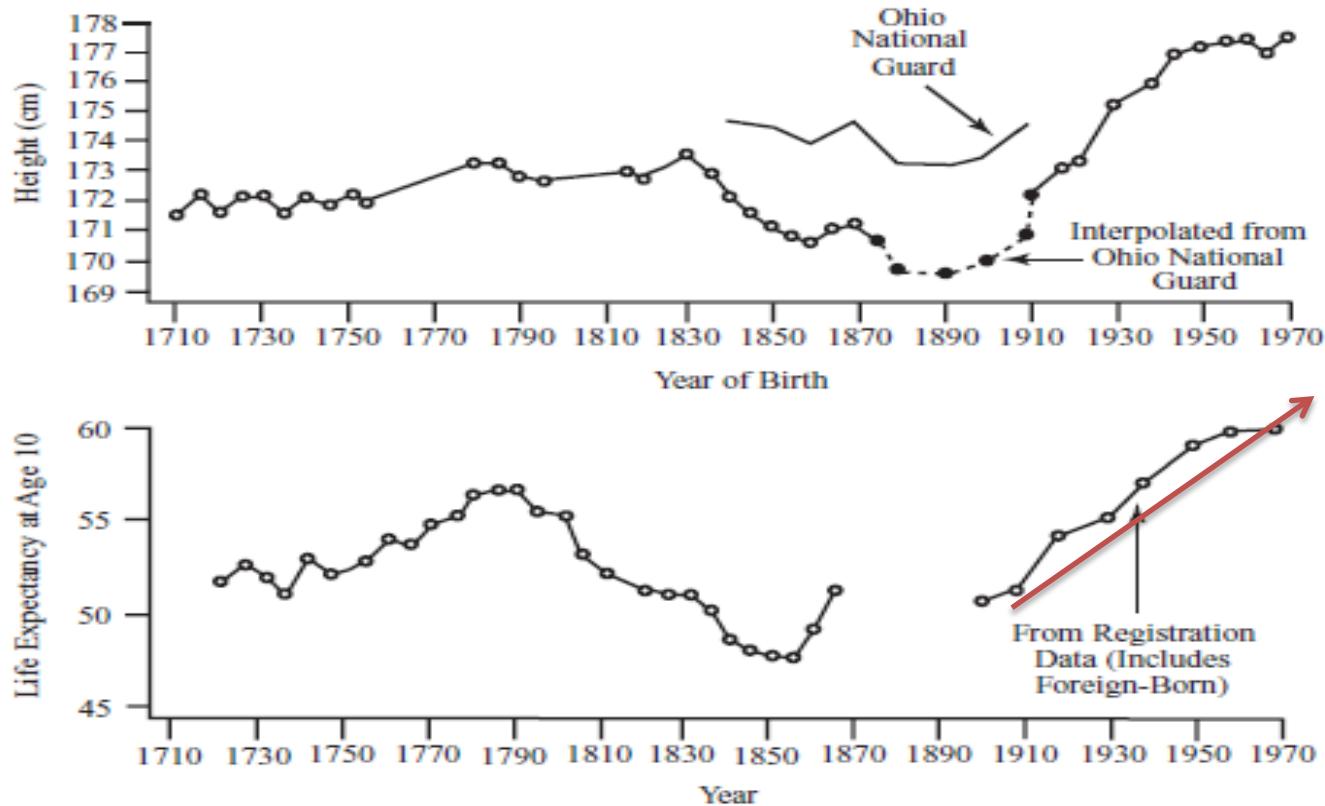


Figure 7-1: Calories, 1700–2013

**Sources:** **United States, England, and France:** *Our World in Data*, Roser 2016d, based on data from Fogel 2004. **China, India, and the World:** Food and Agriculture Organization of the United Nations, <http://www.fao.org/faostat/en/#data>.

# Living standard : Only during the 20th century European could enjoy decent standard of living 2



**Figure 1.2 Trend in Mean Final Height of Native-Born White American Males and Trend in Their Life Expectancy at Age 10.**

Sources: Fogel 1986; Costa and Steckel 1997.

Note: Height is by birth cohort, and life expectancy at age 10 is by period.

In the long run with the economic development inequalities had strongly decreased

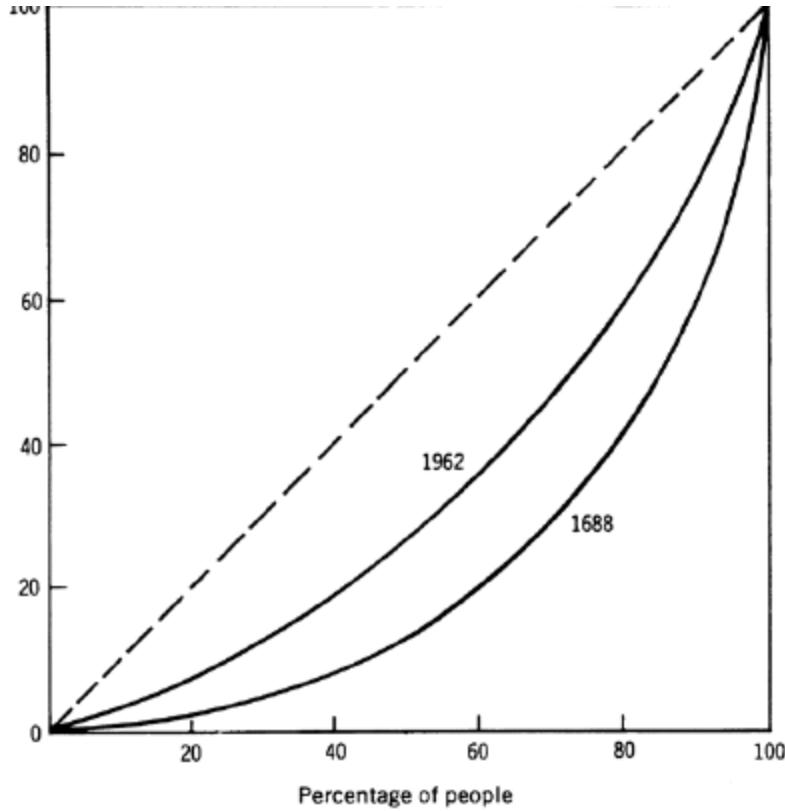


Figure 1.1 Income distribution in Great Britain in 1688 and 1962.

Source: L.Soltow, "Long-run changes in British income inequality," p. 20.

**During the first stage of the industrialization revolution inequalities are first increasing and is decreasing later on during the second growth stage**

A big decrease if the inequalities (pink arrow) occurred during the second stage of the industrial revolution. Inequalities are still rising in the developed world since 1970/1980. Is it a new Kuznets cycle due to the third industrial revolution (red arrow) ?

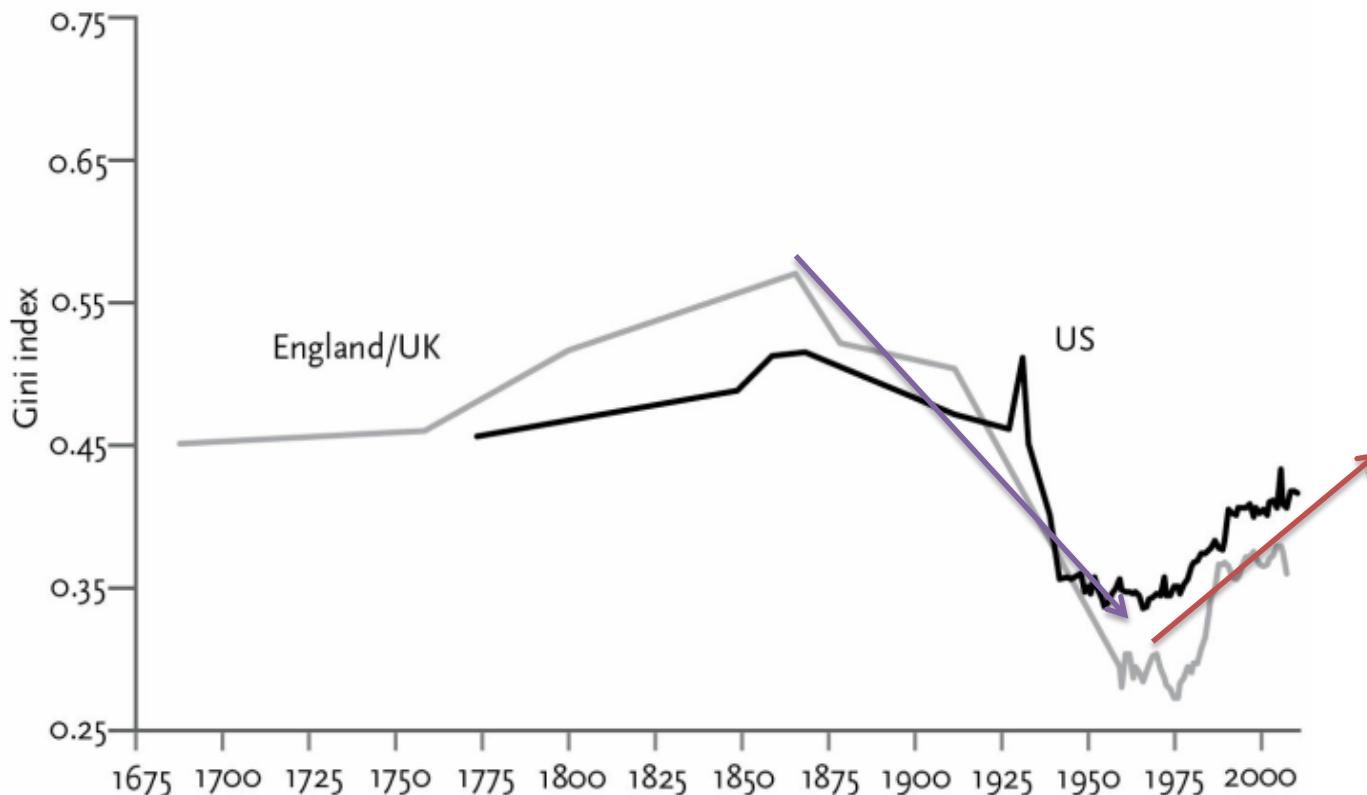


Figure 9-3: Inequality, UK and US, 1688–2013

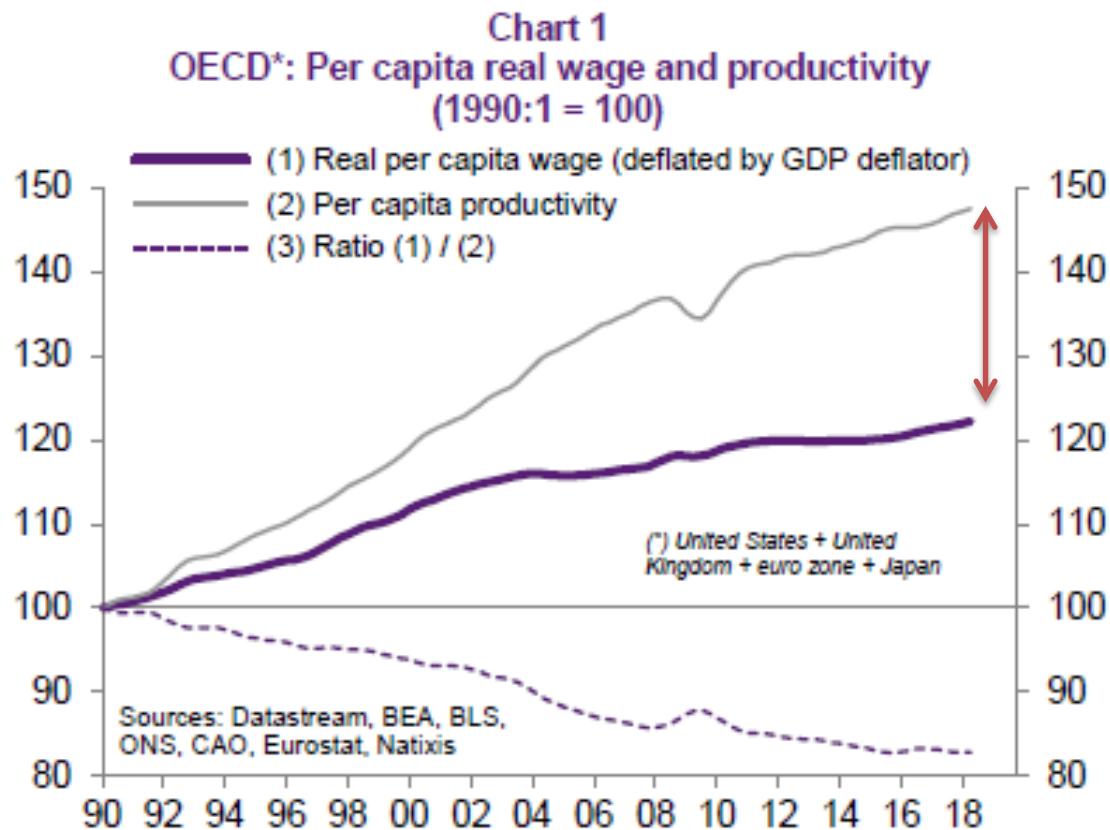
**Source:** Milanović 2016, fig. 2.1, disposable income per capita.

Inequality : In OCDE, income distribution has skewed to the **détriment of wage earners**.

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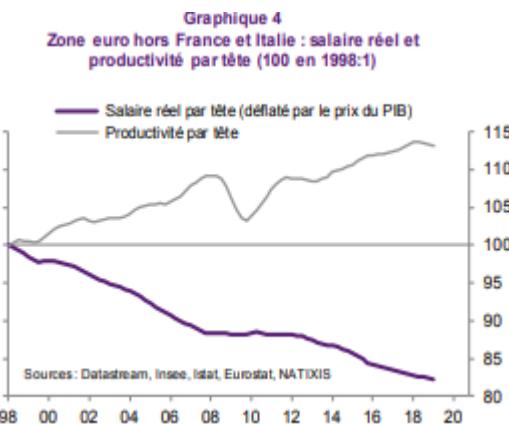
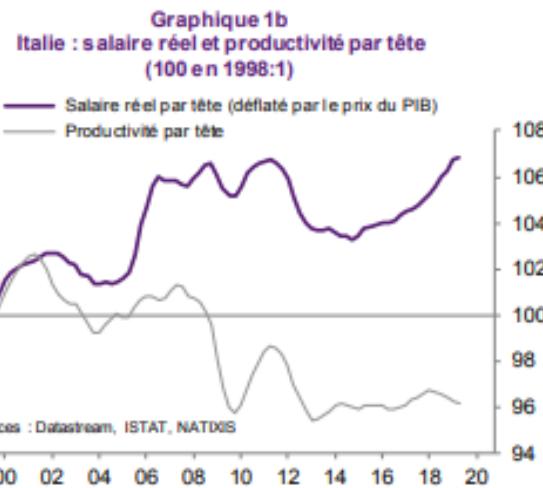
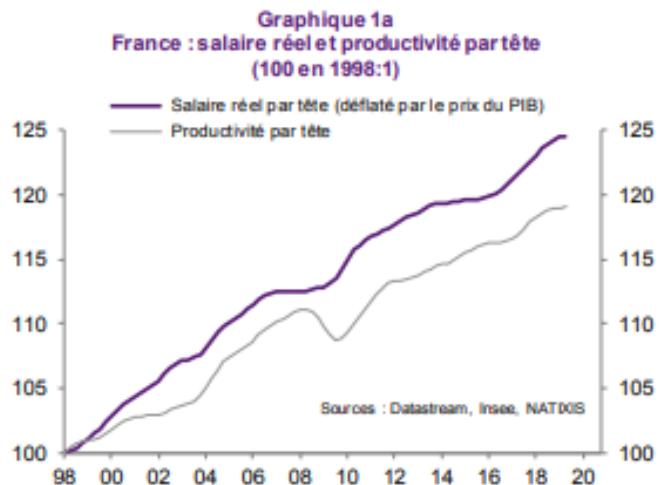
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*Since 1990's real wage are no more following labor productivity in the OCDE countries*



# Inequality : The skewing affects nearly all OECD countries except France and Italy

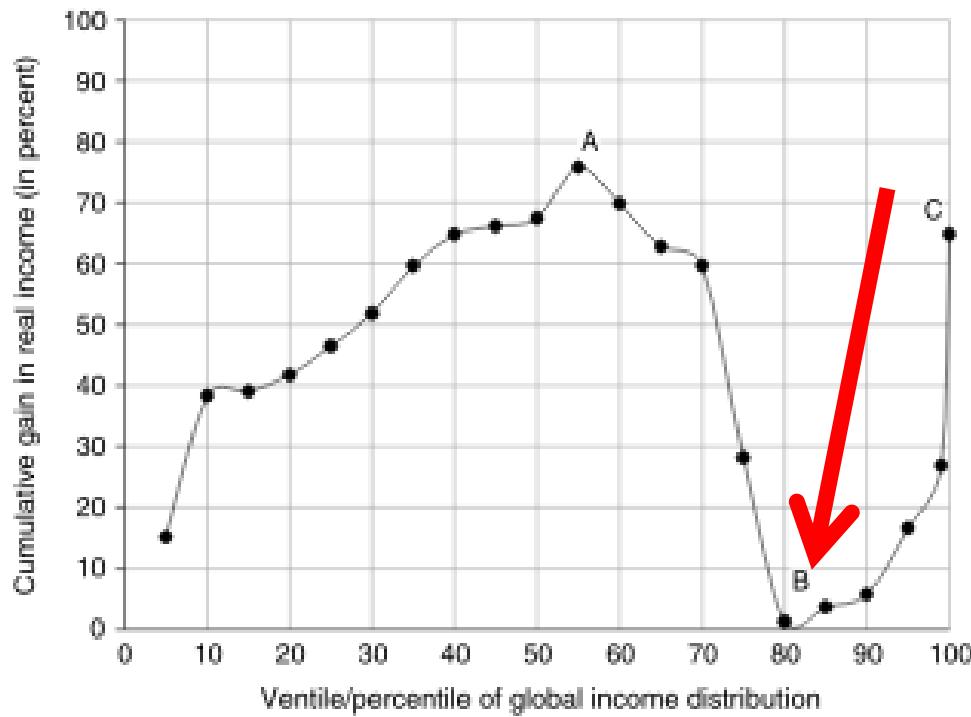
The French labor market is rigged in favor of insiders and in disfavor of outsiders ie the unemployed especially the young people with few educational credentials



# Global Inequality between countries and inside countries

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- With the Globalization, global inequality is decreasing between developed and emerging countries (China/India vs EU/USA) but inequality is increasing inside developed countries (especially USA).
- From 1988 and 2008 the wages of western lower middle class (B) have stagnated, the wages of development countries workers have increased (A) and the wages of western upper middle class an upper class has increased (C).



Branko Milanović *Global inequality: A New Approach for the Age of Globalization*, 2016, Harvard University Press

## Market concentration in the US

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**Table 2.1** The Largest Highly Concentrated Industries

SOURCE: Data from 2012 Economic Census.<sup>39</sup>

<b>Segment</b>	<b>Market Share of Top Four Companies</b>	<b>Annual Revenue (2012)</b>
Warehouse clubs and supercenters	93.6%	\$406 billion
Drug wholesalers	72.1%	\$319 billion
Auto and truck manufacturing	68.6%	\$231 billion
Drug stores	69.5%	\$230 billion
Mobile-phone service	89.4%	\$225 billion
Airlines	65.3%	\$157 billion
Administration of pension funds	76.3%	\$145 billion
Landline-phone service	73.4%	\$142 billion
Cable TV	71.1%	\$138 billion
Airplane manufacturing	80.1%	\$113 billion

# Market concentration in the US

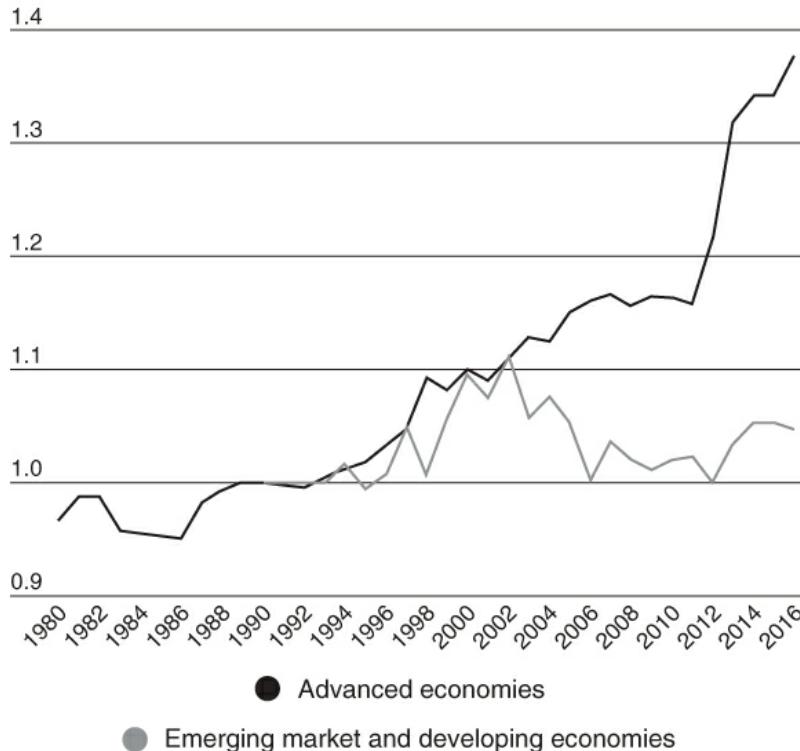
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## Market power

Markups in advanced economies have been rising since the 1980s.

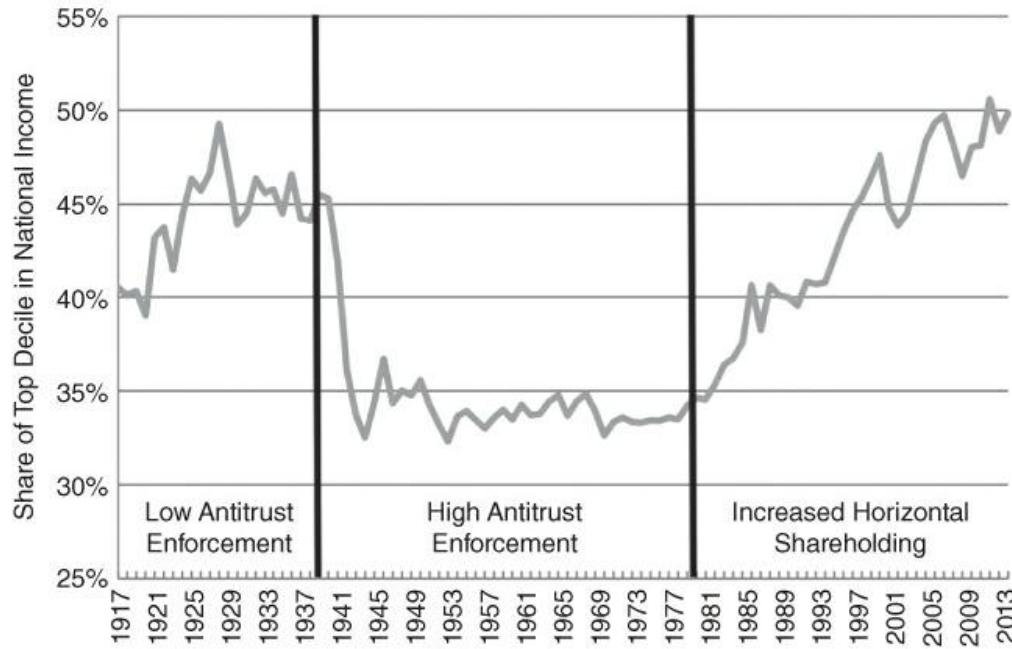
(average markups of listed firms in each country income group, index 1990 = 1)



**Figure 10.9** Markups in Advanced Economies Have Been Rising since the 1980s

SOURCE: International Monetary Fund.

- Inequality is increasing with the market concentration generate by lax antitrust enforcement



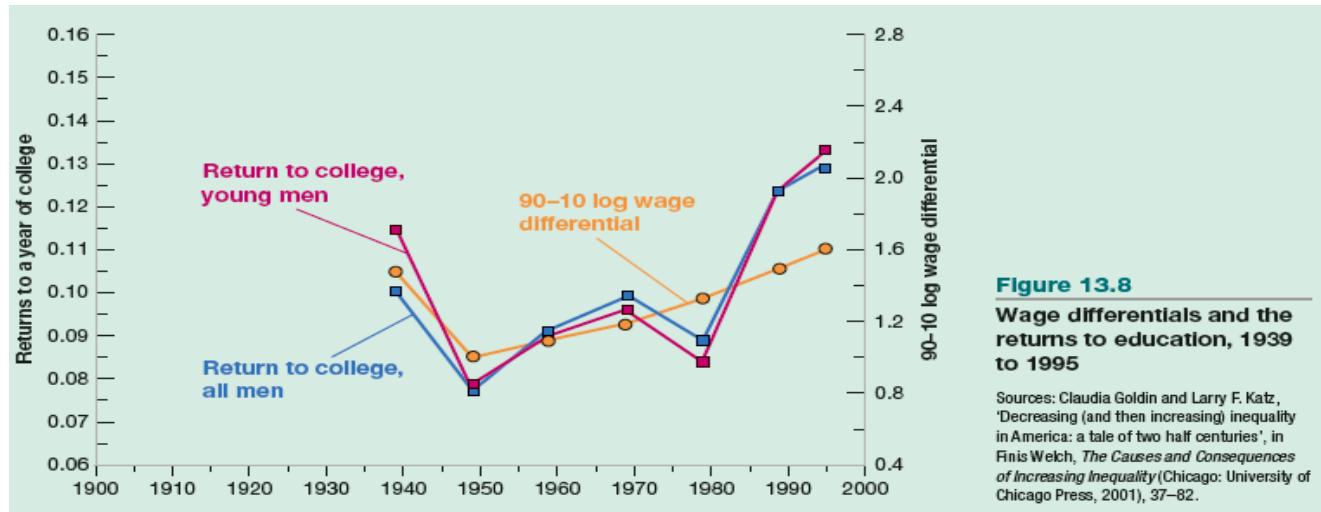
**Figure 10.7** Income Inequality in the United States versus Antitrust Enforcement

SOURCE: Einer Elhauge, "Horizontal Shareholding," *Harvard Law Review* 129, no. 5 (March 2016).

# Global Inequality, Technology and Education

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- The technology revolution is increasing the demand of educated workers



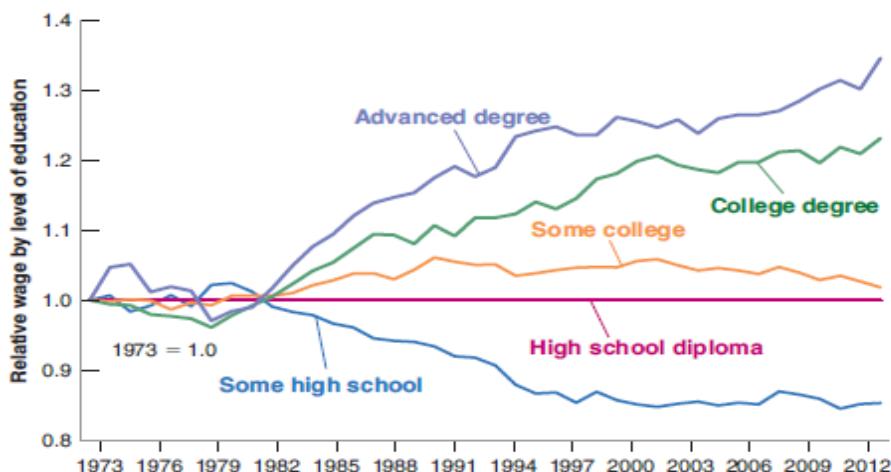
**Figure 13-6**

**Evolution of Relative Wages by Education Level, 1973–2012**

Since the early 1980s, the relative wages of workers with a low education level have fallen; the relative wages of workers with a high education level have risen.

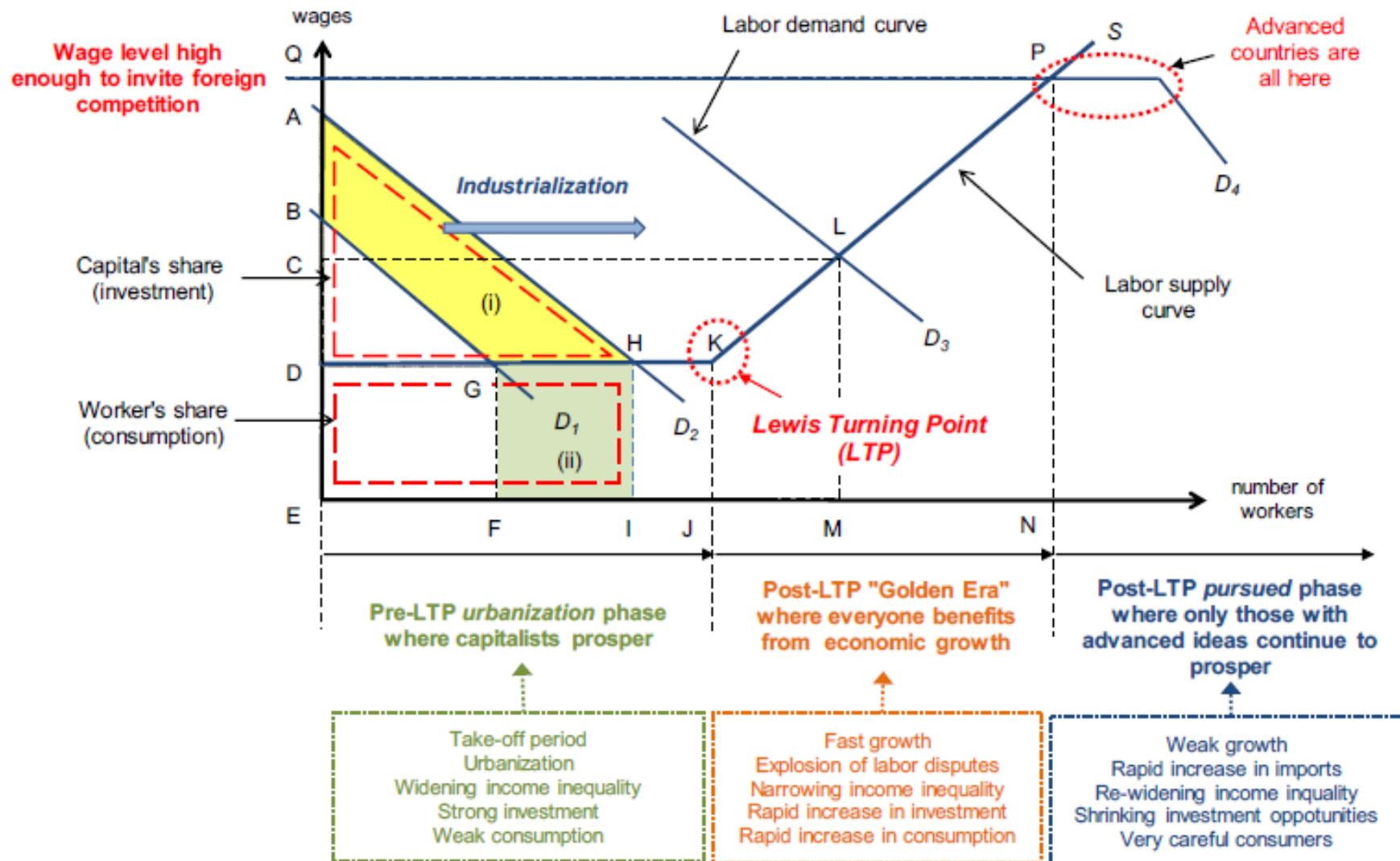
Source: Economic Policy Institute DataZone. [www.epi.org/types/data-zone/](http://www.epi.org/types/data-zone/).

MyEconLab Real-time data



# Globalization : Technology + International trade + Immigration put the pressure on the wages of western unskilled workers and raise the wages of developing countries ' workers

## Richard KOO's three stages of economic Development and the Labor Market



Source: Nomura Research Institute