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?

Metamorphosis: Income per Capita: 1–2020
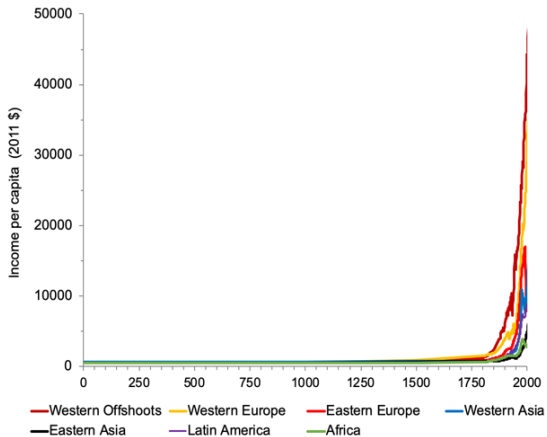
Data Source: Maddison Project (2020)

Great Divergence: 1800–2018
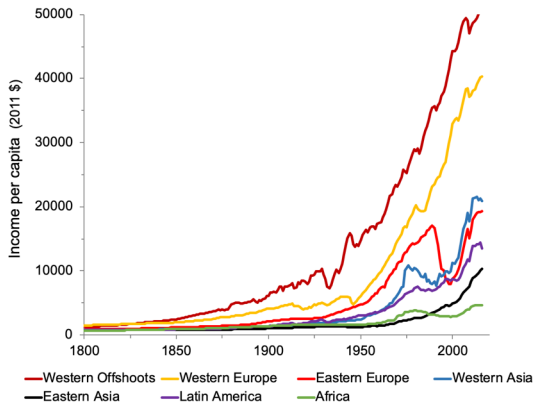
Data Source: Maddison Project (2020)

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

Malthusian Epoch
(99.9%)

300K BP   17–18 CE

Phases of Development: Timeline of the Most Developed Economies

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Post-Malthusian
(0.03%)

17–18 CE   1870s

Phases of Development: Timeline of the Most Developed Economies

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Post-Malthusian
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17–18 CE   1870s
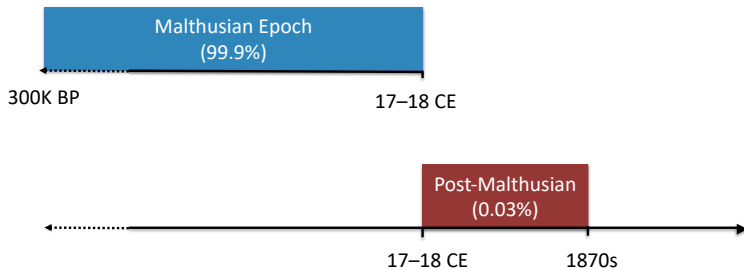
Modern Growth
(0.05%)

1870s
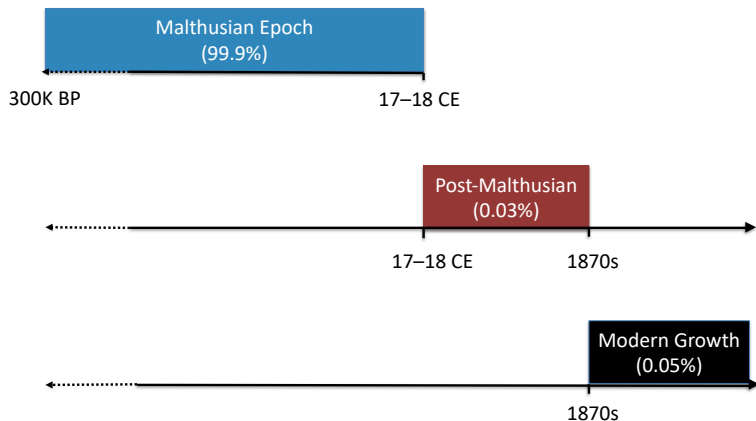
The Transition to the Modern Growth Regime

- 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

- Reversal of the positive relationship between income and population

- Fertility, mortality & population growth decline very rapidly

- The potential impact of technological progress on economic prosperity
  - No longer counterbalanced by population growth
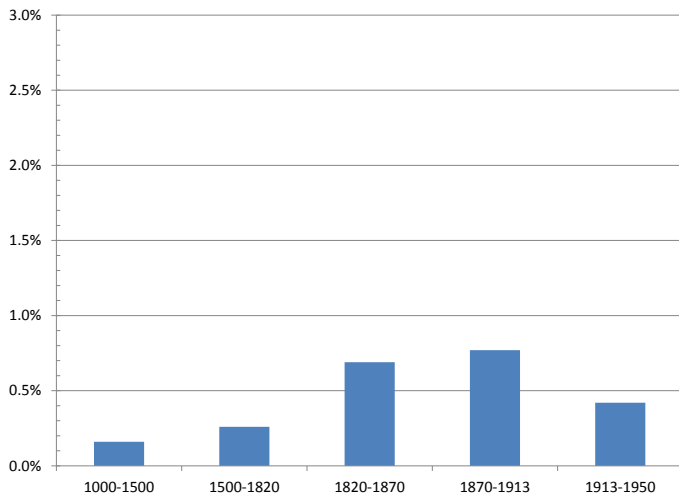 - $\implies$ Transition to Modern Growth

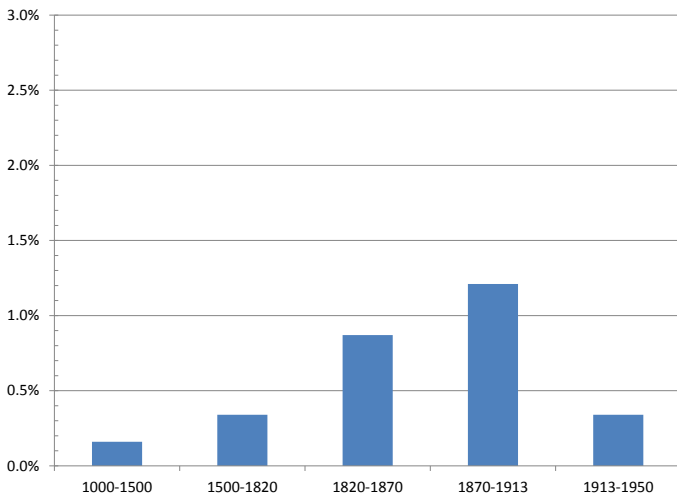# Years Elapsed since the Onset of the Fertility Decline
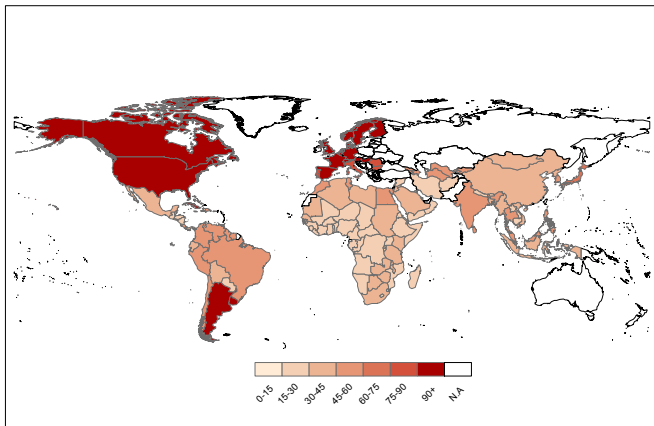
Early Fertility Decline – Western Offshoots
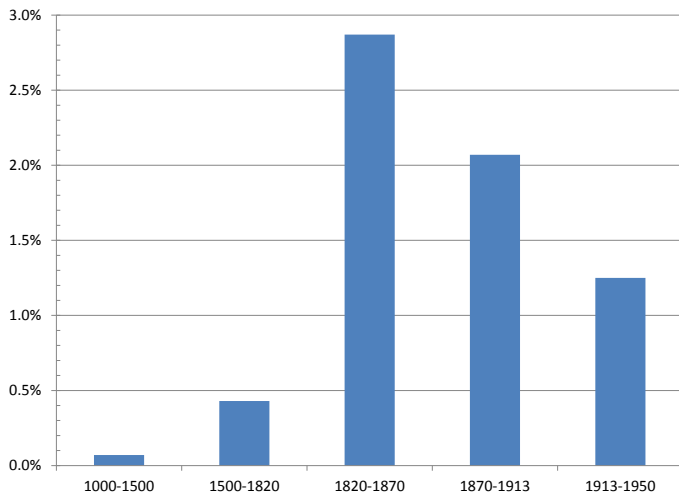
Early Fertility Decline – Western Europe

Early Fertility Decline – Eastern Europe

Late Fertility Decline – Latin America
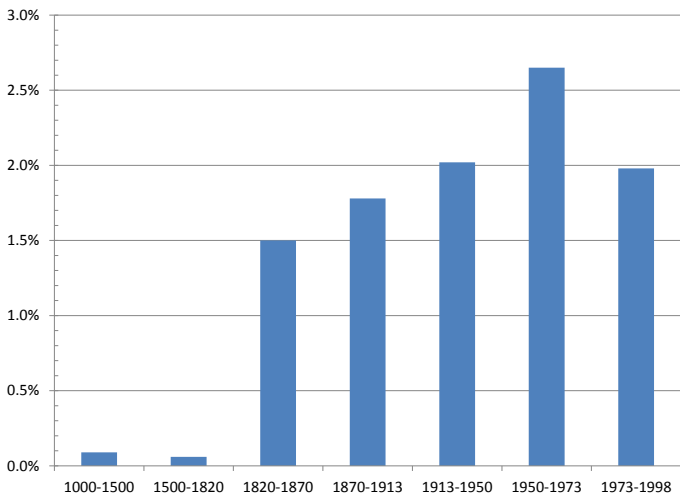
Late Fertility Decline – Asia
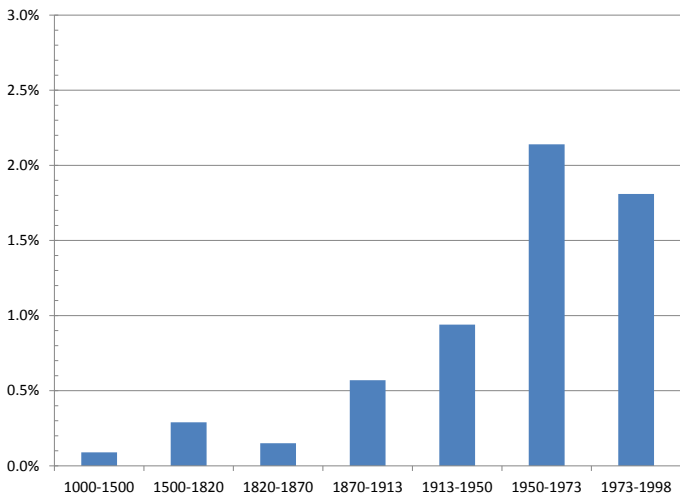
Late Fertility Decline – Africa

Timing of the Demographic Transition and Current Income per Capita

coef = 1.3462847, (robust) se = .10852591, t = 12.41
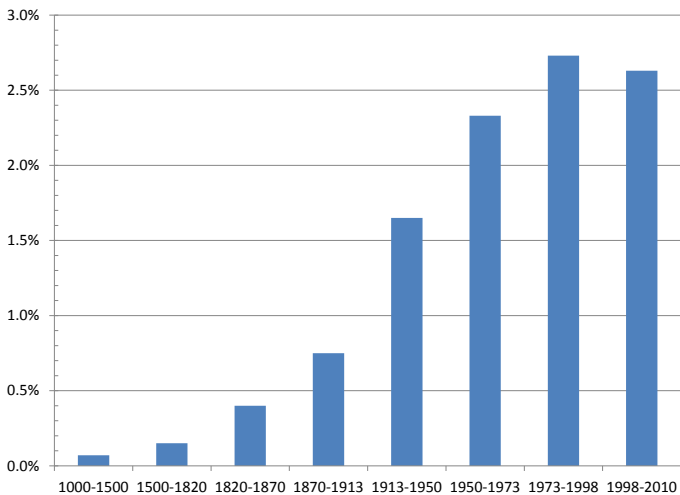
The Demographic Transition in Western Europe: Total Fertility Rates
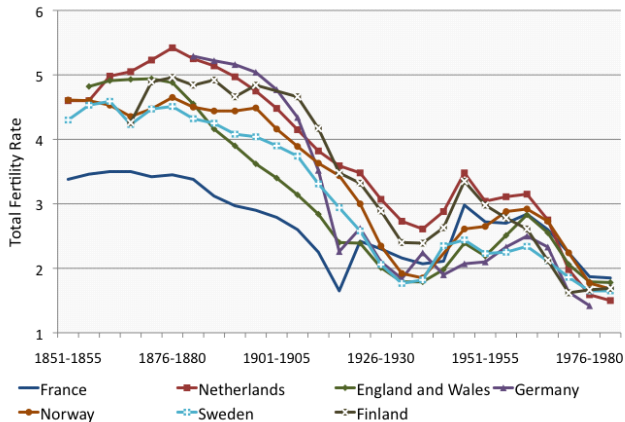
Mortality Decline Western Europe: 1730-1920
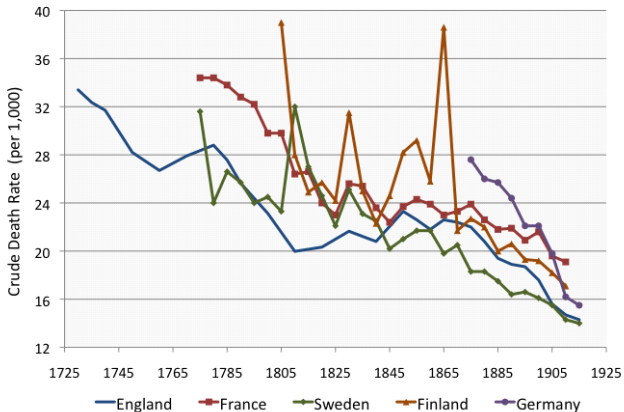
The Evolution of Total Fertility Rate across Regions, 1960-2000
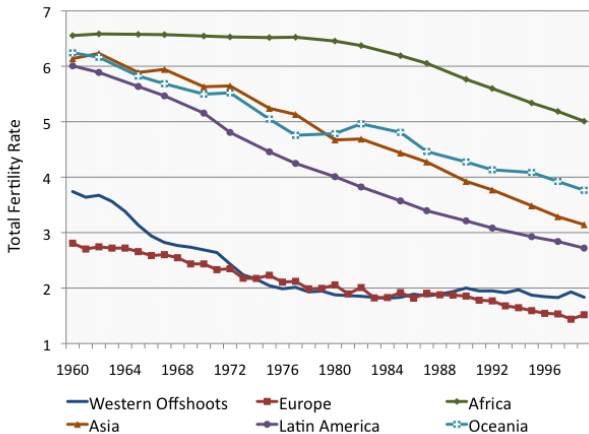
Decline in infant mortality rates across regions, 1960-2000
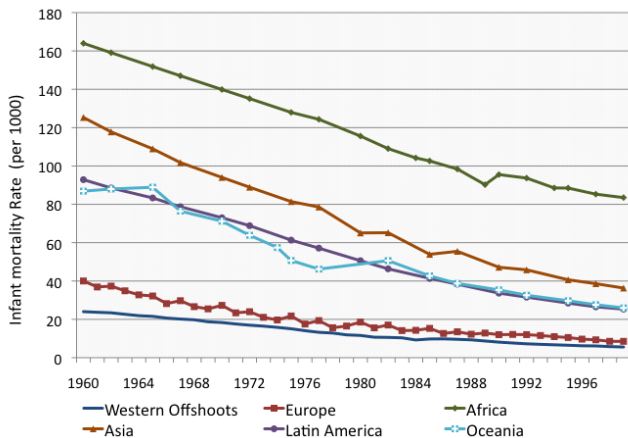
Theories of the Demographic Transition

- 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 Human Capital Formation

  - Industrial demand for human capital increased the return to human capital (Galor and Weil, AER 2000)

    - $\Rightarrow$ Human capital formation
    - $\Rightarrow$ Substitution of child quality for quantity
    - $\Rightarrow$ Reduction in fertility

  - Adaptation in the composition of human traits (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
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    - The income elasticity w/r to child quality is larger than w/r to 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 $\quad n \Uparrow$

  - A substitution effect:
  $$\Uparrow [y\tau]n + c \leq y$$

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

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:

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

- 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 $[y\tau n = \gamma y]$

$$n = \gamma/\tau$$

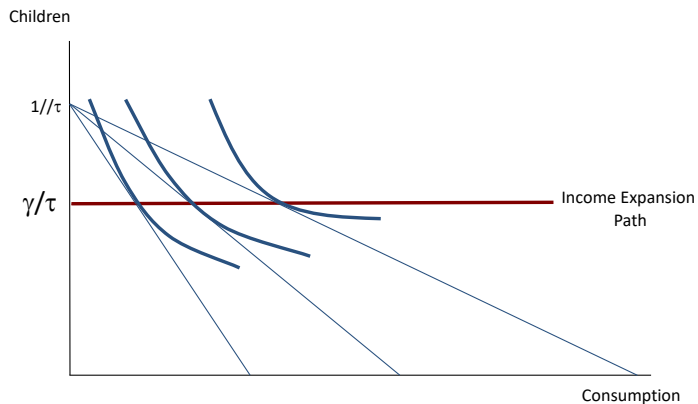- $\Rightarrow$ Income has no effect on fertility, i.e.,

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

- 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

- Cross-Country
  - The timing of the fertility decline is inversely related to the level of income per capita

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

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
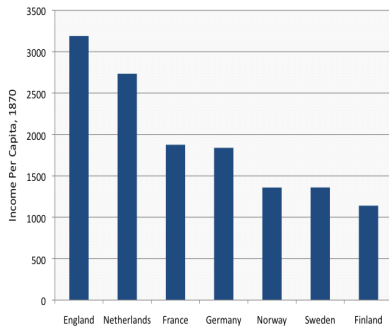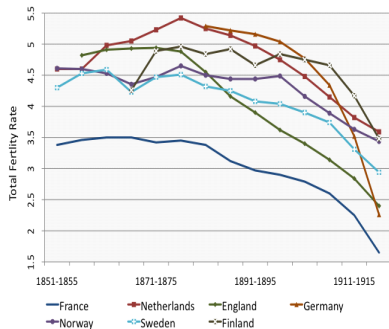
The Rise in Income: Refuting Evidence from Individual Countries

- 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:

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

  - $c \equiv$ 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
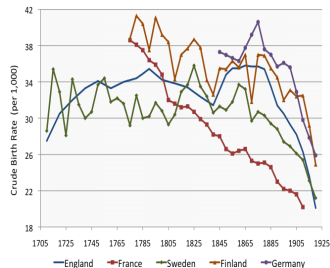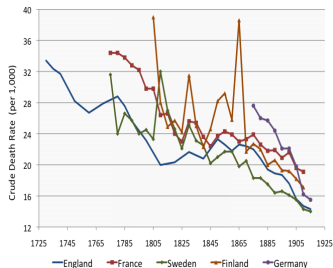
The Decline in Child Mortality – Challenging Evidence to the Theory

- Worldwide
  - NRR and TFR plummet jointly during the demographic transition
    - Basic theory $\Rightarrow$ NO decline in NRR
- NRR would decline if:

  - There exists a precautionary demand for children
  - RA with respect to fertility $>$ RA with respect to consumption (False)

  - Replacement fertility is insignificant (False; empirical estimates 0.2–0.6)

  - Resources saved from investment in non-surviving children are not channeled towards higher fertility

The Decline in Child Mortality – Challenging Evidence to the Theory

- 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 till 1750 fluctuating between 25-40

    - 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
   - BUT had HIGHER reproductive success

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 and 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 $\rightarrow$ $(w^F / w^M) \Uparrow$

  - $w^F \equiv$ women's wages
  - $w^M \equiv$ men's wages

Evolution of the Gender Earning Ratio - US
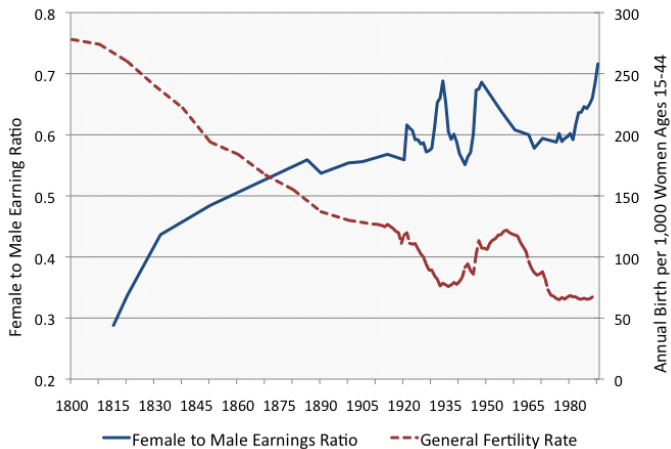
Evolution of the Gender Literacy Gap - England
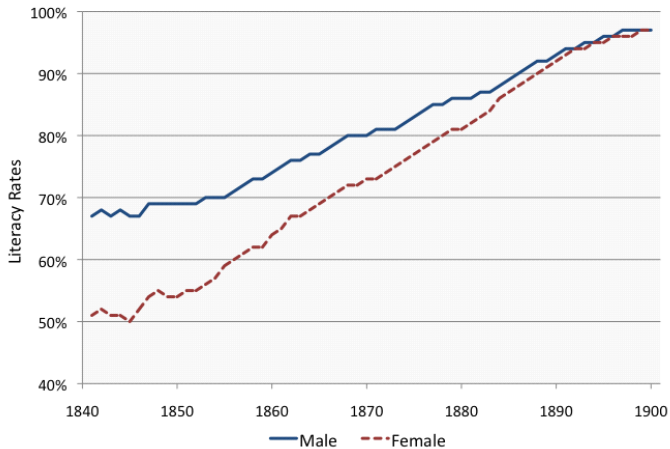
Mechanism: II. Women's Relative Wages and Fertility

- 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 $\implies$ operates towards $n \Uparrow$

  - A substitution effect:

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

    - Opportunity cost of children increases $\implies$ 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 incomei.e.,

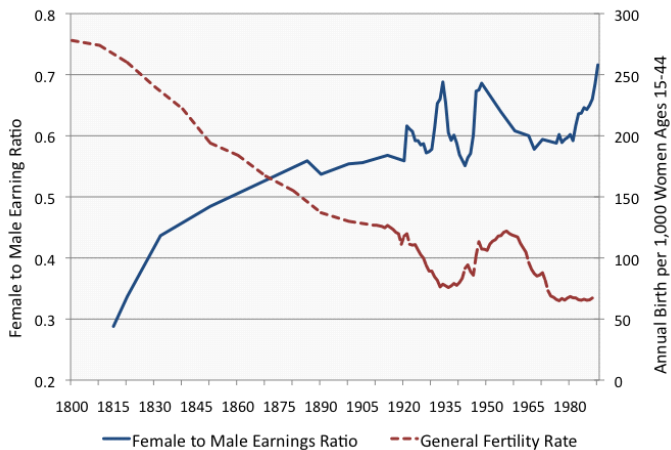$$w^F \Uparrow \implies |\text{Income effect}| < |\text{Substitution effect}|$$

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

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

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

$$\implies \text{ operates towards } n \Uparrow$$

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 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 - 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 education level (quality) e

- $y(\tau^q + \tau^e e) \equiv$ opportunity cost of raising a child with quality e

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

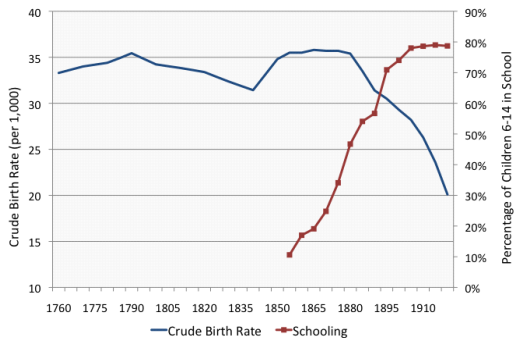$$\partial n / \partial \beta < 0$$

- The cost of raising a child (regardless of quality) increases
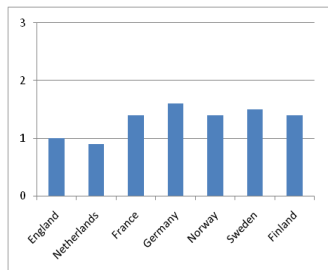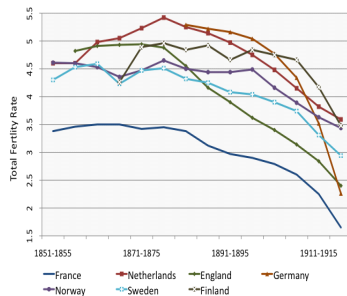
$$\partial n / \partial \tau^q < 0$$

- 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):
    - Eradication of hookworm (1910s) – a positive shock to the return to child quality
        - Adverse effect on fertility (Bleakley-Lange, RESTAT 2009)

    - Opening of kindergartens - an increase in the return to education
        - Adverse effect on fertility (Ager-Cinnirella, 2020)

- Prussia (19th century):
    - The rise in human capital formation (IV: Land concentration & Distance from the birthplace of Protestantism - Wittenberg)
        - Adverse effect on fertility (Becker-Cinnirella-Woessmann, JOEG 2010)

- France (1876–96):
    - Adverse effect of education attainment on fertility rates (Murphy JOEG 2015)

Supporting Evidence

- England (1580-1871)
  - Adverse effect of family size on children's literacy. (Klemp-Weisdorf, EJ 2019)

- China (13th-20th century)
  - Changes in the civil service examination system increase the return to human capital
    - Adverse effect on family size (Shiue, JOEG 2017)

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

Appendix - Optimization

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

- $h_e(e, g) > 0$ & $h_{ee}(e, g) < 0$
    - 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

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 :

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

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

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

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

Optimization

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

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

$\Longrightarrow$

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

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