Differential Fertility and Economic Growth

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Differential fertility: Fertility Rates by Education

		Total Fertility Rate		
Survey	# of Countries	<Elementary	Elementary	Secondary+
WFS, 1975-1979	13 EUR/US	2.40	2.17	1.79
WFS, 1974-1982	30 DC	6.5	5.5	4.0
DHS, 1985-1989	26 DC	5.7	4.9	3.6
DHS, 1990-1994	27 DC	5.29	4.72	3.29

Source: WFS: World Fertility Survey. DHS: Demographic and Health Survey. "Secondary+" is the average of low secondary, high secondary, and post-secondary, where appropriate.

Research program:

Fertility differentials are key to understand the inequality - growth relationship
(de la Croix - Doepke, AER, 2003)

Fertility differentials advocate in favor of public education when income inequality is high
(de la Croix - Doepke, JDevE, 2004)

Fertility differentials in pre-industrial times can help us to understand the industrial revolution (de la Croix - Doepke, work in progress)

Issue 1:

Inequality bad for growth:
"A reduction of the Gini coefficient by 0.1 would raise the growth rate by 0.4 percent per year" (Barro)

Many channels are invoked: political economy, sociopolitical unrest, borrowing constraints...

One neglected channel: differential fertility

We study its importance
– Theoretical model
– Calibration
– Growth regressions

Overview:

- Model with endogenous fertility and human capital
- Inequality causes fertility differentials
- Fertility differentials lower growth rate of human capital
- Calibration shows large effects

The Model:

- People live for three periods: childhood, adulthood, old age

- Individual state: Human capital h_t

- All decisions taken by adults

- Adults choose number of children n_t and education e_t

- Decision problem of an adult:

$$\max \left\{ \ln(c_t) + \beta \ln(d_{t+1}) + \gamma \ln(n_t h_{t+1}) \right\}$$

subject to:

$$c_t + s_t + e_t n_t w_t \bar{h}_t = w_t h_t (1 - \phi n_t)$$

$$d_{t+1} = R_{t+1} s_t$$

$$h_{t+1} = B_t (\theta + e_t)^{\eta} (h_t)^{\tau} (\bar{h}_t)^{\kappa}$$

- Production technology:

$$Y_t = AK_t^{\alpha} L_t^{1-\alpha}$$

- Aggregate state:
  - Capital K_t
  - Human capital distribution $F_t(h_t)$
  - Population P_t

- Equilibrium conditions:

$$P_{t+1} = P_t \int_0^\infty n_t \; \mathrm{d}F_t(h_t)$$

$$K_{t+1} = P_t \int_0^\infty s_t \; \mathrm{d}F_t(h_t)$$

$$F_{t+1}(\hat{h}) = \frac{P_t}{P_{t+1}} \int_0^\infty n_t \, I(h_{t+1} \leq \hat{h}) \; \mathrm{d}F_t(h_t)$$

$$L_t = P_t \left[\int_0^\infty h_t(1 - \phi n_t) \; \mathrm{d}F_t(h_t) - \int_0^\infty e_t n_t \bar{h}_t \; \mathrm{d}F_t(h_t) \right]$$

Solution of the Adult's Problem:

- Relative human capital: $x_t \equiv h_t/\bar{h}_t$

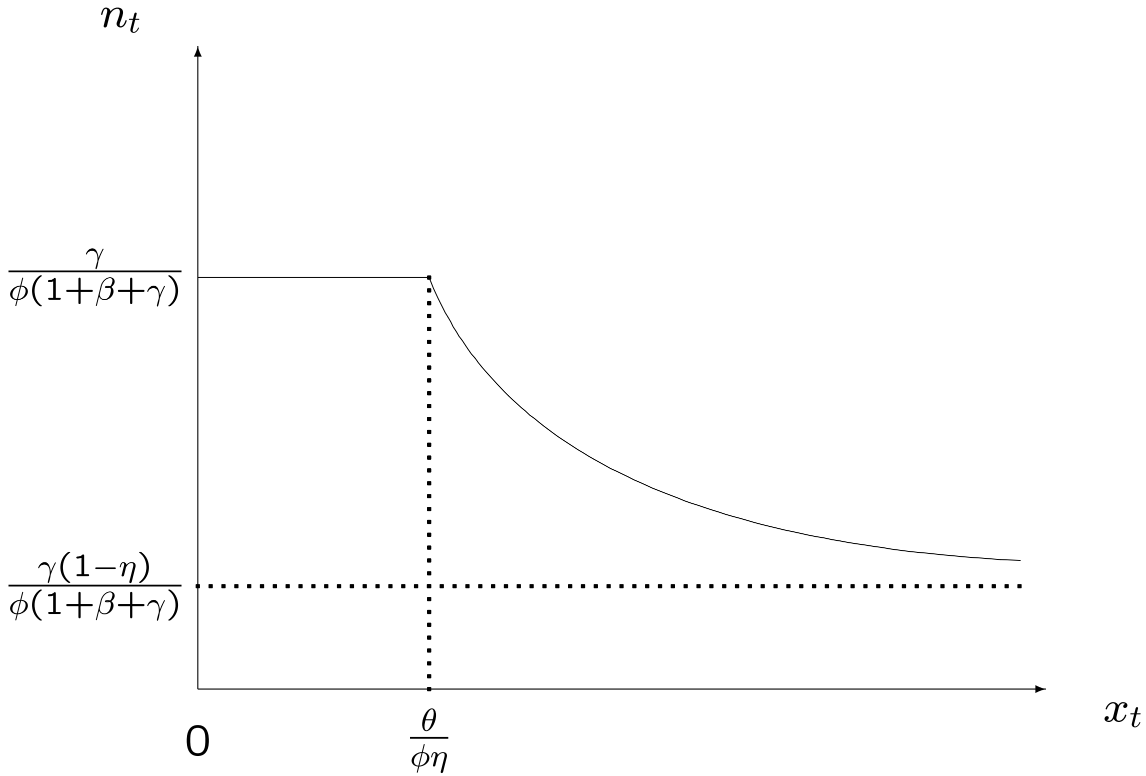
- If $x_t > \frac{\theta}{\phi\eta}$:

$$e_t = \frac{\eta\phi x_t - \theta}{1-\eta}$$
$$n_t = \frac{(1-\eta)\gamma x_t}{(\phi x_t - \theta)(1+\beta+\gamma)}$$

- If $x_t \leq \frac{\theta}{\phi\eta}$ $e_t = 0$ and:

$$n_t = \frac{\gamma}{\phi(1+\beta+\gamma)}$$

Quality-Quantity Tradeoff:



- Maximum fertility differential:

$$\frac{\lim_{x_t \to 0} n_t}{\lim_{x_t \to \infty} n_t} = \frac{1}{1-\eta}$$

Balanced Growth Path:

- If $\eta\phi > \theta$, $\exists$ balanced growth path with:

$$x = 1$$

$$g_t = g^\star = \begin{cases} B\left(\frac{\eta(\phi-\theta)}{1-\eta}\right)^\eta & \text{if} \kappa = 1-\tau \quad \text{(endogenous growth)} \\ 1+\rho & \text{otherwise} \quad \text{(exogenous growth)} \end{cases}$$

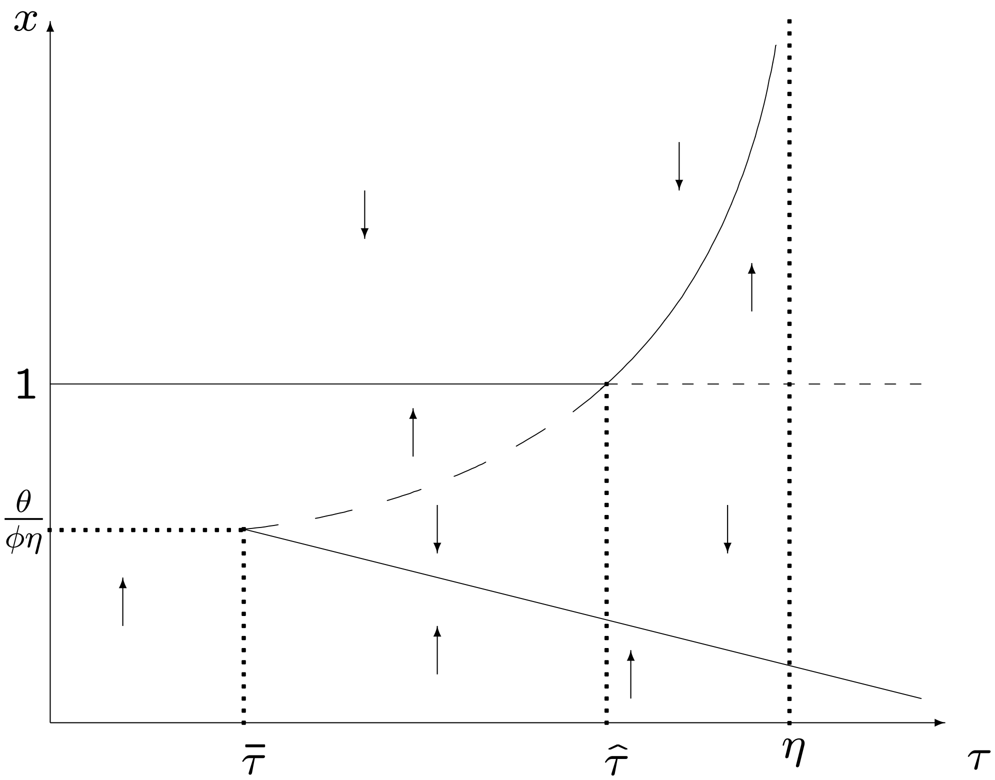
$$N = \frac{(1-\eta)\gamma}{(\phi-\theta)(1+\beta+\gamma)} > 0$$

Dynamics of Individual Human Capital:

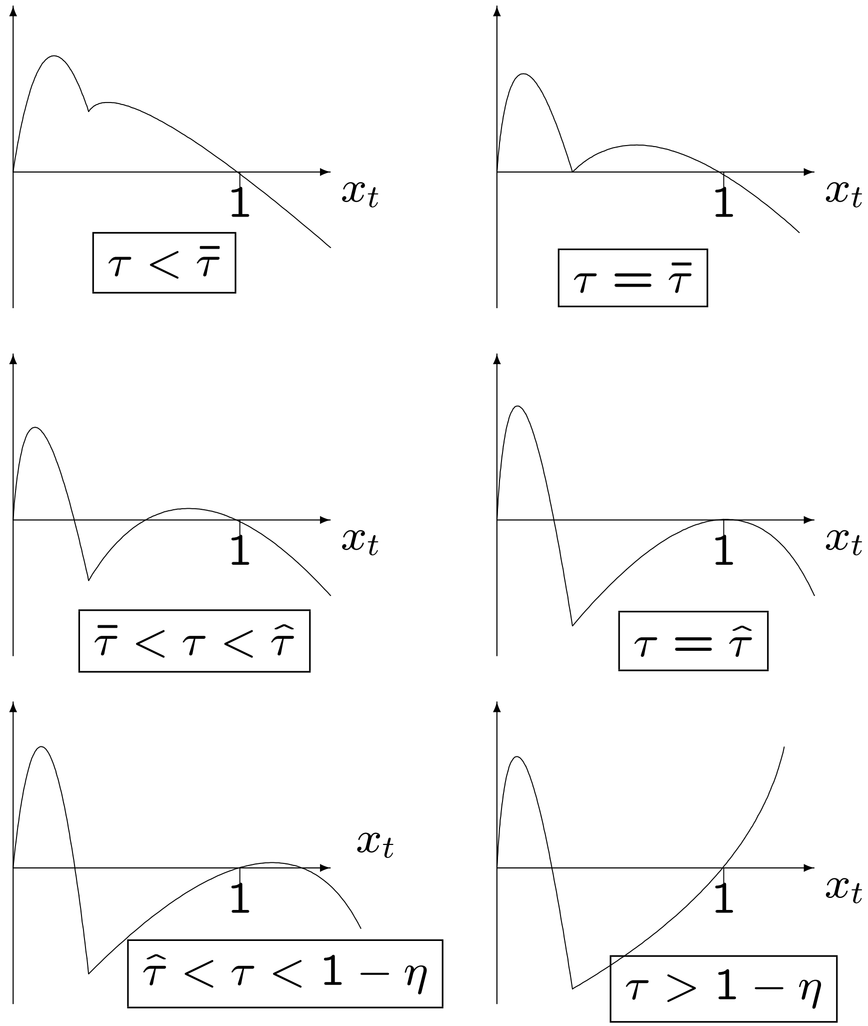
- Examine $x_{t+1} - x_t = \Psi(x_t; \tau)$ for $g = g^{\star}$:

$$\Psi(x; \tau) = \frac{Bx^{\tau}}{g^{\star}} \left(\theta + \max \left[0, \frac{\eta \phi x - \theta}{1 - \eta} \right] \right)^{\eta} - x.$$

Bifurcation Diagram:



$$\widehat{\tau} = 1 - \frac{\eta\phi}{\phi - \theta}$$



x_t
1
$\tau < \bar{\tau}$
x_t
1
$\tau = \bar{\tau}$
x_t
1
$\bar{\tau} < \tau < \hat{\tau}$
x_t
1
$\tau = \hat{\tau}$
x_t
1
$\hat{\tau} < \tau < 1 - \eta$
x_t
1
$\tau > 1 - \eta$

Calibration:

steady state should be the one of a developed economy

- $\beta = .99^{120}$,
  $\rho = 2\%$,
  $\alpha = 1/3$.

- $\gamma = .271 \rightarrow N = 0\%$ per year.

- $\eta = .635$: fertility differential in Brazil
  $\phi = .075$: rearing cost= 15% of time endowment
  – max 27 children
  $\theta = .0119$: share of educ in GDP=7.3%

Calibration:

- our choice of η and θ gives an elasticity of income to schooling of 0.6

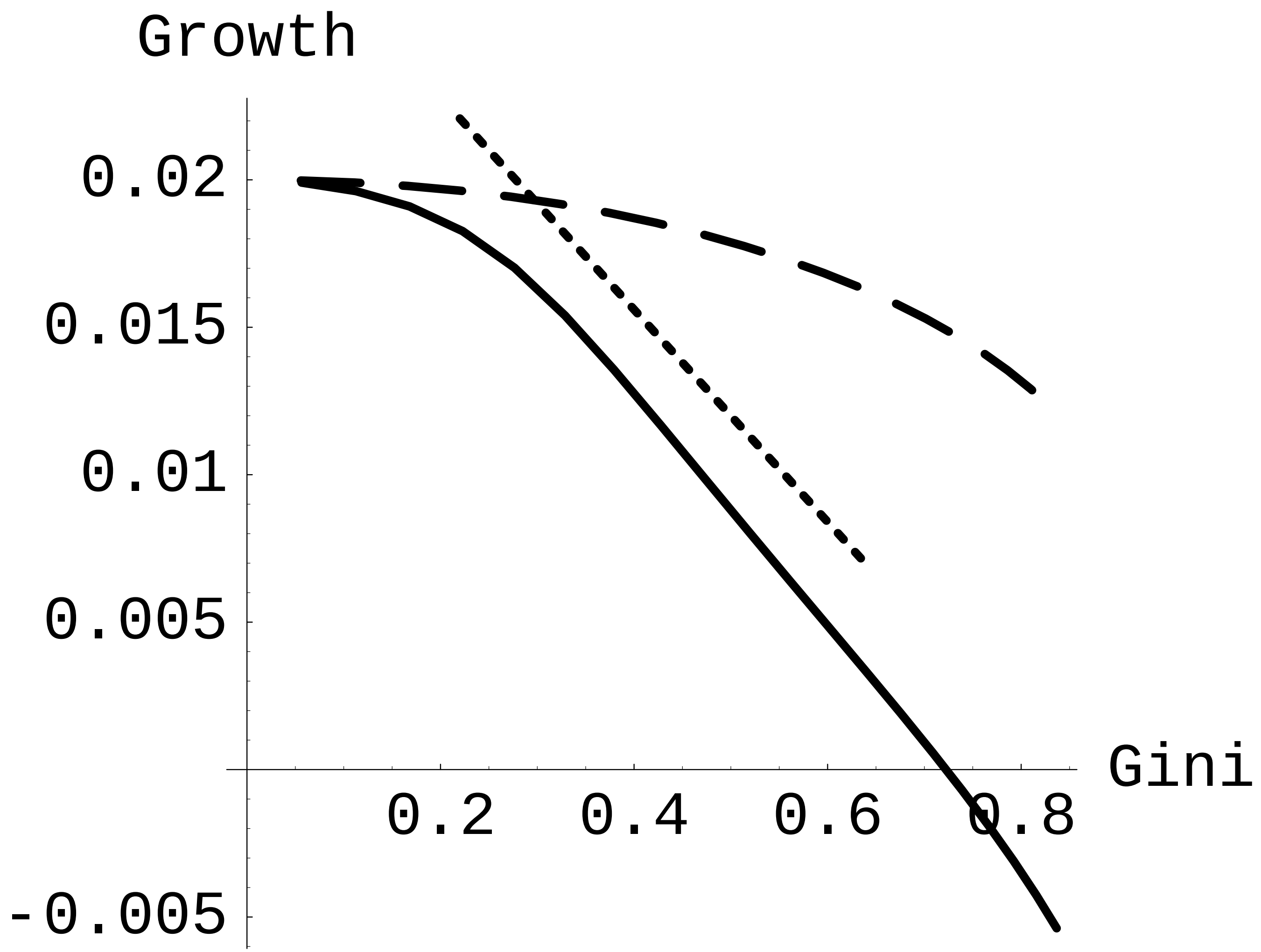
- κ: effect of the quality of schooling. Elasticity of 0.1 alternatively, human capital externalities; also low.

- τ: intergenerational transmission of abilities. does not affect the bgp. $\widehat{\tau} = .246$. Sensitivity analysis

Initial effect of inequality:

	Endogenous Fertility				Exogenous Fertility			
σ^2	g_0	N_0	I_0	D_0	g_0	N_0	I_0	D_0
0.10	2.00%	0.00%	0.056	0.09	2.00%	0%	0.056	0
0.75	1.26%	0.66%	0.404	1.95	1.87%	0%	0.400	0
1.00	0.80%	1.08%	0.520	2.76	1.78%	0%	0.513	0
1.50	0.01%	1.71%	0.707	2.77	1.53%	0%	0.700	0

Notes: σ^2: Variance of income distribution. g_0: Growth rate of human capital per worker. N_0: Growth rate of population. I_0: Income inequality (Gini coefficient). D_0: Fertility differential.
$\tau = 0.2$


Growth
0.02
0.015
0.01
0.005
-0.005
0.2
0.4
0.6
0.8
Gini

Initial effect of inequality:

Our calibrated model accounts for most of the empirical relationship between inequality and growth.

Results robust to the choice of τ.

Also with a uniform distribution.

Dynamics:

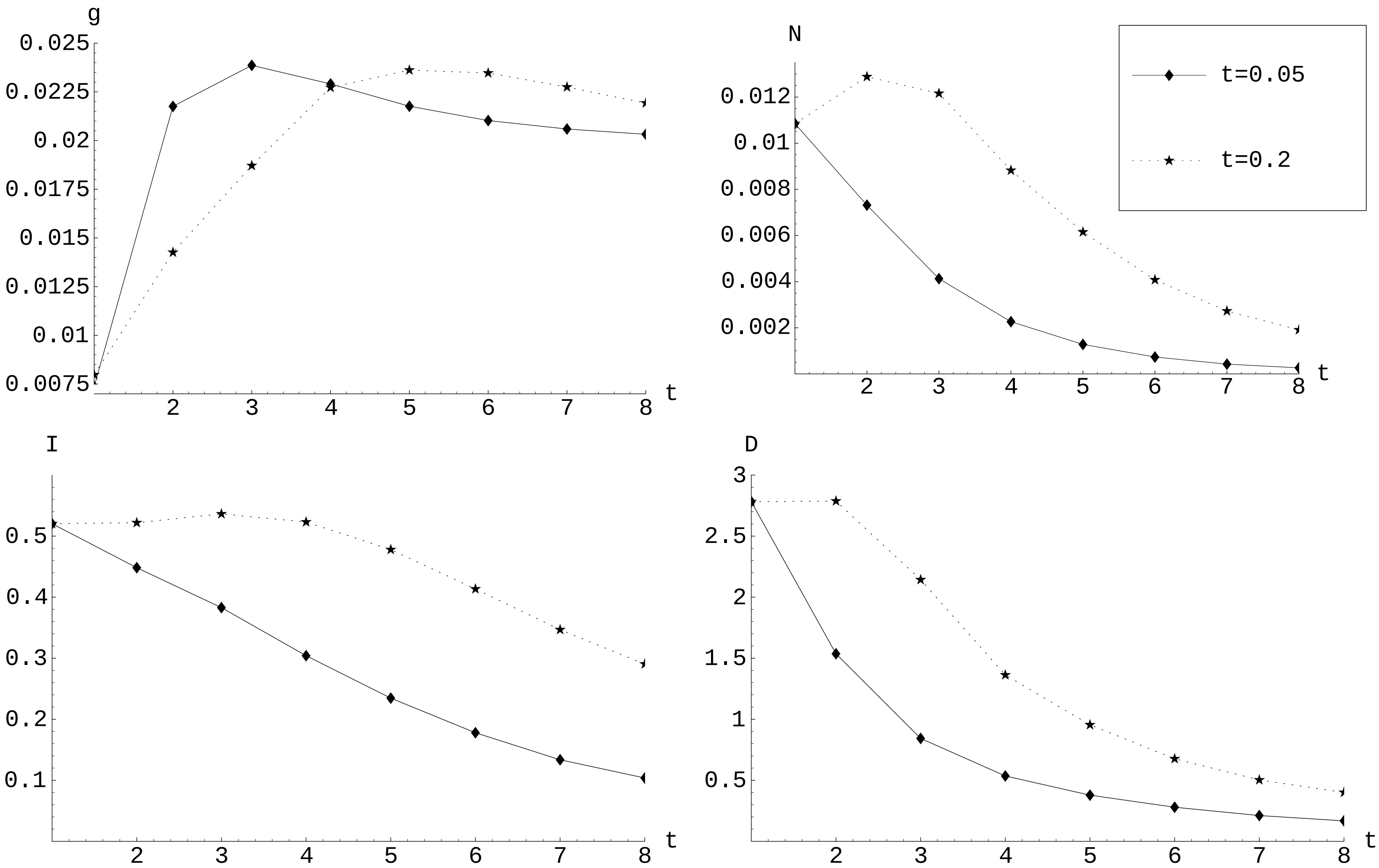
1 period = 30 years.

Look at the past 200 years.

In the UK: fertility increases until 1830 then drops.
Inequality increases until 1870 then drops.
Growth rate increases monotonically.

We start with $\sigma^2 = 1$ (Gini=.5).
We try different values of τ.

Dynamics:

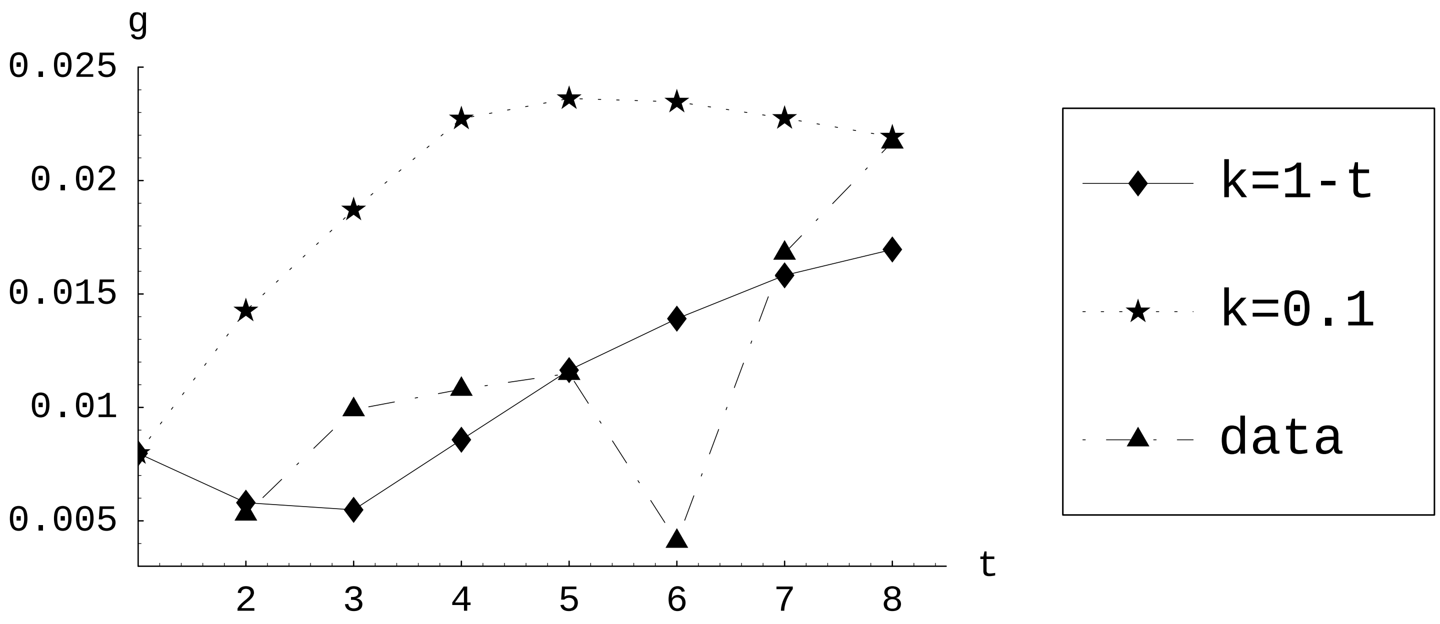

g
0.025
0.0225
0.02
0.0175
0.015
0.0125
0.01
0.0075
2
3
4
5
6
7
8
t
N
0.012
0.01
0.008
0.006
0.004
0.002
t=0.05
t=0.2
I
0.5
0.4
0.3
0.2
0.1
D
3
2.5
2
1.5
1
0.5

Dynamics:

A moderate degree of intergenerational persistence is essential for matching fertility and inequality to data.

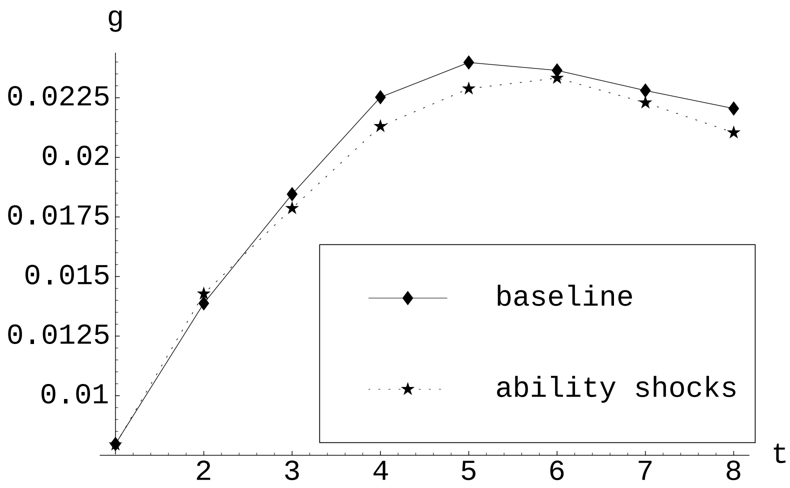
Non monotone behavior related to the corner regime.

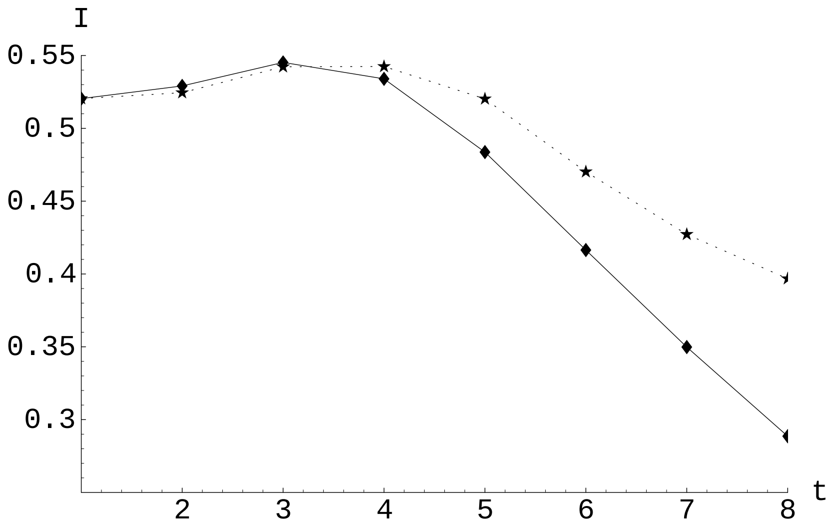
Sensitivity analysis:
endogenous versus exogenous growth.
ability shocks.



More realistic with endogenous growth but large externality

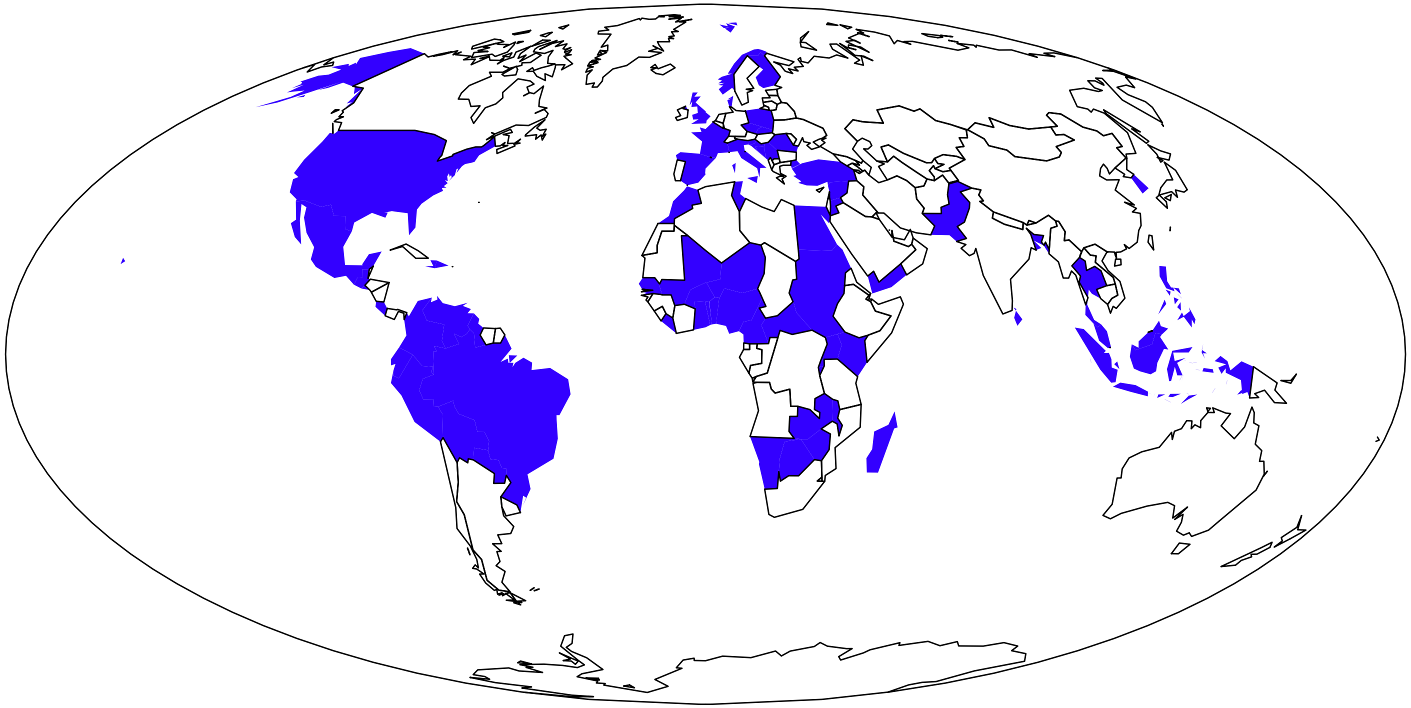
Growth and Inequality with and without Ability Shocks



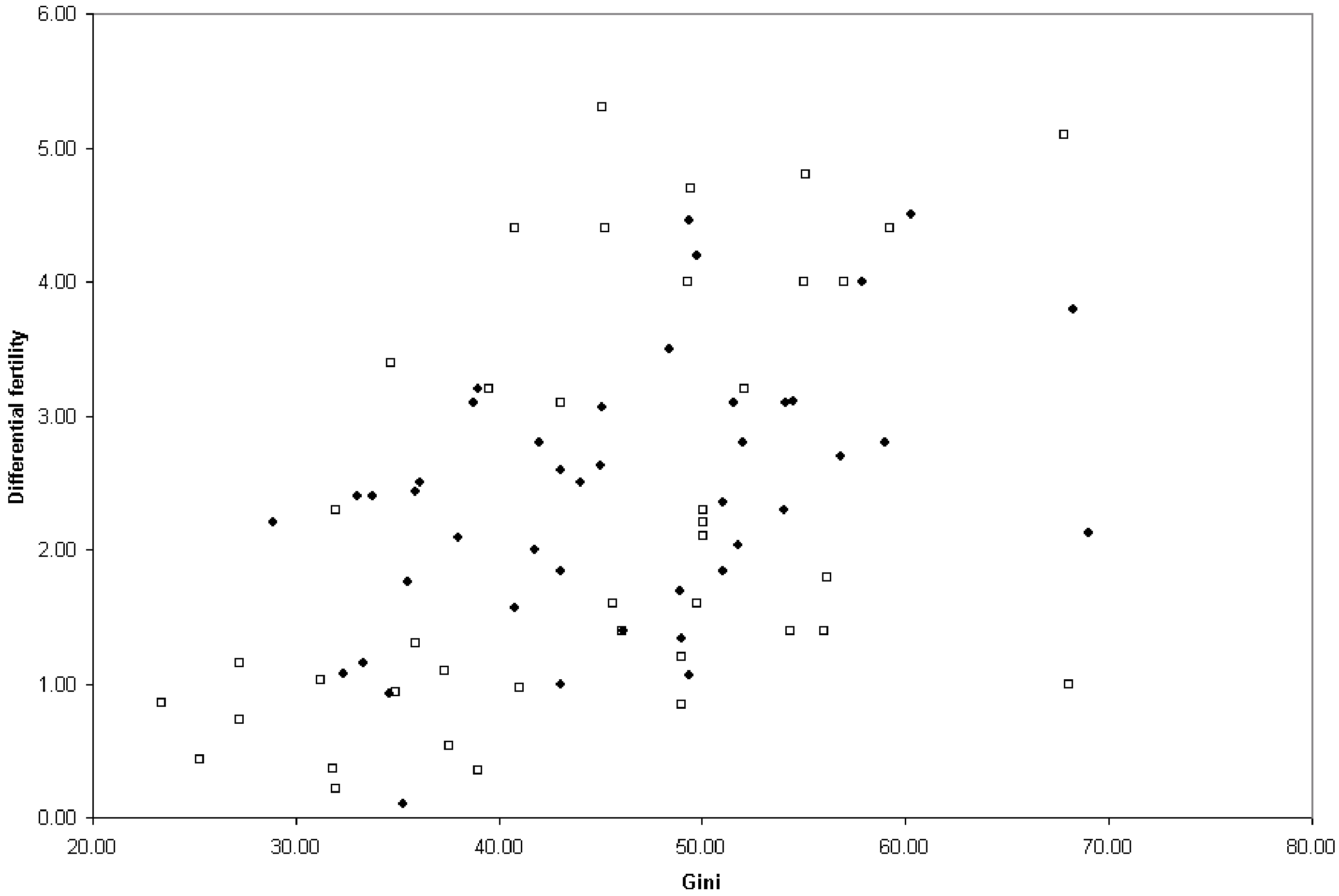


Data:

ıtries for which differential fertility is available



Kremer and Chen:



Descriptive Statistics:

Sample	nobs	data	Mean	S.D.	Min	Max
1960-1976	40	GROWTH	1.95	3.65	-5.75	8.44
		GINI	44.32	11.14	23.38	68.00
		TFR	5.56	1.89	2.02	7.93
		DIFFTFR	2.23	1.56	0.22	5.30
1976-1992	43	GROWTH	0.39	1.89	-3.46	4.97
		GINI	45.91	9.56	28.90	69.00
		TFR	6.06	1.08	3.37	8.00
		DIFFTFR	2.41	0.99	0.10	4.50
Total	83	growth	1.14	2.97	-5.75	8.44
		GINI	45.14	10.32	23.38	69.00
		TFR	5.82	1.54	2.02	8.00
		DIFFTFR	2.32	1.29	0.10	5.30

Estimation results:

Independent variable	Regression							
	(1)		(2)		(3)		(4)	
Constant A	12.35**	(1.31)	12.79**	(1.33)	15.30**	(1.46)	13.92**	(1.69)
Constant B	10.41**	(1.36)	10.98**	(1.38)	13.40**	(1.45)	12.18**	(1.63)
ln(GDP)	-1.33**	(0.17)	-1.21**	(0.16)	-1.37**	(0.15)	-1.55**	(0.20)
I/GDP	0.14**	(0.02)	0.13**	(0.02)	0.07**	(0.03)	0.08**	(0.04)
G/GDP	- 0.08**	(0.03)	-0.07**	(0.03)	-0.05*	(0.03)	-0.05*	(0.03)
AFR	-1.75**	(0.35)	-1.80**	(0.35)	-1.95**	(0.32)	-2.41**	(0.44)
GINI			-0.03**	(0.01)	0.02	(0.03)	0.06	(0.05)
ln(TFR)					-1.84**	(0.87)	-1.01	(1.01)
ln(DTFR)							-1.22**	(0.50)
J_{test}	17.71	[0.48]	17.11	[0.45]	16.79	[0.40]	9.58	[0.85]
LR_1							5.53	[0.01]
LR_2							2.08	[0.35]

Policy implications

Public education: majority voting on public spending
income tax
same quality for all

Private education: different for each agent, as in the model presented before

Standard result: private education is good for growth, public education is good for equality

Public education reduces fertility differentials
and can thus may be also good for growth if fert. dif. are high

Work in progress

Can the inspection of fertility differentials be useful to understand why fertility fell during the Industrial Revolution ?

The three stories of the fall of fertility

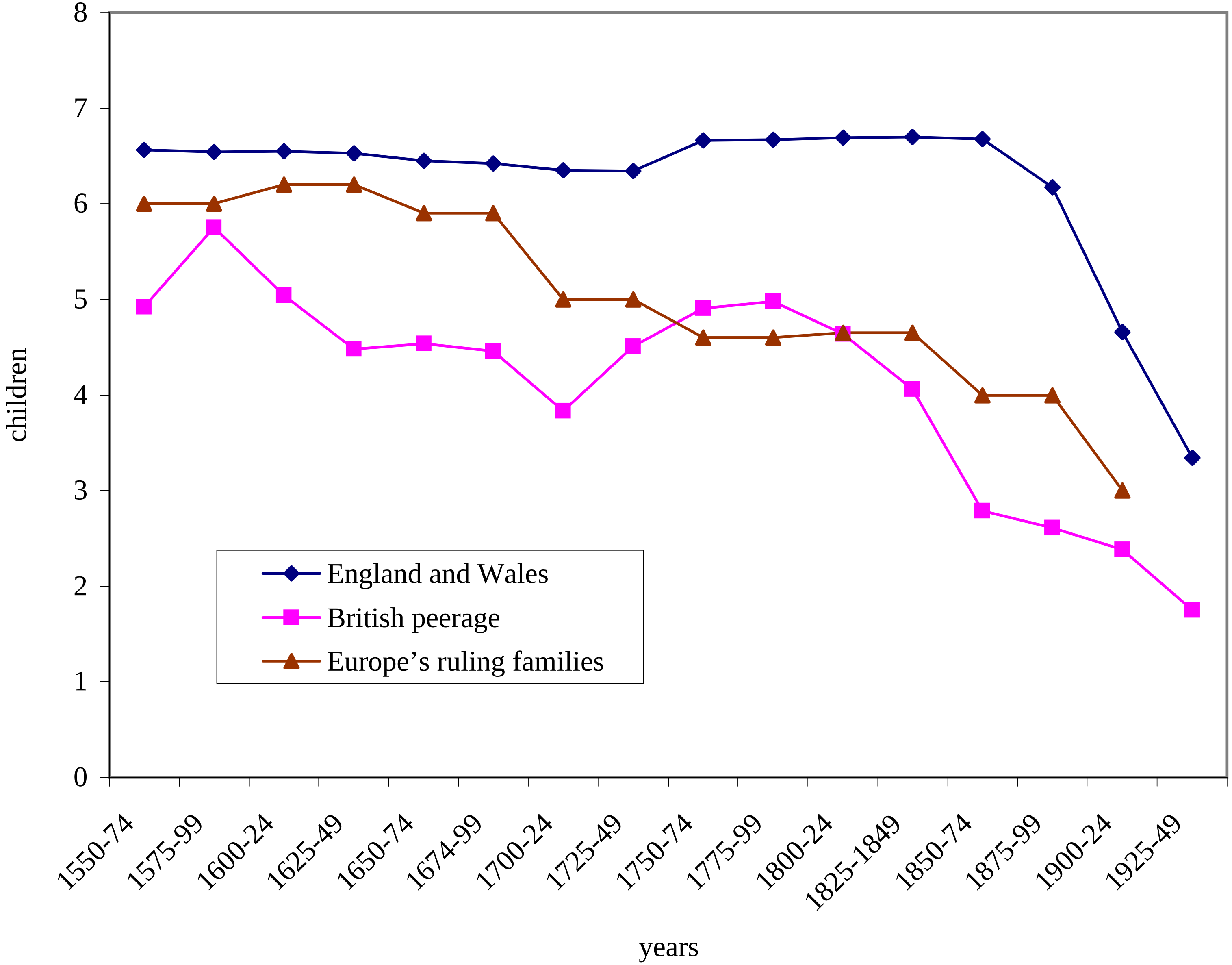
- replacement story: infant mortality fell
- old age support: children were less needed
- return to education: skill premium rose and parents substituted quantity for quality (as if η increased)

How can we weight these different stories ?

One should look at the forerunners

- Upper class (English peers, European ruling families)
- Some cities: Rouen, Geneva
- Jews

Figure 1: Marital fertility



Rouen

Classes	I	notables
	II	merchants
	III	craftsmen
	IV	workmen

	I	II	III	IV
income				
rental value - 1773	488.00	266.00	202.00	77.00
poll tax - 1728	26.80	12.10	9.40	1.22
indexes	100.00	54.51	41.39	15.78
	100.00	45.15	35.07	4.55

Literacy rate

	I	II	III	IV
1670-99	91.99	76.00	60.50	29.50
1700-29	97.42	79.00	71.50	34.00
1730-59	96.11	83.50	77.00	42.50
1760-92	95.70	90.50	82.50	47.50

Fertility per women

	Ia	I	II	III	IV
1670-99	4.66	6.23	6.53	7.19	7.21
1700-29	4.53	4.87	5.51	6.29	6.06
1730-59	3.87	4.84	4.81	5.48	5.67
1760-92	2.71	3.77	3.28	4.84	4.84

Net reproduction rate

	I	II	III	IV
1670-99	1.37	1.51	1.36	1.20
1700-29	1.30	1.27	1.19	1.00
1730-59	0.88	0.95	0.96	0.80
1760-92	0.73	0.58	0.82	0.68
Change 1670-1792	-0.65	-0.93	-0.54	-0.52

Survival probability 15→30

I	II	III	IV
0.865	0.875	0.875	0.857

Survival probability 0→15

0.521	0.474	0.474	0.408

Geneva

I	notables
II	craftsmen
III	workmen

	I	II	III
dowry 1700-4	20160.00	3189.00	1251.00
dowry 1741-5	25092.00	5057.00	2173.00
dowry 1770-4	33730.00	2489.00	2311.00
indexes	100.00	15.82	6.21
	100.00	20.15	8.66
	100.00	7.38	6.85

Literacy rate

	I	II	III
1700-4	86.00	54.50	12.50
1741-5	96.50	83.50	33.50
1770-4	98.50	87.50	58.00

Fertility per women

	I	II	III
1675-96	6.70	7.10	6.20
1700-4	6.70	7.30	5.50
1741-5	4.70	5.70	4.20
1770-4	2.80	5.20	4.70

Net reproduction rate

	I	II	III
1650-84	1.18	1.07	0.60
1687-04	1.23	0.96	0.66
1725-72	0.84	0.83	0.68
1800-10	0.73	0.59	0.66
Change 1650-1810	-0.45	-0.48	0.06

Survival probability 15→30

I	II	III
0.89	0.84	0.80

Survival probability 0→15

0.61	0.452	0.338