The Demographic Transition

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Economic Growth and Comparative Development
Phases of Development: Standard of Living

- The Malthusian Epoch
- The Post-Malthusian Regime
- The Modern Growth Regime
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Phases of Development: Timeline of the Most Developed Economies

- **Malthusian Epoch (99.8%)**

  - 200K BP
  - 1750s
Phases of Development: Timeline of the Most Developed Economies

- **Malthusian Epoch**: 200K BP to 1750s
  - (99.8%)

- **Post-Malthusian**: 1750s to 2014
  - (0.1%)
Phases of Development: Timeline of the Most Developed Economies

- **Malthusian Epoch**: 200K BP - 1750s (99.8%)
- **Post-Malthusian**: 1750s - 1870s (0.1%)
- **Modern Growth**: 1870s - 2014 (0.1%)
The Demographic Transition

- The positive relationship between income and population is reversed
- Fertility, mortality and population growth decline very rapidly
- The impact of technological progress on output per capita are no longer counterbalanced by population growth
- Transition to Modern Growth
The positive relationship between income and population is reversed

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Transition to Modern Growth
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Transition to Modern Growth
Variation in 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

The graph shows the percentage of late fertility decline in Asia from 1000-1500 to 1973-1998. The y-axis represents the percentage, while the x-axis represents the time periods from 1000-1500 to 1973-1998.
Late Fertility Decline – Africa
The Demographic Transition in Western Europe: Total Fertility Rates
Mortality Decline Western Europe: 1730-1920

The Demographic Transition

Growth & Comparative Development
The Evolution of Total Fertility Rate across Regions, 1960-1999
Decline in infant mortality rates across regions, 1960-1999
Timing of the Demographic Transition and Current Income per Capita

Conditional on absolute latitude.

\[ \text{coef} = 1.3462847, \text{(robust)} \text{ se} = .10852591, t = 12.41 \]
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 of child quality is larger than that of quantity
  - The rise in income $\Rightarrow$ substitution of child quality for quantity $\Rightarrow$ reduction in fertility (Becker and Lewis, JPE 1973)

- The Decline in Child Mortality
  - Decline in child mortality enabled families to attain their desirable number of children with lower number of birth
  - The mortality decline $\Rightarrow$ reduction in fertility
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- The Old-Age Security Hypothesis (Caldwell, 1976)
  - Children is a form of investment good (in the absence of access to financial markets)
    - Development of financial markets reduced the demand for children as an investment good
      ⇒ reduction in fertility

- The Decline in the Gender Wage Gap (Galor-Weil, AER 1996)
  - The process of development decreased the gender wage gap
    - The rise in the relative wages of women increased the opportunity cost of raising children more than family income ⇒ reduction in fertility
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Child rearing is time-intensive

Household’s Budget constraint

\[ yτn + c ≤ y \]

- \( y \equiv \) household’s income
- \( c \equiv \) household’s consumption
- \( n \equiv \) household’s children
- \( τ \equiv \) time cost per child
- \( yτ \equiv \) opportunity cost of raising a child

Equivalently

\[ c ≤ y(1 − τn) \]

- \( 1 \equiv \) household’s time endowment
- \( (1 − τn) \equiv \) labor force participation
- \( τn \equiv \) time spent raising children
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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
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- The substituting effect dominates at a higher level of income

- As income increases fertility declines

- Fertility declines in the process of development
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- 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)
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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:
\[ u = n^\gamma c^{(1 - \gamma)} \]
\[ 0 < \gamma < 1 \]

Budget constraint
\[ y\tau n + c \leq y \]

Optimization: (fraction $\gamma$ 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

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The Rise in Income - Homothetic Preferences

- Optimal number of children
  \[ n = \frac{\gamma}{\tau} \]

- 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
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The Rise in Income - Homothetic Preferences

\[ \gamma \]

\[ \text{Time Devoted to Raising Children} \]

\[ \gamma \]

\[ 1 \]
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.
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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.
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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

- France
- Netherlands
- England
- Germany
- Norway
- Sweden
- Finland

Income Per Capita, 1870:
- England
- Netherlands
- France
- Germany
- Norway
- Sweden
- Finland
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 2015)

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 Rise in Income: Refuting Evidence from Individual Countries

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The Decline in Child Mortality - Main Hypothesis

- Parents generate utility from the number of surviving children
- A decline in child mortality permits parents to reach a given level of surviving children with lower fertility
- The decline in mortality triggered the subsequent decline in fertility
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The Decline in Mortality – Mechanism

Preferences:

\[ u = n^\gamma c^{(1-\gamma)} \quad \text{with} \quad 0 < \gamma < 1 \]

- \( c \equiv \) 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
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The Decline in Child Mortality

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

$$y = \gamma y$$
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- Optimal number of surviving children (NRR)

$$n = \gamma/\tau$$

- Optimal fertility (# of successful pregnancies - TFR)

$$n^b = n/\theta = \gamma/(\tau\theta)$$
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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 Mortality – Testable Predictions

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Theories

The Decline in Child Mortality

Worldwide: NRR and TFR plummet jointly during the demographic transition. But the theory does not predict a decline in NRR

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
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The Decline in Mortality and Fertility - 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
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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
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The Old-Age Security Hypothesis - Challenges 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, had larger number of surviving children
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The Decline in the Gender Wage Gap

- The inevitable rise in the relative wages of women in the process of development
  - increases the opportunity cost of raising children more than family income
    - \( \Rightarrow \) reduction in fertility
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The Decline in the Gender Wage Gap

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  - increases the opportunity cost of raising children more than family income
  - ⇒ 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
- $\Rightarrow$ The process of development has (inevitably) increased the productivity of women relative to men:

\[ \text{Economic Development} \Rightarrow \left( \frac{w^F}{w^M} \right) \uparrow \]

- $w^F \equiv$ women’s wages
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Evolution of the Gender Earning Ratio - US
Evolution of the Gender Literacy Gap - England

The Decline in the Gender Wage Gap
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
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- 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
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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 $\Rightarrow$ operates towards $n \uparrow$
  - A substitution effect:
    \[ \uparrow [w^F \tau] n + c \leq w^M + w^F \]
    
    Opportunity cost of children increases $\Rightarrow$ operates towards $n \downarrow$
- A rise in men’s wages generate only an income effect
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Theories: The Decline in the Gender Wage Gap

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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.,

$$w^F \uparrow \quad \Rightarrow \quad |\text{Income effect}| < |\text{Substitution effect}|$$

$$\Rightarrow \quad n \downarrow \quad (\text{even if preferences are homothetic})$$

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

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$$w^M \uparrow \implies n \uparrow$$
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 2015)
Women’s Relative Wages and Fertility - Evidence

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Theories

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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. This leads to a reduction in fertility.
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  \[ \Rightarrow \text{reduction in fertility} \]
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⇒ reduction in fertility
The Model - Preferences

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

- $c \equiv$ consumption
- $n \equiv$ (surviving) children
- $h \equiv$ quality (human capital) of each child
- $\beta \equiv$ degree of preference for child quality; $\beta < 1$
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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) \( e \)
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The Rise in Human Capital Formation

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The Model - Human Capital Formation

\[ h = h(e, g) \]

- \( h_e(e, g) > 0 \) & \( h_{ee}(e, g) < 0 \)
  - HC is increasing (at 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)

- \( h_{eg}(e, g) > 0 \)
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- \( h(0, g) > 0 \) & \( \lim_{e \to 0} h_e(e, g) = \infty; \lim_{e \to \infty} h_e(e, g) = 0 \)
  - Basic level of human capital & interior solution
The Theories of Human Capital Formation

**The Model - Human Capital Formation**

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The Model - Optimization

\[ \{n, e, c\} = \arg \max \gamma[\ln n + \beta \ln h(e, g)] + (1 - \gamma) \ln c \]

s.t. \[ yn(\tau^q + \tau^e e) + c \leq y \]

since \[ c = y[1 - n(\tau^q + \tau^e e)] \quad \Leftrightarrow \]

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

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
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with respect to \(n\):

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

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

\[ \beta h_e(e, g)(\tau^q + \tau^e e) = \tau^e h(e, g) \]
Optimization

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

with respect to \( e \):

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

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\[ \beta h(e, g)(\tau^q + \tau^e e) = \tau^e h(e, g) \]
The Rise in Human Capital Formation

Optimization

\[ n = \frac{\gamma}{(\tau_q + \tau^e e)} \]

\[ \tau^e h(e, g) = \beta h_e(e, g)(\tau_q + \tau^e e) \]

\[ e = e(g, \beta, \tau^e, \tau_q), \]

\[ n = \frac{\gamma}{[\tau_q + \tau^e e(g, \beta, \tau^e, \tau_q)]} \]
Optimization

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

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\[ n = \frac{\gamma}{[\tau^q + \tau^e e(g, \beta, \tau^e, \tau^q)]} \]
Testable Predictions - Investment in Quality

The optimal level of investment in child quality increases if:

- The technological environment changes more rapidly
  \[ \frac{\partial e(g, \beta, \tau^e, \tau^q)}{\partial g} > 0 \]

- Preferences for child quality are higher
  \[ \frac{\partial e(g, \beta, \tau^e, \tau^q)}{\partial \beta} > 0 \]

- The cost of raising a child (regardless of quality) increases
  \[ \frac{\partial e(g, \beta, \tau^e, \tau^q)}{\partial \tau^q} > 0 \]

- The cost of educating a child decreases
  \[ \frac{\partial e(g, \beta, \tau^e, \tau^q)}{\partial \tau^e} < 0 \]
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  \[ \frac{\partial e(g, \beta, \tau_e, \tau_q)}{\partial \tau_e} < 0 \]
The optimal number of children decreases if:

- The technological environment changes more rapidly
  \[ \frac{\partial n}{\partial g} < 0 \]
- Preferences for child quality are higher
  \[ \frac{\partial n}{\partial \beta} < 0 \]
- The cost of raising a child (regardless of quality) increases
  \[ \frac{\partial n}{\partial \tau^q} < 0 \]
- 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
  \[ \frac{\partial n}{\partial \tau^e} < 0 \text{ if } \left[ \frac{\partial e}{\partial \tau^e} \right] \left[ \frac{\tau^e}{e} \right] > -1 \]
Testable Predictions - Investment in Quantity

The optimal number of children decreases if:

- The technological environment changes more rapidly
  \[ \frac{\partial n}{\partial g} < 0 \]
- Preferences for child quality are higher
  \[ \frac{\partial n}{\partial \beta} < 0 \]
- The cost of raising a child (regardless of quality) increases
  \[ \frac{\partial n}{\partial \tau^q} < 0 \]
- 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
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- The cost of raising a child (regardless of quality) increases
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The optimal number of children decreases if:

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Human Capital Formation 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 2015).

- 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).
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Supporting Evidence: Cross-Country

- **US (1910s):** Eradication of hookworm – a positive shock to the return to child quality - had an adverse effect on fertility (Bleckley-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 2015)

- **England (1580-1871)** Adverse effect of family size on children’s literacy. (Klemp-Weisdorf 2016)
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The Rise in Human Capital Formation

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