Economic and Demographic Transition, Mortality, and Comparative Development

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Demographic Transition:

- Increase in adult longevity (50-70 in few generations)
- Reduction in child mortality ($>$ 300 to $\leq$ 5 per thousand in few generations)
- Gross and net fertility (eventually) drop (from 6 children per woman to 2)

Comparative Development: The World Today

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  - Life expectancy at birth below 55 years;
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  - Average total fertility around 6 children per woman;
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- In 2000 40 percent of these countries had not exited the development trap yet.

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- Are the mechanics of long-run development different across these countries?
- What is the role of country-specific (exogenous) mortality environment?

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5. Contributes to the debate on the cross-country distribution of the variables of interest in the last fifty years.

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- OLG framework, individuals face finite life time

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- General Equilibrium: individual choices consistent with aggregate wages
- Endogenous change in mortality and technology (through intergenerational skill externalities)

Set up

- Overlapping Generations of individuals $t \in \mathbb{N}^+$
- In the life of each individual there are two relevant periods:
  - Childhood: duration $k = 5$, survival probability, $\pi_t \in (0, 1)$
  - Adulthood: duration T_t, (life expectancy at age k, certainty)
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- Heterogeneous agents i with ability $a^i \in [0, 1]$ distributed normally with mean μ and standard deviation σ;

Preferences and Choices

Utility from own consumption, quantity and quality of (surviving) children:

$$U(c_t^i, \pi_t n_t^i q_t^i) = \int_0^{T_t} \ln c_t^i(\tau)\, d\tau + \gamma \ln\left(\pi_t n_t^i q_t^i\right)$$

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Individuals decide about fertility and human capital:

- the number of children n_t: **quantity**
- the time spent raising each child r_t: **quality**
- the type of human capital $j = u, s$: **own education**

taking **wages** and **demographic conditions** (child and adults mortality) as given, to maximize their lifetime utility subject to their lifetime budget constraint.

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- Expenditure Constraint:

$$l_t^i w_t^j h_t^j(a) \geq T_t c_t^i \,, \tag{2}$$

Production

- Unique consumption good produced with a *vintage* aggregate production: function.

$$Y_t = A_t \left[x_t \left(H_t^u \right)^\eta + \left(1 - x_t \right) \left(H_t^s \right)^\eta \right]^{\frac{1}{\eta}} \tag{3}$$

with $\eta \in (0, 1)$ and the relative production share $x_t \in (0, 1)$ $\forall t$.

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λ_t: **share of skilled individuals** in generation t.

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$$h^s(a) = e^{\alpha a}$$

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Quality of Offspring:

$$q_t(\underline{r}, \widetilde{r}_t, g_{t+1}) = [\widetilde{r}_t \delta (1 + g_{t+1}) + \underline{r}]^{\beta}$$

$\underline{r}$ is the baseline cost of raising children.

Technological Progress: Skill-biased technical Change

- The productivity of skilled human capital depends on skilled human capital in the parent generation (Nelson-Phelps-Romer)

$$\frac{x_t - x_{t-1}}{x_{t-1}} = X\left(\lambda_{t-1}, x_{t-1}\right) = \lambda_{t-1}(1 - x_{t-1})\,.$$

- TFP increases with skilled human capital

$$g_{t+1} = \frac{A_{t+1} - A_t}{A_t} = G\left(\lambda_t\right) = \phi\lambda_t \quad , \quad \phi > 0\,.$$

Child Mortality and Adult Longevity

Child Survival depends on living conditions (at birth):

$$\pi_t = \prod(\lambda_{t-1}, y_{t-1}) = 1 - \frac{1-\underline{\pi}}{1+\kappa\lambda_{t-1}y_{t-1}}$$

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Adult longevity depends on human capital:

$$T_t = \Upsilon\left(\lambda_{t-1}\right) = \underline{T} + \rho\lambda_{t-1}$$

$\underline{T}$ is the extrinsic (baseline) mortality.

Intra-generational equilibrium

- Individuals maximize their lifetime utility by choosing: **type of human capital** they acquire and the **quantity/quality** of their children, $\{j = \{u, s\}, n, r\}$, given their budget (lifetime earnings and wages) and time constraints;
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The (intra-generational) general equilibrium pins down:

- the share of individuals acquiring each type of human capital

$$\lambda_t = \int_{\widetilde{a}_t}^{1} f(a)\, da = \Lambda(T_t, x_t)$$

which is an increasing function of longevity, T and returns to skill x.

- fertility choice:

$$n_t = N(T_t, \lambda_t, \pi_t)$$

The Effect of Mortality on (Differential) Fertility

Differential fertility by Skills. Average fertility is given by:

$$n_t^* = N\left(T_t, \lambda_t, \pi_t\right) = \frac{\gamma}{\left(T_t + \gamma\right) r_t^* \pi_t} \left[(1-\lambda_t)(\overline{T}_t - \underline{e}^u) + \lambda_t(\overline{T}_t - \underline{e}^s)\right]$$

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- (indirect) effect of T on future quality r^*.

Development Dynamics

The dynamic evolution of economy is characterized by the non-linear dynamic system:

$$\begin{cases} T_t &= \Upsilon(\lambda_{t-1}) \\ x_t &= X(x_{t-1}, \lambda_{t-1}) \\ \lambda_t &= \Lambda(T_t, x_t) \\ A_t &= A_{t-1}\left(1 + G(\lambda_{t-1})\right) \\ \pi_t &= \Pi(T_{t-1}, x_{t-1}, \lambda_{t-1}, A_{t-1}) \\ n_t &= N(T_t, \lambda_t, \pi_t) \end{cases} \tag{5}$$

Illustration of Evolution of (Conditional) Dynamic System

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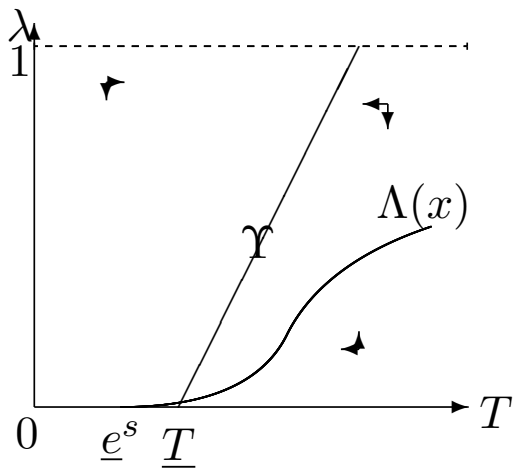

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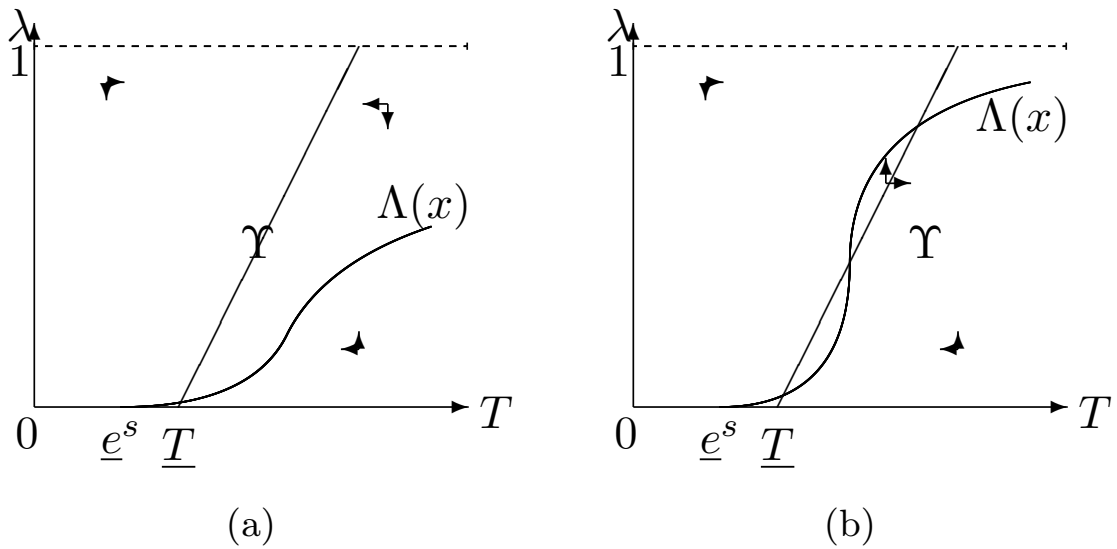

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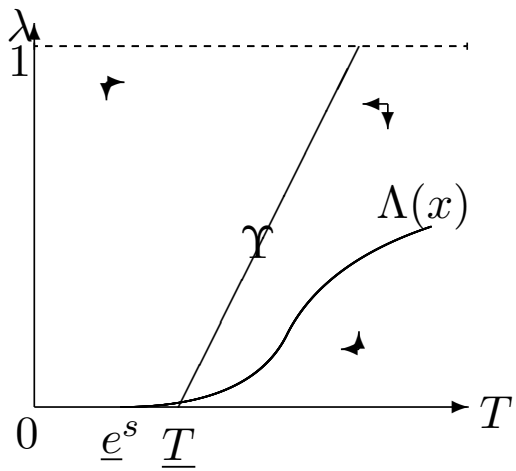

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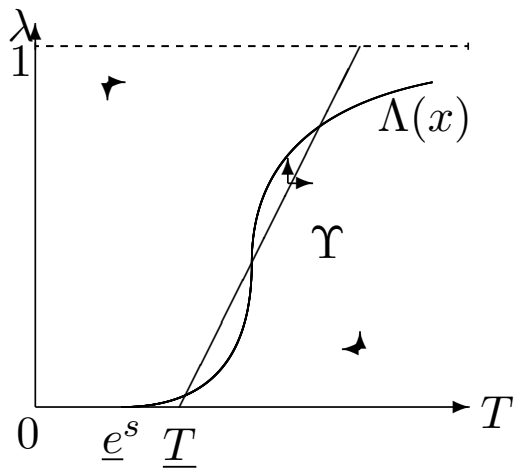

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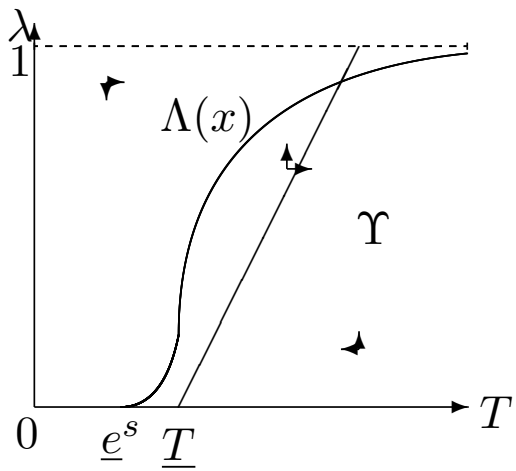

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Proposition

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(i) An initial phase with few individuals acquiring skilled human capital, $\lambda \simeq 0$*, low longevity,* $T \simeq \underline{T}$*, large child mortality* $\pi \simeq \underline{\pi}$*, slow income growth, and gross fertility given by,*

$$n \simeq \gamma \frac{\underline{T} - \underline{e}^u}{(\underline{T} + \gamma)\, \underline{r}\, \underline{\pi}} \,. \tag{6}$$

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(ii) A (rapid) transition with increases in T_t, π_t, λ_t *income per capita* y_t *and technology* x_t*;*

(iii) Balanced growth in income per capita, large life expectancy, $T \simeq \overline{T}$, *low child mortality* $\pi \simeq 1$, *almost the entire population acquiring* h^s, $\lambda \simeq 1$ *and*

$$n \simeq \gamma \frac{min\{\overline{T}, R\} - \underline{e}^s}{\left(\overline{T} + \gamma\right) \overline{r}} \,. \tag{7}$$

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Logic of Calibration and Simulation:

- Need to pin down 15 time invariant parameters;
- Target moments on balanced growth path (year 2000) and at the onset of the transition (year 1800);
- Set initial conditions and unfold the endogenous evolution of all variables of interest from year 0 to year 2000.

Summary of Calibration - Benchmark

Parameter		Value	Matched Moment
Exogenous			
BG Path		2000	$\lambda > 0.999$
Generation	m	20 years	Age first birth
Retirement	R	59	Age of retirement in Sweden 2000
Production	η	0.2857	Elasticity of Substitution

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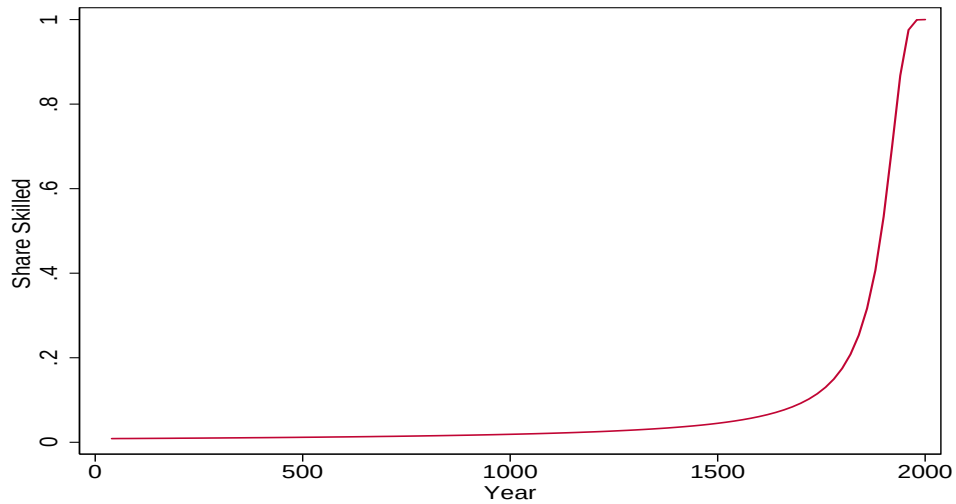
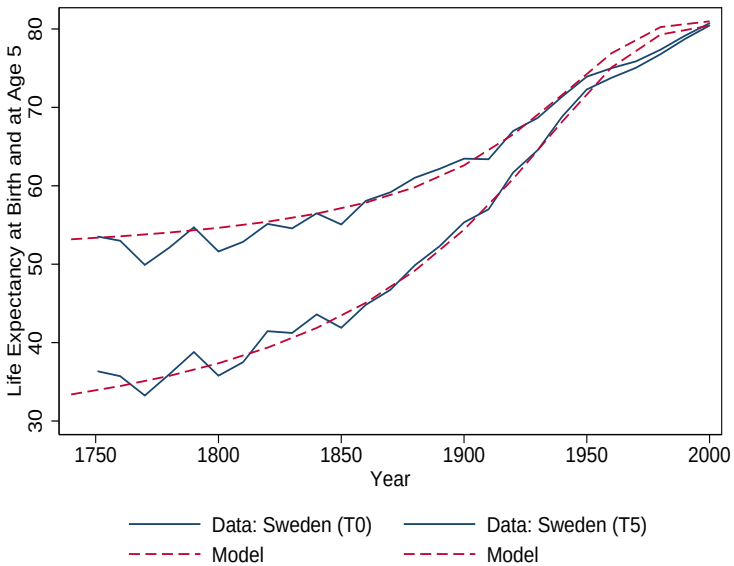
Endogenous			
TFP growth	ϕ	0.61	Growth GDP per capita 1995-2010
Time cost	$\{\underline{e}^u, \underline{e}^s\}$	{0,12}	Years schooling 1820 and 2000
Ability for HC	α	6.1	Spread of log income distribution 2000
Ability Distr.	$\{\mu, \sigma\}$	{0.49,0.066}	Mean and var. log income in 2000
Adult LE	$\{\underline{T}, \rho\}$	{45,31}	LE at 5 in 1760-1800 and 2000
Child Mort.	$\{\underline{\pi}, \kappa\}$	{0.5, 0.005}	Child survival 1800 and 2000
Utility	γ	9	Gross fertility 2000
Q-Quality	$\{\beta, \underline{r}, \delta\}$	$\{0.23, 4.7, 3.54\}$	Pre- and Post- Fertility, $\underline{g}$ 1900
Initial Conditions			
	x_0	0.04	Initial year
	A_0	15	log GDP per capita Sweden 2000

Simulation of the Development Process: 0 AD - 2000 AD

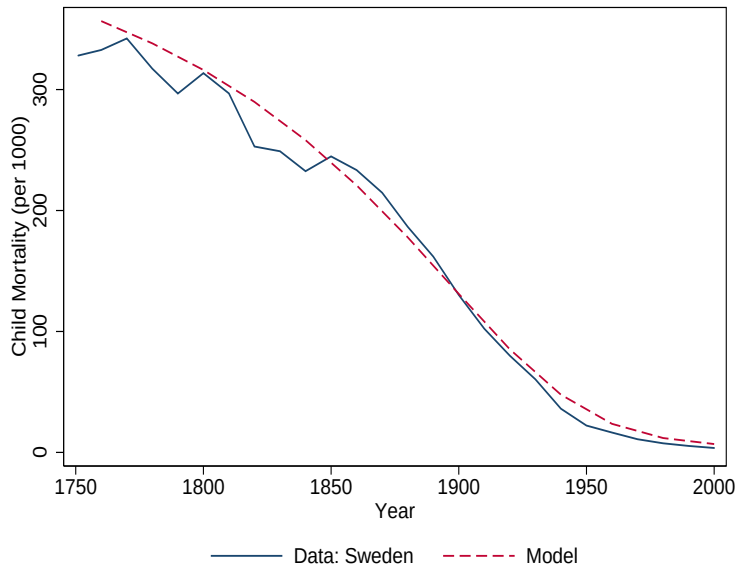


(a) Share Skilled λ

Simulation and Data: Sweden 1750-2000



(b) Life Expectancy at Birth and Life Expectancy at age 5



(c) Child Mortality Rate

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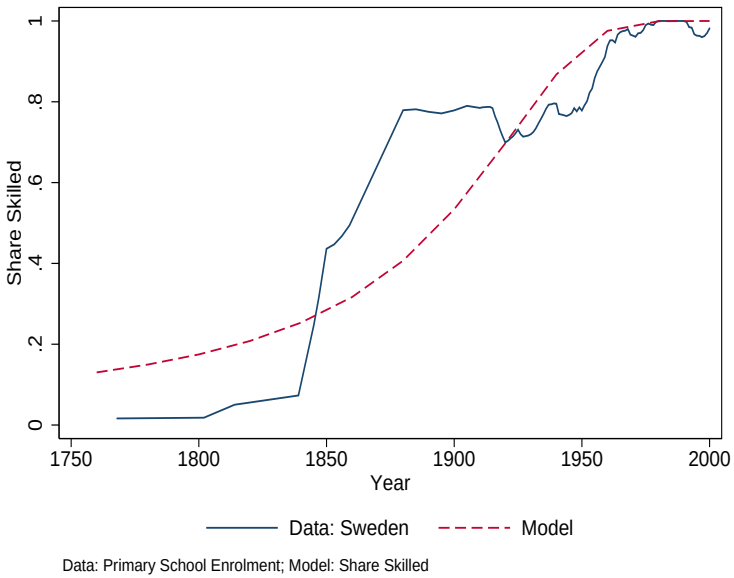
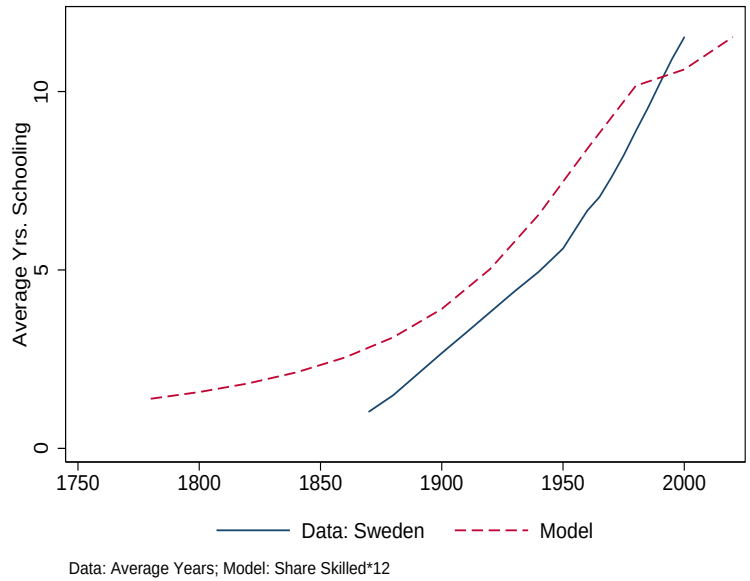


(d) Primary School Enrolment and λ



(e) Average Years of Schooling

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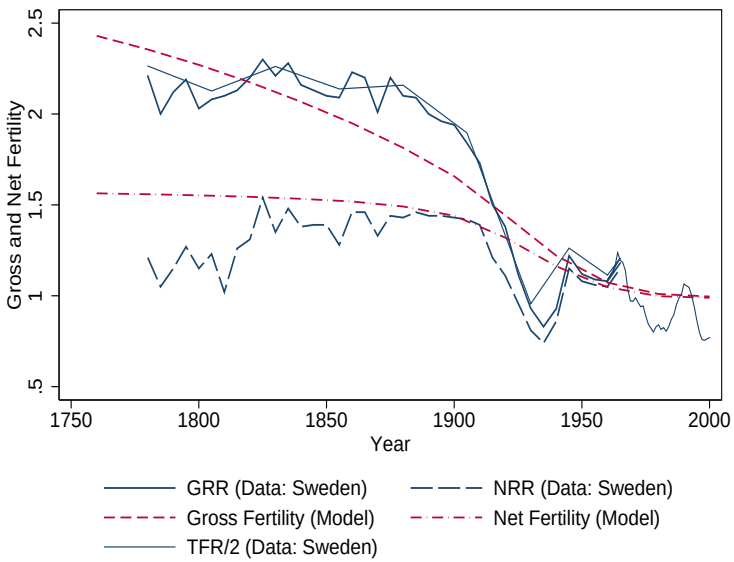
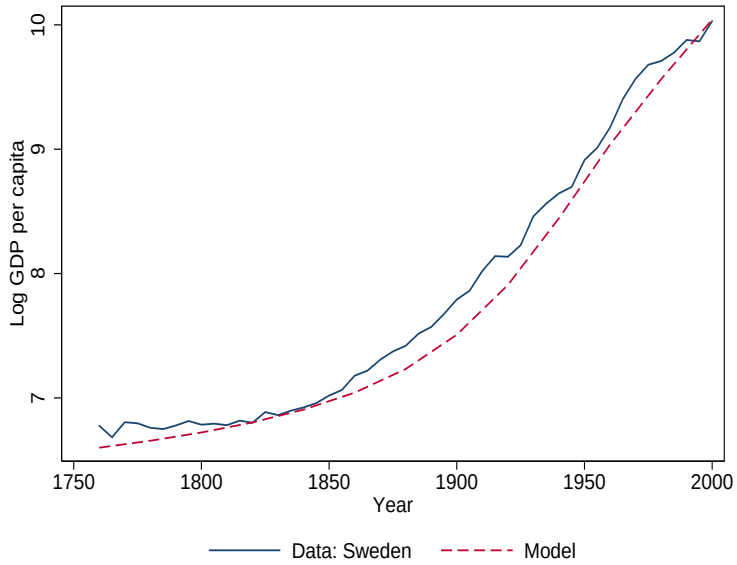


(f) Gross and Net Repr. Rates



(g) log GDP per capita

Comparative Development – Role of Mortality:

Permanent differences in Extrinsic Mortality Environment

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A lower baseline adult longevity, $\underline{T}$ implies (*ceteris paribus*):

- a later onset of the transition;
- (a higher level of economic development in terms of income or productivity at the onset of the transition.)

A lower child survival $\underline{\pi}$ does not affect the timing of transition.

Role of Mortality: A Controlled Experiment

- Recalibrate Baseline Mortality (45 years to target 48 years of life expectancy at age 5 for European Countries in 1800) to 40 years (to target 45 years T5 for Sub-Saharan Africa in 2000)
- Simulate the Benchmark model (same parameters) with alternative baseline longevity)

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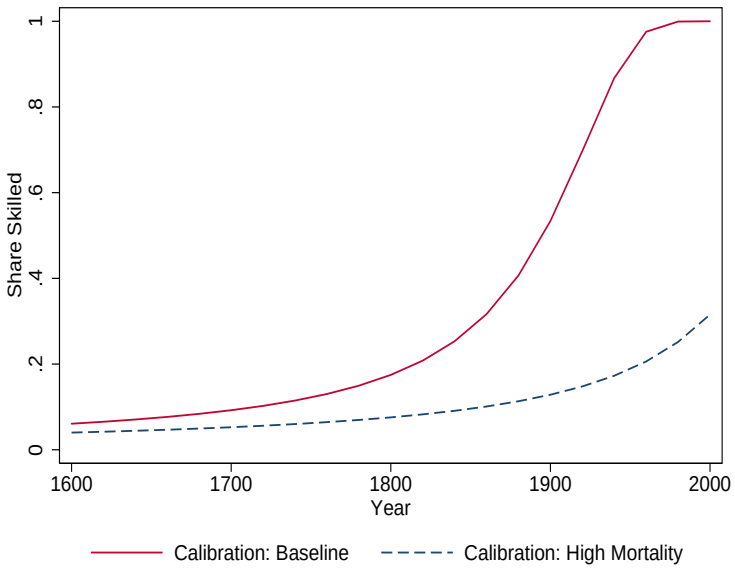
- Recalibrate quantity-quality targeting high fertility countries

Role of Mortality: Dynamic Implications



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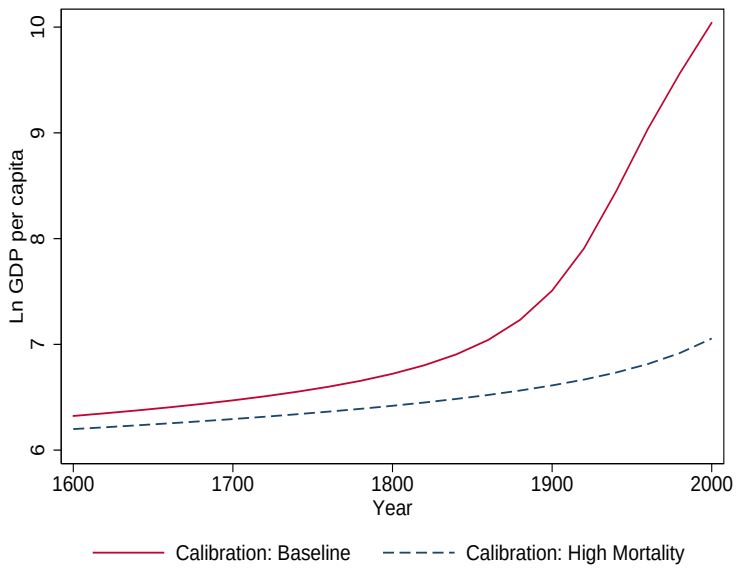


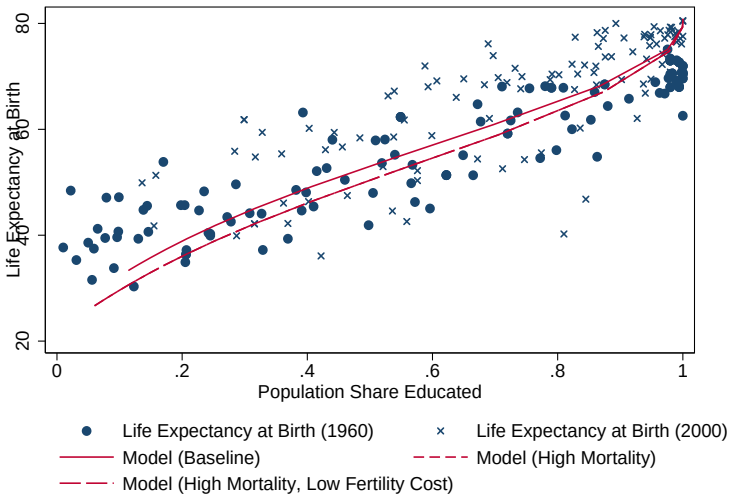
(b) Log Income per capita

From time series to cross-country panel data

Use the UGT is calibrated using data on the historical development of Sweden to 'learn' about cross-country comparative development today:

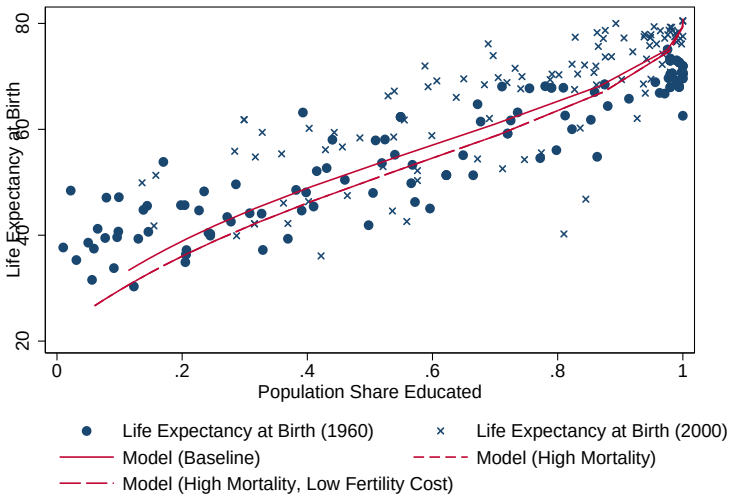
- Look at the historical data 'as if' all countries follow the same development path;
- No cross-country data moments are targeted here ('out of sample');

Cross-Sectional Predictions: Cross-Country 1960-2000



(a) Life Expectancy at Birth

Cross-Sectional Predictions: Cross-Country 1960-2000



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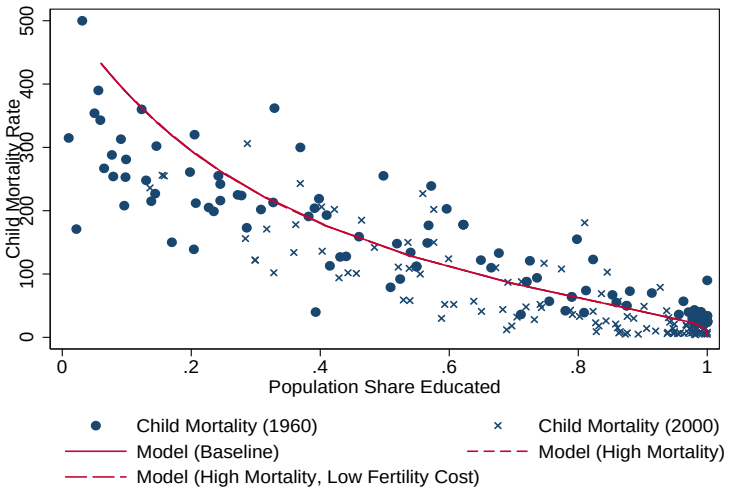
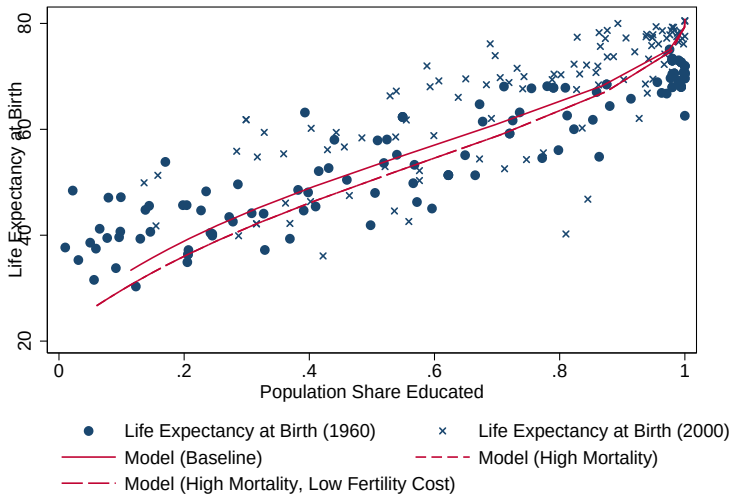
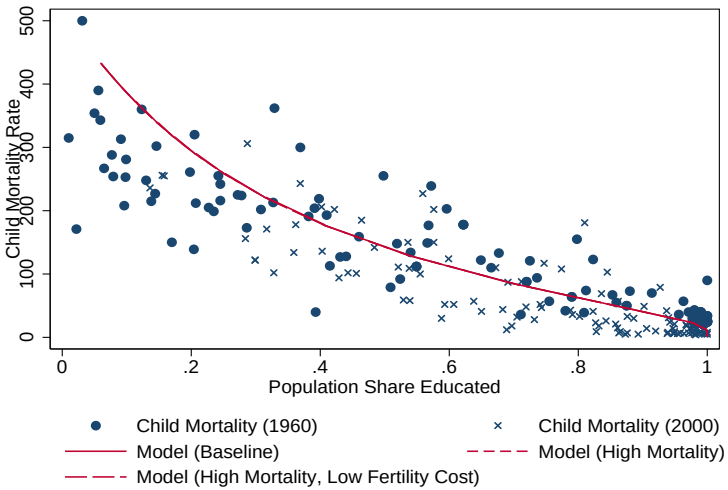


(b) Child Mortality

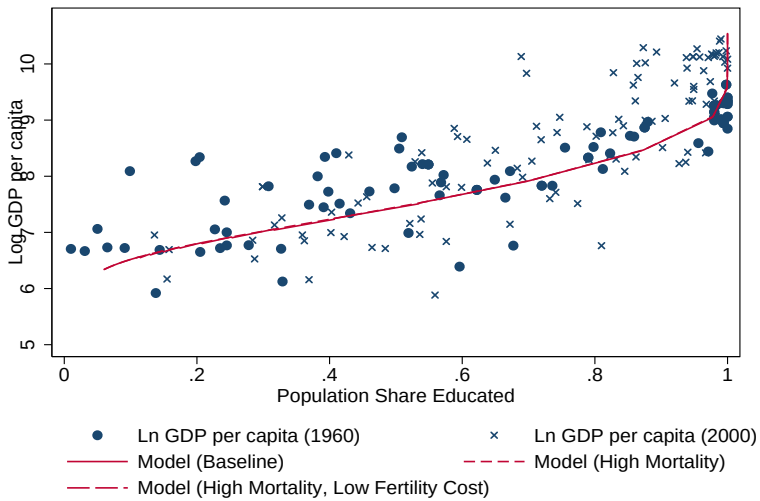
Cross-Sectional Predictions: Cross-Country 1960-2000



(a) Life Expectancy at Birth

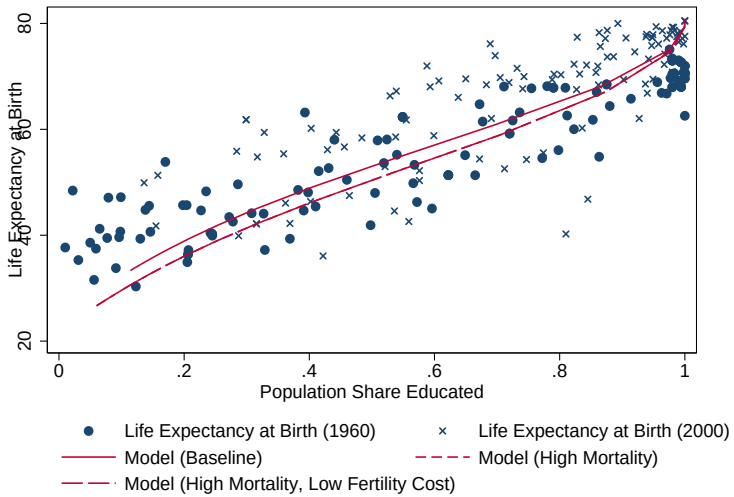


(b) Child Mortality

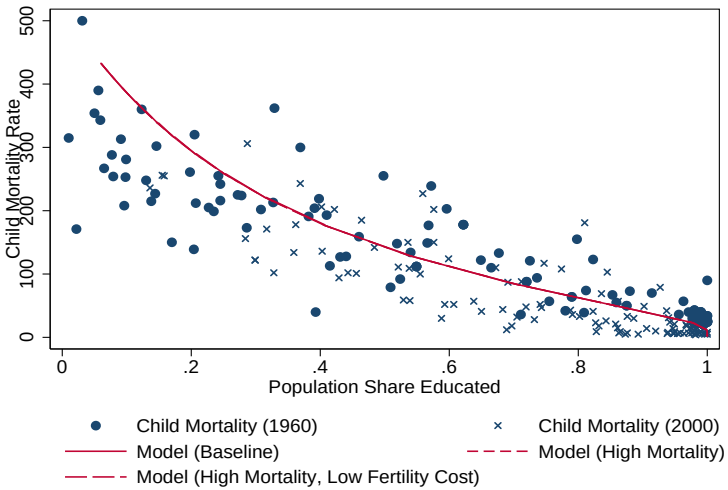


(c) Log GDP per capita

Cross-Sectional Predictions: Cross-Country 1960-2000



(a) Life Expectancy at Birth



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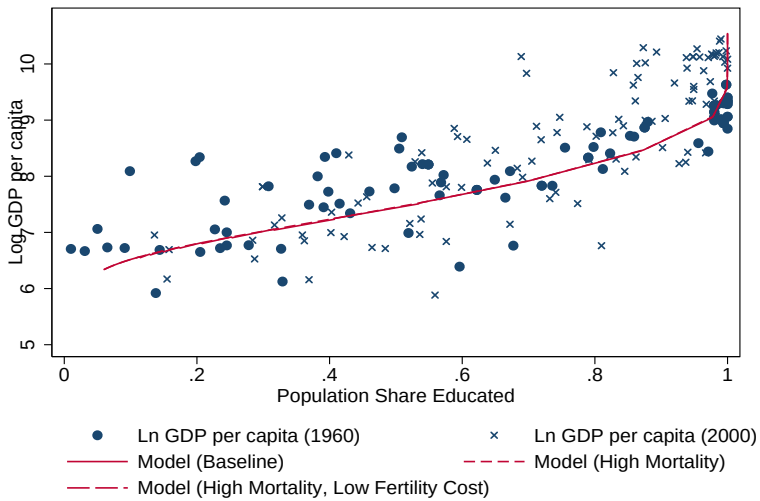
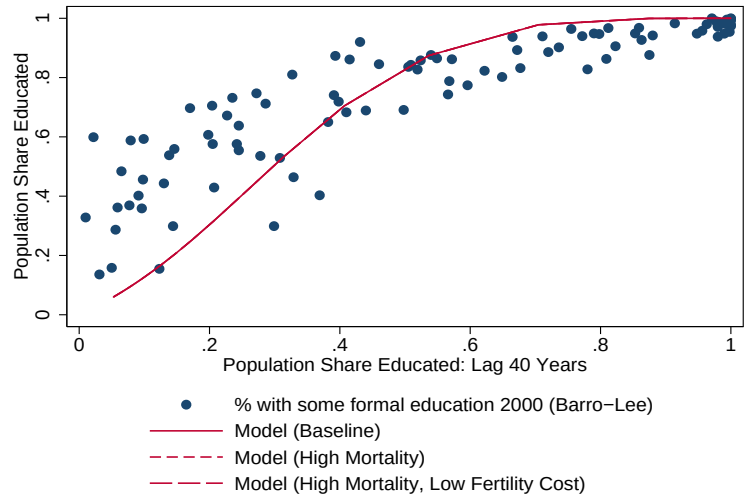
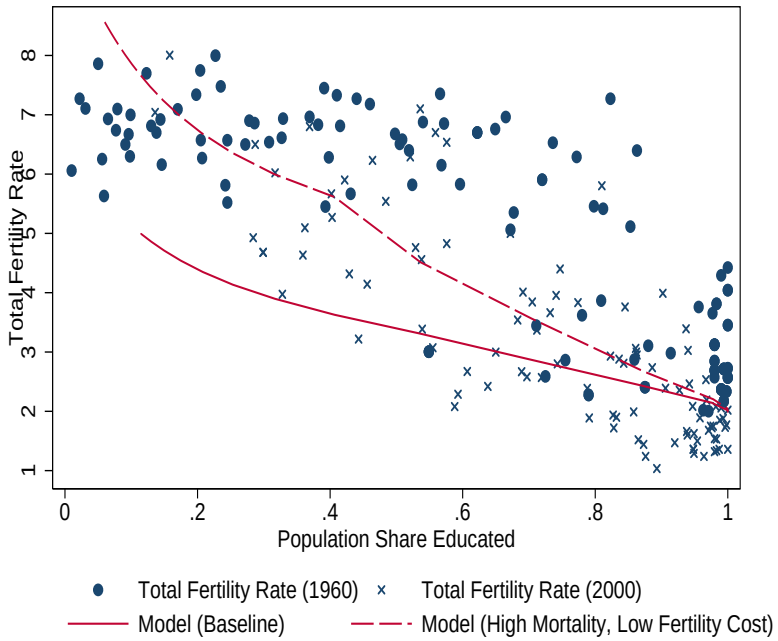


(c) Log GDP per capita

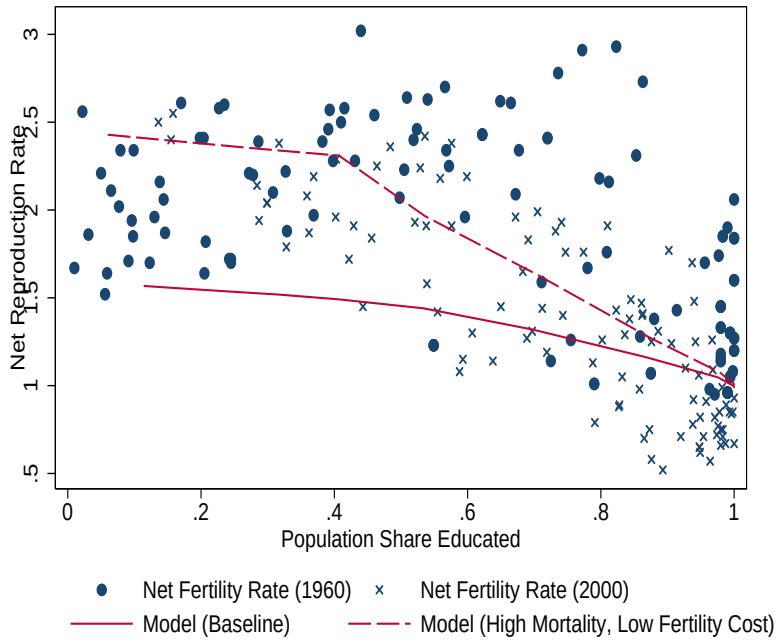


(d) λ 1960 and 2000

Cross-Sectional Predictions: Cross-Country 1960-2000



(a) Total Fertility Rate

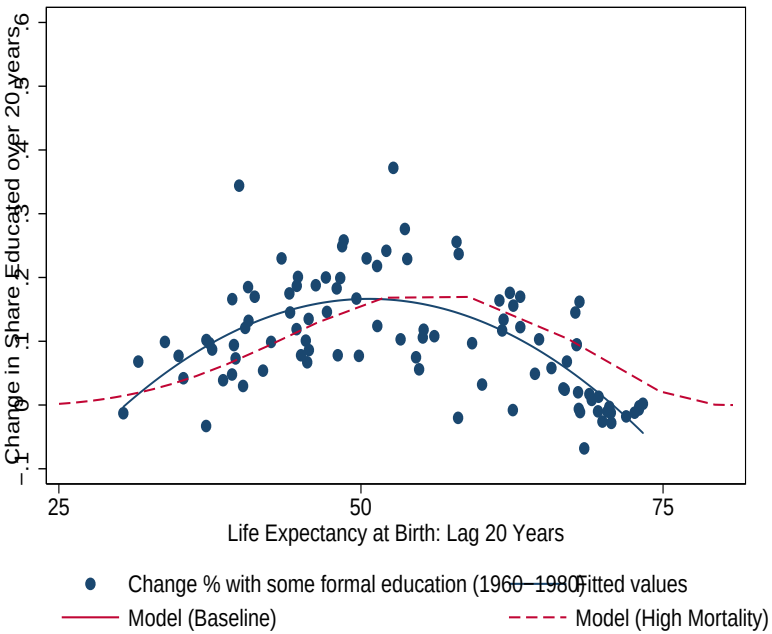


(b) Net Reproduction Rate

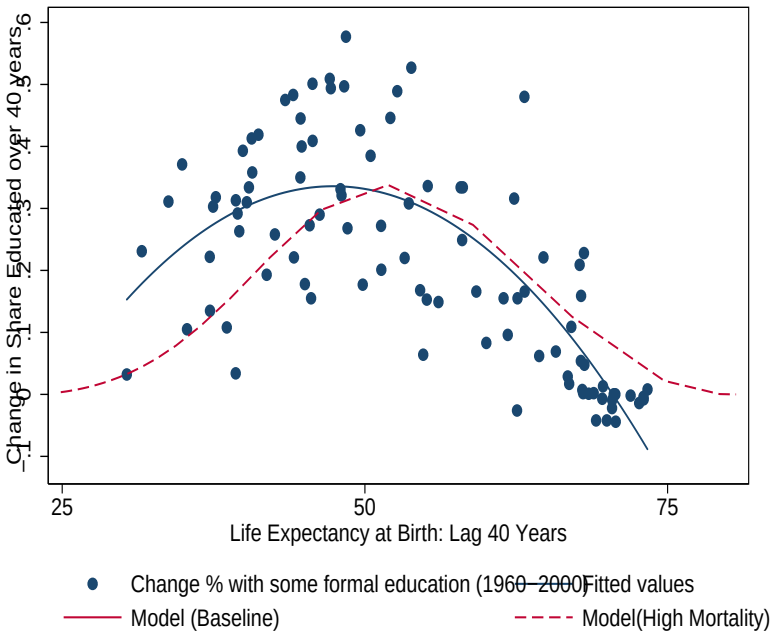
Life Expectancy and Changes in Education Composition

- The change in education composition depends on the "initial level" of longevity:
- Along the development path, the correlation between longevity and the subsequent change in the education composition is hump-shaped.

Life Expectancy and Changes in Education Composition

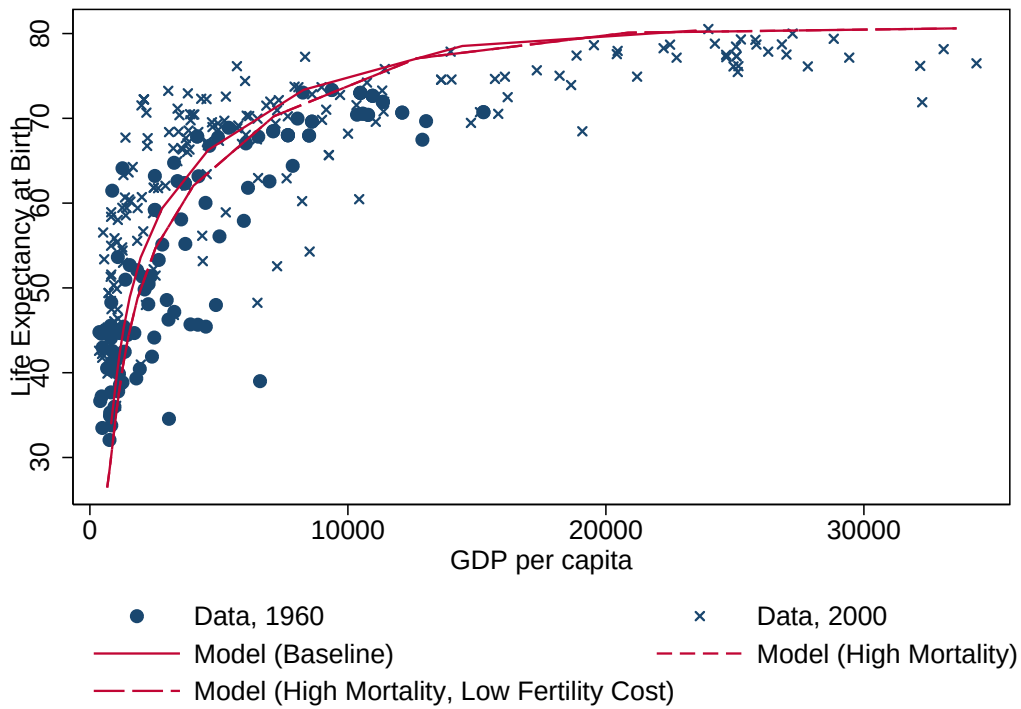


(a) Change in λ over 20 years



(b) Change in λ over 40 years

Life Expectancy and Income per Capita: The "Preston Curve"



Mortality and Comparative Development: Simulating an Artificial World.

Logic of Calibration:

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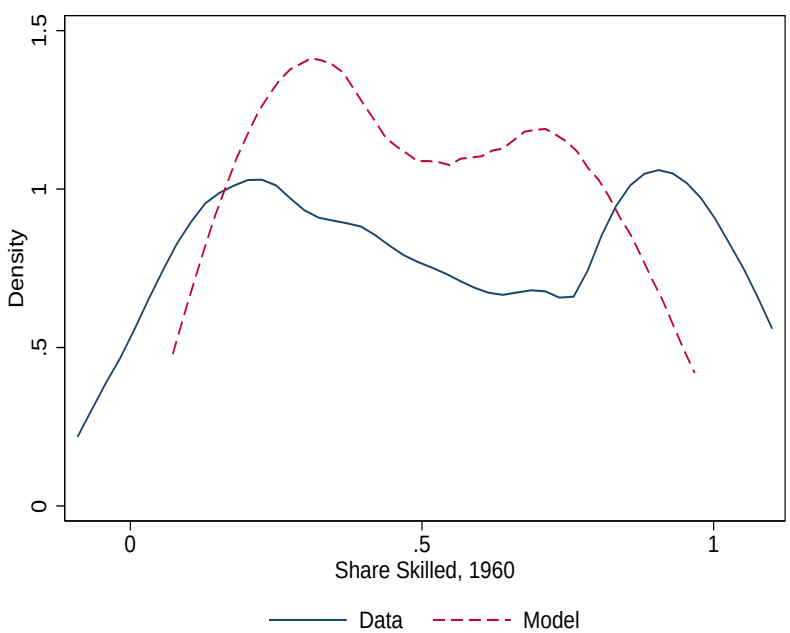
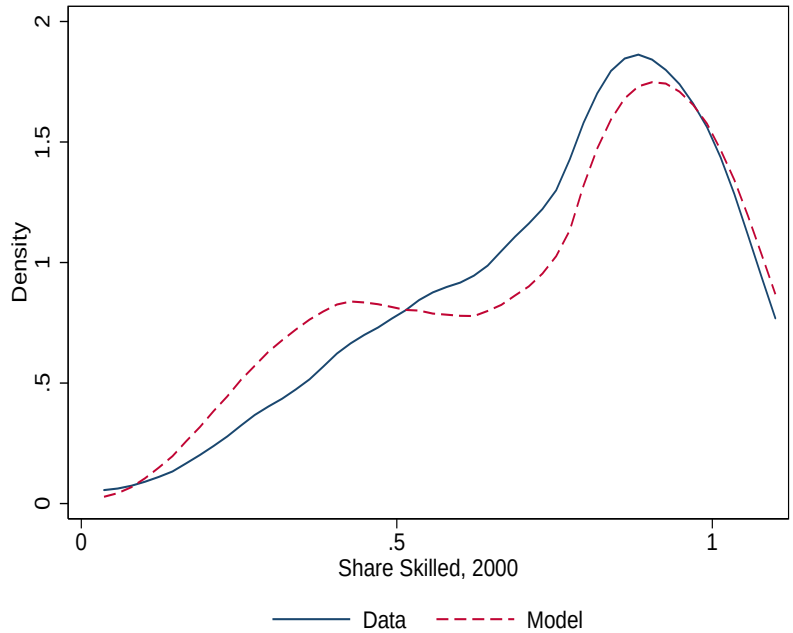
- Controlled Exercise: Create an artificial world of identical countries that only differ in terms of disease environment: baseline longevity $\underline{T}$;
- Exogenously calibrate the distribution baseline longevity (no data moments of the distributions are targeted - 'out of sample'):
  - Exploit newly available information on the historical worldwide distribution/endemicity of multi-host vector transmitted diseases;
  - Data on endemicity (and severe epidemics) for leishmanias, schistosomes, trypanosomes, leprosy, malaria, typhus, filariae, dengue, and tuberculosis from historical data sources collected by 1940;
  - For each disease consider presence/absence: the index is $\{0, 1\}$;
  - Distribution for 113 countries [e.g. index for Sweden (0) is $\underline{T} = 45$, and some countries in S.S.Africa (9) is $\underline{\underline{T}} = 40$].

World Distributions of Mortality, Fertility and Education

The cross-sectional distributions of adult longevity, child mortality, fertility and education are bi-modal, unless all countries are trapped or have completed the transition.

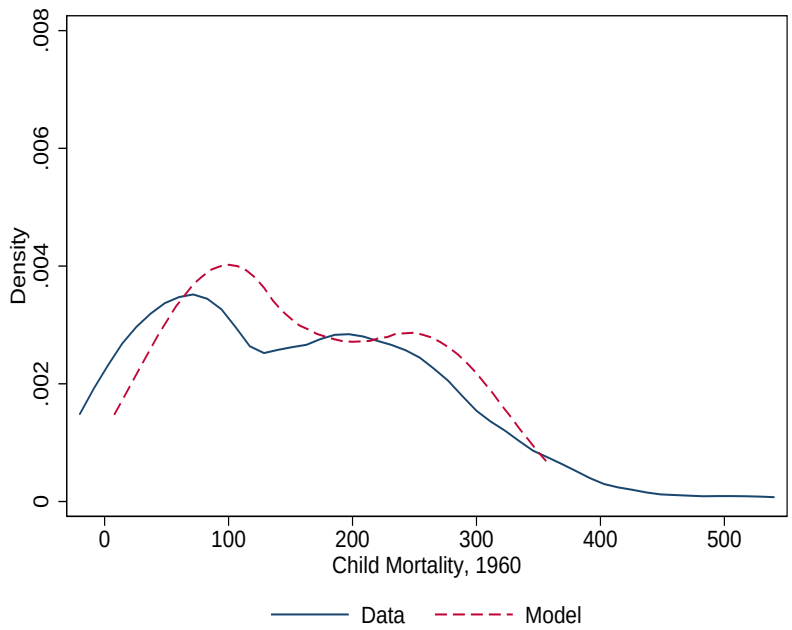
Distributions of Share of Educated Agents (Model and Data 1960-2000)

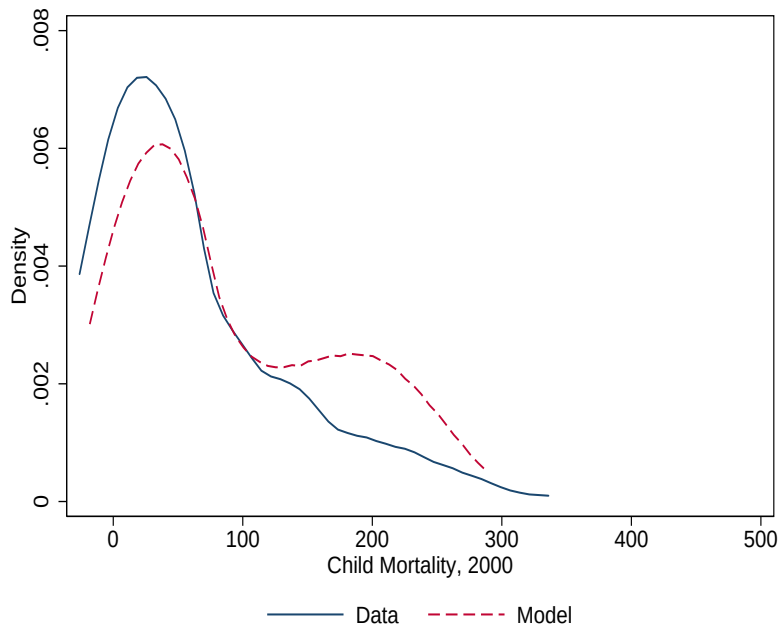




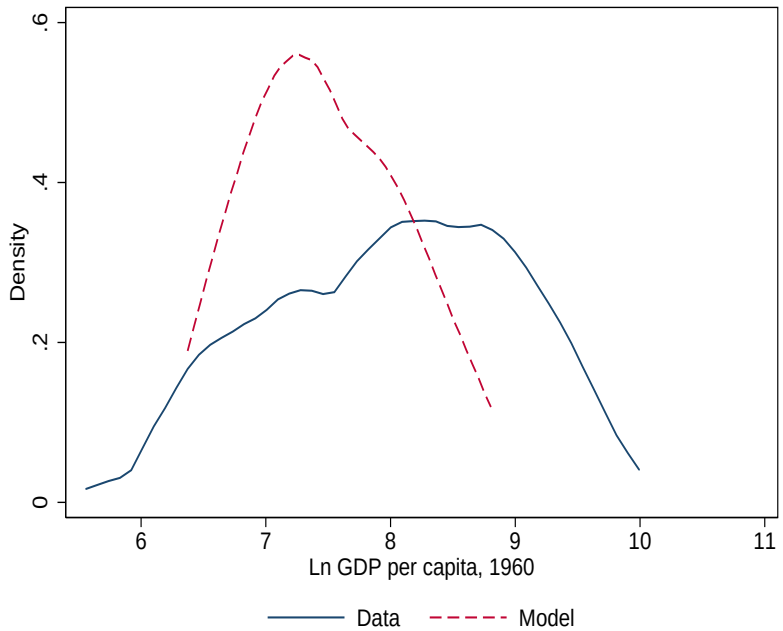
Distributions of Life Expectancy at birth (Model and Data 1960-2000)

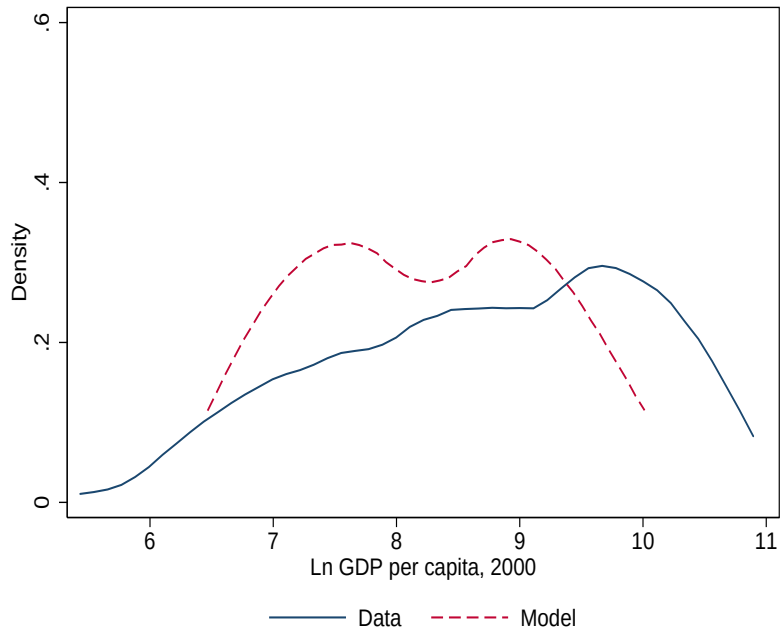
Distributions of Child Mortality (Model and Data 1960-2000)



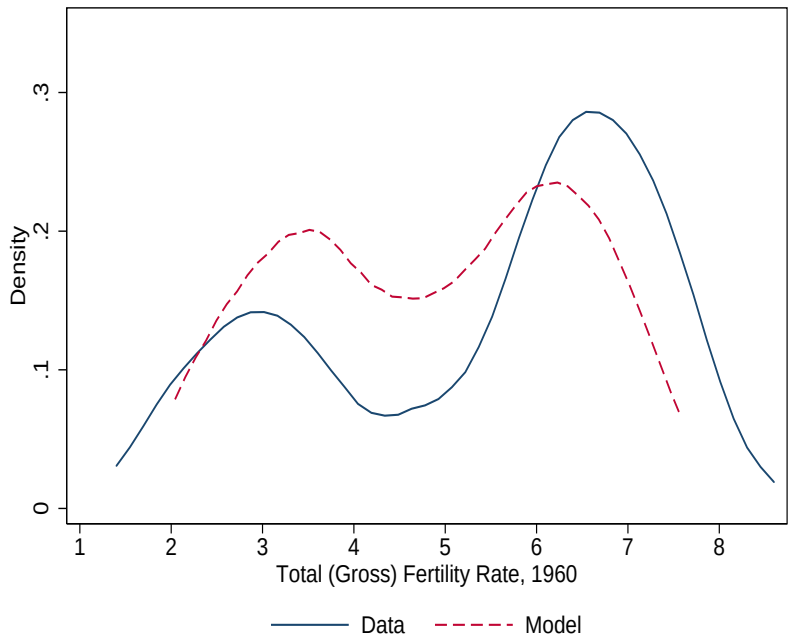


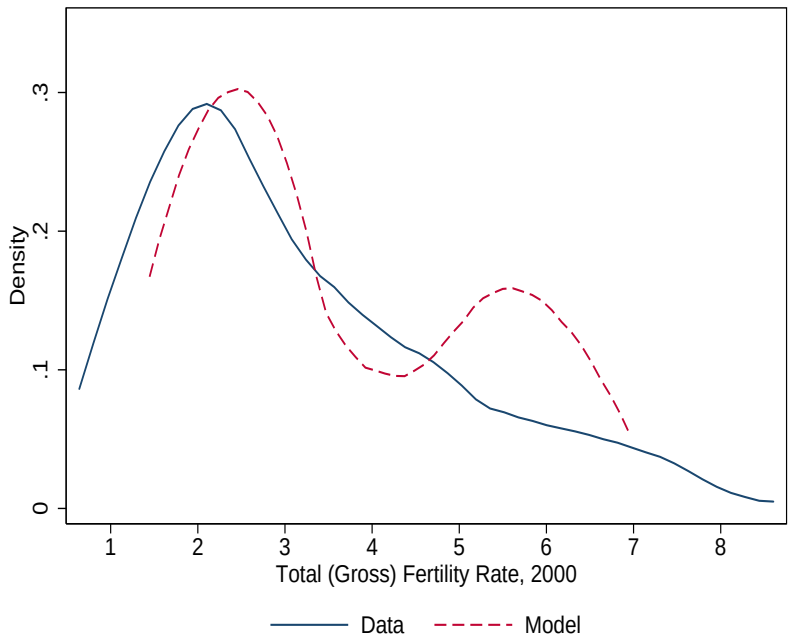
Distributions of Income per Capita (Model and Data 1960-2000)



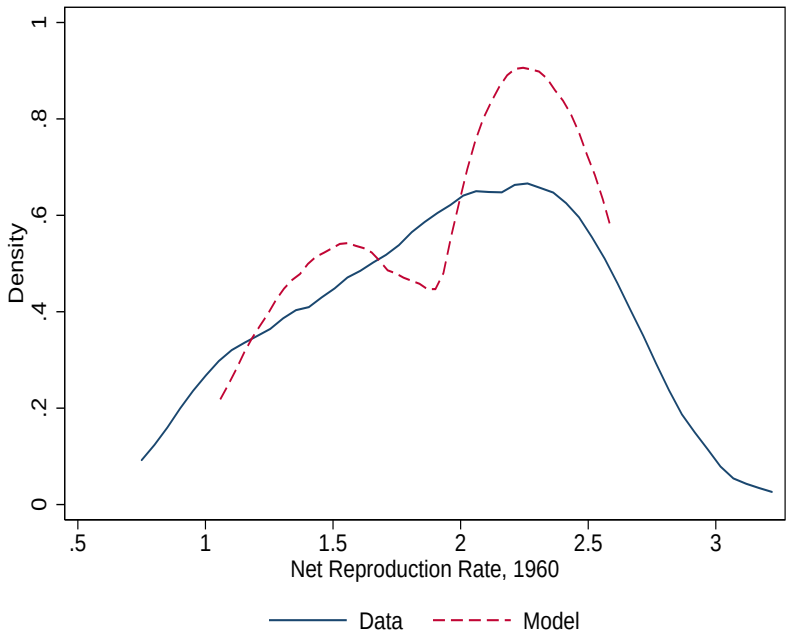


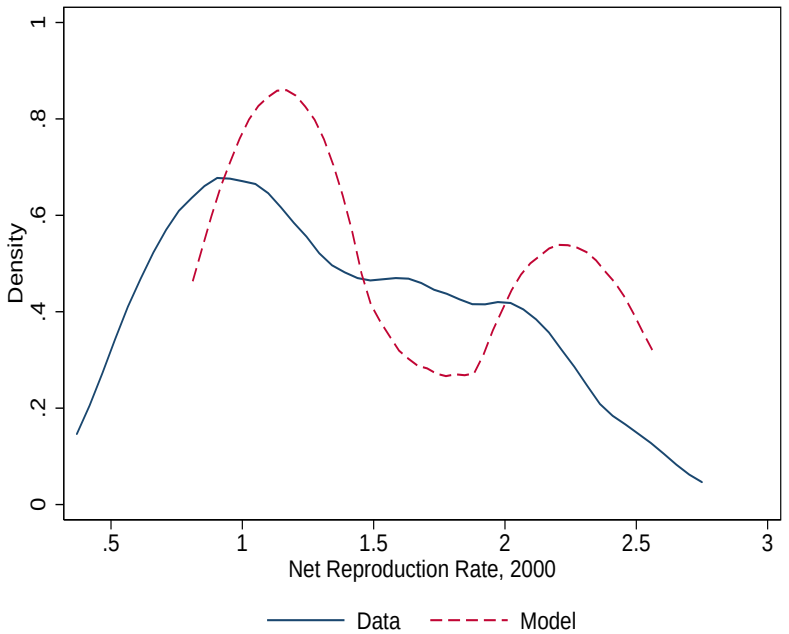
Distributions of Gross Fertility (Model and Data 1960-2000)





Distributions of Net Fertility (Model and Data 1960-2000)





Summary and Concluding Remarks

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- Produces 'out of sample' cross-country patterns of comparative development suggesting that all countries follow similar development patters although with delay.
- Mortality may matter for the delay although it leaves the cross-sectional patterns unchanged.
- Can rationalize cross-sectional correlations (between variables, variables over time, Preston curve, ...) and twin-peak distributions;