Fertility and its Measurement: Further Methods of Analysis

Demography Camp

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1 Natural Fertility

The absence of birth control promotes high fertility among cohabiting women (usually, but not always)

Natural Fertility: not subject to deliberate control

Control can be said to exist when the behavior of the couple is bound by the number of children already born and is modified when this number reaches the maximum. The couple does not want to exceed; it is not the case for a taboo concerning lactation, which is independent of the number of children already born (Henry, 1, p. 81).

Evidence of control?

- Parity determined control reduces fertility at older ages
- Early age at birth of last child
- Age-specific fertility rates decline w/marital duration

Table 1: Ex. Marital Fertility of Old Order Amish Women, born 1860-9

	20-24	25-29	30-34	35-39	40-44
Women married <age 25	0.464	0.425	0.363	0.288	0.152
Women married >age 25	-	0.407	0.414	0.346	0.111
Ratio of rates		0.958	1.141	1.203*	0.734

* statistically significant (.05)

2 Age Specific Marital Fertility Rates

$$ASMFR_i = \frac{annual\ births\ to\ married\ women\ at\ age\ i}{mid-year\ population\ of\ married\ women\ age\ i}$$

Table 2: ASMFR's in Population with Natural Fertility (20-24=100)

20-24	100
25-29	94
30-34	85
35-39	69
40-44	35
45-49	5

Pattern is convex from above.

Index is indicative of biological capacity to produce children.

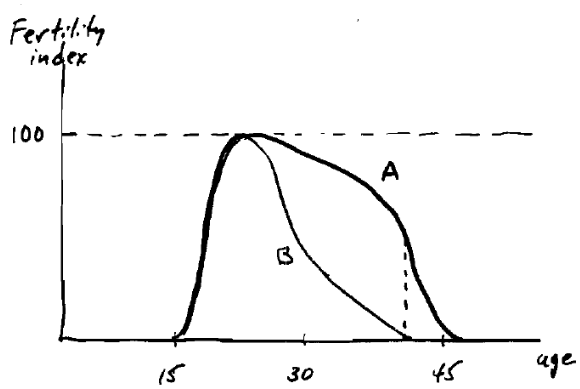

Figure 1: Two examples of Fertility Schedules

- A: natural fertility of cohabiting women (50% at approximately age 40)
- B: Fertility of cohabiting women who practice extensive and effective birth control
  - Concave from above
- On a relative scale, B has lower fertitliy than A

Table 3: TMFR in Natural Fertility Populations

Hutterites, marriages from 1921-1930	10.6
Canada, marriage from 1700-1730	10.6
Europeans of Tunis, marriages from 1840-59	9.1
Crulai (Normandy), marriages from 1674-1742	8.3
Iran, marriages from 1940-1950	7.4
India, marriage from 1946-47	6.0

There is a wide range; natrual fertility does **not** imply biological maximum

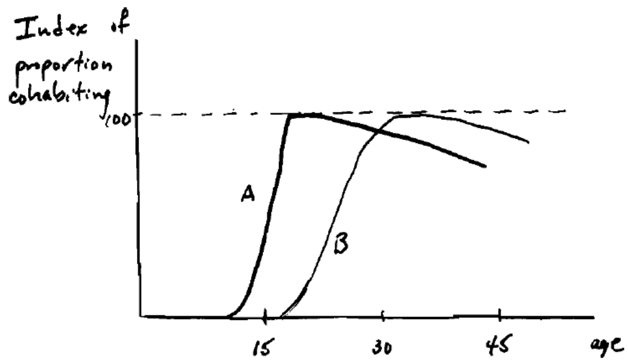

Figure 2: Two examples of Indexes of Proportion Cohabiting

- A: Characteristic of population with very young marriage
- B: Marriage is a prerequisite for cohabitation and marriage delayed

Product of the 2 graphs (fertilty index and index of proportion cohabiting) gives age structure of fertility.

3 Out of Wedlock Childbearing

Marital fertility rates are poor proxies (at least in the US) for fertility of cohabiting couples because a growing fraction of childbearing occurs outside of marriage

Table 4: Percent of Births to Unmarried Women

Year	All races	White	Blacks	Hispanic
1970	10.7	5.7	37.6	
1980	18.4	11.0	55.3	
1985	22.0	14.5	60.1	
1991	29.5	21.8	67.9	
2003	34.6	29.4	68.2	45.0

Table 5: Birth Rates per 1000 Unmarried Women 15-44

Year	All races	White	Blacks	Hispanic
1970	26.4	13.8	95.5	
1980	29.4	17.6	82.9	
1985	32.8	21.8	78.8	
1991	45.2	34.6	89.5	
2003 44.9	40.4	66.3	92.2	

4 Gross Reproduction Rate (GRR)

GRR: is the average number of daughters women would bear if they survived to the end of the childbearing ages and if at each age they were subject to the fertility rates observed in a population in a given year

$$m_i = \frac{annual\ number\ of\ \textbf{daughters}\ to\ women\ at\ age\ i}{mid-year\ population\ of\ women\ age\ i}$$

$$GRR = \sum_{i=15}^{49} m_i$$

GRR usually calculated by assuming the sex ratio (SR) at birth is the same regardless of maternal age

$$SR = \frac{Male\ Births}{Female\ Births} \times 100 = \frac{B_m}{B_f} \times 100$$

$$Proportion\ Female = \frac{B_f}{B_f + B_m} \simeq \frac{100}{100+105} = 0.488$$

$$SR \simeq TFR \times 0.488$$

Table 6: GRR US Females

1940	1.121
1985	0.898
2002	0.983

If we define: ${}_nF_x^f$= age-specific rate of bearing daughters for women between ages x and $x+n$

- and $m(x) = \lim_{n\to 0} {}_nF_x^f$; usually written as $m(a)$
- then $GRR = \int_\alpha^\beta m(a)da$; where α and β are the lower and upper limits, respectively, of childbearing
  - **Note**: GRR ignores mortality

4.1 Examples:

- GRR - 4.17 in the Cocos-Keeling islands; early and near universal marriage; high ASMFR's
- Hutterites- have higher ASMFR than Cocos-Keeling Islands, but later marriage and larger proportions never married
- If you combined Hutterite fertility with Cocos-Keeling marriage paterns, GRR > 6; TFR >12
- Lowest GRR: Vienna in 1934: 0.3
- Today GRR ,0.7 in Singapore, Hong Kong, Austria, W. Germany, and Italy

5 Net Reproduction Rate (NRR)

NRR: imagine a new cohort of infant females who will be subject at each age to the risks of dying and of having daughter. NRR is the average number of daughters per member of the original birth cohort this group of females will produce by the time the survivors reach the end of the childbearing ages

p_i= proportion of women who survive to age i

$NRR = \sum p_i \cdot m_i$
$NRR = \int_{\alpha}^{\beta} p(a)m(a)da$

Table 7: NRR Interpretations

$NRR = 1$	1,000 daughters in one generation are replaced by 1,000 daughters in the next
$NRR < 1$	Population will eventually decrease
$NRR > 1$	Population will eventually increase

Table 8: NRR US Females

1940	1.027
1985	0.881
2001	0.979

6 Relationship Between NRR and GRR

In countries with high $\mathring{e}_0$, GRR and NRR differ little

$NRR \simeq GRR \cdot p(\bar{m})$ where $\bar{m}$ is the mean are of the fertility schedule

Table 9: NRR and GRR

	NRR	GRR	$\frac{NRR}{GRR}$
1940 US Non-White	1.209	1.422	0.850
1960 Mexico	2.49	3.12	0.798
1985 US Whites	0.838	0.853	0.982

For white US women in 1985, mortality reduced cohort fertility by 0.015 daughters per woman, or by less than 2%. In Mexico, by cutting short the lives of potential mothers, mortality reduced fertility bu 0.63 daughters per woman, or by 20%.

7 Replacement Level Fertility

What TFR would be needed to keep the US population in a stationary (i.e. zero population growth) equilibrium, assuming a closed population?

Depends on the level of **mortality**

$$NRR = 1$$

$$GRR = \frac{NRR}{p(\bar{m})}$$

$$\therefore \ Replacement\ TFR = GRR \times \frac{B_m + B_f}{B_f}$$

$$= \frac{NRR}{p(\bar{m})} \times \frac{B_m + B_f}{B_f} = \frac{1}{0.981} \times \frac{1.052 + 1}{1} = 2.09$$

If mortality is higher, a higher TFR is needed for replacement. In Mexico in 1960, $\mathring{e}_0$ was 58.6 and replacement TFR was 2.57

8 Parity Progression Ratios

$$PPR_n = \frac{women\ who\ have\ had\ at\ least\ n\ births}{women\ who\ have\ has\ at\ least\ (n-1)\ births}$$

This gives the probabilty of going on to have another birth given a woman has already reached a particular parity

Parity of a woman: # of children she has had **Birth order** of a child: 1st, 2nd, etc.

9 European Fertility Project

The European Fertility Project was undertaken at OPR. It compared fertility of European women to those of a high fertility population (The Hutterites) to compare fertility in Europe across space and time. The data came from many different sources (mostly censuses and church baptism records). Therefore, mothers were not linked to their children. Thus, an index was creating using age specific fertility rates from the Hutterites.

Table 10: Standard of "maximum" fertility schedule, from Hutterites 1921-1930

	15-19	20-24	25-29	30-34	35-39	40-44	45-49
Births per woman	0.300	0.550	0.502	0.447	0.406	0.222	0.061

9.1 Definitions of fertility indexes

- f_i: Births per woman in i_th age interval (ASFR)
- g_i: Births per married woman in i_th age interval
- h_i: Births per unmarried woman in i_th age interval
- w_i: Number of woman in i_th age interval
- m_i: Number of married woman in i_th age interval
- u_i: Number of unmarried woman in i_th age interval
- F_i: Births per woman in i_th age interval in the standard population (married Hutterite women)

9.2 European fertility indexes

Index of overall fertility:

$$I_f = \frac{\sum f_i w_i}{\sum F_i w_i}$$

Index of marital fertility:

$$I_f = \frac{\sum g_i m_i}{\sum F_i m_i}$$

Index of nonmarital fertility:

$$I_f = \frac{\sum h_i u_i}{\sum F_i u_i}$$

Index of proportion married:

$$I_f = \frac{\sum F_i m_i}{\sum F_i w_i}$$

Note:

$$I_f = I_g \cdot I_m + (1 - I_m) \cdot I_h$$