The Demographic Transition

Oded Galor

Department of Economics
Brown University

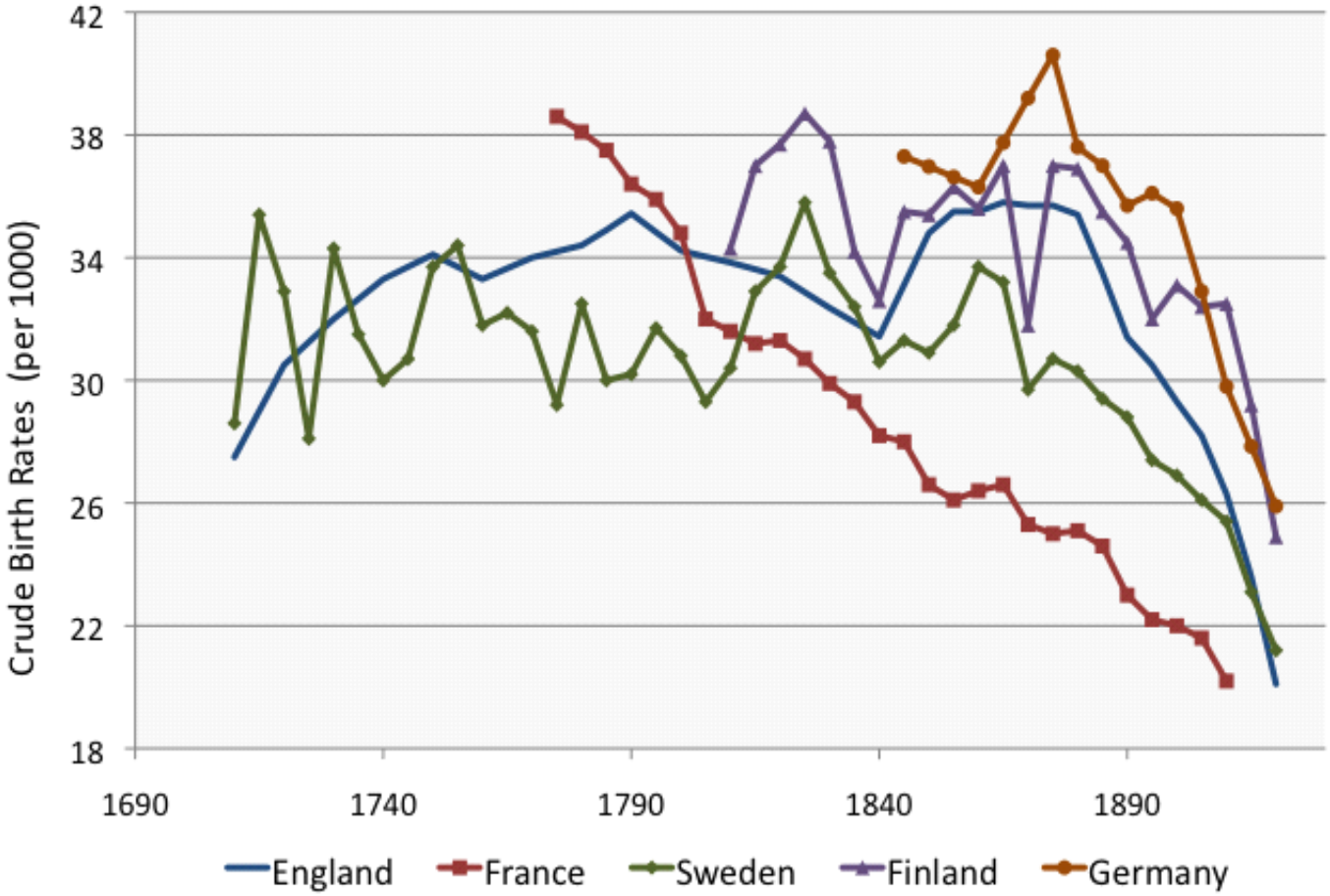
November 29, 2015

The Demographic Transition

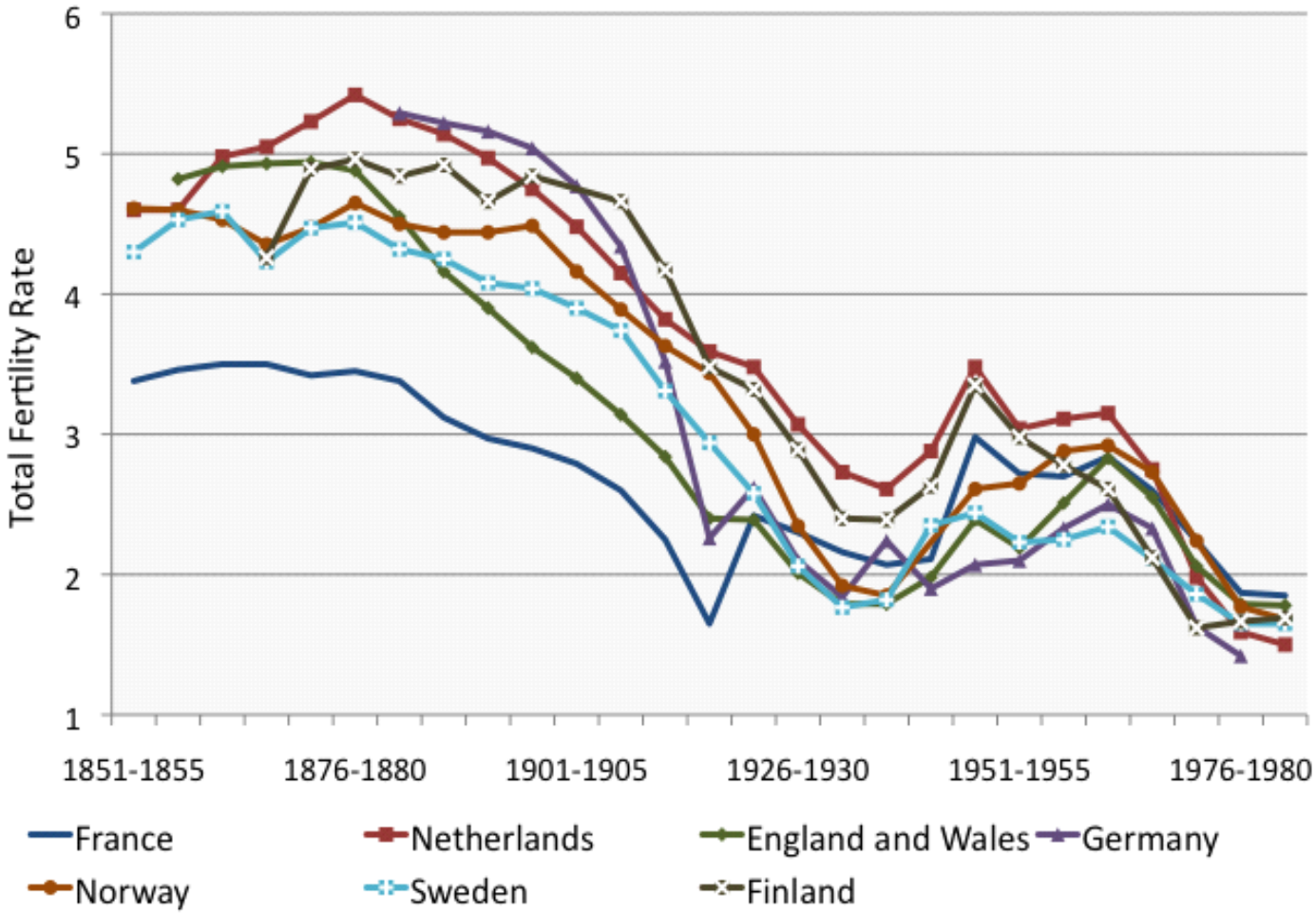
A rapid decline in fertility, mortality and population growth that mark the transition to modern growth:

- The positive relationship between income per capita and population growth is reversed
- Gains in total output are not counterbalanced by population growth

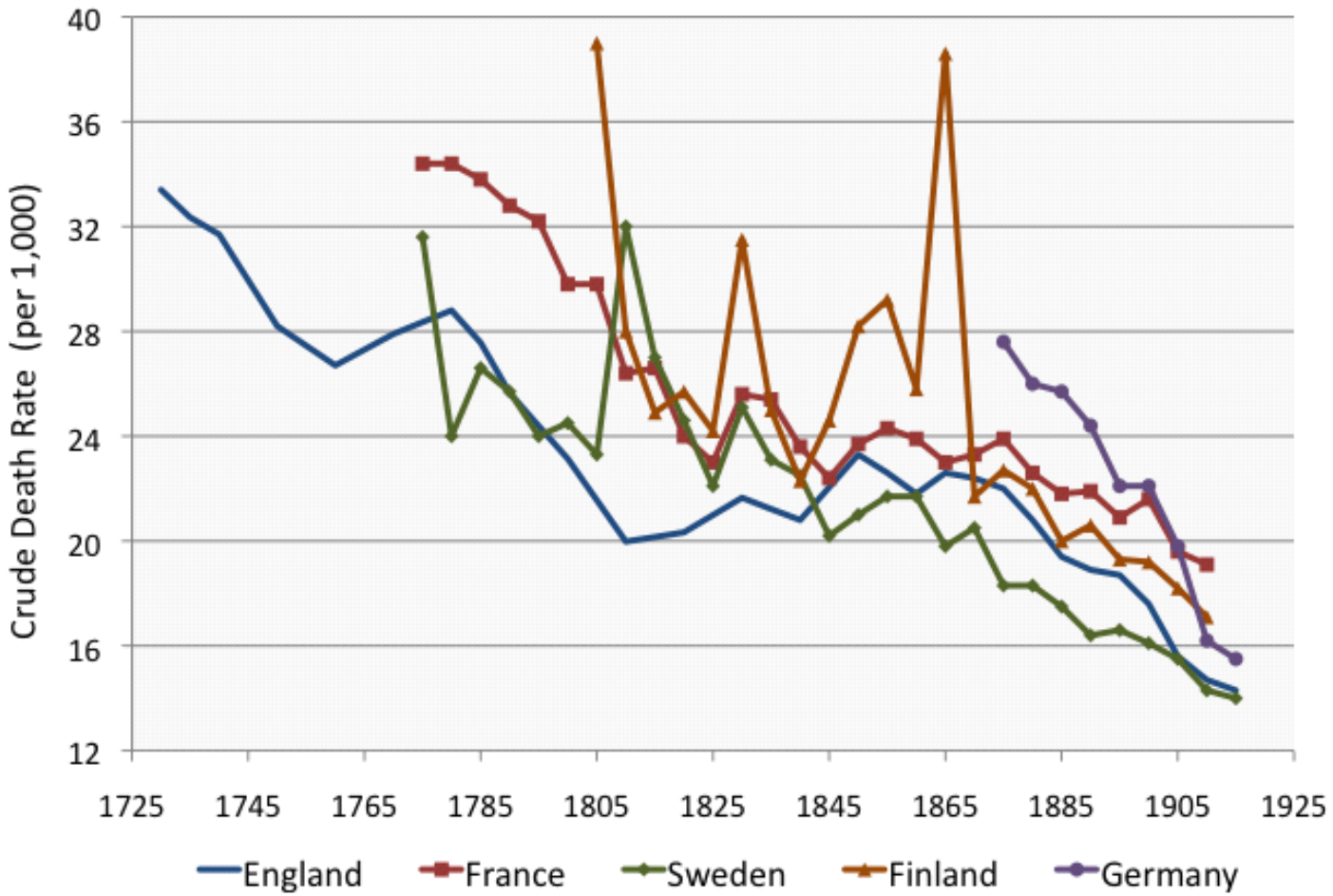
The Demographic Transition in Western Europe: Crude Birth Rates



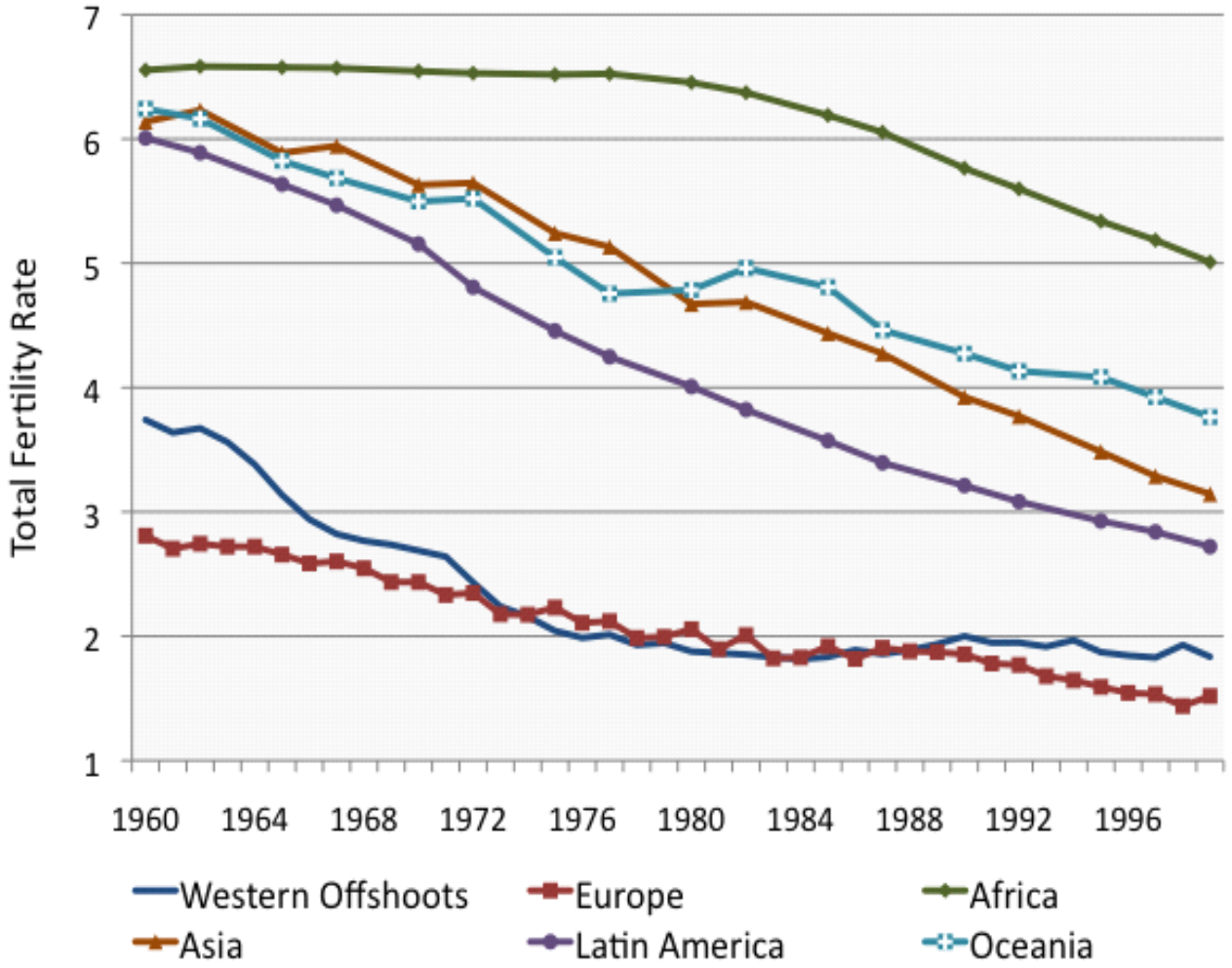
The Demographic Transition in Western Europe: Total Fertility Rates



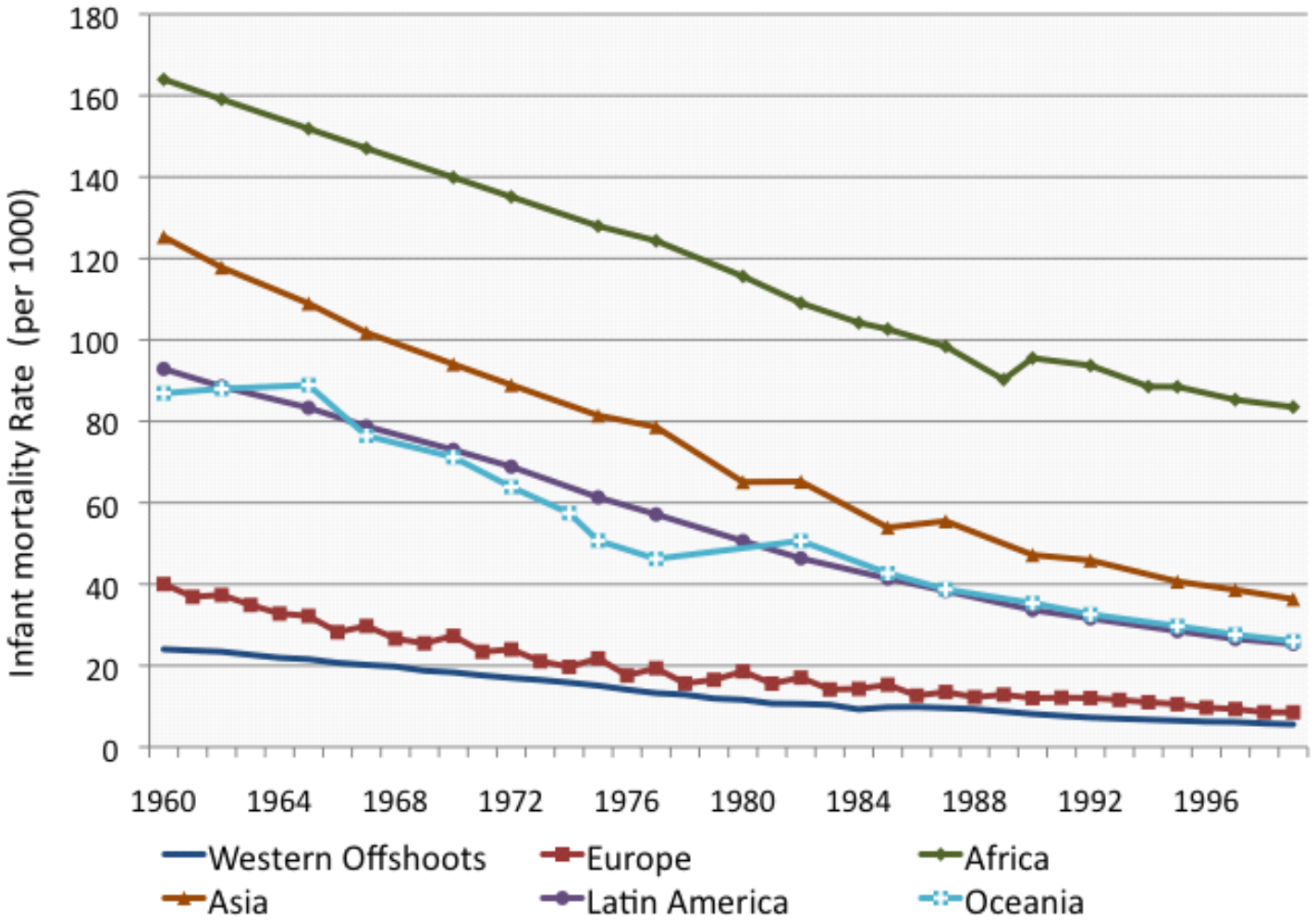
Mortality Decline Western Europe: 1730-1920



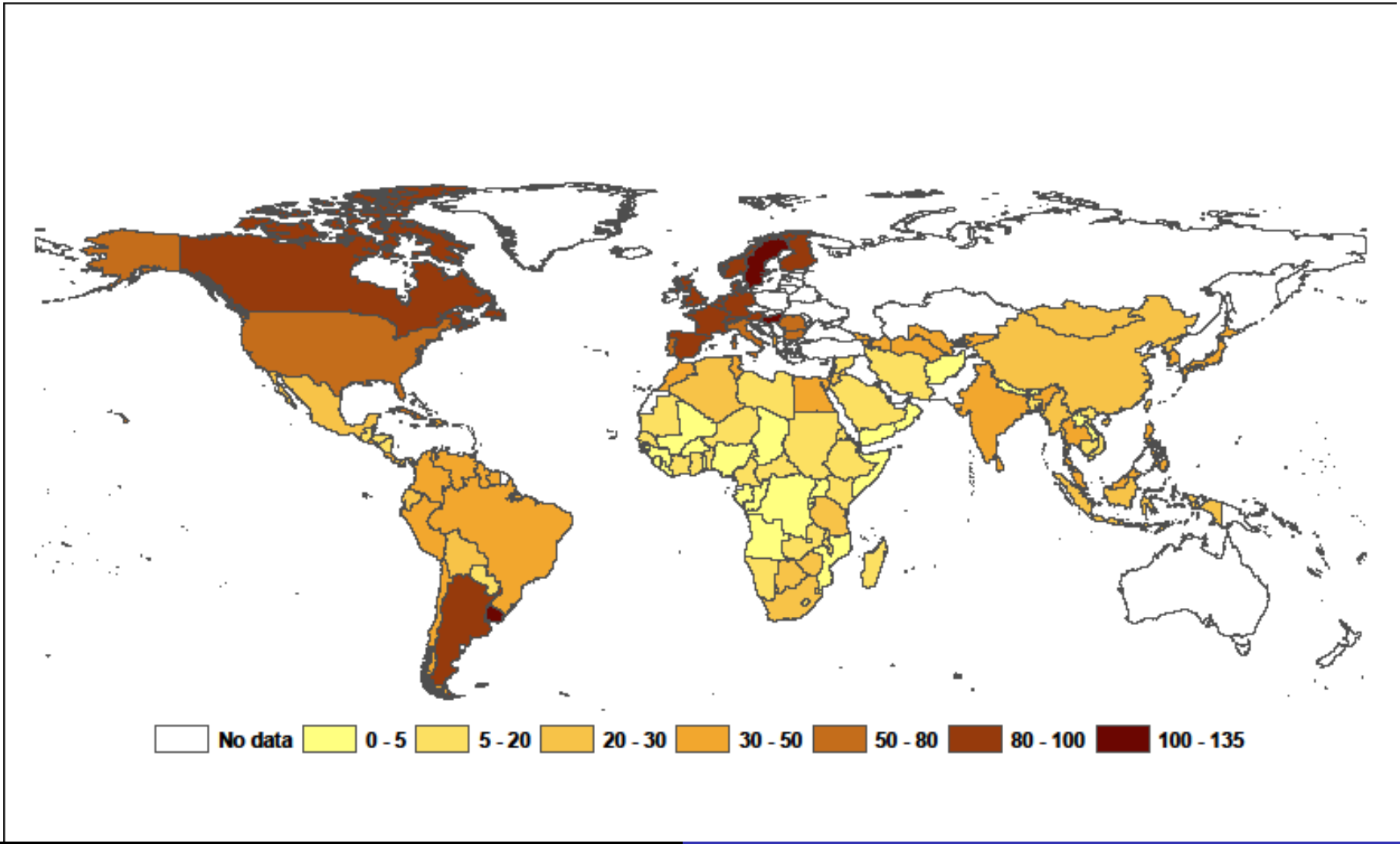
The Evolution of Total Fertility Rate across Regions, 1960-1999



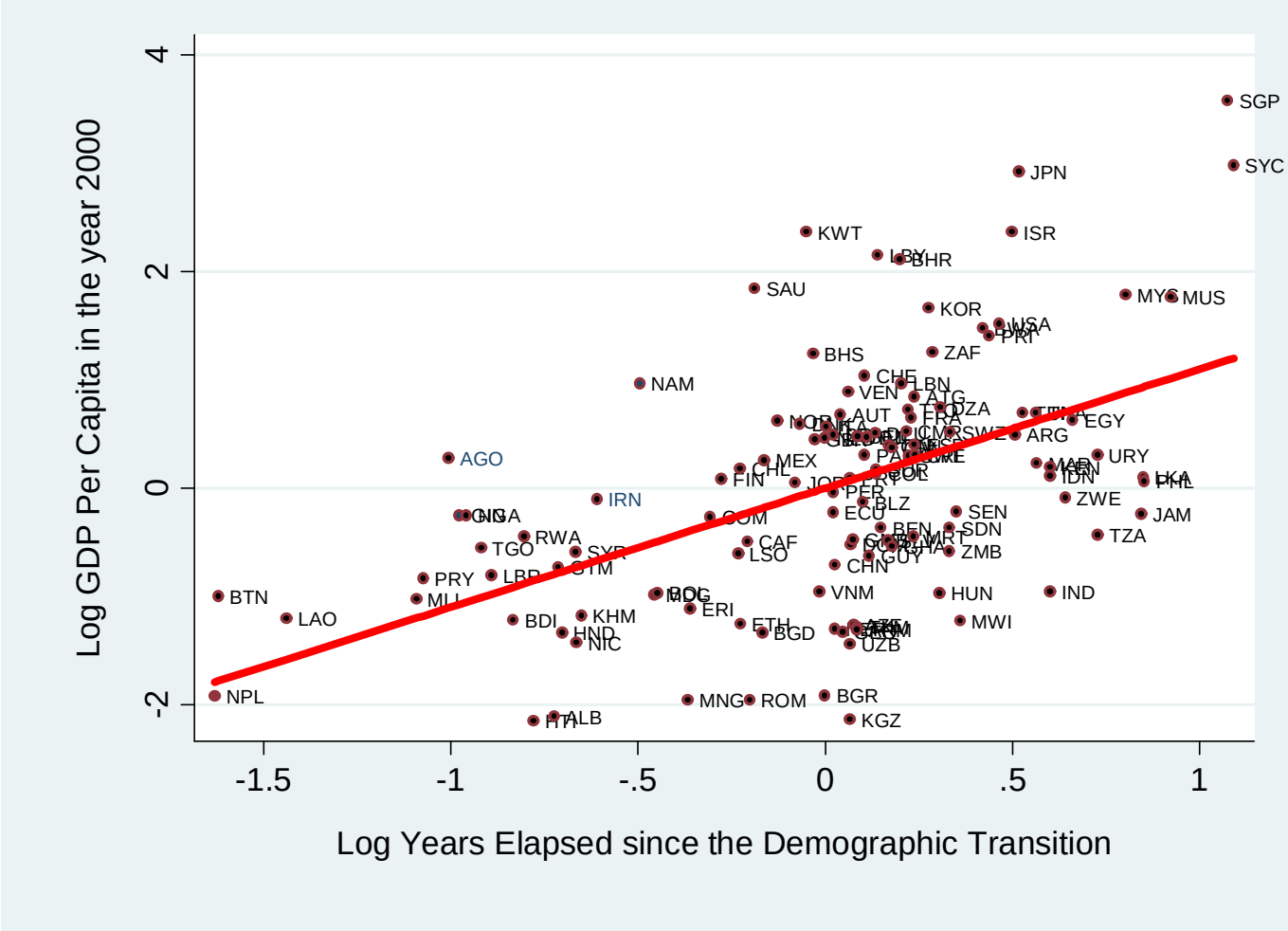
Decline in infant mortality rates across regions, 1960-1999



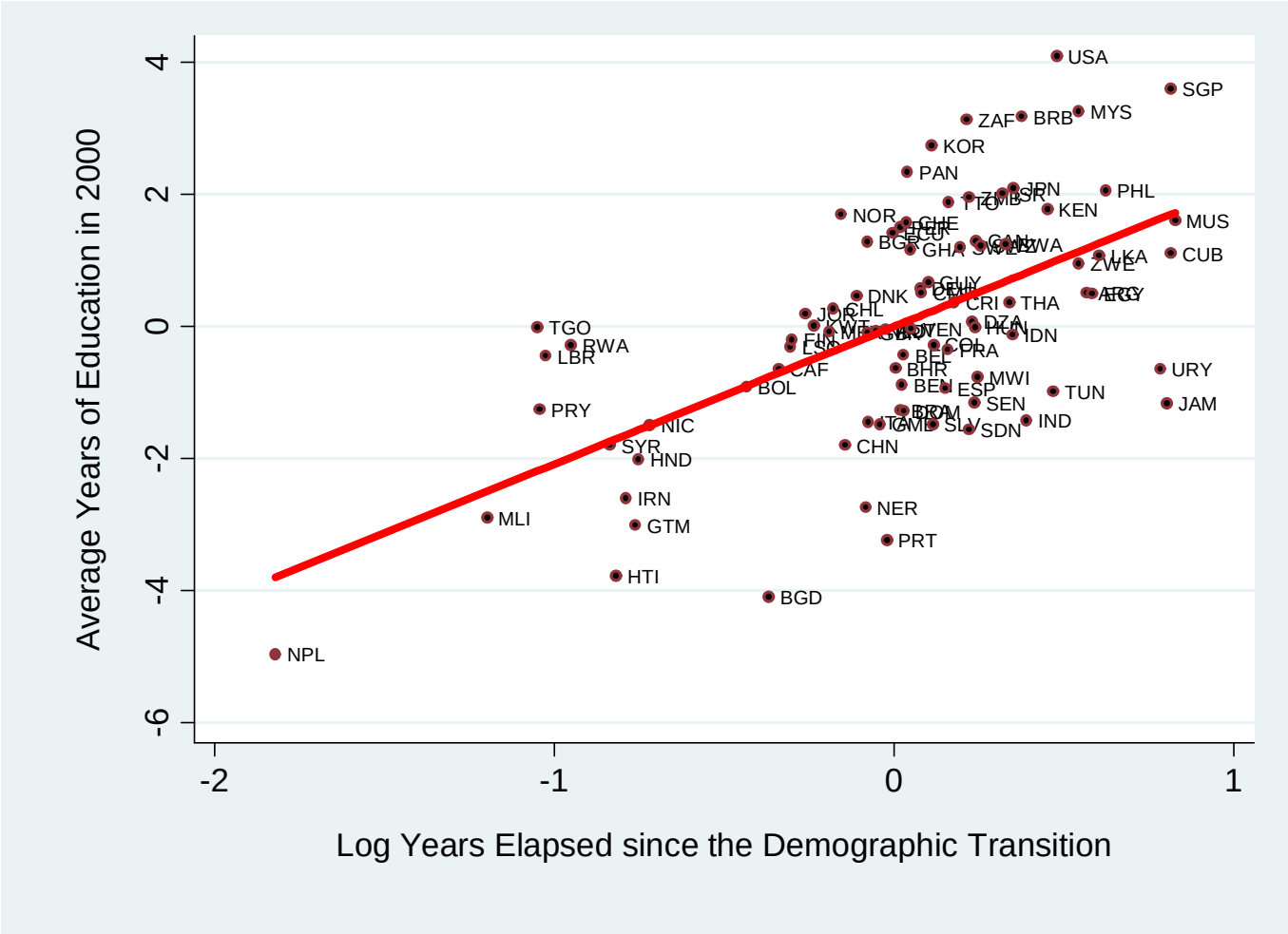
Years Elapsed since the Demographic Transition



Years Elapsed since the Demographic Transition



Years Elapsed since the Demographic Transition



Theories of the Demographic Transition

- The Rise in Income
  - The rise in income increased in the opportunity cost of raising children $\Rightarrow$ reduction in fertility (Becker, 1960)
  - The income elasticity of child quality is larger than that of child quantity $\Rightarrow$ substitution of child quality for quantity $\Rightarrow$ reduction in fertility (Becker and Lewis, JPE 1973)
- The Decline in Child Mortality
  - Mortality decline enabled families to attain the same number of children with lower fertility rates

Theories of the Demographic Transition

- The Old-Age Security Hypothesis (Caldwell, 1976)
  - Development of financial markets reduced the demand for children as an investment good

    $\Rightarrow$ reduction in fertility

- The Decline in the Gender Wage Gap (Galor-Weil, AER 1996))
  - The rise in the relative wages of women increases the opportunity cost of raising children more than family income

    $\Rightarrow$ reduction in fertility

Theories of the Demographic Transition

- The Rise Human Capital Formation:
  - Increased industrial demand for human capital induced human capital formation $\Rightarrow$ substitution of child quality for qunatity $\Rightarrow$ reduction in fertility $\Rightarrow$ (Galor-Weil, AER 1999, 2000)
    - Reinforced by: increased life expectancy
    - Reinforced by: decline in the profitability of child labor

    (Hazan-Berdugo, EJ 2002, Doepke-Zilibotti, AER 2005)
  - Evolution of preferences for child quality (Galor-Moav QJE, 2002)
    - Natural selection favors the quality strategy
    - Religious indoctrination toward literacy (Judaism; Protestantism)

The Rise in Income - Main Hypothesis

- The rise in income increases in the opportunity cost of raising children

  $\Rightarrow$ fertility declines (Becker, 1960)

- The income elasticity of child quality is larger than that of child quantity

  $\Rightarrow$ substitution of quality for quantity as income increases

  $\Rightarrow$ fertility declines (Becker and Lewis, JPE 1973)

The Rise in Income: Mechanism

- Child rearing is time-intensive
- Budget constraint

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

  - $y \equiv$ household's income
  - $c \equiv$ household's consumption
  - $n \equiv$ household's (surviving) children
  - $\tau \equiv$ time cost per child
  - $y\tau \equiv$ opportunity cost of raising a child

The Rise in Income: Mechanism

- The rise in income generates two conflicting effects:
  - An income effect:

$$y\tau n + c \leq [y] \Uparrow$$

    - More income can be devoted to raising children
    - operates towards $n \Uparrow$
  - A substitution effect:

$$\Uparrow [y\tau]n + c \leq y$$

    - The opportunity cost of raising children increases
    - operates towards $n \Downarrow$

The Rise in Income: Mechanism

- The substituting effect dominates at a higher level of income
- As income increases fertility declines
- Fertility declines in the process of development

The Rise in Income - Theoretical Evaluation

- Preference-based theory (unattractive)
  - Innate bias against child quantity beyond a certain level of income - non-refutable
  - Non-robust (e.g., the class of homothetic preferences will not trigger a fertility decline)

The Rise in Income - Homothetic Preferences

- Preferences:

$$u = \gamma \ln n + (1-\gamma) \ln c$$

- Budget constraint

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

- Optimization: (fraction γ of income is spent on children and $(1-\gamma)$ on consumption)

$$y\tau n = \gamma y$$
$$c = (1-\gamma)y$$

The Rise in Income - Homothetic Preferences

- Optimal number of children

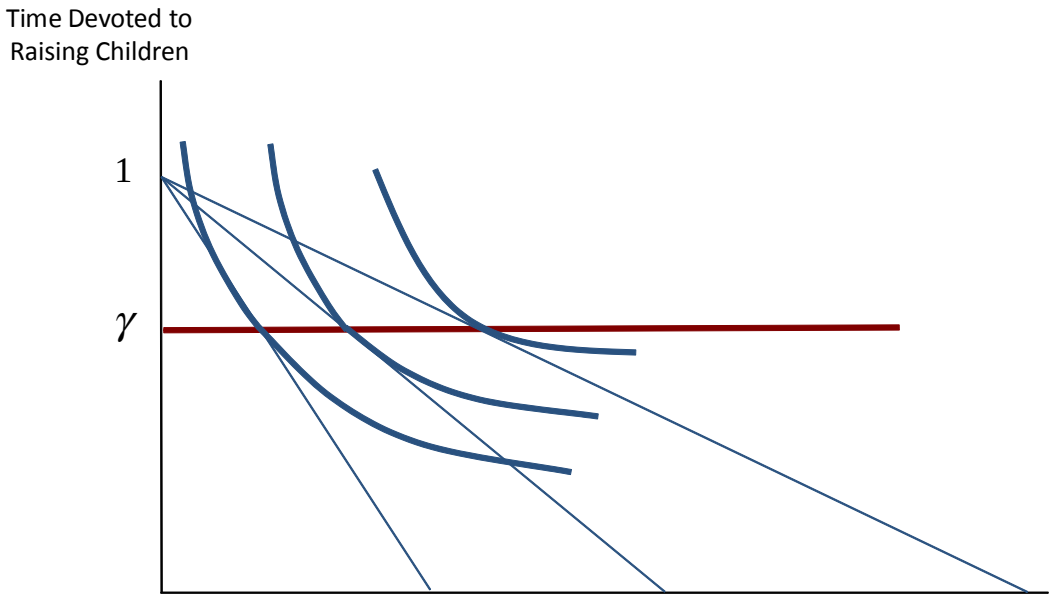
$$n = \gamma/\tau$$

- The rise in income has no effect on fertility, i.e.,

$$|\text{Income effect}| = |\text{Substitution effect}|$$

- Fertility is unaffected by the process of development

The Rise in Income - Homothetic Preferences



The Rise in Income: Testable predictions

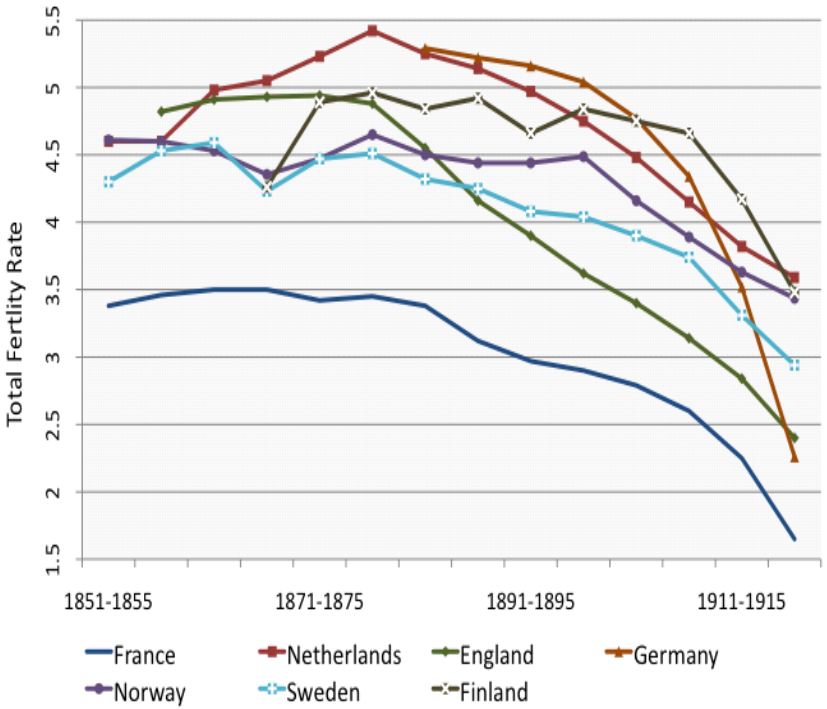
- Across countries that are similar in sociocultural characteristics (and thus in noneconomic factors that may affect fertility decisions), the timing of the fertility decline is inversely related to the level of income per capita.

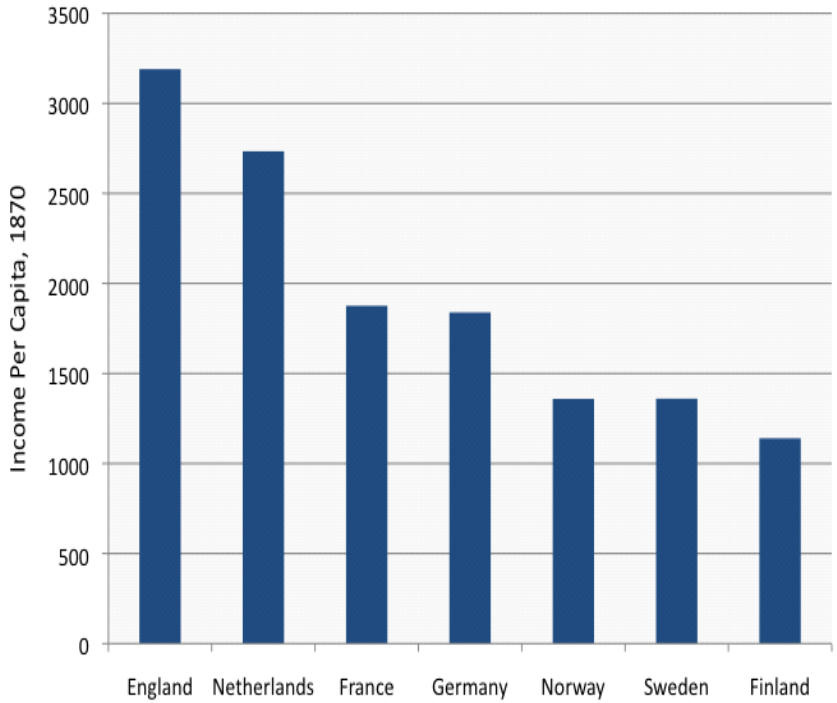
- Within an economy, the number of (surviving) children across households is inversely related to their levels of income.

The Rise in Income: Refuting Cross Country Evidence

- Cross Section of Countries (1870-2000) - Income per worker was positively associated with fertility rates, accounting for mortality rates and education (Murtin (2009).
- Western Europe (1870s) The DT occurred among countries that differed significantly in their income per capita.

Simultaneous DT across European Countries that Differ in Income per Capita





The Rise in Income: Refuting Evidence from Individual Countries

- France (1876–96) Income per capita had a positive effect on fertility rates during France's demographic transition, accounting for education, the gender literacy gap, and mortality rates (Murphy 2009)
- England (During the DT):The force associated with the rise in income would have led to an increase in fertility rates (Fernandez Villaverde (2001)
- England (1630s) Reproductive success increases with income (Clark (JEH 2006)

The Decline in Child Mortality - Main Hypothesis

- Parents generates utility from the number of surviving children
- A decline in child mortality permit parents to reach a given level of surviving children with lower fertility
- The decline in mortality triggered the subsequent decline in fertility

The Decline in Mortality – Mechanism

- Preferences:

$$u = \gamma \ln n + (1 - \gamma) \ln c$$

  - $c \equiv$ household's consumption
  - $n \equiv$ household's surviving children

- Survival children

$$n = \theta n^b$$

  - $\theta \equiv$ probability of a child to survive infancy
  - $n^b \equiv$ household's children born

The Decline in Mortality – Mechanism

- Budget constraint

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

  - $y \equiv$ household's income
  - $c \equiv$ household's consumption
  - $\tau \equiv$ time cost of raising a surviving child
  - $0 \equiv$ time cost of raising a surviving child
  - $y\tau \equiv$ opportunity cost of raising a surviving child

The Decline in Mortality – Mechanism

- Optimization: (fraction γ of income is spent on children and $(1-\gamma)$ on consumption)

$$y\tau n = \gamma y$$
$$c = (1-\gamma)y$$

- Optimal number of surviving children (NNR)

$$n = \gamma/\tau$$

- Optimal fertility (# of successful pregnancies - TFR)

$$n^b = n/\theta = \gamma/(\tau\theta)$$

The Decline in Mortality – Testable Predictions

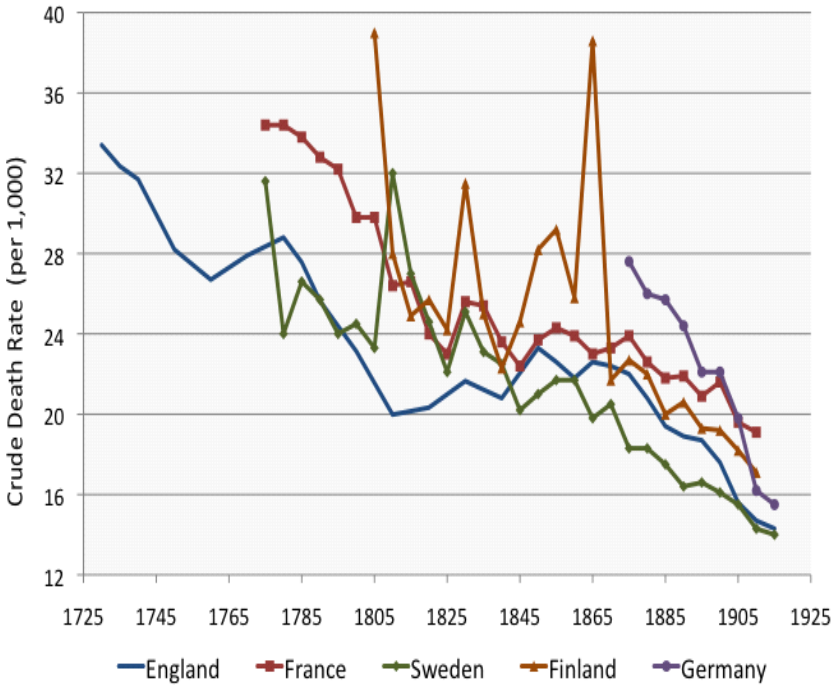
- Child mortality rate, $(1-\theta)$, has a positive effect on TFR
- Child mortality rate, $(1-\theta)$, has no effect on (Net Reproduction Rate) NRR

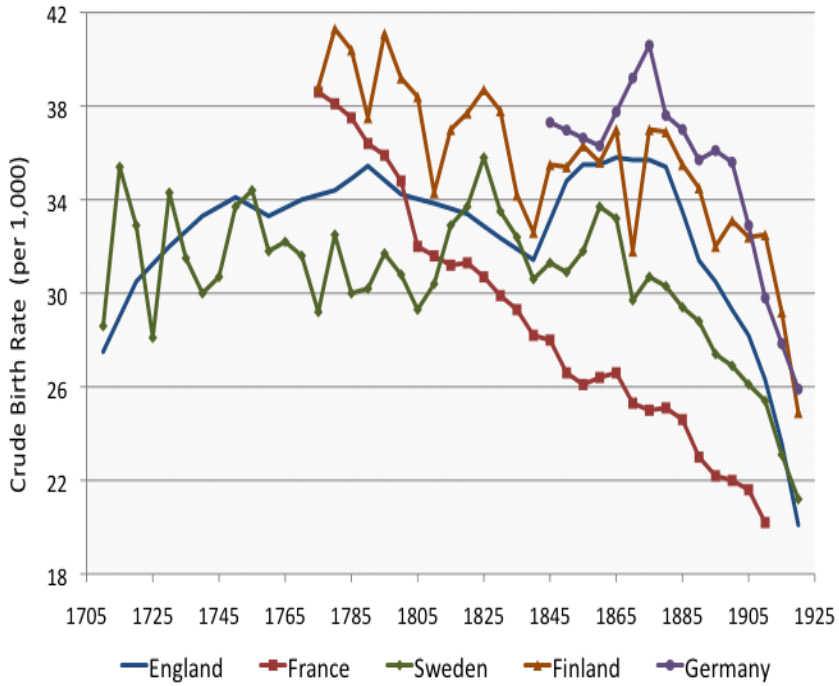
...The Decline in Child Mortality

NRR does not decline unless:

- There exists a precautionary demand for children
- RA with respect to fertility $>$ RA with respect to consumption
- Replacement fertility is insignificant (empirical estimates 0.2–0.6)
- Resources saved from investment in non-surviving children are not channeled towards higher fertility

The Decline in Mortality and Fertlity - Evidence





The Decline in Child Mortality – Challenges to the Theory

- Worldwide: NRR and TFR plummets jointly in during the demographic transition. but the theory does not predict a decline in NRR
- US, France and Some LDCs: The decline in mortality did not precede the decline in fertility
- Western Europe: No change in the patterns of mortality decline at the time of the sharp decline in fertility
- England: The decline in mortality started in England in the 1730s (140 years before the fertility decline) and was accompanied by a steady increase in fertility rates until 1800

The Decline in Mortality: Refuting Evidence from Individual Countries

- France (1876–96): Mortality rate had no effect on fertility during France's demographic transition, accounting for education, income, and the gender literacy gap. (Murphy 2009)
- England (1861–1951):The force associated with the decline in child mortality would have led to an increase in fertility rates (Fernandez Villaverde (2001); Doepke (2005)

The Old-Age Security Hypothesis

- Children is a form of investment good (in the absence of capital markets)
- The development of financial markets reduced the demand for children for investment purposes and triggered a decline in fertility

The Old-Age Security Hypothesis - Challenge to the Theory

- The decline in the importance of old-age support is unlikely to be a major force behind the significant reduction in fertility – at a rate of 30–50% – during the demographic transition:
  - Rare examples in nature of offspring that support their parents in old age
- Institutions supporting individuals in their old age were formed well before the demographic transition
  - England (16th century) Parents did not rely on support from children in their old age (Pelling and Smith-1994)
- Prior to the demographic transition, richer individuals who presumably had better access to financial markets, did not have fewer surviving children

Contributions to the field of Economic Growth

- Gender and Growth
  - First attempt to examine the role of differences across gender in the growth process
- Heterogeneity and Growth
  - Galor and Zeira (1993) – first attempt to explore the effect of heterogeneity, across households, and the growth process
  - Galor and Weil (1996) – first attempt to explore the effect of heterogeneity, within the households, on the growth process

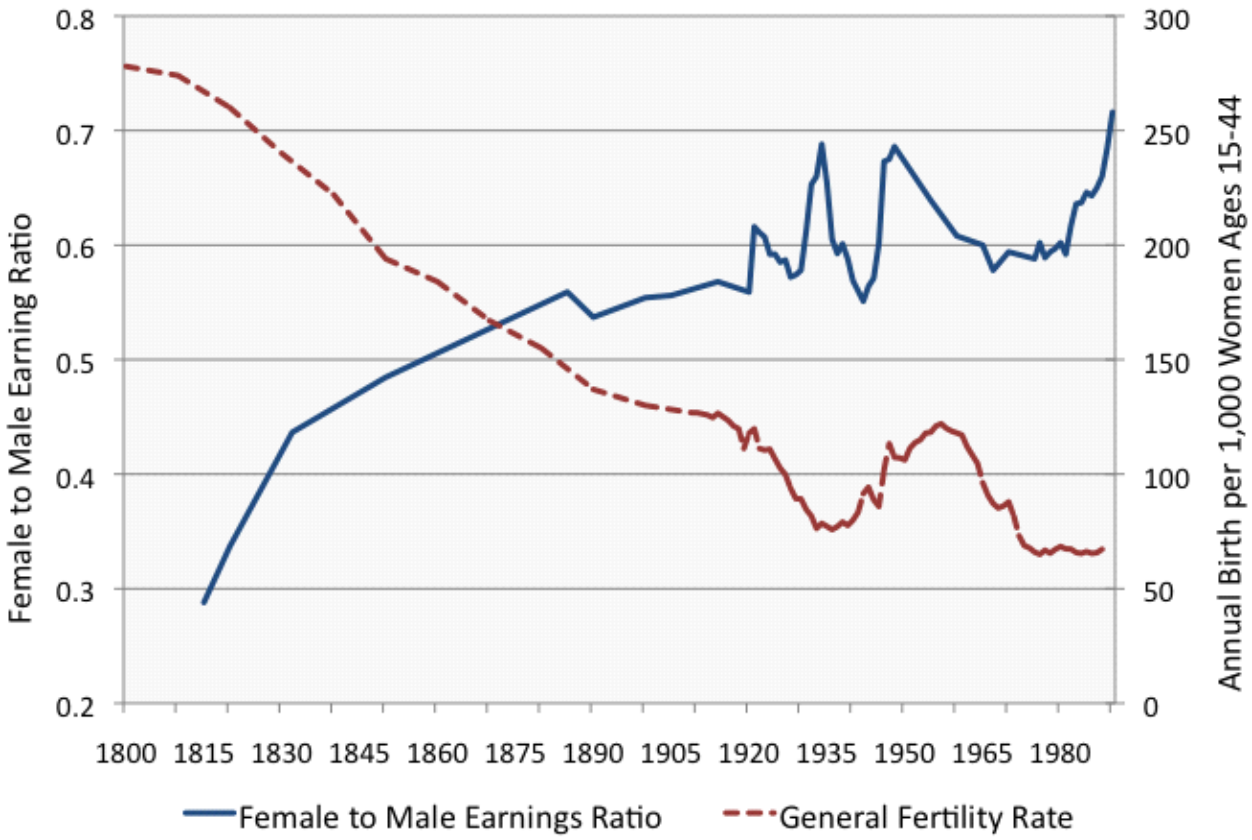
Mechanism: I. Development and Women's Wages

- Female-Biased Technical change
  - Mechanization and advanced technologies have complemented mental tasks more than physical tasks
  - Women have physiological comparative advantage in mental (rather than physical) tasks
- $\Longrightarrow$ The process of development has (inevitably) increased the productivity of women relative to men:

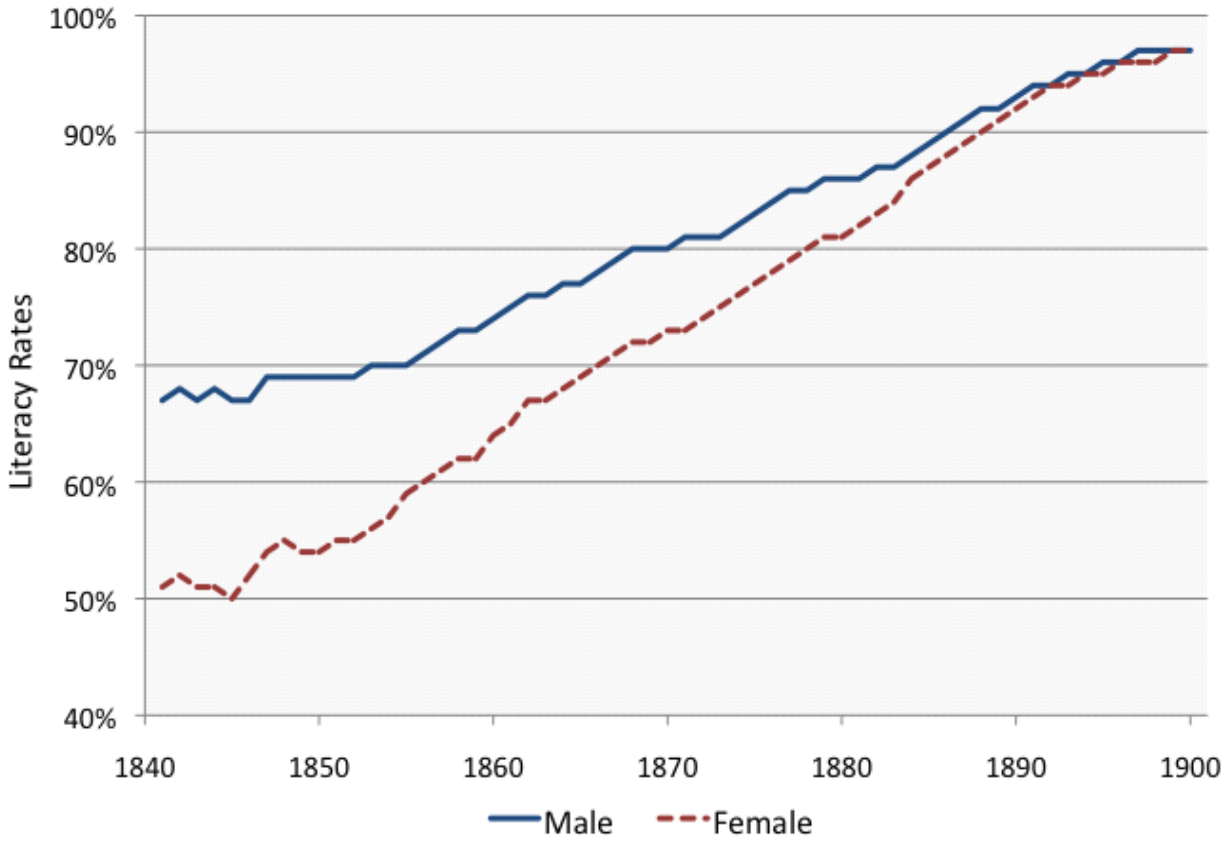
$$k \Uparrow \Longrightarrow \left(w^F/w^M\right) \Uparrow$$

  - $w^F \equiv$ women's wages
  - $w^M \equiv$ men's wages
  - $k \equiv$ capital-labor ratio

Evolution of the Gender Earninig Ratio - US



Evolution of the Gender Literacy Gap - England



Mechanism: II. Women's Relative Wages and Fertility

- Child rearing is time-intensive
- Women are the prime care-takers engaged in child rearing
- Budget constraint (if only women raise children)

$$w^F \tau n + c \leq w^M + w^F$$

  - $w^F + w^M \equiv$ household's income
  - $c \equiv$ household's consumption
  - $n \equiv$ household's (surviving) children
  - $\tau \equiv$ time cost per child
  - $w^F \tau \equiv$ opportunity cost of raising a child

Mechanism: II. Women's Relative Wages and Fertility

- The rise in women's wages, w^F, generates two conflicting effects:
  - An income effect:

$$w^F \tau n + c \leq w^M + [w^F] \Uparrow$$

    - More income for raising children $\Longrightarrow$ operates towards $n \Uparrow$
  - A substitution effect:

$$\Uparrow [w^F \tau] n + c \leq w^M + w^F$$

    - Opportunity cost of children increases $\Longrightarrow$ operates towards $n \Downarrow$
- A rise in men's wages generate only an income effect

$$w^F \tau n + c \leq [w^M] \Uparrow + [w^F]$$

.The Decline in the Gender Wage Gap

- If women work and raise children, an increase in w^F increases the opportunity cost of raising children more than family incomei.e.,

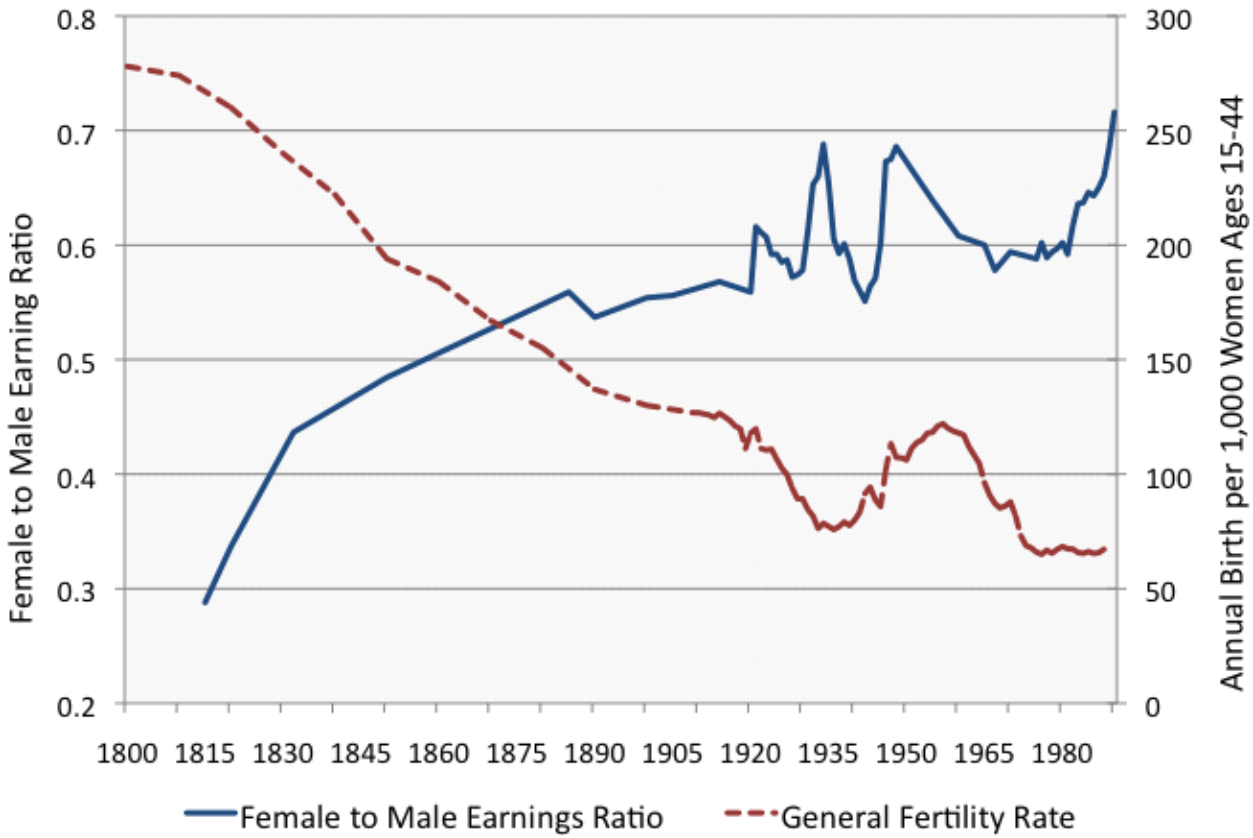
$$w^F \Uparrow \implies |\text{Income effect}| < |\text{Substitution effect}|$$

$$\implies n \Downarrow \text{ (even if preferences are homothetic)}$$

- A rise in men's wages generate only an income effect

$$w^M \Uparrow \implies n \Uparrow$$

Women's Relative Wages and Fertility - US



Women's Relative Wages and Fertility - Evidence

- US (1970s): $w^F \Uparrow \implies n \Downarrow$ & $w^M \Uparrow \implies n \Uparrow$ (Heckman and Walker (ECT 79))
- Sweden's demographic transition: $(w^F/w^M) \Uparrow \implies n \Downarrow$ Schultz (1985)
- France (1876–1896): reduction in the gender literacy gap had an adverse effect on fertility, accounting for income per capita, educational attainment, and mortality rates (Murphy (2009))

The Rise in the Demand for Human Capital - Main Thesis

- The acceleration in the rate of technological progress in the 2nd phase of industrialization increased the demand for human capital

  education enabled individuals to cope with a rapidly changing technological environment

- The rise in the demand for human capital induced a substitution of quality for quantity of children triggering a demographic transition

  $\Longrightarrow$ reduction in fertility

The Model - Preferecnes

$$u = (1-\gamma)\ln c + \gamma[\ln n + \beta \ln h]$$

- $c \equiv$ consumption
- $n \equiv$ (surviving) children
- $h \equiv$ quality (human capital) of each child
- $\beta \equiv$ degree of preference for child quality; $\beta < 1$

The Model - Budget Constraint

$$yn(\tau^q + \tau^e e) + c \leq y$$

- $y \equiv$ household potential income
- $\tau^q \equiv$ fraction of the household's unit-time endowment required to raise a child, regardless of quality
- $\tau^e \equiv$ fraction of the household's unit-time endowment required for each unit of education per child
- $(\tau^q + \tau^e e) \equiv$ time cost of raising a child with a level of education (quality) e
- $y(\tau^q + \tau^e e) \equiv$ opportunity cost of raising a child with quality e

The Model - Human Capital Formation

$$h = h(e, g)$$

- $h_e(e, g) > 0$ & $h_{ee}(e, g) < 0$
  - HC is increasing (in decreasing rates) in the parental time investment in the education of the child
- $h_g(e, g) < 0$ & $h_{gg}(e, g) > 0$
  - HC is decreasing in the rate of technological progress (obsolescence of HC in a changing technological environment)
- $h_{eg}(e, g) > 0$
  - Education lessens the obsolescence of HC in a changing technological environment
- $h(0, g) > 0$ & $\lim_{e \to 0} h_e(e, g) = \infty$; $\lim_{e \to \infty} h_e(e, g) = 0$
  - Basic level of human capital & interior solution

The Model - Optimization

$$\{n, e, c\} = \arg\max \gamma[\ln n + \beta \ln h(e, g)] + (1 - \gamma) \ln c$$
$$s.t. \qquad yn(\tau^q + \tau^e e) + c \leq y$$

$$\text{since } c = y[1 - n(\tau^q + \tau^e e)] \iff$$

$$\{n, e\} = \arg\max \gamma[\ln n + \beta \ln h(e, g)] + (1 - \gamma) \ln y[1 - n(\tau^q + \tau^e e)]$$

Optimization

$$\{n, e\} = \arg\max \gamma[\ln n + \beta \ln h(e, g)] + (1-\gamma) \ln y[1 - n(\tau^q + \tau^e e)]$$

with respect to n:

$$\frac{\gamma}{n} = \frac{(1-\gamma)y(\tau^q + \tau^e e)}{y[1 - n(\tau^q + \tau^e e)]}$$

$$\gamma[1 - n(\tau^q + \tau^e e)] = (1-\gamma)(\tau^q + \tau^e e)n$$

$$n(\tau^q + \tau^e e) = \gamma$$

Optimization

$$\{n, e\} = \arg\max \gamma[\ln n + \beta \ln h(e, g)] + (1-\gamma) \ln y[1 - n(\tau^q + \tau^e e)]$$

with respect to e :

$$\frac{\gamma\beta h_e(e, g)}{h(e, g)} = \frac{(1-\gamma) y n \tau^e}{y[1 - n(\tau^q + \tau^e e)]}$$

since $n(\tau^q + \tau^e e) = \gamma$

$$\frac{\gamma\beta h_e(e, g)}{h(e, g)} = n\tau^e \quad \Longrightarrow \quad \frac{\beta h_e(e, g)}{h(e, g)} = \frac{\tau^e}{(\tau^q + \tau^e e)}$$

$$\beta h_e(e, g)(\tau^q + \tau^e e) = \tau^e h(e, g)$$

Optimization

$$n = \gamma/(\tau^q + \tau^e e)$$

$$\tau^e h(e,g) = \beta h_e(e,g)(\tau^q + \tau^e e)$$

$\Longrightarrow$

$$e = e(g, \beta, \tau^e, \tau^q),$$

$$n = \gamma/[\tau^q + \tau^e e(g, \beta, \tau^e, \tau^q)]$$

Testable Predictions - Investment in Quality

The optimal level of investment in child quality increases if:

- The technological environment changes more rapidly

$$\partial e(g, \beta, \tau^e, \tau^q)/\partial g > 0$$

- Preferences for child quality are higher

$$\partial e(g, \beta, \tau^e, \tau^q)/\partial \beta > 0$$

- The cost of raising a child (regardless of quality) increases

$$\partial e(g, \beta, \tau^e, \tau^q)/\partial \tau^q > 0$$

- The cost of educating a child decreases

$$\partial e(g, \beta, \tau^e, \tau^q)/\partial \tau^e < 0$$

Testable Predictions - Investment in Quantity

The optimal number of children decreases if:

- The technological environment changes more rapidly

$$\partial n/\partial g < 0$$

- Preferences for child quality are higher

$$\partial n/\partial \beta < 0$$

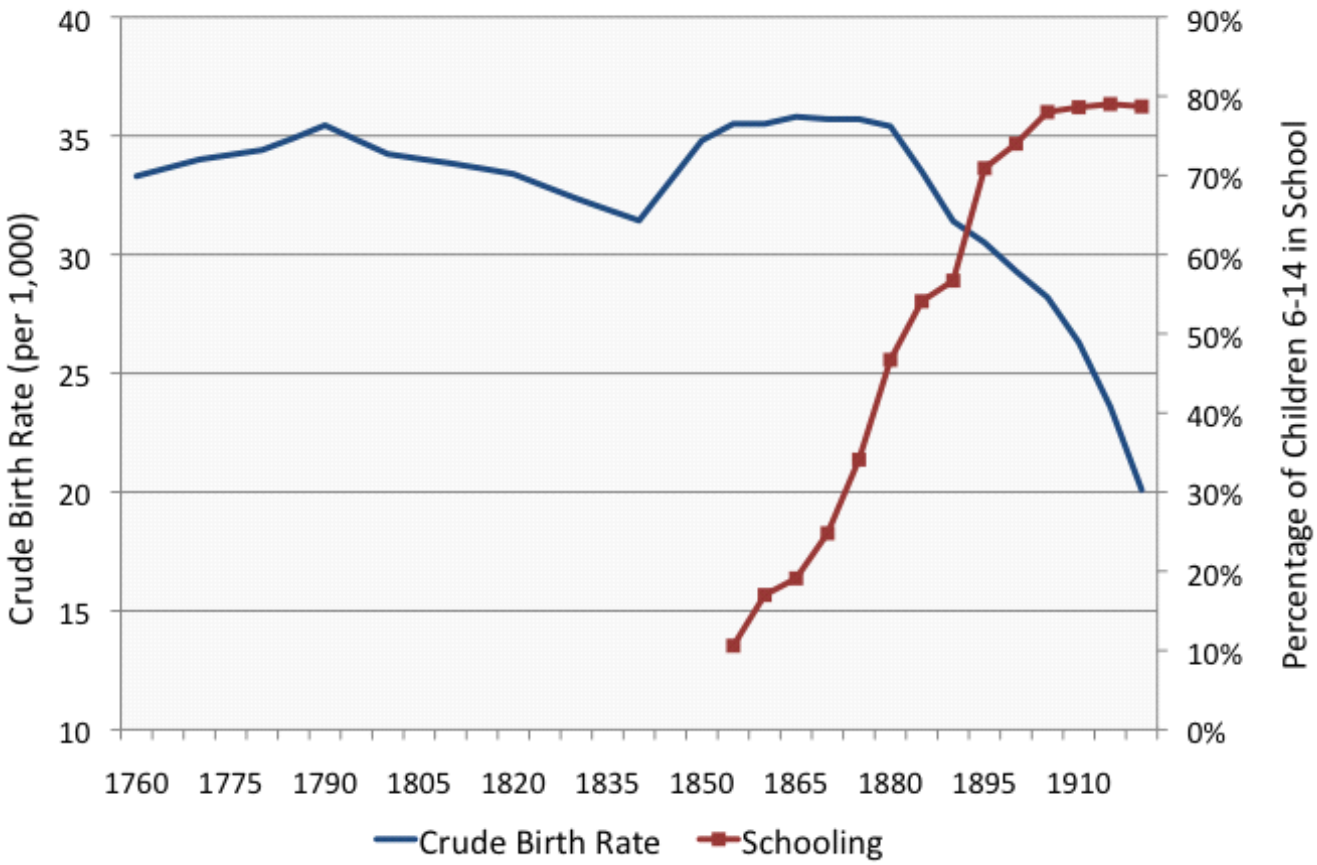
- The cost of raising a child (regardless of quality) increases

$$\partial n/\partial \tau^q < 0$$

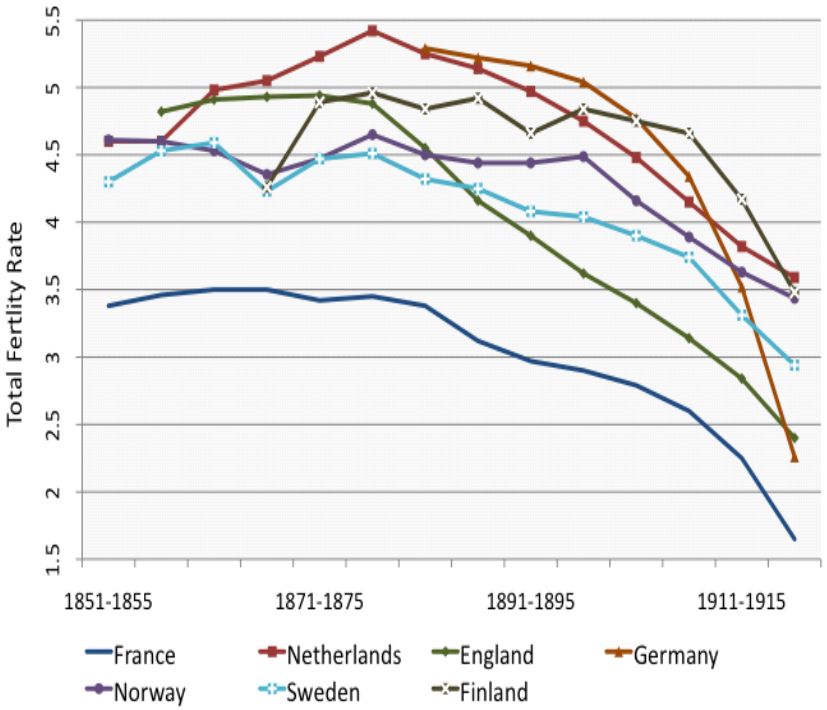
- The cost of educating a child increases and the elasticity of child quality with respect to the cost of child quality is smaller than one in absolute value

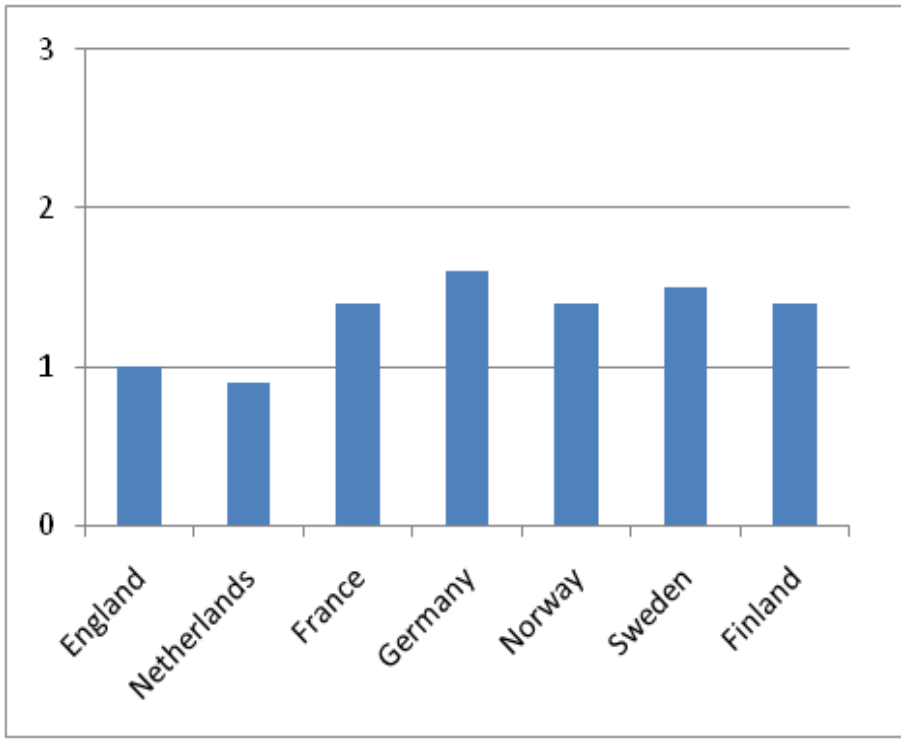
$$\partial n/\partial \tau^e < 0 \text{ if } [\partial e/\partial \tau^e][\tau^e/e] > -1$$

Human Capital Fomration and the DT - England



Growth Rates 1870-1913 and DT





Supporting Evidence: Cross-Country

- Cross Section of Countries (1870-2000) - educational attainment has been negatively associated with fertility, accounting for income per worker and mortality rates (Murtin (2009).
- Cross Section of Countries (1960-1999): adverse effect on net fertility of an increase in productivity in advanced stages of development, when education demand dominates (Lehr 2009)

Supporting Evidence: Cross-Country

- US (1910s): Eradication of hookworm – a positive shock to the return to child quality - had an adverse effect on fertility

  (Bleakley-Lange-2009)

- Prussia (19th century): the rise in human capital formation has had an adverse effect on fertility (IV: Land concentration & Distance from the birthplace of Protestantism - Wittenberg)

  (Becker-Cinnirella-Woessmann (2010)

- France (1876–96): the level of education attainment had an adverse effect on fertility rates during France's demographic transition, accounting for income per capita, the gender literacy gap, and mortality rates. (Murphy 2009)

- England (1580-1871) Adverse effect of family size on individual literacy (IV parental fecundity). (Klemp-Weisdorf (2010))