Fertility

Ernesto F. L. Amaral

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References:
Outline

• The fertility transition
  – Weeks 2015, Chapter 6, pp. 189–250

• Period fertility
  – Wachter 2014, Chapter 6, pp. 125–152
The fertility transition
(Weeks 2015, Chapter 6, pp. 189–250)

• What is the fertility transition?
• How high could fertility levels be?
• Why was fertility high for most of human history?
• The preconditions for a decline in fertility
• Ideational changes that must take place
• Motivations for lower fertility levels
• How can fertility be controlled?
• How do we measure changes in fertility?
• How is the fertility transition accomplished?
• Geographic variability in the fertility transition
• Case studies in the fertility transition
What is the fertility transition?

• Fertility limitation and delayed childbearing

• The shift from high fertility, with minimal individual control, to low fertility, which is entirely under a woman’s control
  – A shift from “family building by fate” to “family building by design” (Lloyd and Ivanov 1988)

• It involves a later start to childbearing and an earlier end to childbearing
  – “Not too early, not too close, and not too many”
Biological component (fecundity)

• A fecund person can produce children
• An infecund (sterile) person cannot
• Couples who have tried unsuccessfully for at least 12 months to conceive a child
  – Called “infertile” by physicians
  – “Infecund” by demographers
• 2006–10 National Survey of Family Growth (NSFG)
  – 6% of American couples (where the wife was aged 15 to 44) are infecund/infertile by that criterion
How many children could you have?

• Assume you and partner(s) are fully fecund
• First pregnancy at age 15
• Little less than 9 months per pregnancy (to account for some pregnancy losses, such as miscarriages)
• 18 months between the end of one pregnancy and the start of the next
• Thus, a woman could have a child every 2.2 years between ages 15–49
• This would result in 16 live births (Bongaarts 1978)
Natural fertility

• No known society has ever had 16 births on average
  – Health and mortality experience of mothers
  – Poor nutrition raises age at menarche and produces anovulatory cycles in which no egg is released

• Natural fertility (Henry 1961, Coale and Trussell 1974)
  – Level of reproduction in the absence of deliberate fertility control
  – Closer to 6 or 7 live births per woman
  – 25% of completed fertility is due to genetics (same as mortality)

• Hutterites had 11 children per woman in the 1930s
  – Early age at marriage, good diet, good medical care, regularly engage in intercourse without contraception or abortion
Age-specific fertility rates

<table>
<thead>
<tr>
<th>Year</th>
<th>Hutterite “Natural”</th>
<th>Mexico 2010</th>
<th>US 2010</th>
<th>Canada 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>1930</td>
<td>250</td>
<td>63</td>
<td>31</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>460</td>
<td>121</td>
<td>88</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td>431</td>
<td>123</td>
<td>115</td>
<td>102</td>
</tr>
<tr>
<td></td>
<td>396</td>
<td>80</td>
<td>99</td>
<td>110</td>
</tr>
<tr>
<td></td>
<td>321</td>
<td>42</td>
<td>50</td>
<td>51</td>
</tr>
<tr>
<td></td>
<td>167</td>
<td>9</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

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Social component

• Social component explains actual levels of fertility
• For most of human history, fertility was high to replenish society, especially to combat high infant mortality
• Motivating women/couples to have children
  – Children as security and labor (quantity matters more than quality)
  – Lower status for women leads to a desire for sons
  – Children as essential for status and prestige
• Accomplished by
  – Having children early and often (requires control over women)
  – No tolerance for contraception/abortion/infanticide
Total fertility rates, 2015

Total Fertility Rate Estimated for 2015

- 1.1 - 1.9
- 2.0 - 2.2
- 2.3 - 2.5
- 2.6 - 3.0
- 3.1 - 7.6
Preconditions for fertility decline

• Ready, willing, and able (RWA) model (Ansley Coale)
  • Ready
    – Acceptance of calculated choice as a valid element in marital fertility
    – Ideational changes, secularization, status of women
  • Willing
    – Perception of advantages from reduced fertility
    – Motivation for limiting fertility
  • Able
    – Knowledge and mastery of effective techniques of birth control (controlling reproduction)
Supply-demand framework

• This framework (new household economics) helps explaining motivations for fertility (Richard Easterlin)
  – Neoclassical economics: rational choices about what people want

• Trade-off between quantity/quality of children (Gary Becker)
  – It emphasizes the need for households to balance supply/demand
  – The demand for children: what are they good for?
  – Time, expectations, and costs of children enter the equation

• Motivation to limit fertility when supply exceeds demand
  – Mortality declines and children cannot be afforded
  – And/or the opportunity costs of children rise
  – Changes from what are they good for, to how good are they?
Education and fertility

• Better-educated women have lower fertility than others
  – Education breaks traditional view of society
  – Increases social mobility, innovative behavior, fertility limitation
  – It reevaluates role of women in society
  – People reassess value of children

• Lowest-low fertility countries, relation gets complicated
  – Better-educated women are in position to have larger families
  – Family-friendly public policies (e.g. daycare) in specific countries encourage higher fertility
  – Gender equality provides environment to combine family and career
Female education can change opportunity costs of having children.
Cultural perspective

- Innovation/diffusion influence fertility decline (Brown 1981; Rogers 1995), through social networks (Bernardi, Klärner 2014)

- Two theories of social stratification have strong implications for fertility behavior (Lesthaeghe, Surkyn 1988)

- Cultural innovation takes place in higher social strata as a result of privilege, education, and resources
  - Lower social strata adopt new preferences through imitation

- Rigid social stratification or closure of class/caste inhibits downward cultural mobility and thus inhibits diffusion of low fertility ideas
Innovation/diffusion in history

• European fertility history suggests a pattern of geographic diffusion of innovation of fertility limitation within marriage

• Spread across areas with common language and ethnic origin

• Despite varying levels of mortality and economic development

• Some societies are more prone to accept innovation than others (Watkins 1991; Pollack, Watkins 1993)

• To accept innovation and change behavior, one must be “empowered”
  – Believe that it’s within your control to alter behavior
Supply-demand & Innovation-diffusion

• Diffusion of an innovation requires that people believe that they have some control over their life

• This is the essence of the rational-choice model (economic approach to fertility transition)

• Supply-demand model and innovation-diffusion model tend to be complementary

• Couples might influence others if they improve their own and their children’s economic and social success by concentrating resources on a smaller number of children
Demographic links between fertility transition and reproductive health

- Increased longevity
  - Less pressure to marry early
  - Greater freedom before marriage and childbearing
    - Higher levels of education
      - Lower fertility
        - Less time spent bearing and rearing children
          - Higher levels of reproductive control and improved reproductive health
          - Public policy that promotes gender equity and reproductive rights
    - Urbanization
      - Greater availability of paid employment
        - Increased likelihood of financial independence
Influences on fertility transition

Contextual structural (economic/cultural) determinants → Family structure → Family control (over marriage) → Pregnancy wastage/maternal mortality

Contextual social pressure (diffusion) determinants → Mother characteristics → Father of baby characteristics → Fertility control (contraception, including breastfeeding) → Live births → Child control (infanticide, fosterage, orphanage)

Infant/child mortality → Net reproduction
How can fertility be controlled?

- Dealing with unwanted children in the past
  - Infanticide, general neglect, or inattention that leads to early death
  - Fosterage of child by another family that needs or can afford it
  - Orphanage: involves abandoning a child so she/he is likely to be found and cared for by strangers
Proximate determinants of fertility

• Means for regulating fertility have been popularly labeled the *intermediate variables* (Davis, Blake 1955)
  – 11 variables through which any social factor influencing the level of fertility will operate
  – 3 phases to fertility (intercourse, conception, gestation)

• **Proximate determinants of fertility** (Bongaarts 1978, 1982)
  – 4 of these variables account for differences in fertility between populations
  – Their importance varies across time and space
<table>
<thead>
<tr>
<th>Most Important of the Proximate Determinants</th>
<th>Proximate Determinants or Intermediate Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Factors affecting exposure to intercourse (“intercourse variables”).</td>
<td></td>
</tr>
<tr>
<td>A. Those governing the formation and dissolution of unions in the reproductive period.</td>
<td></td>
</tr>
<tr>
<td>1. Age of entry into sexual unions</td>
<td></td>
</tr>
<tr>
<td>2. Permanent celibacy: proportion of women never entering sexual unions.</td>
<td></td>
</tr>
<tr>
<td>3. Amount of reproductive period spent after or between unions.</td>
<td></td>
</tr>
<tr>
<td>a. When unions are broken by divorce, separation, or desertion.</td>
<td></td>
</tr>
<tr>
<td>b. When unions are broken by death of husband.</td>
<td></td>
</tr>
<tr>
<td>B. Those governing the exposure to intercourse within unions.</td>
<td></td>
</tr>
<tr>
<td>4. Voluntary abstinence.</td>
<td></td>
</tr>
<tr>
<td>5. Involuntary abstinence (from impotence, illness, unavoidable but temporary separations).</td>
<td></td>
</tr>
<tr>
<td>6. Coital frequency (excluding periods of abstinence).</td>
<td></td>
</tr>
<tr>
<td>II. Factors affecting exposure to conception (“conception variables”)</td>
<td></td>
</tr>
<tr>
<td>7. Fecundity or infecundity, as affected by involuntary causes, but including breastfeeding.</td>
<td></td>
</tr>
<tr>
<td>8. Use or nonuse of contraception.</td>
<td></td>
</tr>
<tr>
<td>a. By mechanical and chemical means.</td>
<td></td>
</tr>
<tr>
<td>b. By other means.</td>
<td></td>
</tr>
<tr>
<td>9. Fecundity or infecundity, as affected by voluntary causes (sterilization, medical treatment, and so on).</td>
<td></td>
</tr>
<tr>
<td>III. Factors affecting gestation and successful parturition (“gestation variables”).</td>
<td></td>
</tr>
<tr>
<td>10. Fetal mortality from involuntary causes (miscarriage).</td>
<td></td>
</tr>
<tr>
<td>11. Fetal mortality from voluntary causes (induced abortion).</td>
<td></td>
</tr>
</tbody>
</table>

**Sources:** Adapted from Kingsley Davis and Judith Blake (1955); and John Bongaarts (1982).
Main proximate determinants

• Proportion married (limiting exposure to intercourse)
  – Younger woman (less sexual intercourse)
  – Household with both mother and father (closer surveillance)
  – Mother well-educated (awareness of costs of pregnancy)
  – Later age at marriage (lower levels of fertility)

• Involuntary infecundity
  – Breastfeeding prolongs postpartum amenorrhea and suppresses ovulation

• Use of contraceptives

• Induced abortion (Hodgson 2009)
## Contraceptive use, U.S., 2006–2010

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Number of pregnancies per 100 women during first year of use</th>
</tr>
</thead>
<tbody>
<tr>
<td>15–44</td>
<td>37.8 69.5 41.7 34.7 30.3 25.4 24.7</td>
</tr>
<tr>
<td>15–19</td>
<td>26.5 0.0 2.6 16.4 30.0 37.4 50.6</td>
</tr>
<tr>
<td>20–24</td>
<td>Male sterilization 10.0 0.0 0.9 4.1 9.5 16.6 20.1</td>
</tr>
<tr>
<td>25–29</td>
<td>Pill 27.5 53.1 47.0 32.9 25.4 17.0 9.8</td>
</tr>
<tr>
<td>30–34</td>
<td>Implant, Lunelle, or contraceptive patch 1.4 2.3 1.9 2.3 1.3 0.7 0.0</td>
</tr>
<tr>
<td>35–39</td>
<td>3-month injectable (Depo-Provera) 3.7 11.5 5.7 5.2 2.4 1.3 0.8</td>
</tr>
<tr>
<td>40–44</td>
<td>Contraceptive ring 2.1 2.3 4.6 3.7 2.0 0.7 0.5</td>
</tr>
<tr>
<td></td>
<td>Intrauterine device (IUD) 5.6 2.6 5.7 7.2 7.0 6.4 3.2</td>
</tr>
<tr>
<td></td>
<td>Male condom 16.4 20.0 25.6 20.8 15.5 12.1 9.0</td>
</tr>
<tr>
<td></td>
<td>Periodic abstinence—fertility awareness methods 1.2 0.0 0.3 0.8 1.7 1.3 1.5</td>
</tr>
<tr>
<td></td>
<td>Withdrawal 5.1 6.9 5.7 6.3 4.6 5.5 3.5</td>
</tr>
<tr>
<td></td>
<td>Other methods (including emergency contraception and sponge) 0.5 0.7 0.0 0.5 1.7 0.8 0.5</td>
</tr>
</tbody>
</table>
Contraceptive use and fertility, 2015

![Graph showing the relationship between percent using modern methods of contraception and total fertility rate. The correlation coefficient (r) is 0.76.]

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Period measures of fertility

- Crude birth rate (CBR)
- General fertility rate (GFR)
- Child-woman ratio (CWR)
- Age-specific fertility rate (ASFR)
- Total fertility rate (TFR)
- Gross reproduction rate (GRR)
- Net reproduction rate (NRR)
- Mean length of generation
- Princeton indices
Crude birth rate (CBR)

• CBR is the number of live births (b) in a year divided by the total midyear population (p)

\[ CBR = \frac{b}{p} \times 1,000 \]

• It is usually multiplied by 1,000 to reduce decimals

• It does not take into account which people in the population were at risk of having births

• It ignores age structure of the population, which can affect the number of live births in a year
General fertility rate (GFR)

- GFR is the total number of births in a year ($b$) divided by the number of women in childbearing ages ($_{30}F_{15}$)

\[ GFR = \frac{b}{{}_{30}F_{15}} \times 1,000 \]

- It is sometimes called “the fertility rate”
- It uses information about the age and sex structure of a population
- It usually equals to about 4.5 times the CBR
Child-woman ratio (CWR)

- CWR is measured by the ratio of young children (0 to 4) enumerated in the census to the number of women of childbearing ages (15 to 49)

\[
CWR = \frac{4p_0}{35F_{15}} \times 1,000
\]

- It provides an index of fertility that is conceptually similar to GFR, but it relies only on census data.

- It uses an older upper limit on women’s age, because some of the children (0–4) will have been born up to five years prior to the census.
Age-specific fertility rate (ASFR)

• ASFR is the number of births (b) occurring in a year to mothers aged x to x+n \( \left( \frac{n b_x}{n F_x} \right) \) per 1,000 women \( (p_f \text{ or } F) \) of that age

\[
ASFR = \frac{n b_x}{n F_x} * 1,000
\]

• It is usually calculated in five-year age groups

• It requires comparisons of fertility be done on an age-by-age basis

• We can combine ASFRs into a single fertility index...
Total fertility rate (TFR)

- TFR is the sum of the ASFRs over all ages
  \[ TFR = \Sigma ASFR \times 5 \]
- Multiplied by 5 only if ASFRs grouped into 5-year intervals
- It is the average number of children born per woman
- **Assumption**: current birth rates remain constant and no woman dies before reaching the end of childbearing years
- **Synthetic cohort**: ASFRs are used to project what could happen if all women went through their lives bearing children at the same rate as women at a given date
- It can be compared across populations, because it takes into account differences in age structure
Gross reproduction rate (GRR)

- GRR is the sum of age-specific birth rates using only female babies (ASFR$_f$), since only female babies will bear children
  \[ GRR = \sum ASFR_f \times 5 \]

- It is the number of female children that a female just born may expect to have during her lifetime
  - GRR=1; women replace themselves
  - GRR<1; women do not replace themselves
  - GRR>1; next generation of women will be bigger than the present one

- **Assumption**: current birth rates remain constant and no woman dies before reaching the end of childbearing years
Net reproduction rate (NRR)

• NRR is the age-specific birth rates using only female babies (ASFR$_f$) multiplied by the probability that a woman will survive to the midpoint of the age interval

\[
NRR = \sum [(ASFR_f \times 5)(nLx / 5*l_0)] = \sum (ASFR_f \times nLx / l_0)
\]

• The probability that a woman will survive to the midpoint of the age interval equals nLx (number of women surviving to the age interval x to x+n) divided by 5*l$_0$ (radix multiplied by 5)

• NRR is less than GRR, since some women die before the end of the reproductive period

• NRR=1; each generation of females has the potential to replace itself (generational replacement)
Mean length of generation

- Mean length of generation is the average age at childbearing
- Multiply the midpoint of each age interval by the surviving daughters per woman for that age interval
- Divide the sum of those calculations by the net reproduction rate (NRR)
# Calculation of fertility rates, U.S., 2012

<table>
<thead>
<tr>
<th>Age group</th>
<th>Mid-point of age group</th>
<th>Number of women in age group</th>
<th>Number of births to women in age group</th>
<th>Age-specific fertility rate</th>
<th>Number of female births to women in age group</th>
<th>Female births per woman</th>
<th>nLx</th>
<th>Proportion of female babies surviving to midpoint of age interval</th>
<th>Surviving daughters per woman during 5-year interval</th>
<th>Column (2) x Column (10)</th>
<th>Verify Column (10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-14</td>
<td>12.5</td>
<td>10,102,004</td>
<td>3,672</td>
<td>0.0004</td>
<td>1,794</td>
<td>0.0002</td>
<td>496,173</td>
<td>0.9923</td>
<td>0.0009</td>
<td>0.0110</td>
<td>0.0009</td>
</tr>
<tr>
<td>15-19</td>
<td>17.5</td>
<td>10,397,841</td>
<td>305,388</td>
<td>0.0294</td>
<td>149,182</td>
<td>0.0143</td>
<td>495,615</td>
<td>0.9912</td>
<td>0.0711</td>
<td>1.2444</td>
<td>0.0711</td>
</tr>
<tr>
<td>20-24</td>
<td>22.5</td>
<td>11,033,747</td>
<td>916,811</td>
<td>0.0831</td>
<td>447,862</td>
<td>0.0406</td>
<td>494,662</td>
<td>0.9893</td>
<td>0.2008</td>
<td>4.5176</td>
<td>0.2008</td>
</tr>
<tr>
<td>25-29</td>
<td>27.5</td>
<td>10,553,440</td>
<td>1,123,900</td>
<td>0.1065</td>
<td>549,025</td>
<td>0.0520</td>
<td>493,440</td>
<td>0.9869</td>
<td>0.2567</td>
<td>7.0594</td>
<td>0.2567</td>
</tr>
<tr>
<td>30-34</td>
<td>32.5</td>
<td>10,417,089</td>
<td>1,013,416</td>
<td>0.0973</td>
<td>495,054</td>
<td>0.0475</td>
<td>491,925</td>
<td>0.9839</td>
<td>0.2338</td>
<td>7.5978</td>
<td>0.2338</td>
</tr>
<tr>
<td>35-39</td>
<td>37.5</td>
<td>9,773,586</td>
<td>472,318</td>
<td>0.0483</td>
<td>230,727</td>
<td>0.0236</td>
<td>489,852</td>
<td>0.9797</td>
<td>0.1156</td>
<td>4.3365</td>
<td>0.1156</td>
</tr>
<tr>
<td>40-44</td>
<td>42.5</td>
<td>10,569,227</td>
<td>109,579</td>
<td>0.0104</td>
<td>53,529</td>
<td>0.0051</td>
<td>486,656</td>
<td>0.9733</td>
<td>0.0246</td>
<td>1.0475</td>
<td>0.0246</td>
</tr>
<tr>
<td>45-49</td>
<td>47.5</td>
<td>10,962,854</td>
<td>7,157</td>
<td>0.0007</td>
<td>3,496</td>
<td>0.0003</td>
<td>481,639</td>
<td>0.9633</td>
<td>0.0015</td>
<td>0.0730</td>
<td>0.0015</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>83,809,788</strong></td>
<td><strong>3,952,241</strong></td>
<td><strong>0.3760</strong></td>
<td><strong>1,930,669</strong></td>
<td><strong>0.1837</strong></td>
<td><strong>0.9051</strong></td>
<td><strong>25.8872</strong></td>
<td><strong>0.9051</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[
\text{GFR (15-44)} = \frac{\text{sum of column (4)}}{\text{sum of column (5) x 5}} = 1.88
\]

\[
\text{TFR (10-49)} = \frac{\text{sum of column (6)}}{\text{sum of column (7) x 5}} = 0.918
\]

\[
\text{GRR (10-49)} = \frac{\text{Radix = 100,000}}{\text{sum of column (10) x 5}} = 0.905
\]

\[
\text{NRR (10-49)} = \frac{\text{Mean length of generation (10-49) = sum of column (11) divided by NRR = 28.6}}{\text{sum of column (11) x 5}} = 0.905
\]

Source: Data from Table 6.3 (Weeks 2015, p. 225). Only nLx from Table 5.3 (Weeks 2015, p.174).
Accomplishing fertility transition

Mexico

1975 TFR = 6.5
2015 TFR = 2.2

India

1975 TFR = 5.3
2015 TFR = 2.5

Iran

1975 TFR = 6.2
2015 TFR = 1.9

Nigeria

1975 TFR = 6.6
2015 TFR = 6.0

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Regional differences in fertility transition, 1950–2050
Fertility transition in England

- 1800 TFR = 5.6
- 2015 TFR = 2.0
Fertility transition in China and Taiwan
Recent fertility trends, U.S.
Fertility by race/ethnicity, U.S.
Princeton indices

• The Princeton European Fertility Project proposed
  – Overall index of fertility ($I_f$)
  – Index of marital fertility ($I_g$)
  – Index of marriage ($I_m$)
  – Index of non-marital fertility ($I_h$)

• Data
  – Counts of births at local levels broken down by marital status of mothers (birth registration systems)
  – Counts of women by age and marital status (national censuses)

Applicability of Princeton indices

- Can be calculated with data widely and uniformly available at a provincial or local level across Europe since the mid-1800s
- Measure how favorable the patterns of age at marriage are to high fertility
- Separate out the effects of changing ages of marriage from changes in fertility within marriage

Hutterite rates as standard

- Princeton indices are a form of indirect standardization
- Take a standard schedule of age-specific fertility rates (Hutterites)
- Compare the number of births that a population actually has in a period with the number that the population would have had if their fertility rates had been equal to the Hutterite rates

Overall index of fertility ($I_f$)

• Numerator
  – Births to all women observed in the actual population ($B^{overall}$)

• Denominator
  – Hypothetical total of implied births
  – Multiply actual counts of women ($nK_x$) by standard Hutterite rates ($5F_{x,Hutt}$)

\[
I_f = \frac{B^{overall}}{\sum (5K_x)(5F_{x,Hutt})}
\]

Index of marital fertility ($I_g$)

- **Numerator**
  - Births to married women in the actual population ($B^\text{marital}$)

- **Denominator**
  - Hypothetical implied births within marriage
  - Multiply actual counts of married women ($nK_{x,\text{married}}$) by standard Hutterite rates ($5F_{x,Hutt}$)

\[
I_g = \frac{B^\text{marital}}{\sum (5K_{x,\text{married}})(5F_{x,Hutt})}
\]

## Data for Berlin, 1900

<table>
<thead>
<tr>
<th>Age x</th>
<th>Hutterite Rates</th>
<th>Overall Women</th>
<th>Implied Babies</th>
<th>Married Women</th>
<th>Implied Babies</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>0.300</td>
<td>91,358</td>
<td>27,407</td>
<td>1,538</td>
<td>461</td>
</tr>
<tr>
<td>20</td>
<td>0.550</td>
<td>114,464</td>
<td>62,955</td>
<td>28,710</td>
<td>15,791</td>
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<td>0.502</td>
<td>99,644</td>
<td>50,021</td>
<td>55,417</td>
<td>27,819</td>
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<tr>
<td>30</td>
<td>0.407</td>
<td>88,886</td>
<td>36,177</td>
<td>62,076</td>
<td>25,265</td>
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<td>35</td>
<td>0.406</td>
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<td>30,746</td>
<td>55,293</td>
<td>22,449</td>
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<tr>
<td>40</td>
<td>0.222</td>
<td>66,448</td>
<td>14,751</td>
<td>47,197</td>
<td>10,478</td>
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<tr>
<td>45</td>
<td>0.061</td>
<td>54,485</td>
<td>3,324</td>
<td>36,906</td>
<td>2,251</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>591,014</td>
<td>225,381</td>
<td>287,137</td>
<td>104,514</td>
</tr>
</tbody>
</table>

- Also know: 49,638 births of which 42,186 within marriage

Calculating $I_f$ and $I_g$ for Berlin, 1900

- Overall index of fertility

$$I_f = B^{overall} / [\Sigma (5K_x)(5F_{x,Hutt})] = 49,638 / 225,381 = 0.220$$

  - Limitation overall was well advanced by 1900 in Berlin

- Index of marital fertility

$$I_g = B^{marital} / [\Sigma (5K_{x,married})(5F_{x,Hutt})] = 42,186 / 104,514 = 0.404$$

  - Fertility within marriage was not wholly responsible for limitation

Index of marriage ($I_m$)

- Measures how conducive marriage pattern is to high fertility
- Numerator
  - Take the denominator from $I_g$
  - Hypothetical implied births within marriage
- Denominator
  - Take the denominator from $I_f$
  - Hypothetical total of implied births

$$I_m = \frac{\sum (K_{x,married}) (F_{x,Hutt})}{\sum (K_x) (F_{x,Hutt})}$$

$$= \frac{104,514}{225,381} = 0.464$$

- Low proportions marrying contribute to low levels of overall fertility

Index of non-marital fertility ($I_h$)

• It is rarely employed, when illegitimate fertility is a small part of overall fertility

• Numerator
  – Observed births out of wedlock

• Denominator
  – Hypothetical births that unmarried women in the population would have had at Hutterite rates

• When non-marital fertility is small, $I_h$ can be neglected, and $I_f$ is close to the product of $I_g$ with $I_m$

\[ I_f = (I_g)(I_m) + (I_h)(1 - I_m) \approx (I_g)(I_m) \]
