The Demographic Transition

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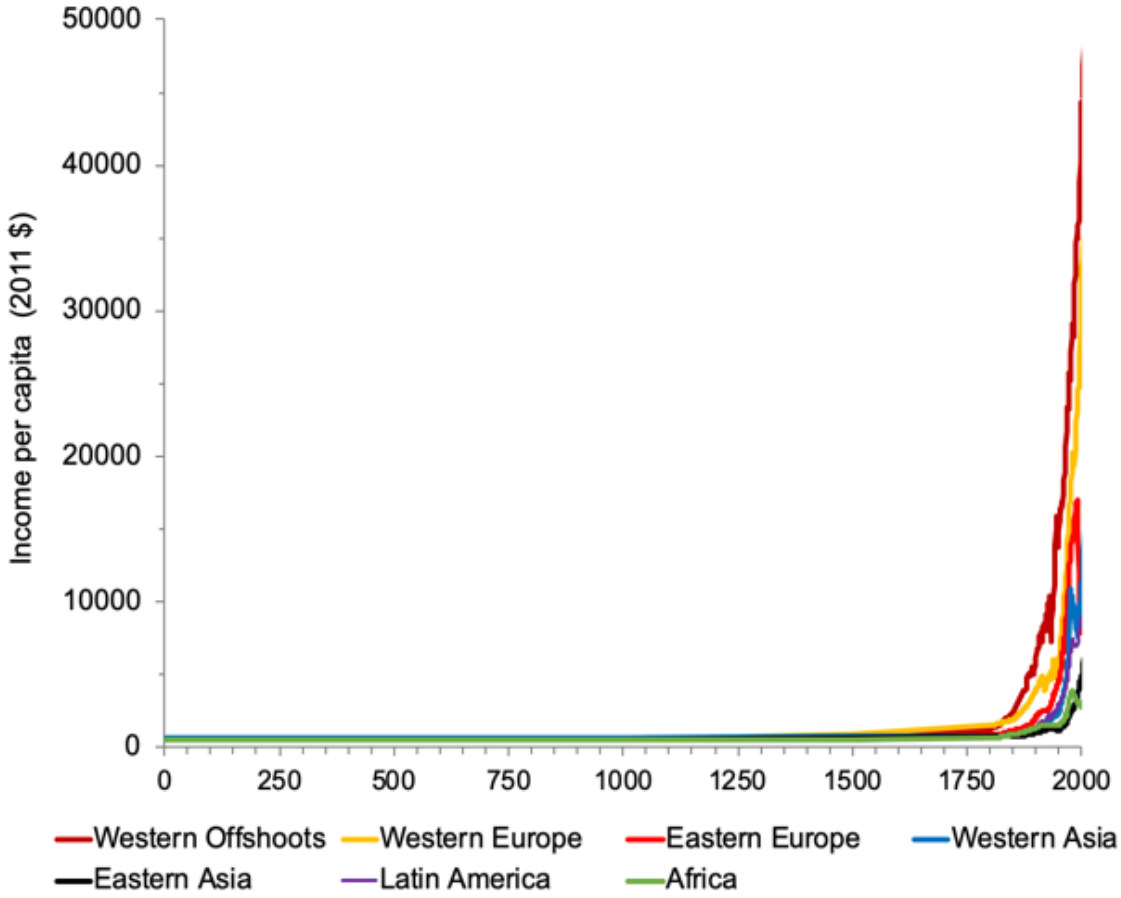
Two Mysteries

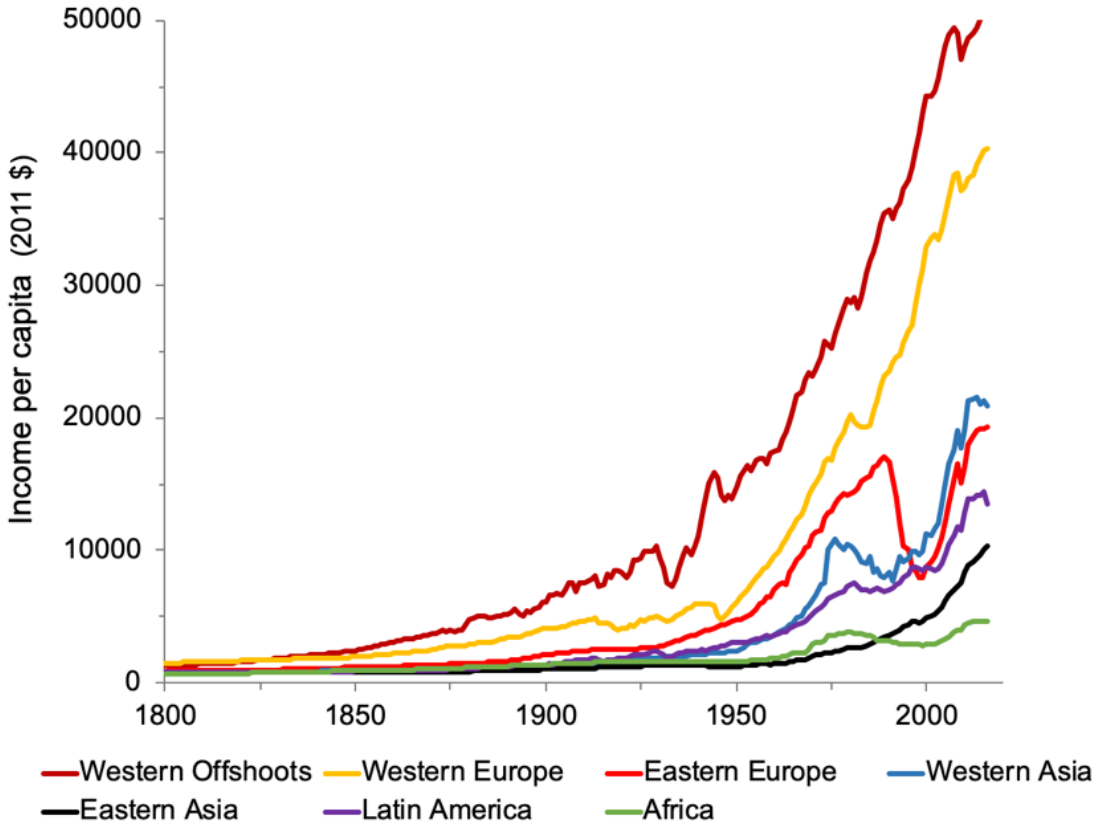
- The Mystery of Growth:
  - What are the roots of the dramatic improvement in living standards in the past two centuries, after hundreds of thousands of years of stagnation?
- The Mystery of Inequality
  - What is the origin of the vast inequality in income per capita across countries and regions?

Dramatic Increase in Income per Capita in the Past 200 Years



Data Source: Maddison Project (2020)

Regional Divergence in Income Per Capita: 1800–2020



Data Source: Maddison Project (2020)

Resolution of these Mysteries

- Requires the identification of:
  - Forces that permitted the transition from stagnation to growth
  - The origins of the differential timing of the transition across the globe
  - The role of historical & pre-historical factors in this process
- Provides important insights about:
  - Design of strategies to mitigate inequality across the globe

Evidence

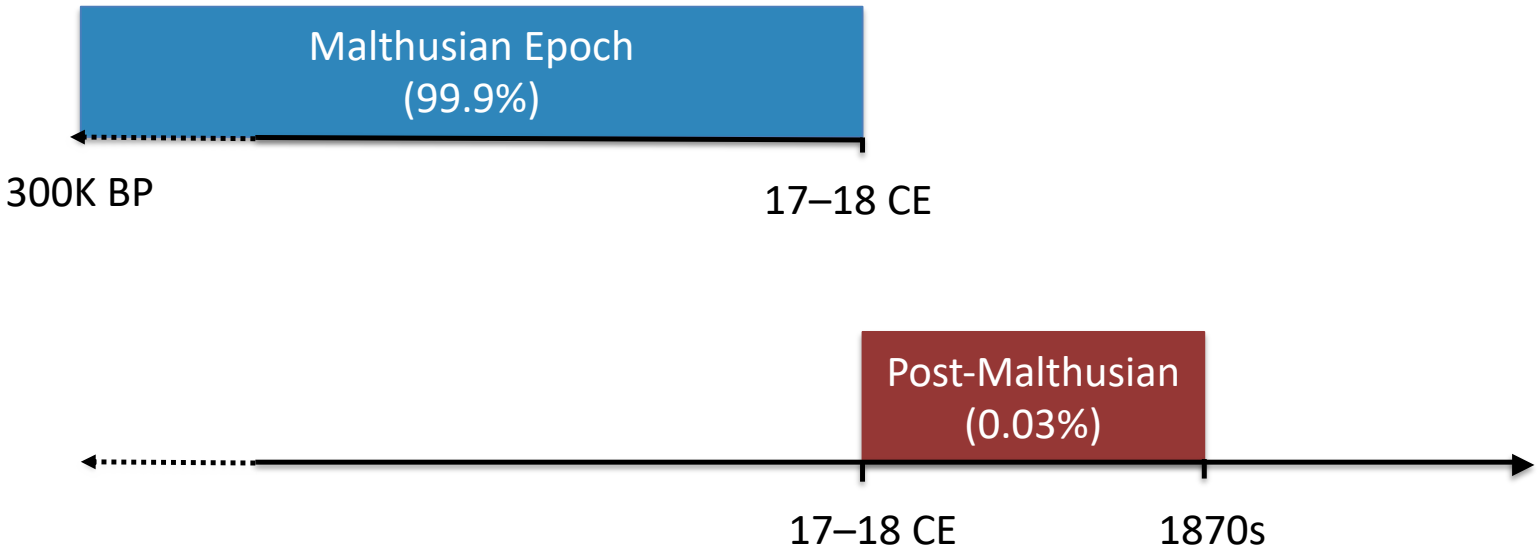
- The demographic transition is critical for the understanding of:
  - The timing of the transition from stagnation to growth
  - The vast inequality across countries and regions
- The forces that triggered the onset of the demographic transition
  - Central to the resolution of the mysteries of growth & inequality

Phases of Development

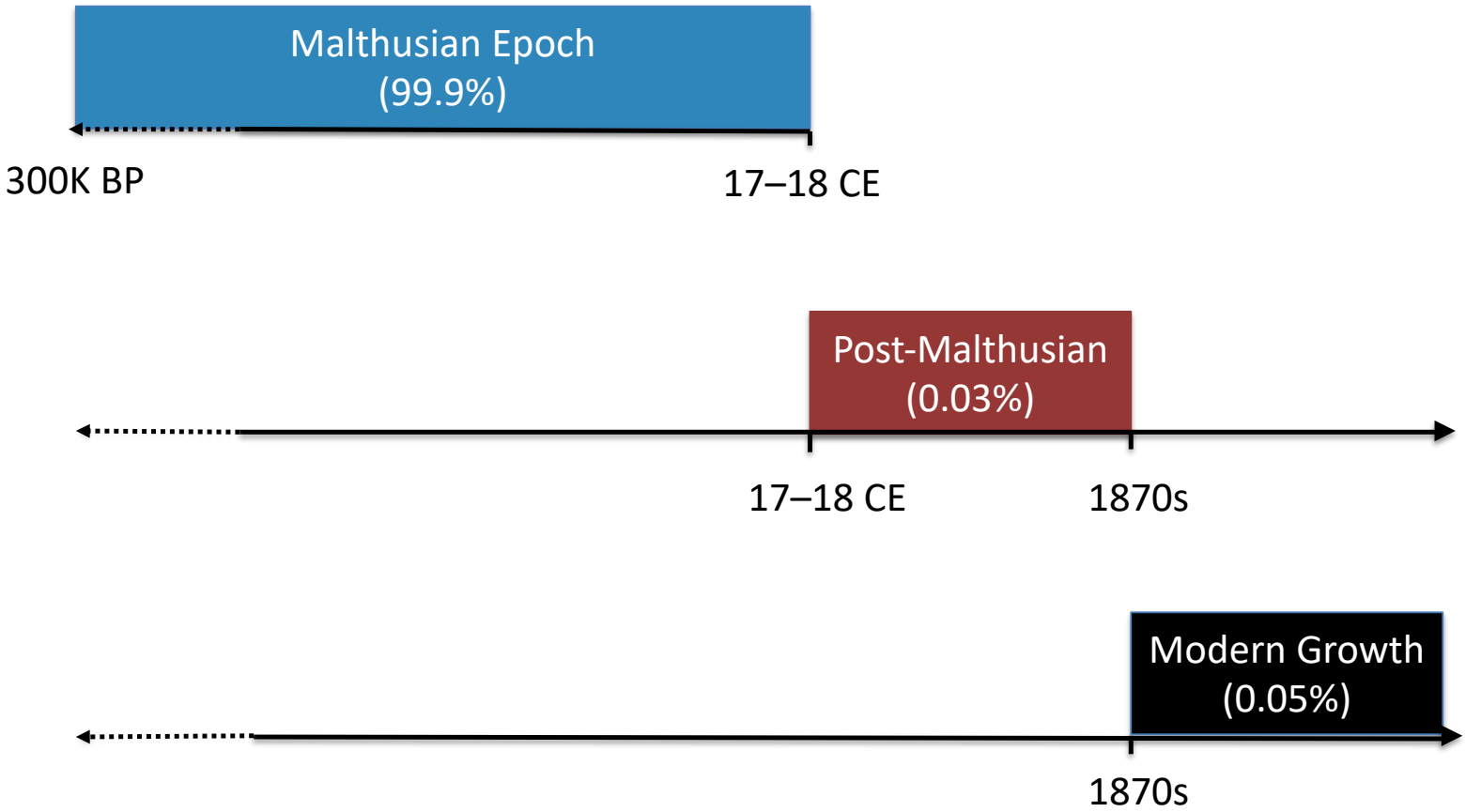
- The Malthusian Epoch
- The Post-Malthusian Regime
- The Modern Growth Regime

Phases of Development: Timeline in the Most Developed Economies

Phases of Development: Timeline of the Most Developed Economies



Phases of Development: Timeline of the Most Developed Economies



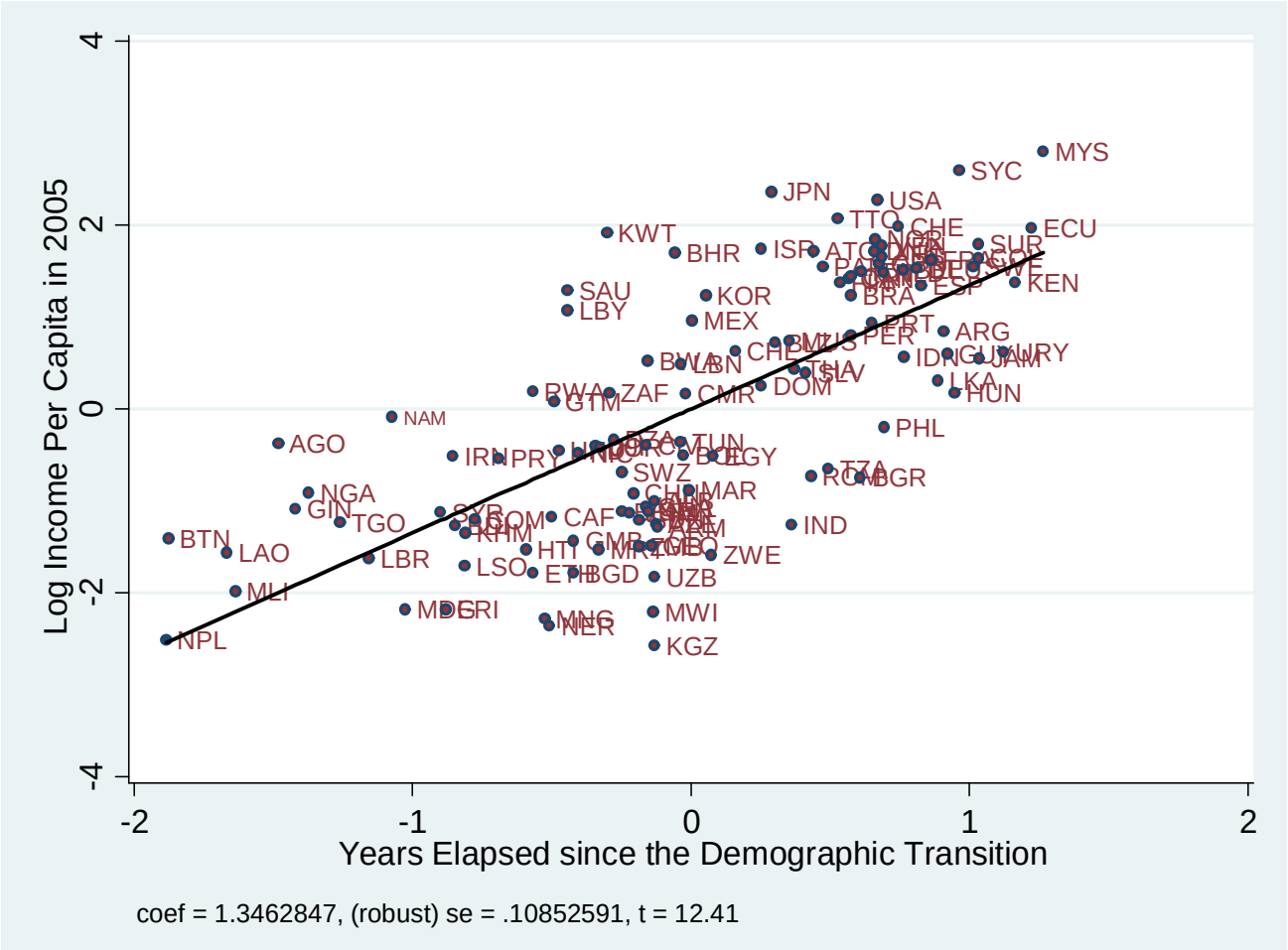
The Transition to the Modern Growth Regime

- The rotation of the 'Wheels of Change' intensified
  - Population size & composition $\Rightarrow$ Technological progress
  - Technological progress $\Rightarrow$ Population size & composition
- Technological progress accelerated & ultimately reaching a critical threshold
  - Human capital became essential for coping with the rapidly changing technological environment
- Human capital formation triggered a reduction in fertility (quantity-quality trade-off)
  - The Malthusian equilibrium vanished
  - Growth was freed from the counterbalancing effect of population
- Tech progress & human capital formation & decline in population growth
  - $\Rightarrow$ Sustained economic growth

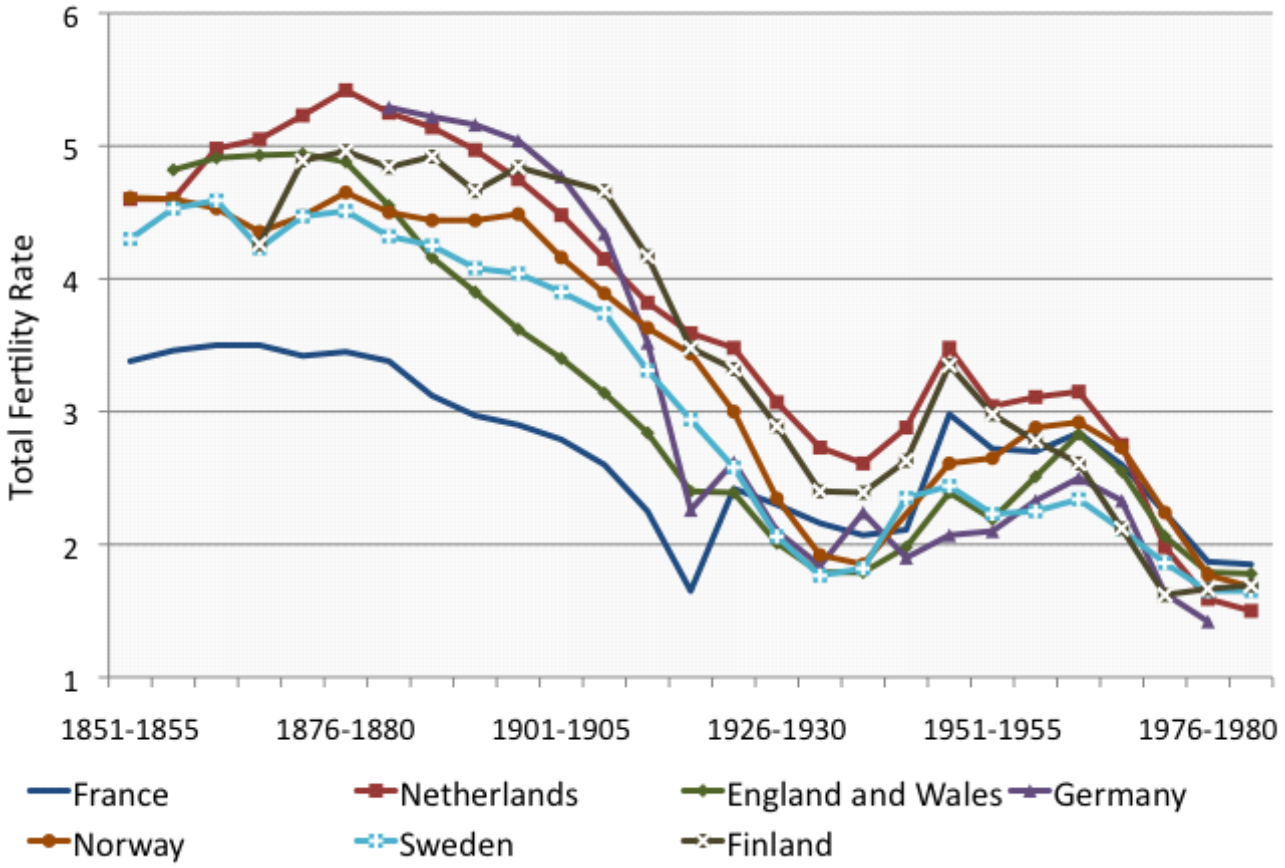
The Demographic Transition

- Key elments:
  - Reversal of the positive relationship between income and population
  - Fertility, mortality & population growth decline very rapidly
- The Demographic Transition
  - Freed the growth process from the counterbalancing effect of population
  - $\rightarrow$ Transition to Modern Growth

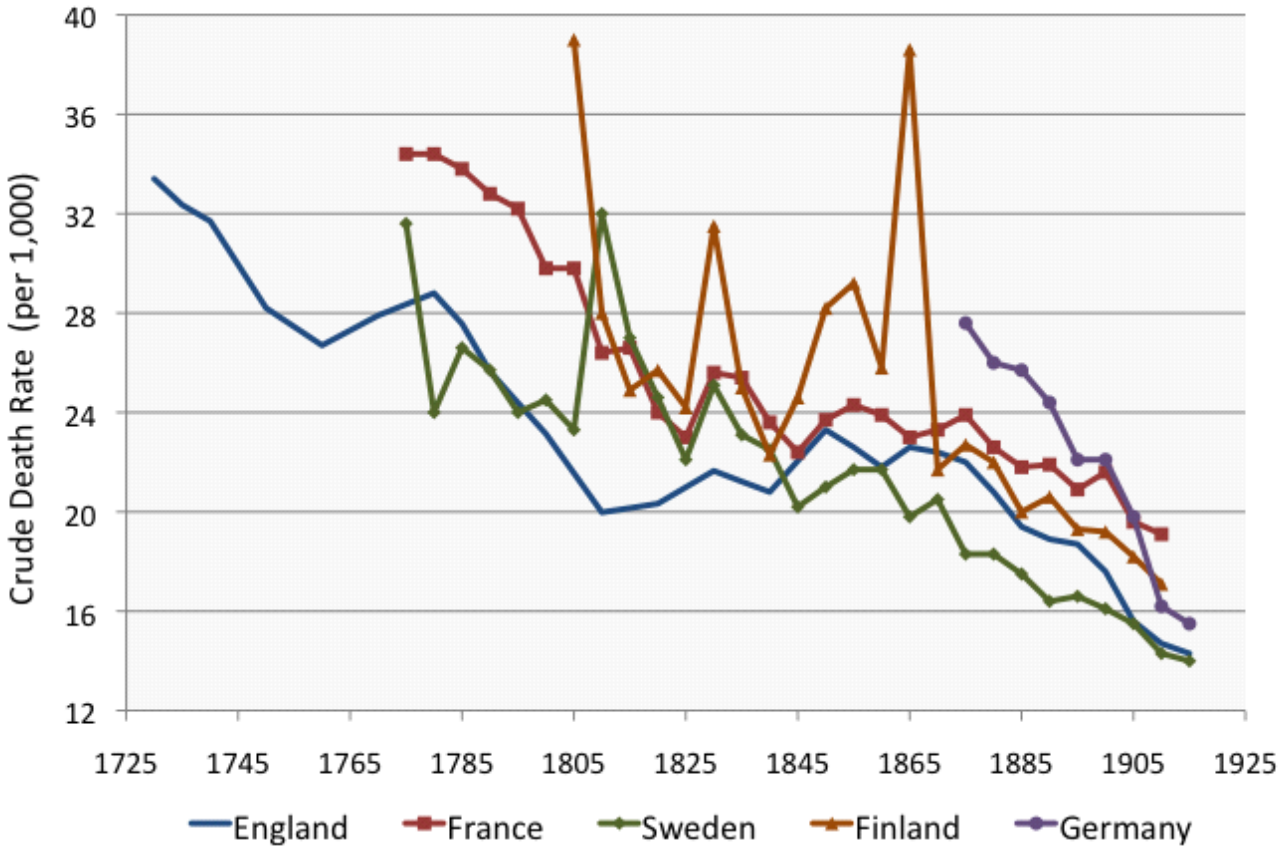
Timing of the Demographic Transition and Current Income per Capita



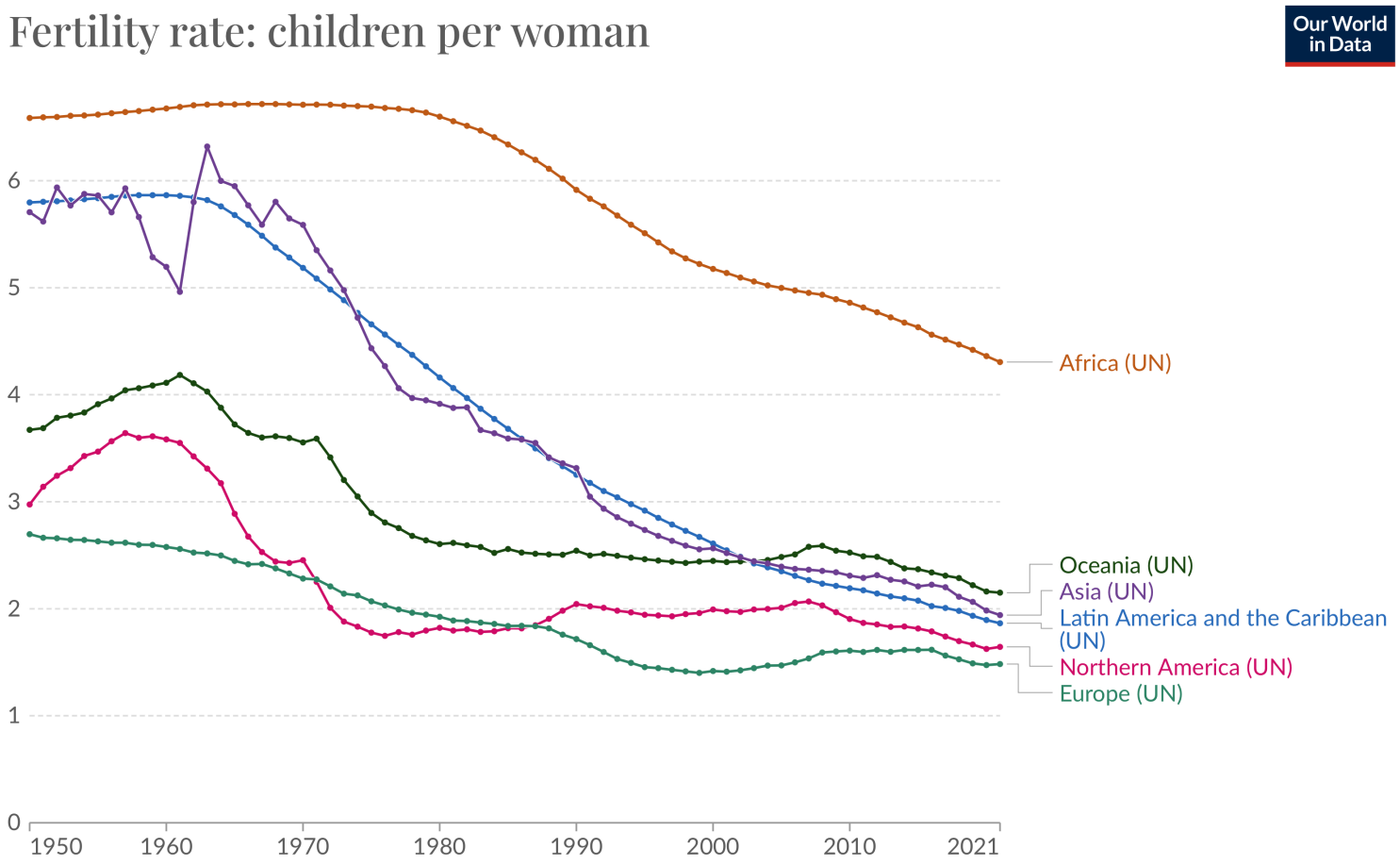
The Demographic Transition in Western Europe: Total Fertility Rates



Mortality Decline Western Europe: 1730-1920



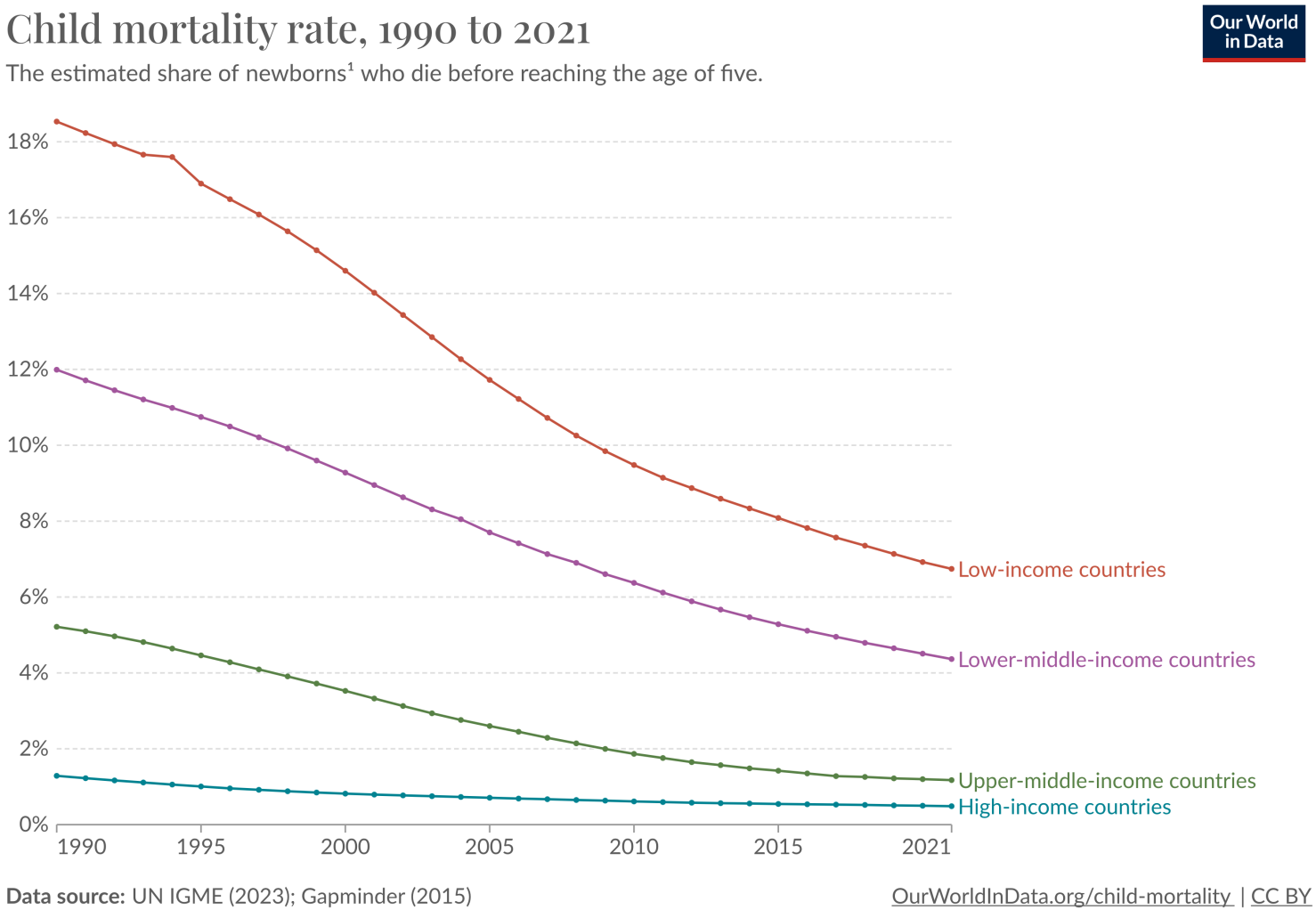
Total Fertility Rate Across Regions, 1950-2021



Data source: United Nations, World Population Prospects (2022) OurWorldInData.org/fertility-rate | CC BY

Note: The total fertility rate is the number of children born to a woman if she were to live to the end of her childbearing years and give birth to children at the current age-specific fertility rates.

Child Mortality Rates Across Income Groups, 1990-2021



1. Newborn: A newborn is defined as a baby born alive, and usually refers to neonates – under 28 days old. Read more in our article: How do statistical organizations define age periods for children?

Theories of the Demographic Transition

- The Rise in Income (Becker, 1960)
  - The cost of raising children is primarily parental time
    - The rise in income increased the opportunity cost of raising children
    - $\Rightarrow$ Reduction in fertility (Becker, 1960)
  - The income elasticity w/r to child quality is larger than that w/r to quantity
    - The rise in income $\Rightarrow$ substitution of child quality for quantity
    - $\Rightarrow$ Reduction in fertility (Becker and Lewis, JPE 1973)

Theories of the Demographic Transition

- The Decline in Child Mortality
  - In an environment characterized by higher child mortality
    - Higher birth is required to attain the desirable number of children
  - The decline in child mortality
    - Reduced the birth rate needed to achieve the desirable # of children
    - $\Rightarrow$ Reduction in fertility

Theories of the Demographic Transition

- The Old-Age Security Hypothesis (Caldwell, 1976)
  - In an environment characterized by limited financial markets
    - Children can provide old-age support
    - Children are partly a form of an investment good
  - Development of financial markets
    - $\Rightarrow$ Reduced the demand for children as an investment good
    - $\Rightarrow$ Reduction in fertility

Theories of the Demographic Transition

- The Decline in the Gender Wage Gap (Galor-Weil, AER 1996)
  - The process of development decreased the gender gap
    - Mechanization - Female-biased technological progress
  - The rise in the relative wages of women:
    - Opportunity cost of raising children] $\Uparrow$ > [family income] $\Uparrow$
    - $\Rightarrow$ Reduction in fertility

Theories of the Demographic Transition

- The Rise in Human Capital Formation
  - Industrial demand for human capital increased the return to human capital (Galor and Weil, AER 2000)
    - HC formation $\Rightarrow$ Substitution of child quality for quantity
    - $\Rightarrow$ Reduction in fertility
  - Reinforced by:
    - The increased in life expectancy (the duration of the return in HC)
    - The decline in child labor (reduction in the profitability of children)
    - Increase urbanization (higher return to HC & cost of children)
- Cultural adaptation(Galor and Moav, QJE 2002, Galor and Klemp, Nature EE, 2019)
  - Increase in the prevalence of predisposition towards child quality
  - $\Rightarrow$ Substitution of child quality for quantity
  - $\Rightarrow$ Reduction in fertility

The Rise in Income - Main Hypothesis

- The Rise in Income (Becker, 1960)
  - The cost of raising children is primarily parental time
    - The rise in income increased the opportunity cost of raising children
    - $\Rightarrow$ Reduction in fertility (Becker, 1960)
  - The income elasticity w/r to child quality is larger than w/r to quantity
    - The rise in income $\Rightarrow$ substitution of child quality for quantity
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The Rise in Income: Mechanism

- Child rearing is time-intensive
- Household's Budget constraint

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

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

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

  - $1 \equiv$ household's time endowment
  - $\tau n \equiv$ time spent raising children
  - $(1 - \tau n) \equiv$ labor force participation

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

The Rise in Income - Theoretical Evaluation

- Preference-based theory
  - Assumes innate bias against child quantity beyond a certain level of income
- Non-robust
  - Different preferences will generate qualitatively different results
    - Homothetic preferences: a rise in income will NOT trigger fertility decline

The Rise in Income - Homothetic Preferences

- Preferences:

$$U = n^{\gamma} c^{(1-\gamma)} \qquad 0 < \gamma < 1$$

- Budget constraint

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

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

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

The Rise in Income - Homothetic Preferences

- Optimal number of children $[y\tau n = \gamma y]$

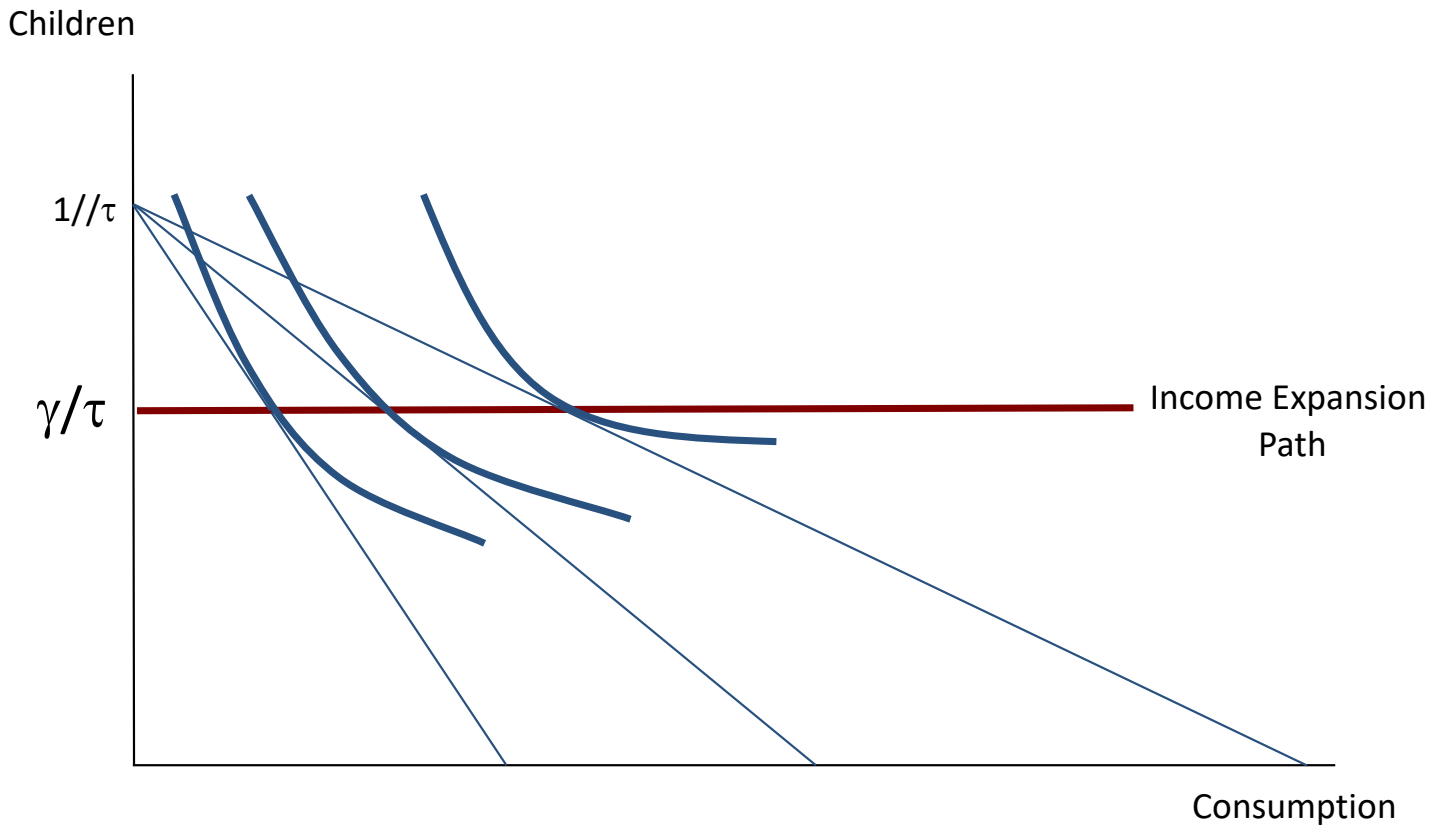
$$n = \gamma/\tau$$

- $\Rightarrow$ Income has no effect on fertility, i.e.,

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

- Fertility is unaffected by the rise in income

The Rise in Income - Homothetic Preferences



- $1 =$ Household's time endowment
- $\gamma =$ The optimal time devoted to children ($\gamma/\tau =$ optimal number of children)
  - $\Rightarrow$ number of children is independent of the level of income

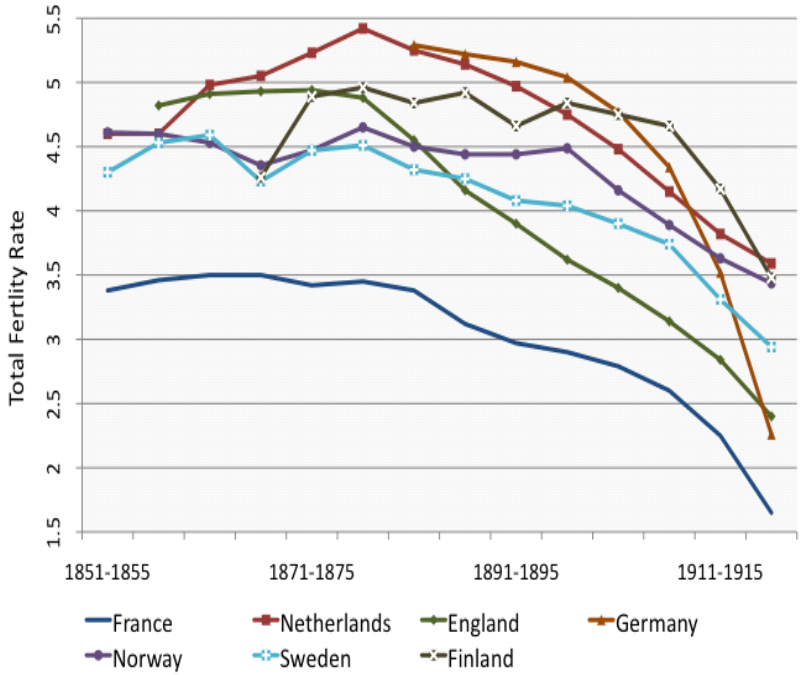
The Rise in Income: Testable predictions

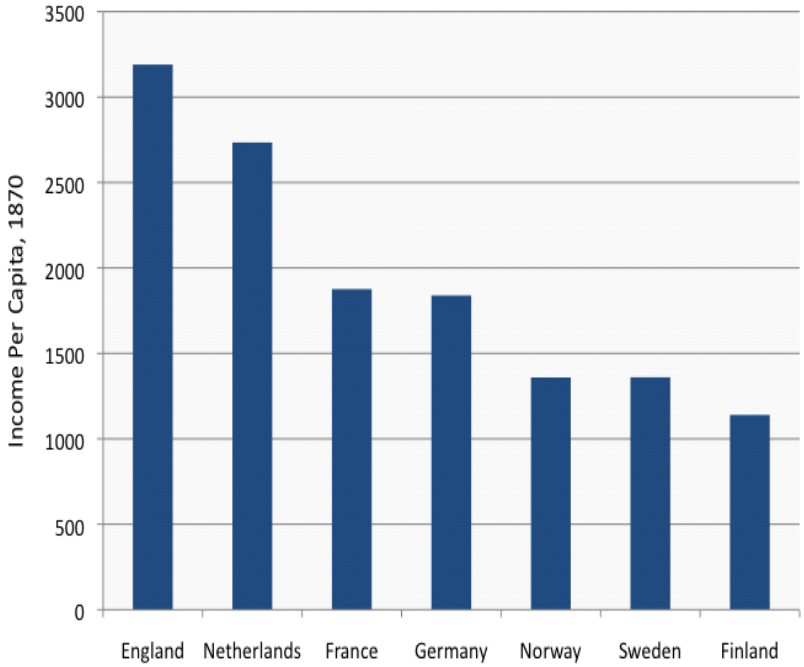
- Holding all else constant:
  - Cross-Country
    - The timing of the fertility decline is inversely related to the country's income per capita
  - Within an economy
    - The number of (surviving) children is inversely related to households's income

The Rise in Income: Refuting Cross Country Evidence

- Cross Section of Countries (1870-2000)
  - Income per worker is positively associated with fertility rates, accounting for mortality rates and education (Murtin, RESTAT 2015).
- Western Europe
  - The DT occurred within the same decade across countries that differed significantly in their income per capita

Simultaneous DT despite large gaps in income: W. Europe in the 1870s





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 JOEG 2015)
- England (During the DT):
  - The rise in income had led to an increase in fertility rates (Fernandez Villaverde, 2001)
- England (pre-industrialization)
  - Reproductive success increases with income (Clark (JEH 2006, De la Croix et al.,, JEG 2019)

The Decline in Child Mortality - Main Hypothesis

- Parents generates utility from the number of surviving children
- In an environment characterized by higher child mortality
  - Higher birth is required to attain the desirable number of children
- The decline in child mortality
  - Reduced the birth rate needed to achieve the desirable # of children
  - $\Rightarrow$ Reduction in fertility

The Decline in Mortality – Mechanism

- Preferences:

$$u = n^{\gamma} c^{(1-\gamma)} \qquad 0 < \gamma < 1$$

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

- Surviving children

$$n = (1 - \theta) n^{b}$$

  - $n^{b} \equiv$ household's children born
  - $\theta \equiv$ child mortality rate

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
  - $y\tau \equiv$ opportunity cost of raising a surviving child
  - $0 \equiv$ time cost of raising a non-surviving child

The Decline in Mortality – Mechanism

- Optimization:

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

- Optimal number of surviving children (NRR - Net Reproduction Rate)

$$n = \gamma/\tau$$

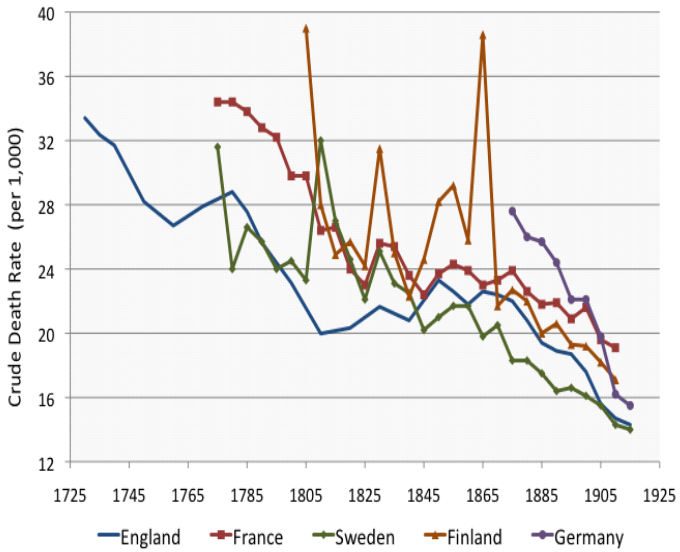
- Optimal number of children born (TFR - Total Fertility Rate)

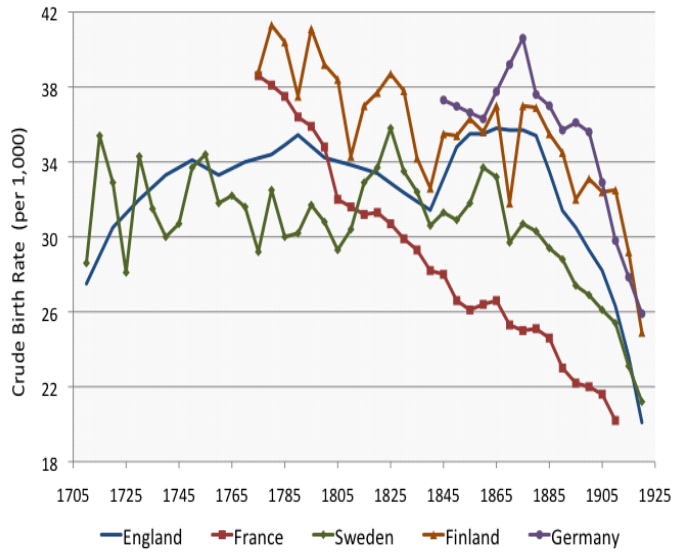
$$n^b = \frac{n}{(1-\theta)} = \frac{\gamma}{(1-\theta)\tau}$$

The Decline in Mortality – Testable Predictions

- Child mortality rate, θ, has
  - A positive effect on TFR
    - $n^b = \gamma/[\tau(1-\theta)]$ increases in θ
  - No effect on NRR
    - $n = \gamma/\tau$ is independent of θ

The Decline in Mortality and Fertility (TFR) - Evidence





The Decline in Child Mortality – Challenges

- Worldwide
  - NRR and TFR plummet jointly during the demographic transition
    - Yet, the basic theory $\Rightarrow$ NO decline in NRR
- NRR would decline if:
  - There exists a precautionary demand for children
    - Highly plausible
  - RA with respect to fertility $>$ RA with respect to consumption
    - Yet, evolutionary theory $\Rightarrow$ RA with respect to n $<$ RA with respect to c
  - Replacement fertility is insignificant
    - Yet, replacement fertility is sizable ranging from 0.2–0.6)
  - Resources saved from investment in non-surviving children are not channeled towards higher fertility

The Decline in Child Mortality – Challenging Anecdotal Evidence

- France, USA & 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 1720s (150 years before the fertility decline) and was accompanied by a rise in fertility rates til 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 JOEG 2015)
- 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, J.Pop.E 2005)

The Old-Age Security Hypothesis

- In an environment characterized by limited financial markets
  - Children can provide old-age support
  - Children are (partly) a form of an investment good
- Development of financial markets
  - $\Rightarrow$ Reduced the demand for children as an investment good
  - $\Rightarrow$ Reduction in fertility

The Old-Age Security Hypothesis - Challenge to the Theory

- Old-age support is unlikely to be a major determinant of fertility & 30–50% decline in fertility during the DT
  - Rare examples in nature of offspring that support their parents
  - Life expectancy in the UK in 1850: (at birth) 38 & (at age 20) + 40
  - Institutions that provided old age support were formed before the DT
  - Richer individuals had better access to financial markets prior to the DT
    - $\Rightarrow$ Lower need for children as investment good
    - Yet in fact they had more children

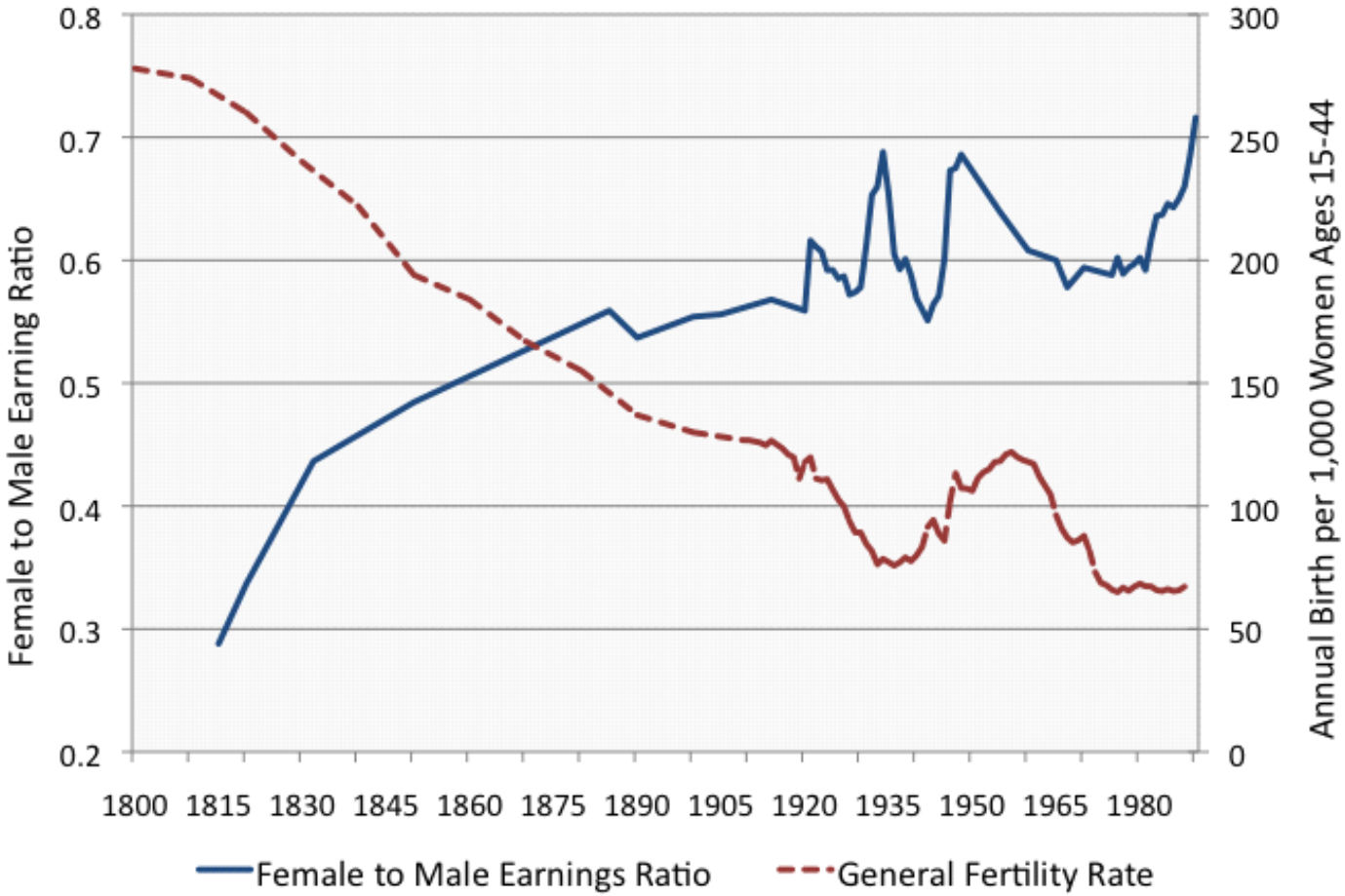
The Decline in the Gender Wage Gap

- The process of development decreased the gender gap
  - Mechanization - Female-biased technological progress
- The rise in the relative wages of women:
  - [opportunity cost of raising children] $\uparrow$ $>$ [family income] $\uparrow$
  - $\Rightarrow$ Reduction in fertility

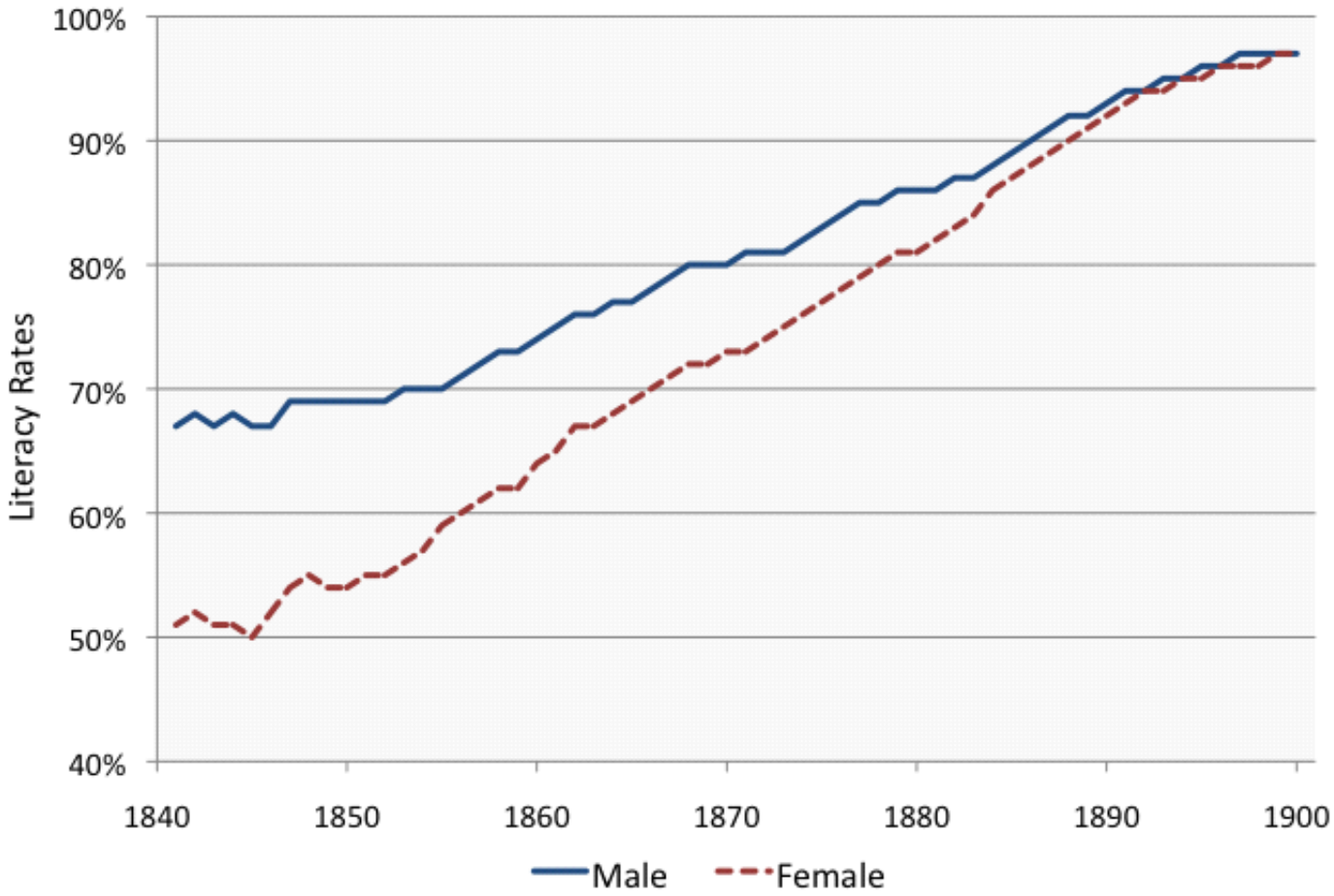
Mechanism: I. Development and Women's Wages

- Female-Biased technical change
  - Mechanization & advanced technologies have complemented mental tasks more than physical tasks
  - Women have physiological comparative advantage in mental (rather than physical) tasks
- The process of development has increased the productivity of women relative to men:
  - Economic Development $\rightarrow \quad (w^F / w^M) \Uparrow$
  - $w^F \equiv$ women's wages
  - $w^M \equiv$ men's wages

Evolution of the Gender Earning 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 $n \Downarrow$

.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 income i.e.,

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

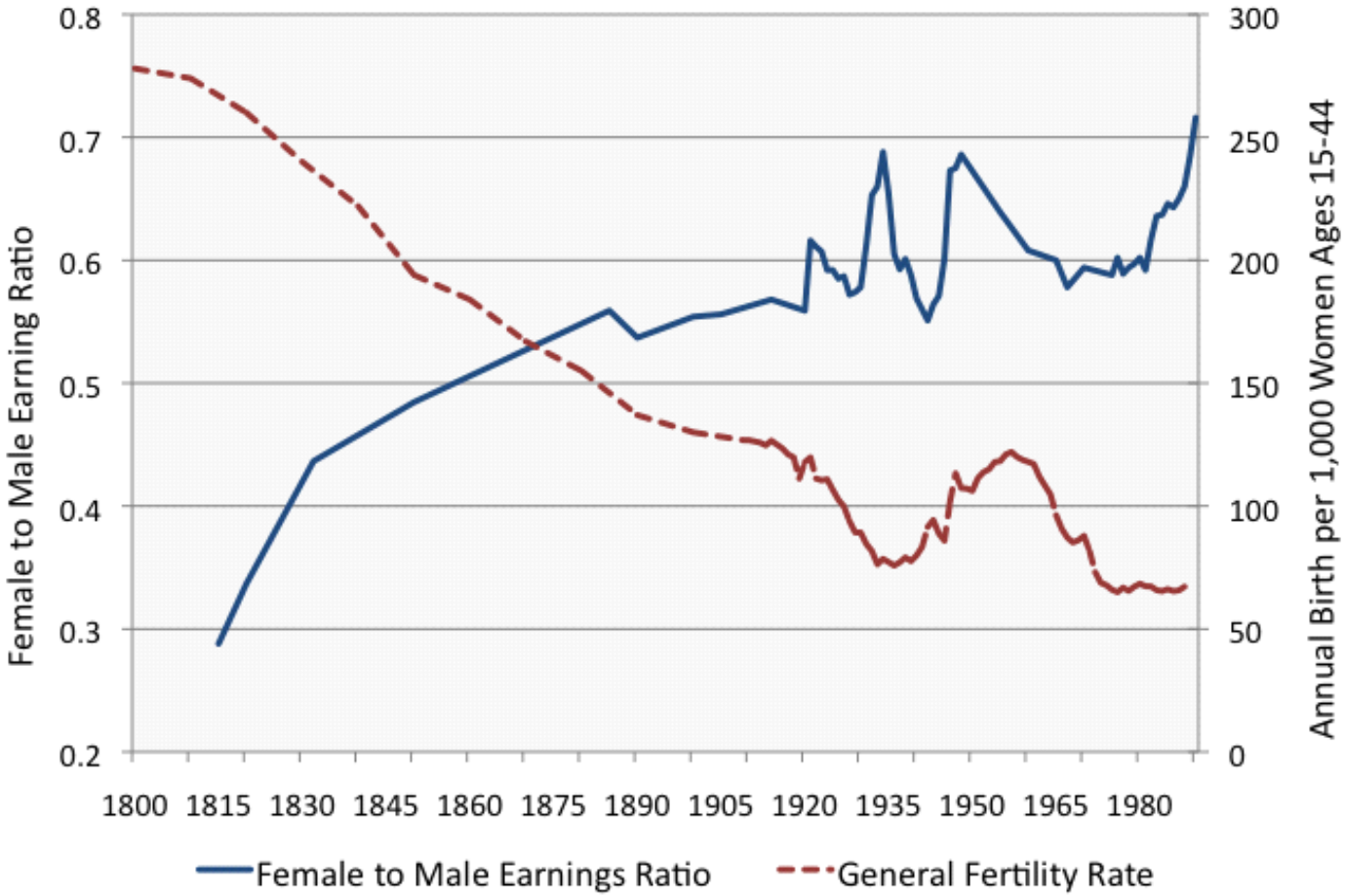
$$\implies n \Downarrow \text{ (even if preferences are homothetic)}$$

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

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

$\implies$ operates towards $n \Uparrow$

Women's Relative Wages and Fertility - US



Women's Relative Wages and Fertility - Evidence

- Sweden (1936-1955)
  - $[w^F \Uparrow \implies n \Downarrow]$ & $[w^M \Uparrow \implies n \Uparrow]$

    (Heckman and Walker (ECT 1990)
- Sweden (19th century)
  - $(w^F/w^M) \Uparrow \implies n \Downarrow$

    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 JOEG 2015)

The Rise in Human Capital Formation

- Industrial demand for human capital increased the return to human capital (Galor and Weil, AER 2000)
  - HC enabled individuals to cope with changing technological environment
    - $\Rightarrow$ HC formation $\Rightarrow$ Substitution of child quality for quantity
    - $\Rightarrow$ Reduction in fertility
  - Reinforced by:
    - The increased in life expectancy (the duration of the return in HC)
    - The decline in child labor (reduction in the profitability of children)
    - Increase urbanization (higher return to HC & cost of children)
- Adaptation of human traits (Galor and Moav, QJE 2002, Galor and Klemp, Nature EE, 2019)
  - An increase in the prevelance of predisposition towards child quality
  - $\Rightarrow$ Substitution of child quality for quantity
  - $\Rightarrow$ Reduction in fertility

The Model - Preferences

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

- $c \equiv$ consumption
- $n \equiv$ (surviving) children
- $h \equiv$ quality (human capital) of each child
- e time investment in child quality
- g rate of technological change
- $\beta \equiv$ 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 education level (quality) e
- $y(\tau^q + \tau^e e) \equiv$ opportunity cost of raising a child with quality e

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
- $h_{eg}(e, g) > 0$
  - Technology-skill complementarity
- $h(0, g) = 1$ & $\lim_{e \to 0} h_e(e, g) = \infty$; $\lim_{e \to \infty} h_e(e, g) = 0$
  - Basic level of human capital & interior solution

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

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

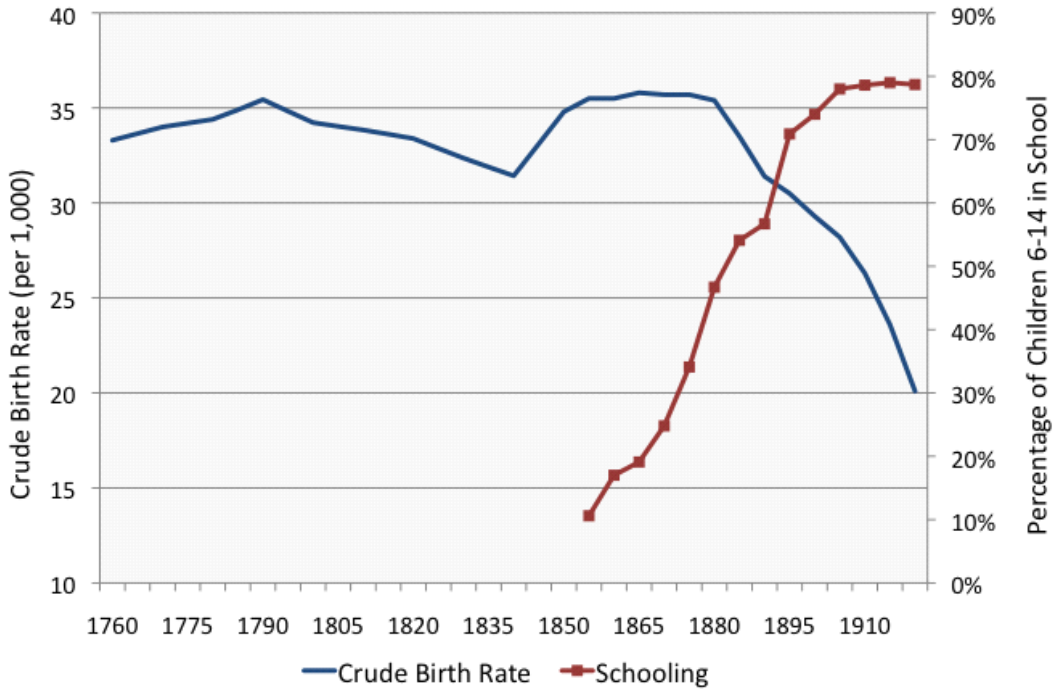
- The cost of raising a child (regardless of quality) increases

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

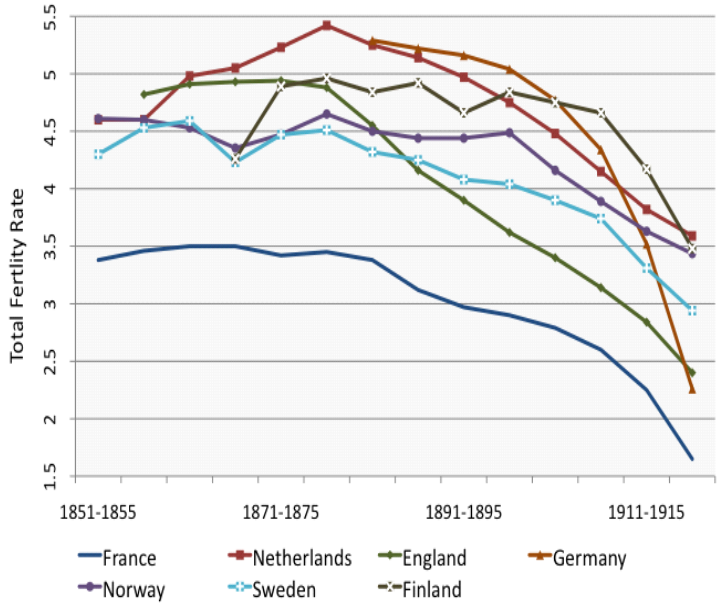
- The cost of educating a child increases and the elasticity of child quality with respect to the cost of child quality is smaller than one in absolute value

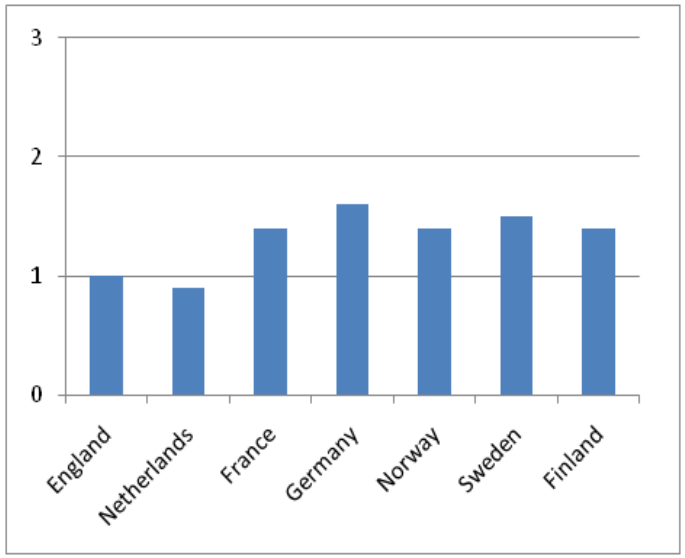
$$\partial n/\partial \tau^e < 0 \text{ if } [\partial e/\partial \tau^e][\tau^e/e] > -1$$

Human Capital Formation and the Fertility Decline - England



Growth Rates 1870-1913 and DT





Supporting Evidence

- US (1880-1910):
  - The rise in the return to child quality $\Rightarrow$ fertility decline
    - Variation in the extent of the eradication of hookworm (1910s) across the US South (Bleakley-Lange, RESTAT 2009)
    - Variation in the opening of kindergartens across the US (Ager-Cinerella, 2020)
- Prussia (19th century):
  - The rise in human capital formation $\Rightarrow$ fertility decline
    - IV: variation in land concentration
    - IV: Distance from the birthplace of Protestantism - Wittenberg (Becker-Cinnirella-Woessmann, JOEG 2010)

Supporting Evidence

- England (1580-1871)
  - Adverse effect of family size on children's literacy.
    - IV for family size – Time to first birth

    (Klemp-Weisdorf, EJ 2019)
- China (13th-20th century)
  - An increase the return to human capital $\Rightarrow$ fertility decline
    - Changes in the civil service examination system overtime

    (Shiue, JOEG 2017)
- Ireland (1911)
  - Adverse effect of education attainment on fertility rates

    (Fernihough, JOEG 2017)

Appendix - 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

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

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

$\Longrightarrow$

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

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