From Stagnation to Growth: Unified Growth Theory

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Outline

- From Stagnation to Modern Growth: Historical Evidence
- The Malthusian Theory
- Theories of the Demographic Transition
- Unified Growth Theory (UGT)
- UGT and Comparative Development Across the Globe

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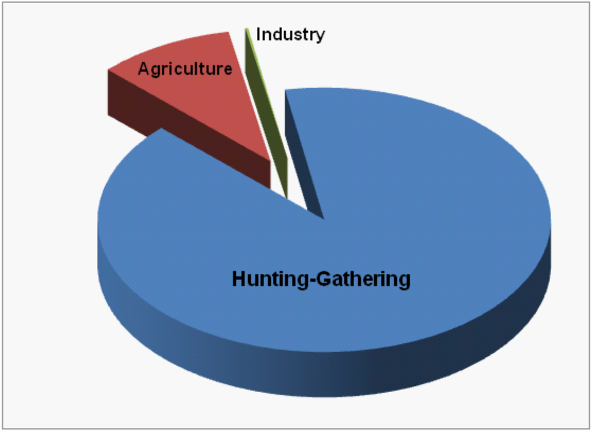
Human Time Line



The Complexity of the Process of Development

- The Malthusian Epoch

Developed Countries	$100,000$ *BCE* - 1750
LDCs	$100,000$ *BCE* - 1900

- The Post Malthusian Regime

Developed Countries	1750 - 1870
LDCs	1900 -

- The Modern Growth Regime

Developed Countries	1870 - present
LDCs	

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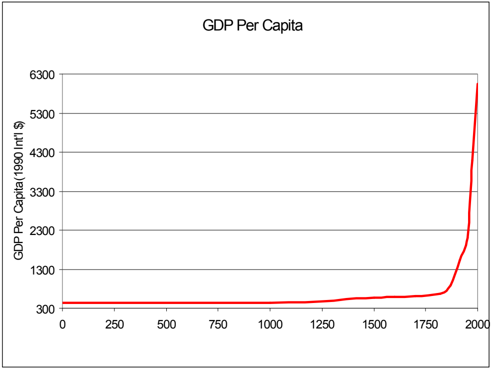
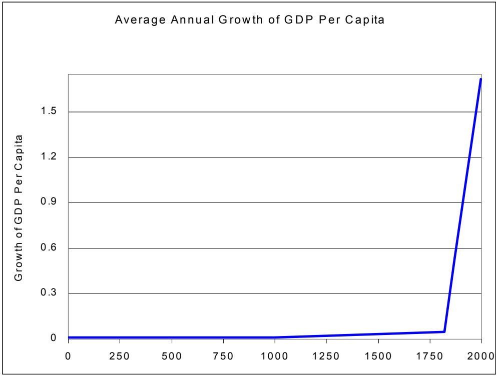
World Income per Capita: 0-2000



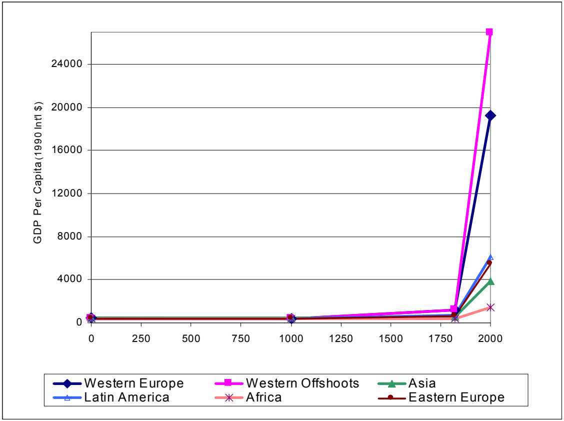
Year	0	1000	1500	1600	1700	1820	1870	1913	1950	1973	2001
GDP	445	436	566	595	615	667	875	1525	2111	4091	6049

Growth Rates: World Income Per Capita, 0-2000



Year	0-1000	1000-1820	1820-2001
Growth of GDP	-0.00%	0.05%	1.21%

Regional Income per Capita, 0-2000



Inequality in Income Per Capita, 0-2000

Year	Western Offshoots	Western Europe	Latin America	Asia	Africa	Ratio: Rich/Poor
0	400	450	400	450	425	1.1 : 1
1000	400	400	400	450	416	1.1 : 1
1820	1202	1,204	692	581	418	3 : 1
2001	26,943	19,265	6,150	3861	1,489	18 : 1

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- Population growth is positively affected by the level of income per capita
- Technological progress exits but it is slow and it results in a proportional increase in output and population
- Output per capita fluctuates around a subsistence level

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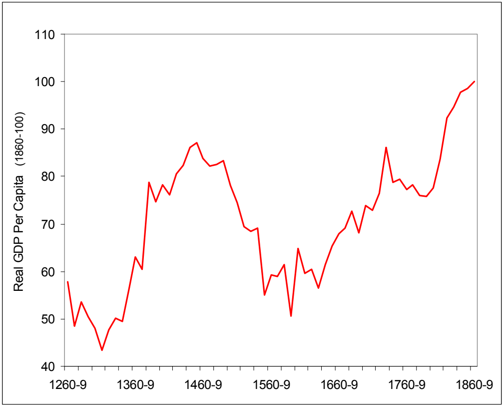
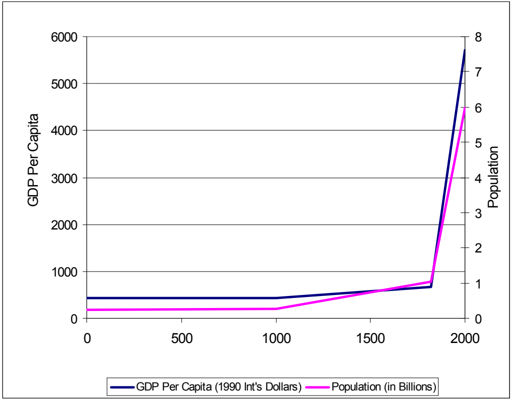
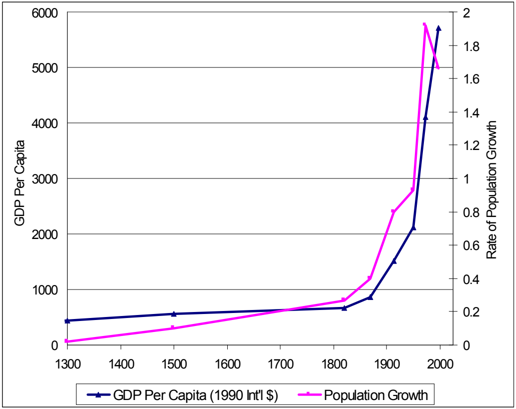
Malthusian Fluctuations in GDP Per Capita: England, 1260-1870



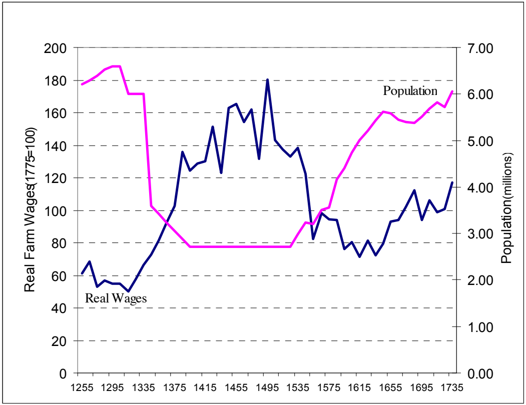
Malthusian Relationship between World Income and Population



Malthusian Relationship between World Income and Population Growth



Malthusian Relationship between Income and Population: England 1250-1750



The Post-Malthusian Regime

Economies take-off from a Malthusian equilibrium:

- Population growth is still positively affected by the level of income per capita
- Technological progress accelerates and it results in a larger increase in output than in population
- Income per capita and population grow at an increasingly faster pace

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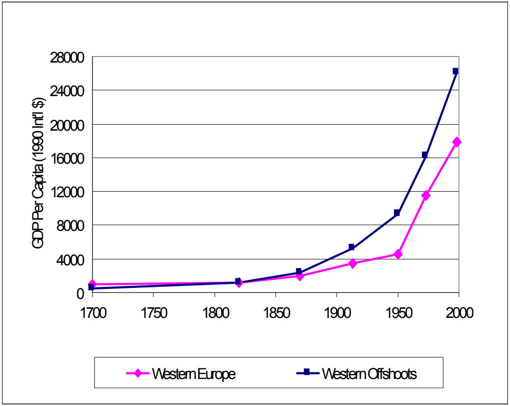
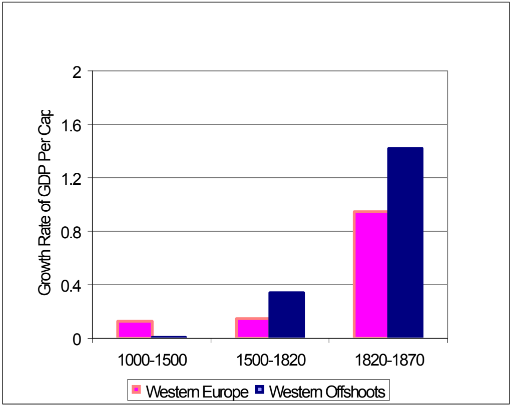
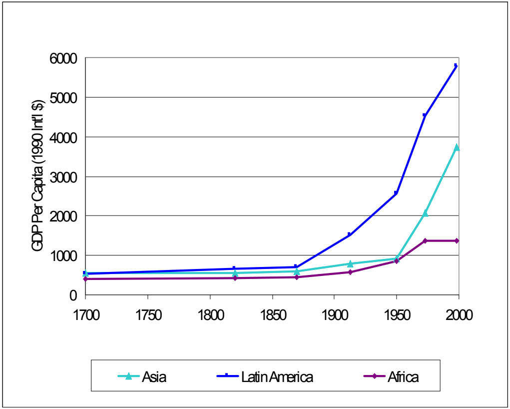
Regional Variation in the Timing of the Take-off (Level): Early Take-Off



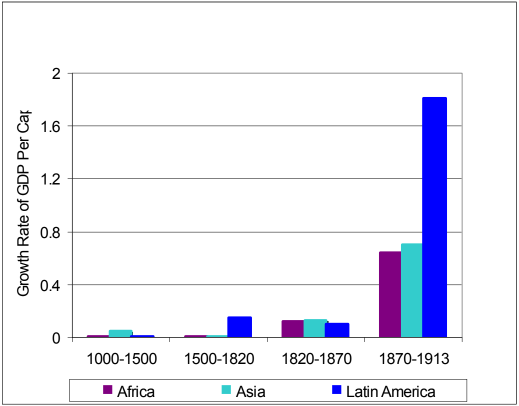
Variation in the Timing of the Take-off (Growth): Early Take-Off



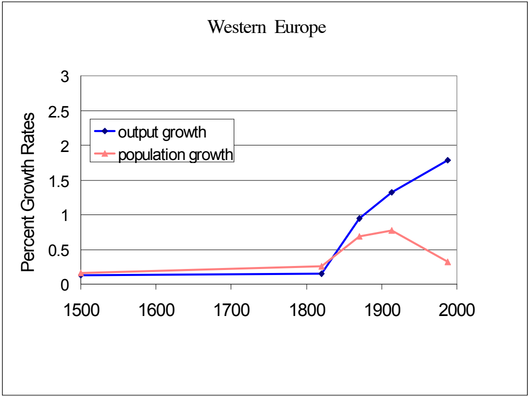
Regional Variation in the Timing of the Take-off: (Levels) Late Take-Off



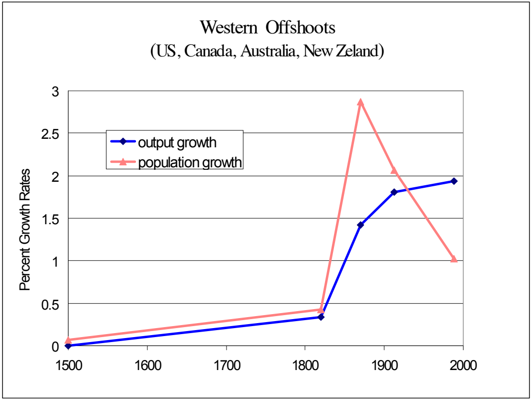
Variation in the Timing of the Take-off (Growth): Late Take-Off



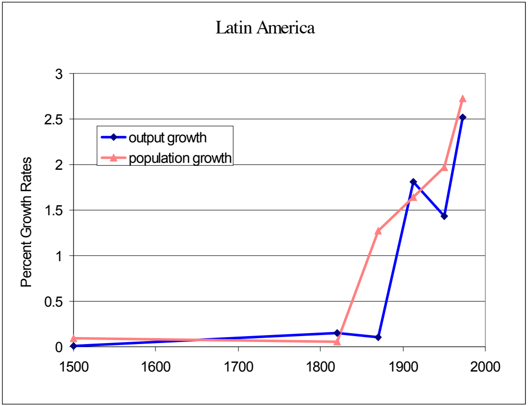
Growth of GDP Per Capita and Population: Western Europe, 1500-2000



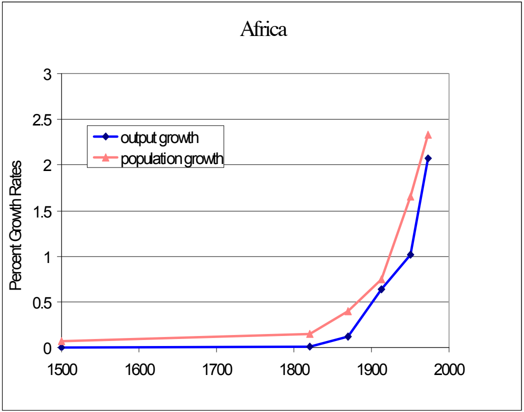
Growth of GDP Per Capita and Population: Western Offshoots, 1500-2000



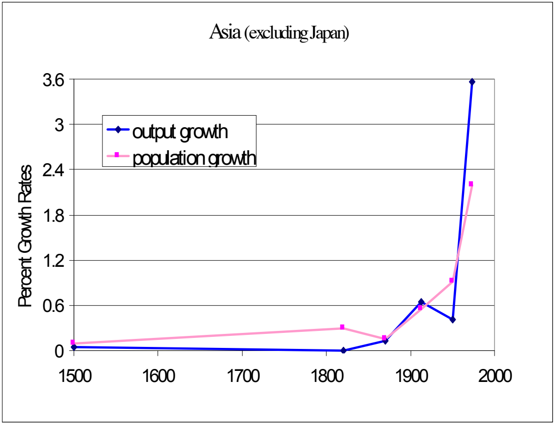
Growth of GDP Per Capita and Population: Latin America 1500-2000



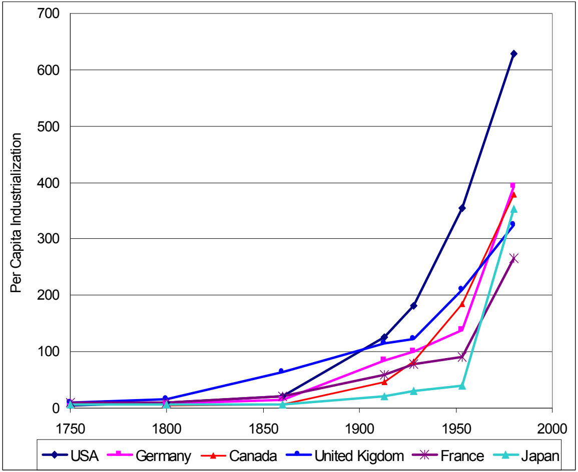
Growth of GDP Per Capita and Population: Africa 1500-2000



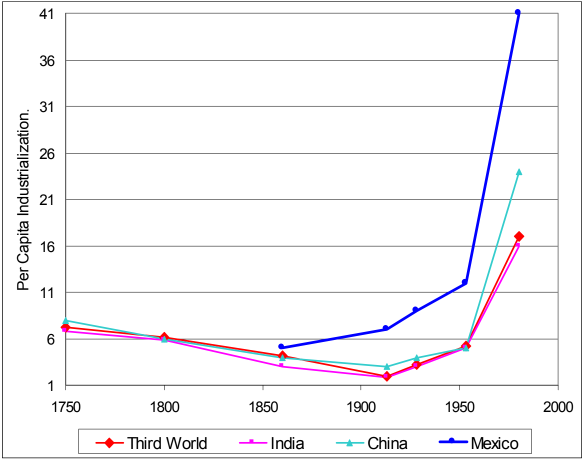
Growth of GDP Per Capita and Population: Asia, 1500-2000



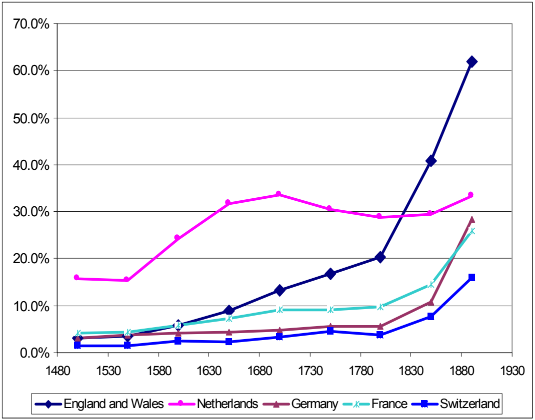
Industrialization: Developed Economies



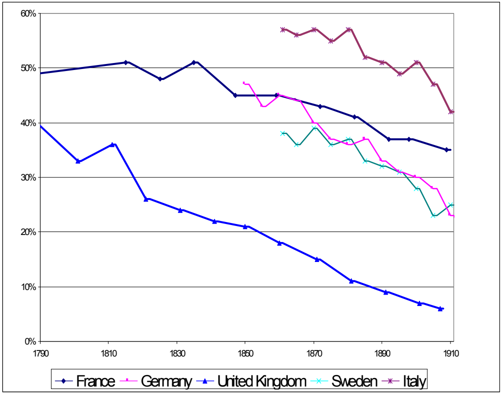
Industrialization: Less Developed Economies



Urbanization (Population in Cities larger than 10,000)



Agricultural Production in Total Output: Europe: 1790-1910



The Modern Growth Regime

- Technological progress accelerates
- The demand for human capital increases
- Population growth declines – The Demographic Transition
- Gains in total output are not counterbalanced by population growth
- Output per capita grows at a high sustainable level

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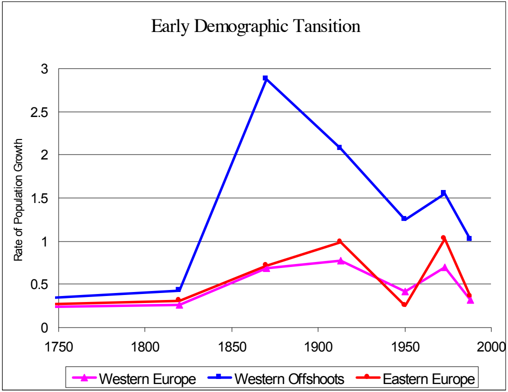
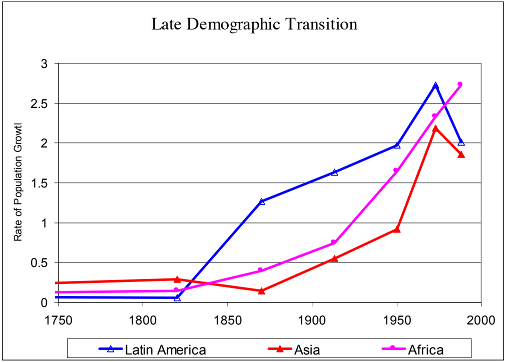
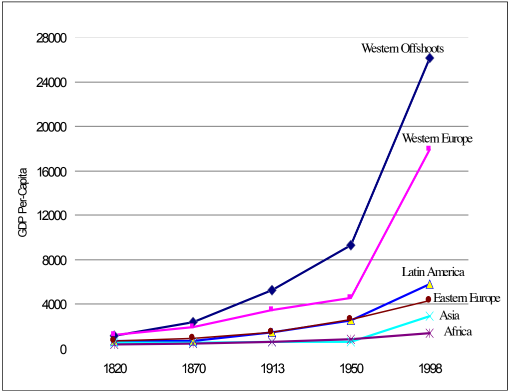
Timing of the Demographic Transition across Regions: Early Transition



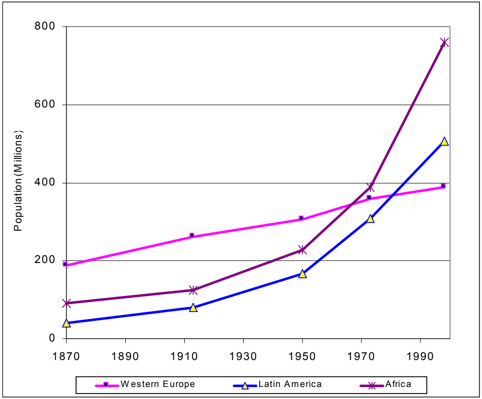
Timing of the Demographic Transition across Regions: Late Transition



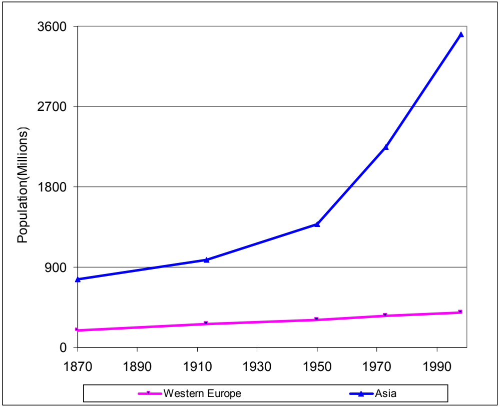
Variations in the timing of the Transition: Divergence in Income per Capita



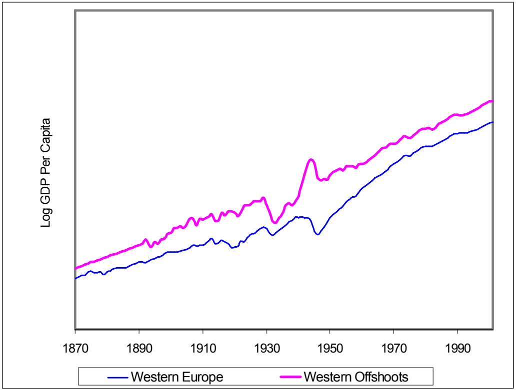
Divergence in Population: Africa and Latin America Vs. Western Europe



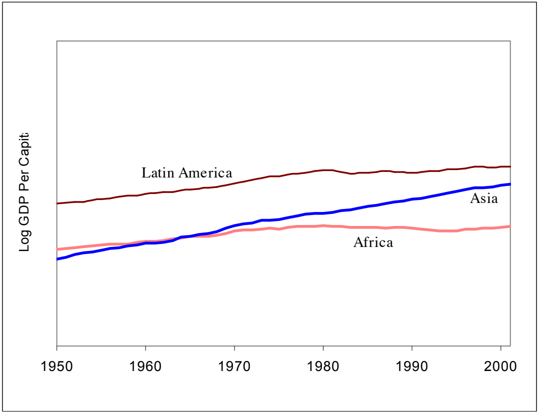
Divergence in Population: Asia vs. Western Europe



Sustained Economic Growth: Western Europe and Western Offshoots, 1870-2001



Growth of Income Per Capita: Africa, Asia and Latin America, 1950-2001



Major Puzzles

Context: The Malthusian Epoch

- What accounts for the epoch of stagnation that characterized most of human history?
- Why had episodes of technological progress in the pre-industrialization era failed to generate sustained economic growth?
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Inconsistency of non-UGT with the Growth Process

- Inconsistent with the qualitative aspects of the growth process during the Malthusian epoch and the Post-Malthusian Regime
- Limited to the modern growth regime – a miniscule fraction (0.1%) of the entire process of development
- Do not capture the forces that brought about the transition of developed countries from stagnation to growth and hence unable to shed light of the hurdles faced by LDCs in their attempt to take-off to a state of sustained economic growth
- Unable to capture fundamental forces that led to sustained differences in income per-capita across countries

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Lessons from other Scientific Disciplines

- The evolution of theories in older scientific disciplines suggests that theories that are founded on the basis of a subset of existing observations and their driving forces, may be attractive in the short run, but non-robust and ultimately non-durable in the long run (e.g., Classical Thermodynamics)
- Attempts to develop unified theories in Physics (e.g., Unified Field Theory) have been based on the conviction that all physical phenomena should ultimately be explainable by some underlying unity
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The Basic Structure of the Malthusian Model

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- $t = 0, 1, 2, 3...$
- One homogeneous good
- 2 factors of production:
  - Labor
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- Overlapping-generations economy
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Optimization

$$c_t = (1-\gamma)y_t$$

$$n_t = \gamma y_t/\rho.$$

Population Dynamics

- The evolution of population size

$$L_{t+1} = n_t L_t = (\gamma/\rho) y_t L_t = (\gamma/\rho)(AX)^{\alpha} L_t^{1-\alpha} \equiv \phi(L_t; A)$$

- The steady-state level of population size

$$\bar{L} = (\gamma/\rho)^{1/\alpha}(AX) \equiv \bar{L}(A)$$

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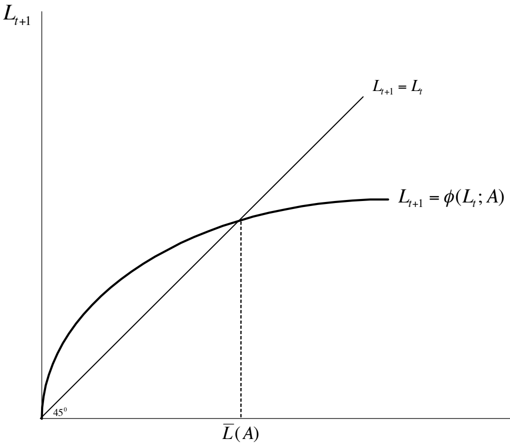
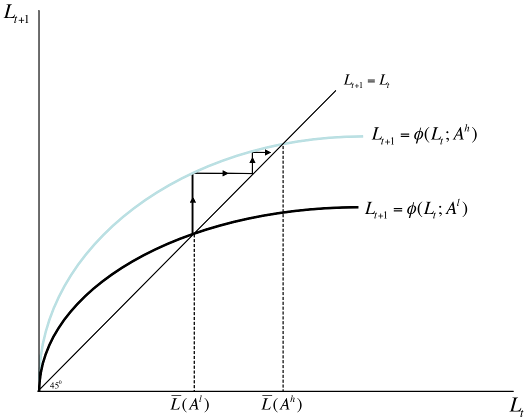


Adjustment of Population to Advancements in Technology or Land Productivity



The Evolution of Income Per Worker

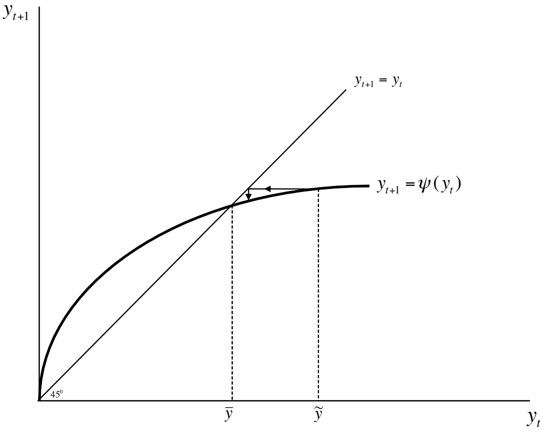
- The time path of income per capita

$$y_{t+1} = \left[\frac{AX}{L_{t+1}}\right]^{\alpha} = \left[\frac{AX}{n_t L_t}\right]^{\alpha} = \frac{y_t}{n_t^{\alpha}} = \left[\frac{\rho}{\gamma}\right]^{\alpha} y_t^{1-\alpha} \equiv \psi(y_t)$$

- The steady-state level of income per capita

$$\bar{y} = \left[\frac{\rho}{\gamma}\right]$$

The Evolution of Income Per Worker



The Effect of Advancment in Technology or Land Productivity

- Increases the steady-state level of population

$$\frac{\partial \bar{L}}{\partial A} > 0$$

- Increases the level of income per capita in the short-run but does not affect the steady-state levels of income per worker

$$\frac{\partial y_t}{\partial A} > 0 \quad \text{and} \quad \frac{\partial \bar{y}}{\partial A} = 0$$

Testable Implications

- Variations in technology and land quality across countries will be reflected primarily in variation in population density:
  - Technological superiority will result primarily in higher population density without any sizable effect on income per-capita in the long-run
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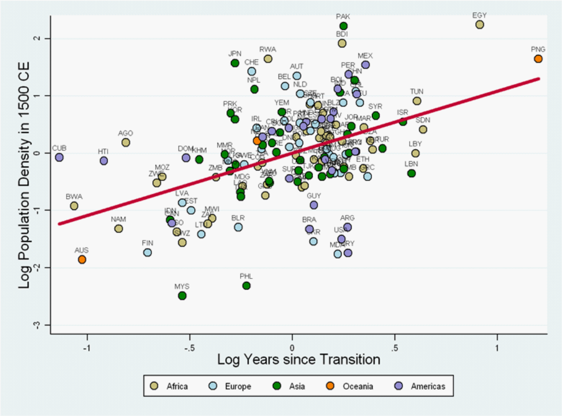
Determinants of Population Density in 1500 CE

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	OLS	OLS	OLS	IV
	Dependent Variable: **Log population density in 1500 CE**					
Log years since Neolithic	**0.827**		**1.024**	**1.087**	**1.389**	**2.077**
	(0.299)***		**(0.223)*****	**(0.184)*****	**(0.224)*****	**(0.391)*****
Log land productivity		**0.584**	**0.638**	**0.576**	**0.573**	**0.571**
		(0.068)***	**(0.057)*****	**(0.052)*****	**(0.095)*****	**(0.082)*****
Log absolute latitude		-0.426	-0.354	-0.314	-0.278	-0.248
		(0.124)***	(0.104)***	(0.103)***	(0.131)**	(0.117)**
Distance to nearest coast or river				-0.392	0.220	0.250
				(0.142)***	(0.346)	(0.333)
% land within 100 km of coast or river				0.899	1.185	1.350
				(0.282)***	(0.377)***	(0.380)***
Continental dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	148	148	148	147	96	96
R^2	0.40	0.60	0.66	0.73	0.73	0.70
First-stage F-statistic						14.65
Overident. p-value						0.44

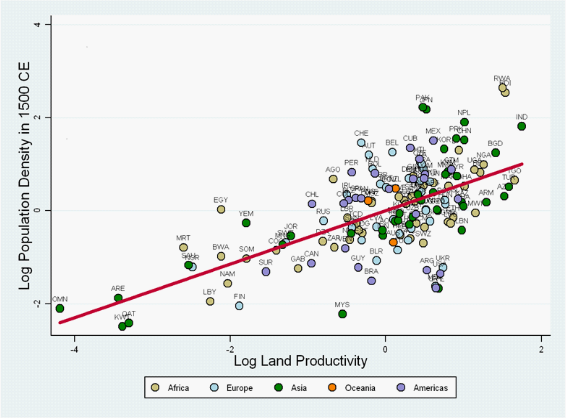
Notes: Robust standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$
Source: Ashraf and Galor (2008)

Timing of Neolithic and Population Density in 1500 CE



Conditional on land productivity, geographical factors, and continental fixed effects

Land Productivity and Population Density in 1500 CE



Conditional on transition timing, geographical factors, and continental fixed effects

Effects on Income Per Capita versus Population Density

	OLS	OLS	OLS	OLS	OLS	OLS
	(1)	(2)	(3)	(4)	(5)	(6)
	Log Income Per Capita in			Log Population Density in		
	1500 CE	1000 CE	1 CE	1500 CE	1000 CE	1 CE
Log years since Neolithic	**0.159**	**0.073**	**0.109**	**1.337****	**0.832****	**1.006****
	(0.136)	(0.045)	(0.072)	(0.594)	(0.363)	(0.483)
Log land productivity	**0.041**	**-0.021**	**-0.001**	**0.584*****	**0.364*****	**0.681****
	(0.025)	(0.025)	(0.027)	(0.159)	(0.110)	(0.255)
Log absolute latitude	-0.041	0.060	-0.175	0.050	-2.140**	-2.163**
	(0.073)	(0.147)	(0.175)	(0.463)	(0.801)	(0.979)
Distance to nearest coast or river	0.215	-0.111	0.043	-0.429	-0.237	0.118
	(0.198)	(0.138)	(0.159)	(1.237)	(0.751)	(0.883)
% land within 100 km of coast or river	0.124	-0.150	0.042	1.855**	1.326**	0.228
	(0.145)	(0.121)	(0.127)	(0.820)	(0.615)	(0.919)
Continental dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	31	26	29	31	26	29
R^2	0.66	0.68	0.33	0.88	0.95	0.89

Notes: Robust standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$
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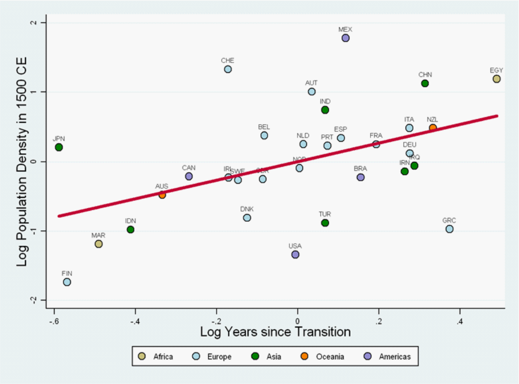
Transition Timing and Population Density in 1500 CE



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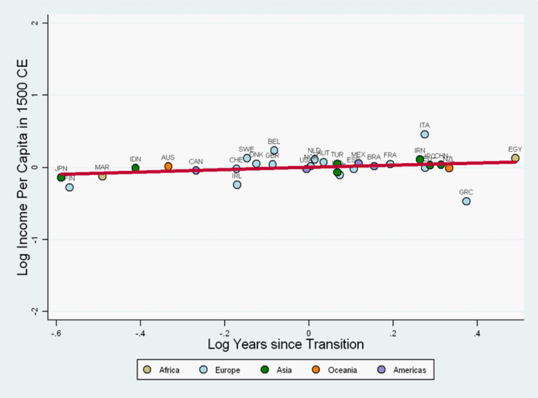

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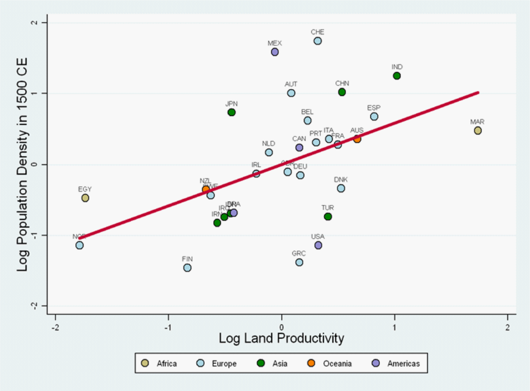

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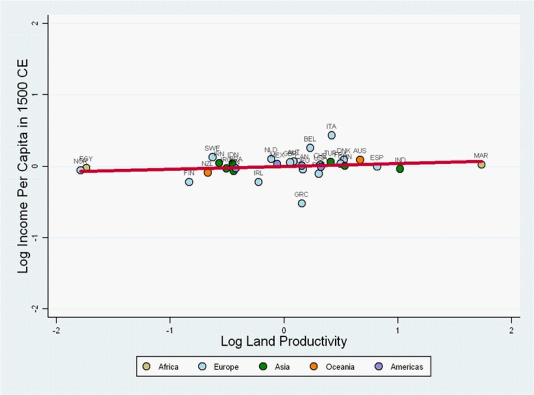

Conditional on transition timing, geographical factors, and continental fixed effects

The Demographic Transition

A rapid decline in population growth that mark the transition to modern growth:

- The positive relationship between income per capita and population growth is reversed
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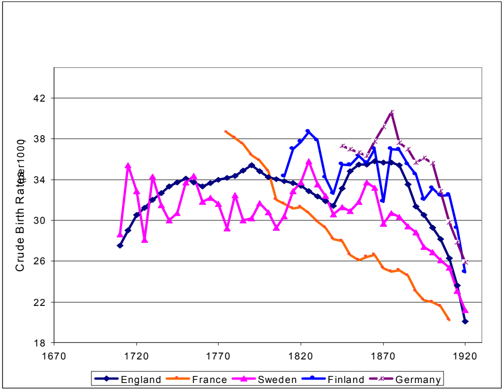
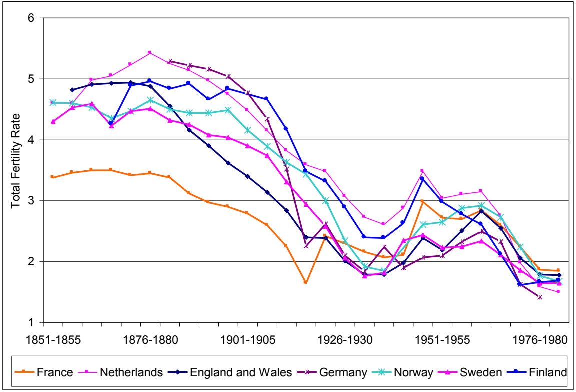
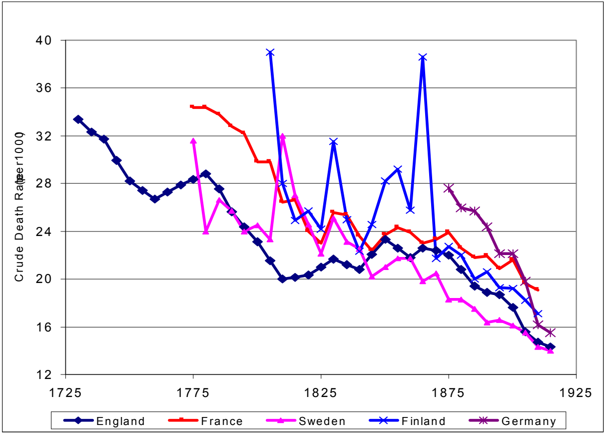
The Demographic Transition in Western Europe: Crude Birth Rates



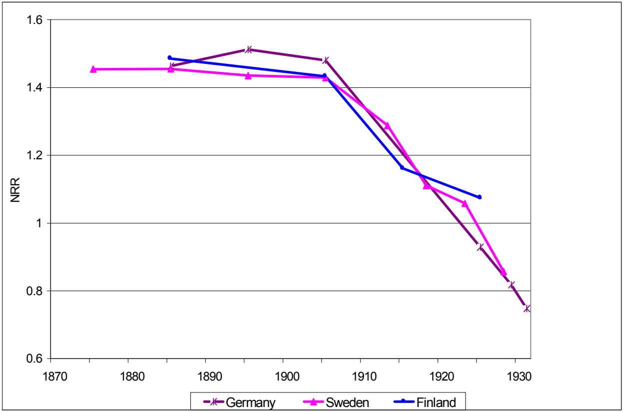
The Demographic Transition in Western Europe: Total Fertility Rates



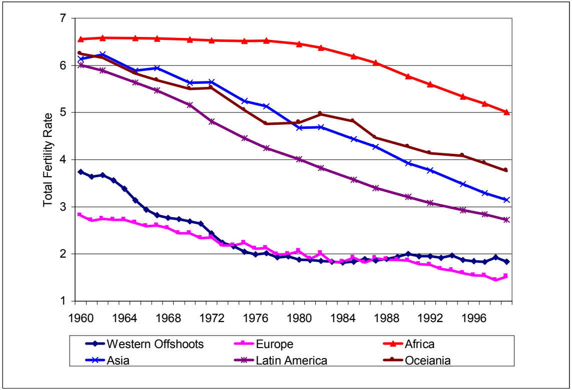
Mortality Decline Western Europe: 1730-1920



The Decline in NRR in Western Europe



The Evolution of Total Fertility Rate across Regions, 1960-1999



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- The Decline in Mortality
- The Decline in the Gender Wage Gap (Galor-Weil, AER 1996))
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Theory: The rise in income brought about the DT
Mechanism: (Unattractive) preference-based theory:

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  - An income effect - more income can be devote to raising children
  - A substitution effect - the opportunity cost of raising children increases

$$y\tau n + c \leq y$$

y household income; c consumption; n children; τ time cost per child

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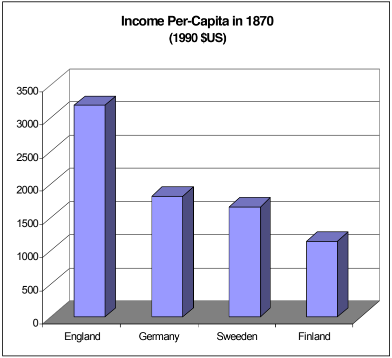

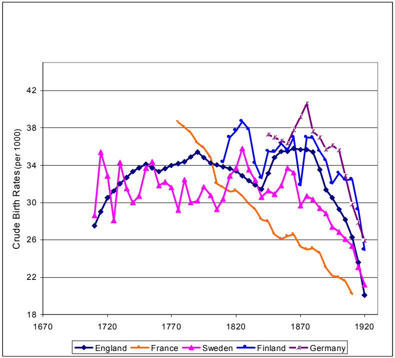

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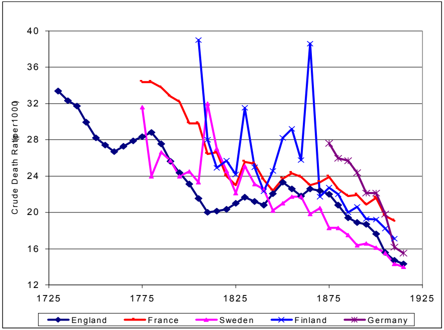

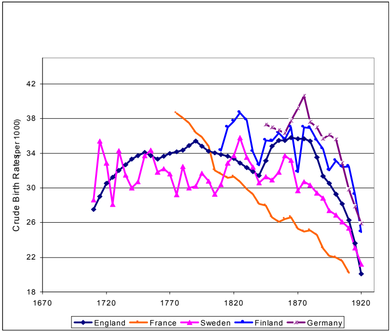

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Challenges to the Theory:

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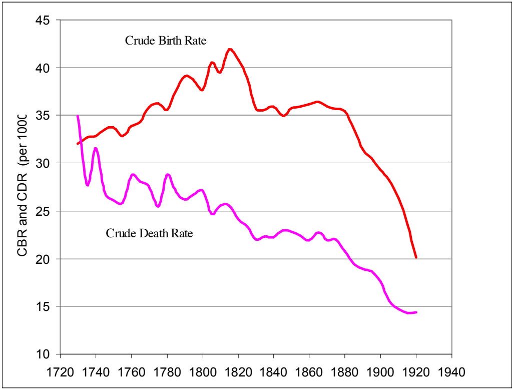
Sharp Decline in Fertility without Changes in the Patterns of Mortality Decline: England 1730-1920



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- The process of development narrowed the gender wage gap (It complemented mental tasks more than physical tasks and thus increased the productivity of women relative to men)

- The rise if the relative wages of women induced a decline in fertility:
- If women are primarily engaged in child rearing an increase in the wages of women, y^F increases the opportunity cost of raising children more than family income, inducing a reduction in fertility)

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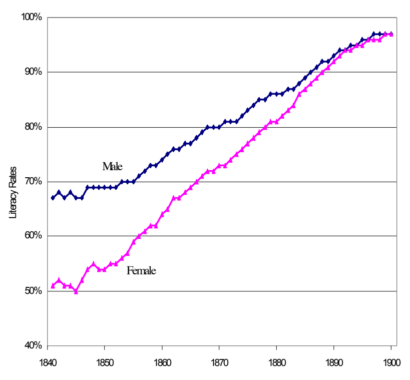

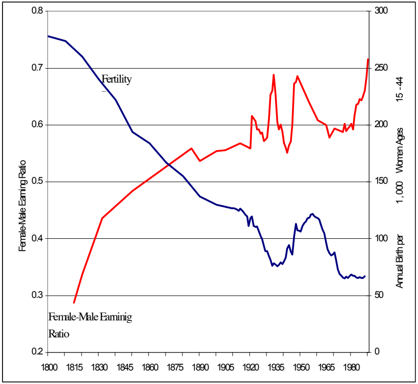

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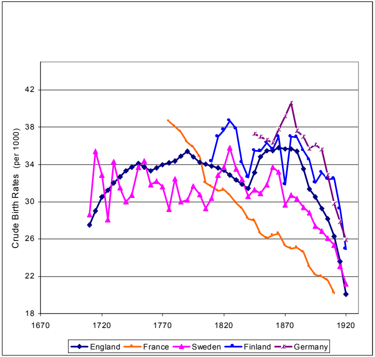

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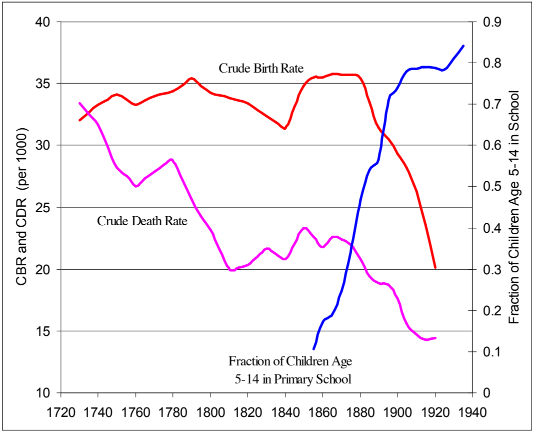

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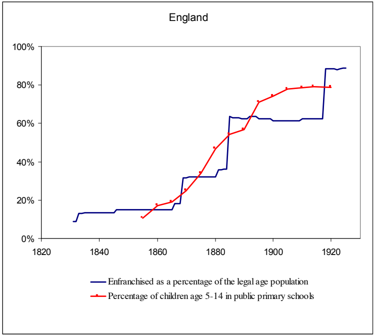
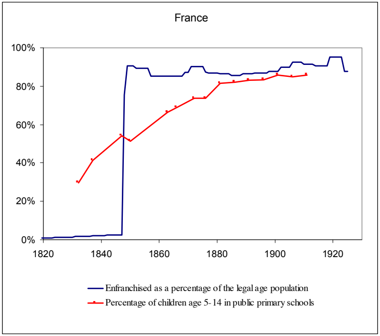
- Investment in human capital prior to the demographic transition is a response to industrial demand rather than being triggered by political reforms (Galor-Moav, RES 2006).





Decline in the Desiarability of Child Labor

The effect of the rise in the demand for human capital on the reduction in the desirable number of surviving offspring was reinforced via its adverse effect on child labor. It gradually increased the wage differential between parental labor and child labor inducing parents to reduce the number of their children and to further invest in their quality (Hazan and Berdugo, 2002). Moreover, the rise in the importance of human capital in the production process induced industrialists to support education reforms (Galor and Moav, RES 2006) and thus laws that abolish child labor (Doepke, JEG 2004; Doepke and Zilibotti, AER 2005), reducing child labor and thus fertility.

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Selection of Preferences for Child Quality

During the epoch of Malthusian stagnation, individuals with a higher valuation for offspring quality (in the context of the quantity-quality survival strategies) gained an evolutionary advantage and their representation in the population gradually increased, reinforcing the substitution towards child quality, setting the stage for a more rapid decline in fertility along with a significant increase in investment in human capital. (Galor and Moav (QJE 2002).

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- The increase in the rate of technological progress increases the demand for human capital
  - Human capital permits individuals to better cope with the changes in the technological environment
    - Shcultz (1970), Nelson and Phelps (1966), Foster and Rosenzweig (1996)
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- The rise in the *demand* for human capital in the second phase of Industrialization induces parents to substitute quality for quantity of children
- The rise in income along with the rise in the potential return to human capital generates:
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- The economy is a Malthusian steady-state equilibrium
- Technological progresses is slow
- The return to human capital is low $\Longrightarrow$ parents have no incentive to substitute child quality for quantity
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- Parents are induced to further substitute child quality for quantity
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- The Model

The Basic Structure of the Model

- Overlapping-generations economy
- $t = 0, 1, 2, 3...$
- One homogeneous good
- 2 factors of production:
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- The output produced in period t

$$Y_t = H_t^{\alpha}(A_t X)^{1-\alpha}$$

  - $H_t \equiv$ efficiency units of labor
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- Output per worker produced at time t

$$y_t = h_t^{\alpha} x_t^{(1-\alpha)} \equiv y(h_t, x_t)$$

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Individuals

- Live for 2 period
- Childhood: (1st Period):
  - Consume a fraction of their parental unit-time endowment. The required time increases with children's quality
- Parenthood (2nd Period):
  - Allocate time between childrearing and work
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Second period budget constraint:

$$w_t h_t n_t(\tau + e_{t+1}) + c_t \leq w_t h_t$$

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Human capital of children of generation t

$$h_{t+1} = h(e_{t+1}, g_{t+1})$$

- $g_{t+1} \equiv (A_{t+1} - A_t)/A_t$ rate of tech progress
- $e_{t+1} \equiv$ education
- $h_{eg}(e_{t+1}, g_{t+1}) > 0$
- $h_e(e_{t+1}, g_{t+1}) > 0, \quad h_{ee}(e_{t+1}, g_{t+1}) < 0,$
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$$\{n_t, e_{t+1}\} = argmax\{w_t h_t[1 - n_t(\tau + e_{t+1})]\}^{1-\gamma}\{(n_t h(e_{t+1}, g_{t+1})\}^{\gamma}$$

Subject to:

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$$n_t = \begin{cases} \frac{\gamma}{\tau + e(g_{t+1})} \equiv n^b(g_{t+1}) & if \quad z_t \equiv w_t h_t \geq \tilde{z} \\ \\ \frac{1 - [\tilde{c}/z_t]}{\tau + e(g_{t+1})} \equiv n^a(g_{t+1}, z(e_t, g_t, x_t)) & if \quad z_t \equiv w_t h_t \leq \tilde{z} \end{cases}$$

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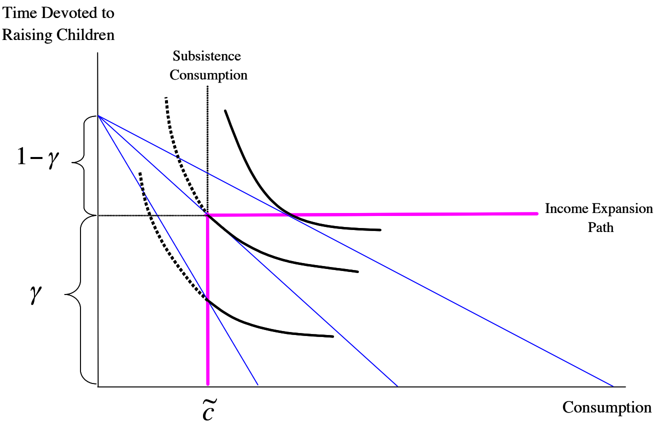
Optimization: Income Expansion Path



Optimal Investment in Child Quality

$$e_{t+1} = e(g_{t+1}) \begin{cases} = 0 & \textit{if} \quad g_{t+1} \leq \hat{g} \\ > 0 & \textit{if} \quad g_{t+1} > \hat{g} \end{cases}$$

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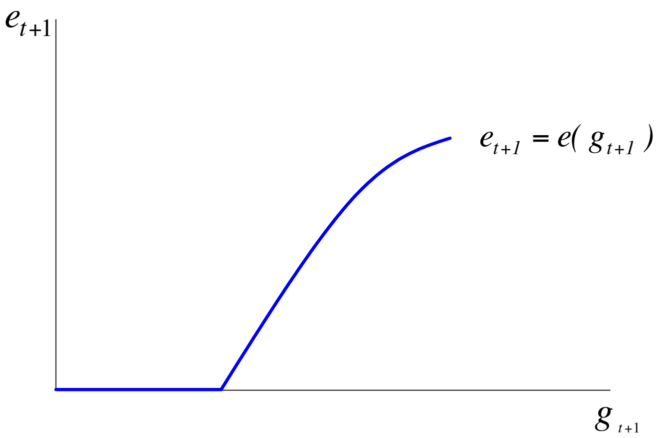

Technological Progress

Technological progress over time

$$g_{t+1} \equiv \frac{A_{t+1} - A_t}{A_t} = g(e_t, L_t)$$

- $g(0, L_t) > 0$
- $g_i(e_t, L_t) > 0$ and $g_{ii}(e_t, L_t) < 0, \quad i = e, L$

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Population Dynamics

$$L_{t+1} = n_t L_t$$

$$L_{t+1} = \begin{cases} n^b(g_{t+1})L_t & \text{if} \quad z_t \geq \tilde{z} \\ n^a(g_{t+1}, z(e_t, g_t, x_t))L_t & \text{if} \quad z_t \leq \tilde{z} \end{cases}$$

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Dynamics of the Level of Resources per Worker

$$x_{t+1} = \frac{A_{t+1}X}{L_{t+1}} = \frac{(1+g_{t+1})A_tX}{n_tL_t} = \frac{1+g_{t+1}}{n_t}x_t$$

$$x_{t+1} = \begin{cases} \frac{[1+g(e_t,L_t)][\tau^q+\tau^e e(g(e_t,L_t))]}{\gamma}x_t \equiv \phi^b(e_t;L)x_t & z_t \geq \tilde{z} \\ \frac{[1+g(e_t,L_t)][\tau+e(g(e_t,L_t))]}{1-[\tilde{c}/z(e_t,g_t,x_t)]}x_t \equiv \phi^a(e_t,g_t,x_t,L_t)x_t & z_t \leq \tilde{z}, \end{cases}$$

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A sequence $\{x_t, e_t, g_t, L_t\}_{t=0}^{\infty}$ such that:

$$\begin{cases} x_{t+1} = \phi(e_t, g_t, x_t, L_t)x_t \\ e_{t+1} = e(g(e_t, L_t)) \\ g_{t+1} = g(e_t, L_t) \\ L_{t+1} = n(e_t, g_t, x_t, L_t)L_t \end{cases}$$

The Conditional Evolution of Technology and Education

A sequence $\{g_t, e_t; L\}_{t=0}^{\infty}$ such that:

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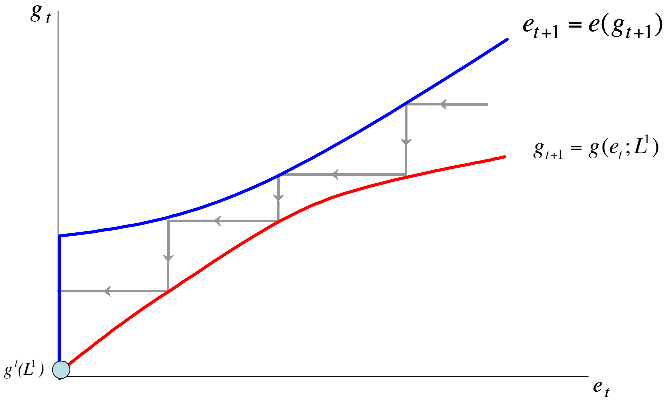
The Evolution of Education and Technology



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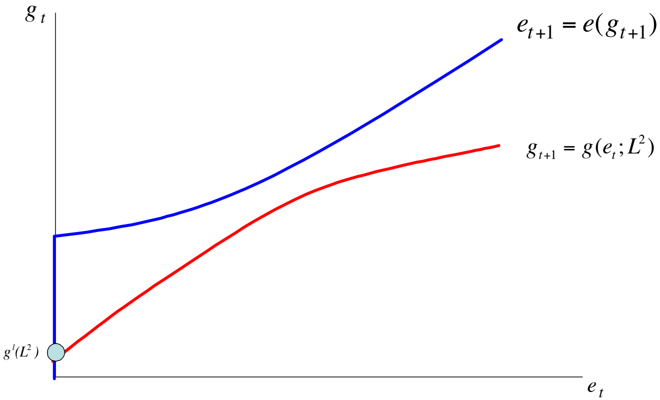

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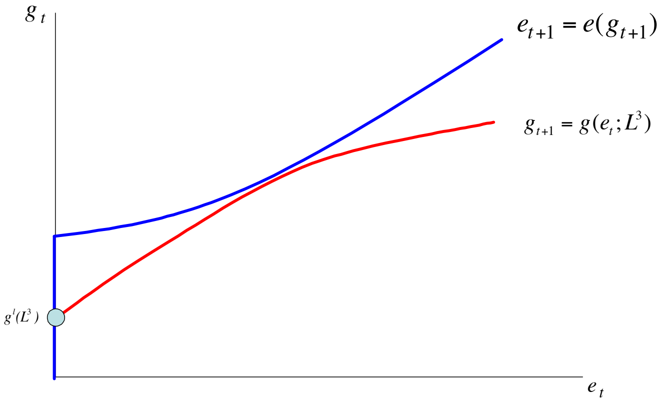

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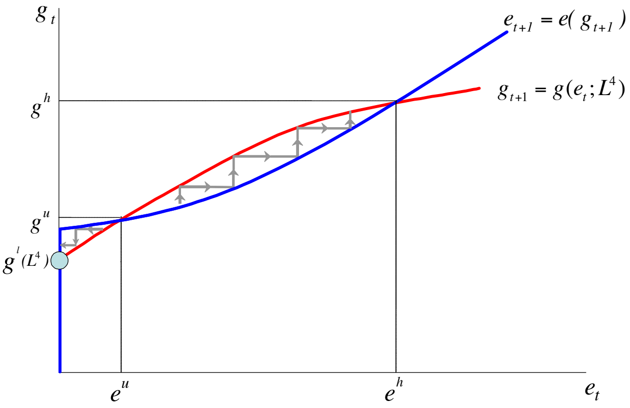

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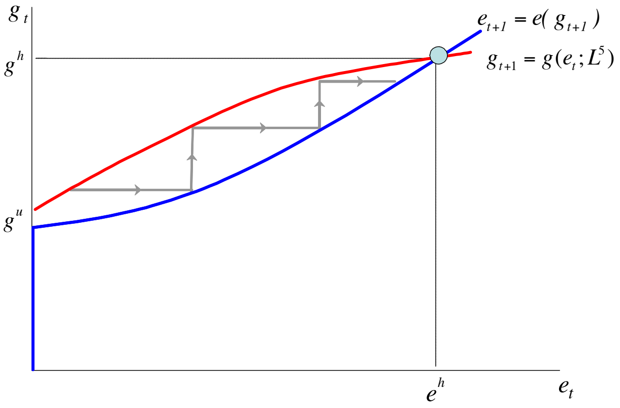
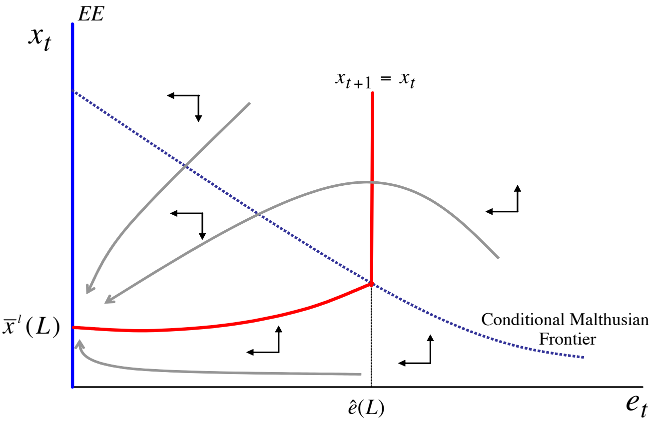
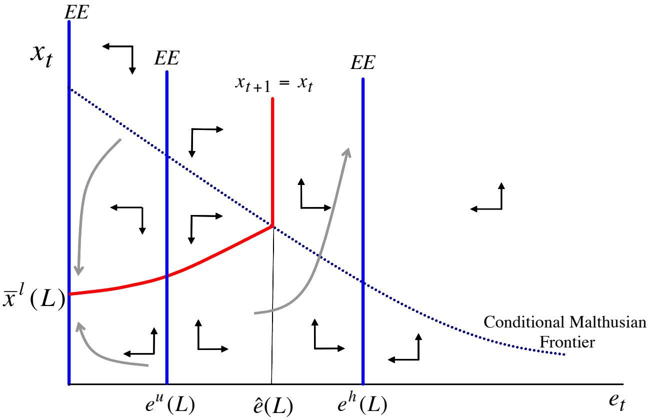


The Evolution of Education and Resources Per Worker: Small Population



The Evolution of Education and Resources Per Worker: Intermediate Population



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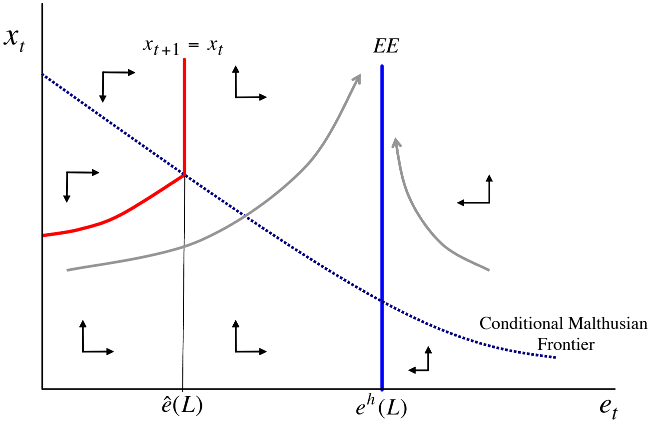

Calibrations of Galor-Weil - (Lagerlof RED 2006)

Table 1
Parameter values, baseline case

	Interpretation	Value
Parameters		
α	Labor share	0.6
τ	Fixed time cost of children	0.15
ρ	Educational part of τ	0.879
a^*	Scale effect parameter	11.42
γ	Weight on fertility in utility function	0.225
θ	Scale effect parameter	1
X	Land	1
$\tilde{c}$	Subsistence consumption	1
m	Adult mortality	1
Endogenous variables		
e^*	Education, modern growth	0.075
g^*	Techn. growth, modern growth	2.362
n^*	Fertility, modern growth	1
$\hat{L}$	Threshold population	7.278
Initial conditions		
n_0	Initial fertility	1
L_0	Initial population	0.364
A_0	Initial technology	0.870
e_0	Initial education	0
g_0	Initial techn. growth	0.048
z_0	Initial per-worker income	1.176

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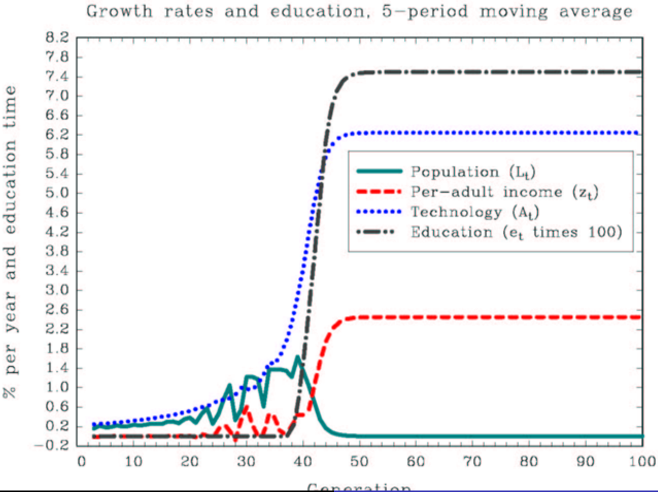

Implications

- The transition from stagnation to growth is an *inevitable* by-product of the process of development
- The inherent Malthusian interaction between technology and population, accelerated the pace of technological progress, and eventually brought an industrial demand for human capital
- Human capital formation, triggered a demographic transition, enabling economies to convert a larger share of the fruits of factor accumulation and technological progress into growth of income per capita
- Variations in the timing of the take-off from stagnation to growth contributed significantly to the Great Divergence

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Implications for the Emergence of Convergence Clubs

- Differences in the timing of the take-off from stagnation to growth across countries contributed to the emergence of convergence clubs

- Although the long-run equilibrium may not differ across economies, differential timing of takeoffs from stagnation to growth segmented economies into three fundamental regimes the differ in their growth structure:
    - Slow growing economies in the vicinity of a Malthusian regime
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- The decline in the profitability of child Labor (Hazan Berdugo, EJ 2002)
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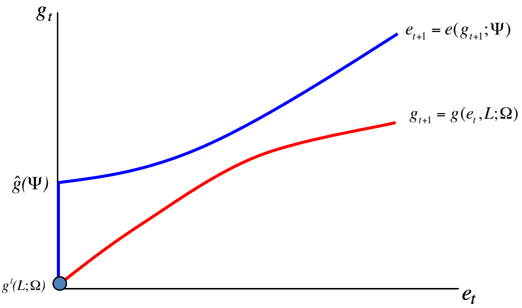

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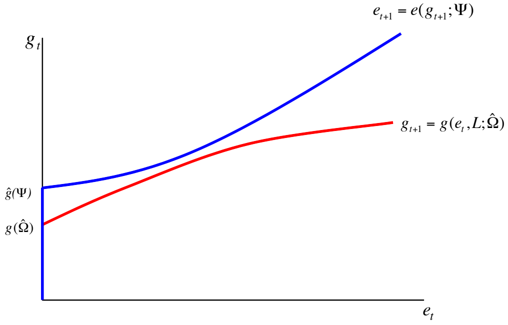

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- Concentration of land ownership $\Longrightarrow$ The prevalence of public education
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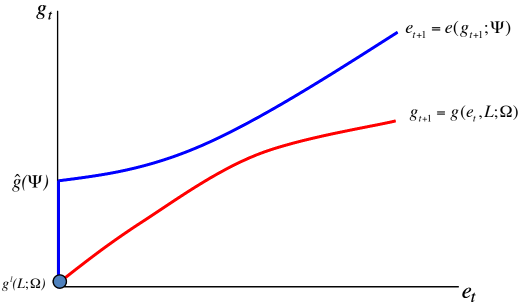

Deep Rooted Factors in Comparative Development

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  - Migratory distance from the geographical origins of Homo sapiens affects contemporary variations in economic development via Genetic Diversity
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References

Underlying Philosophy:

- "Towards a Unified Theory of Economic Growth: Oded Galor on the Transition from Malthusian Stagnation to Modern Economic Growth," World Economics, June 2008 (An interview by Brian Snowdon)

References

Foundations:

- Galor Oded, "From Stagnation to Growth: Unified Growth Theory," Handbook of Economic Growth, 2005, 171-293
- Galor Oded and David N. Weil, "From Malthusian Stagnation to Modern Growth," *American Economic Review*, 89, 150-154, (May 1999)
- Galor Oded and David N. Weil, "Population, Technology and Growth: From Malthusian Stagnation to the Demographic Transition and Beyond," *American Economic Review*, 90, 806-828, (September 2000)

References

Implications for Comparative Development

- Galor Oded and Andrew Mountford, "Trading Population for Productivity: Theory and Evidence", *Review of Economic Studies*, 75, 2008.
- Galor Oded, Omer Moav and Dietrich Vollrath, "Inequality in Land Ownership, the Emergence of Human Capital Promoting Institutions, and the Great Divergence," *Review of Economic Studies*, forthcoming 2008.
- Ashraf Quamrul and Oded Galor, "Cultural Assimilation, Cultural Diffusion and the Origin of the Wealth of Nations," 2007.
- Ashraf Quamrul and Oded Galor, "Human Genetic Diversity and Comparative Economic Development," 2008

References

Additional Readings:

- Ashraf Quamrul and Oded Galor, "Malthusian Population Dynamics," 2008
- Galor Oded and Omer Moav, "The Neolithic Origins of Contemporary Variation in Life Expectancy", 2007
- Galor Oded and Omer Moav, "Natural Selection and the Origin of Economic Growth," Quarterly Journal of Economics, 117, 1133-1192 (November 2002)