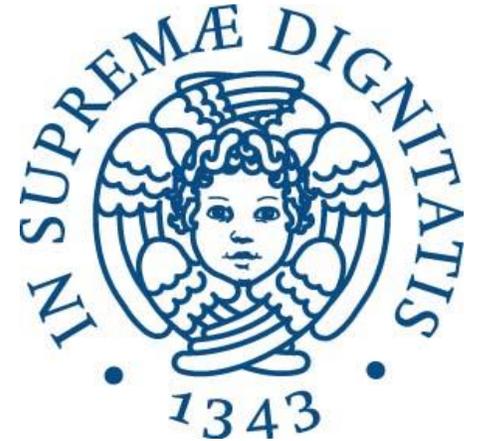# A unified growth theory of economic, demographic and ecological transitions

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Outline and keywords

- **Background:** Unified Growth Theory (Galor and Weil, 2000, Galor, 2011), ecological transition (Baldwin, 1995), demographic and economic transitions over the course of economic development, Environmental Kuznets Curve, EKC), Malthusian regime, Modern growth regime.

- **Objectives:** UGT to encompass the ecological transition, which has accompanied both the demographic and economic transitions over the course of economic development.

- **The model:** OLG growth model with endogenous fertility, human capital and individual (private) environmental maintenance (green investment).

- **Results:** The U-shaped relationship between income and environment quality (EKC) is the result of both the take-off and environmental concerns related to the transition from the Malthusian epoch to the Modern regime of growth.

Background 1

- In two pioneering works, Galor and Weil (1999, 2000) introduced a new approach to study economic growth and development, the so-called Unified Growth Theory (UGT).

- The main aim of the UGT is to understand the causes of the long-term development of different societies over the course of economic history in order to infer about current policy implications.

- The basic model can describe the endogenous switch from the Malthusian era to the Modern era (sustained growth), occurred since the beginning of the industrial revolution around 1750 AD. This shift was characterised by the economic and demographic transitions.

- The economic transition represents the switch from persistent stagnation to persistent growth. The demographic transition characterises the switch from a regime where mortality and fertility rates were high to a regime where these rates were low (mortality and fertility transitions), with a progressive substitution from quantity to quality of children (Becker and Tomes, 1976).

- This substitution implies subsequent increases in human capital investment and endowments leading to improvements in technological progress causing the take-off during the industrial revolution.

Background 2

- The UGT is a powerful tool allowing to improve our knowledge of human development over the very long term, resulting to be of interests not only for economists but also for a wider range of social scientists and historians (Galor, 2005).

- However, the UGT neglects one dimension of the transition characterising the take-off of modern economies, namely the environmental or ecological transition (Baldwin, 1995).

- The switch from agricultural to manufacturing production implied an increase in the level of pollution generated by human activity that in turn decreased environmental quality.

- After an initial fall in environmental conditions (1750-1980), there were concerns about the sustainability of the human activity leading to an increase in purposeful investments in environmental protection (1980-today).

- This process generated a U-shaped relationship (EKC) between environmental quality and income (alternatively, an inverted U-shaped relationship between environmental degradation and income) implying also that the environment has faced a transition due to the industrial revolution.

Background 3

- John and Pecchenino (1994) were first in modelling this narrative simply in an OLG growth model, allowing individuals to devote resources in environmental maintenance.

- So far, the economic literature has not already developed a general theory able to encompass the three different (economic-demographic-ecological) dimensions of the transitions occurred in industrialised countries over the last two hundred years.

- This article combines the UGT approach of Galor and Weil (2000) with the theory of environmental protection developed by John and Pecchenino (1994).

- The argument is intuitive: the falling arm of the EKC is a side-product of the economic take-off and the relocation of activity from agriculture to manufacture associated with the earlier stage of economic development.

- The increasing arm instead is due to the increase in the amount of resources devoted to environmental protection due to economic growth observed later.
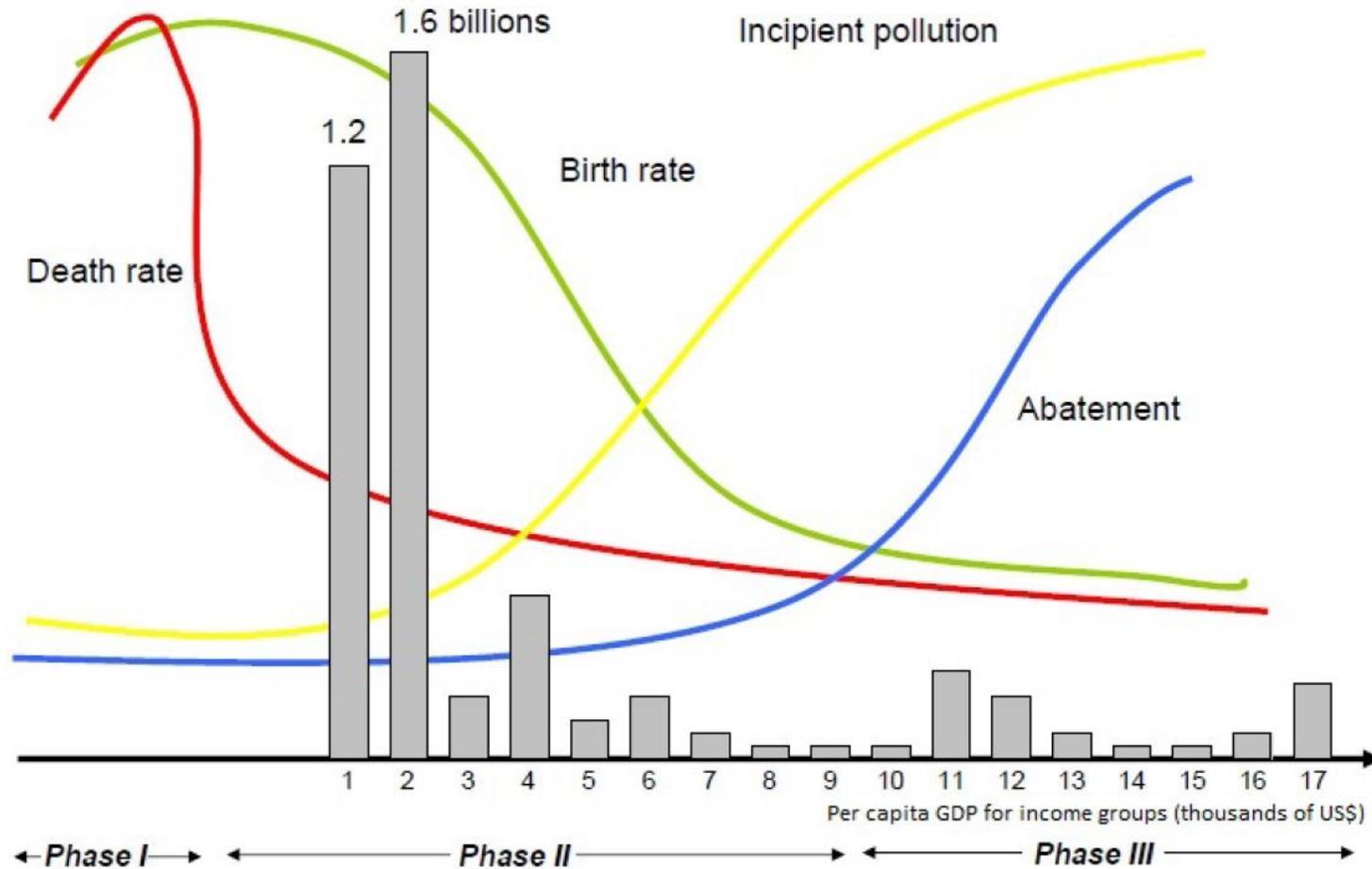
Ecological transition accompanying the demographic transition. [Source: Baldwin (1995).]

Objectives

- The model aims at showing the endogenous transition amongst the various phases of economic development in industrialised countries.

- Starting from a phase in which individuals do not invest in education and do not spend in environmental protection (due to the low profitability of the former activity and the abundance of environmental quality), there exists a second phase in which individuals start investing in education marking the start from child quantity (the precautionary demand for children) to child quality, i.e. the well-known quantity/quality trade-off.

- This causes an increase in human capital accumulation and a decline in environmental quality (due to the increased production).

- This phase is followed by a final stage in which individuals begin to endogenously invest in defensive expenditure (due to degraded environmental conditions) thus triggering a phase of improvement in environmental quality.

The model 1

- OLG UGT general equilibrium model with finite-lived individuals, quantity-quality trade-off [Galor and Weil (2000), de la Croix and Doepke (2003)] and individual environmental protection [John and Pecchenino (1994)]. Three cohorts:

  - Childhood (non-economically active time)

  - Young adults (working period)

  - Old age (retiring period)

- Endogenous fertility and education decisions

- As in John and Pecchenino (1994), environmental dynamics depends on its natural deterioration, the human-driven deterioration and the size of the green investment.

The model 2

- Lifetime utility $\quad U_t = \ln(c_t) + \beta[\ln(h_{t+1}n_t) + \ln(E_{t+1})]$

- Budget constraint $\quad c_t + m_t + v_t n_t = w_t h_t (1 - \tau n_t)$

- Environmental dynamics $\quad E_{t+1} = E_t(1 - \eta) - \phi Y_t + \sigma m_t N_t$

- Human capital accumulation $\quad h_{t+1} = \delta h_t^\theta (\mu + v_t)^{1-\theta}$

- Production function $\quad Y_t = AH_t = Ah_t(1 - \tau n_t)N_t$

- Profits $\quad \Pi_t = Y_t - w_t H_t \Rightarrow w_t = A \quad$ marginal productivity of labour (per unit of human capital)

The model 3

- The representative individual maximises the lifetime utility U_t with respect to fertility, n_t education, v_t and green investment, m_t subject to the budget constraint and taking into account the dynamics of both human capital and environmental quality

- The model shows the existence of three development regimes and the endogenous transition amongst them depending on the initial conditions of human capital (history):

- **Regime I**: Precautionary demand for children, No education, No green investment

- **Regime II**: Child quantity/quality trade-off, No green investment

- **Regime III**: Child quantity/quality trade-off, Green investment

- **Regime I**

$$\begin{cases} m_t = 0 \\ v_t = 0 \\ n_t = n = \dfrac{\beta}{\tau(1+\beta)} \end{cases}, \quad if \quad h_t \leq h := \dfrac{\mu}{A\tau(1-\theta)}$$

The marginal benefit of giving birth to an extra child is larger than both the marginal cost of additional education and the marginal cost of additional green investment, so that a parent does not want starting investments in education and environmental maintenance. The economy is entrapped in a poverty trap with a higher precautionary demand for children and no education. An increase in production negatively affects the environment but individuals do not have (private) incentive to green investment.

- **Regime II**

$$
\begin{cases}
m_t = 0 \\[2mm]
v_t = \dfrac{A\tau(1-\theta)h_t - \mu}{\theta} \quad , \quad if \quad h_t > h \\[4mm]
n_t = \dfrac{\beta\theta h_t}{(1+\beta)[A\tau h_t - \mu]}
\end{cases}
$$

The marginal benefit of giving birth to an extra child is smaller than the marginal cost of additional education but larger than the marginal cost of additional green investment, so that a parent starts investing in education but there is incentive to environmental maintenance. The child quantity/quality trade-off marks the start for economic development. Environmental quality continues to reduces and income increases.

- **Regime III**

$$
\begin{cases}
m_t = \dfrac{Ah_t[\beta(\sigma+\phi)+\phi]-(1-\eta)(1+\beta)e_t}{\sigma(1+2\beta)} \\[4mm]
v_t = \dfrac{A\tau(1-\theta)h_t-\mu}{\theta} \\[4mm]
n_t = \dfrac{\beta[A(\sigma-\phi)h_t+(1-\eta)e_t]}{\sigma(1+2\beta)(A\tau h_t-\mu)}
\end{cases}
\quad , \quad if \quad h_t > h \quad and \quad \dfrac{e_t}{h_t} < \dfrac{A[\beta(\sigma+\phi)+\phi]}{(1-\eta)(1+\beta)}
$$

The marginal benefit of giving birth to an extra child is smaller than both the marginal cost of additional education and the marginal cost of additional green investment, so that a parent starts investments in education and environmental maintenance (due to degraded environmental conditions). Economic development endogenously generates the conditions to start investing in environmental protection so that there is an improvement in environmental quality as income increases.
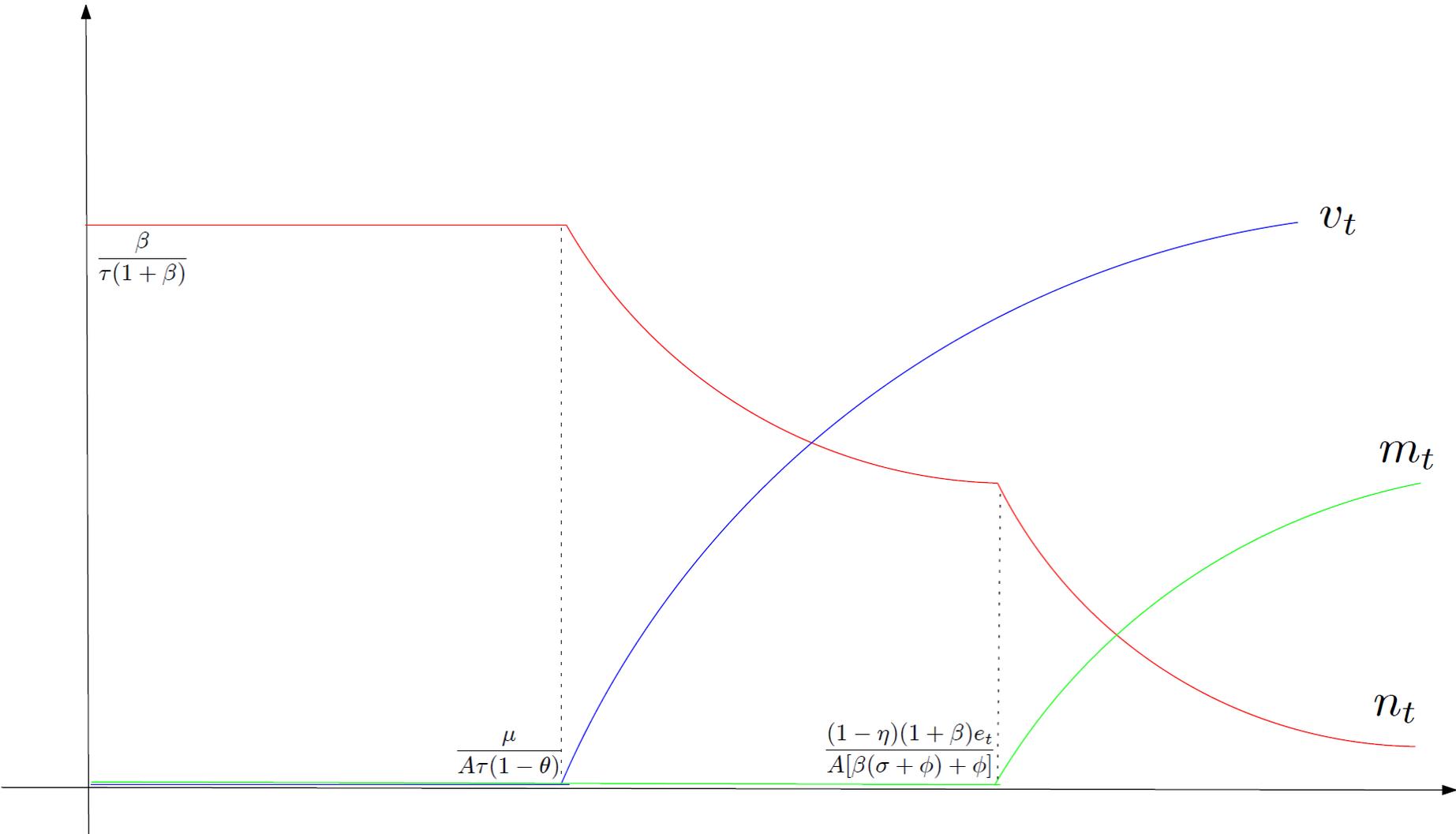
Conclusions

- This work extended the traditional unified growth theory (Galor and Weil, 1999, 2000) to encompass the ecological transition (Baldwin, 1995), which has accompanied both the demographic and economic transitions.

- The argument was straightforward: increases in income associated with economic development first lower environmental standard and then allow for larger environmental maintenance improving environmental quality.

- Such a U-shaped relationship between per capita income and environmental quality (the so-called environmental Kuznets curve) is simply the result of the take-off and environmental concern related to the transition from the Malthusian to the Solowian era.