Outline

The Gross Reproduction Rate

The Gross Reproduction Rate

Although the TFR represents an improvement with respect to previous measures, there is still room for more improvements. Since we have agreed to study fertility from the women's side, a more realistic measure of fertility is the **Gross Reproduction Rate**[a] (GRR).

- The GRR is the number of live born girl babies a woman is expected to have under two conditions:
  - 1) A woman survives to the end of her reproductive period.
  - 2) Her fertility is according to the schedule of $F_{i,h}$'s.

[a] In Spanish: "Tasa Bruta de Reproducción".

The Gross Reproduction Rate

The GRR

Although it can vary from place to place, we can consider that the average human sex ratio is around 105/100.

- That means there are 100 girl babies per 205 newborns. Thus, every time a conception occurs, the probability of getting a baby girl is

$$\frac{100}{205} = \frac{1}{2.05} \approx 0.4878.$$

- Taking that into consideration, then the GRR is defined as:

$$\begin{aligned} \mathrm{GRR} &= \frac{1}{2.05} h \sum_{i=a}^{b} F_{i,h} \\ &= \frac{1}{2.05} \mathrm{TFR}. \end{aligned}$$

The GRR

- Basically, after getting the TFR, it's immediate to obtain the GRR just by multiplying it by 0.4878.

Age-specific fertility rates, TFRs, GRRs, NRRs for Italy, 1961 and 1991 (Pop. in 10^3)								
	Births		Women		ASFR		ASFR (per 1000 women)	
					A	B		
Age	1961	1991	1961	1991	1961	1991	1961	1991
15-19	34.8	17.2	1860.4	2133.9	0.0187	0.0081	18.7	8.1
20-24	224.1	115.2	2013.1	2317.8	0.1113	0.0497	111.3	49.7
25-29	297.8	214.3	1894.4	2363.4	0.1572	0.0907	157.2	90.7
30-34	219.1	149.3	1943.6	2078.5	0.1127	0.0718	112.7	71.8
35-39	119	56	1948.6	1912.8	0.0611	0.0293	61.1	29.3
40-44	32.1	10.5	1415.1	2037.1	0.0227	0.0052	22.7	5.2
45-49	2.9	0.3	1690.0	1715.2	0.0017	0.0002	1.7	0.2
				SUM	0.4854	0.2549		
				TFR	**2.43**	**1.27**		
				GRR	**1.18**	**0.62**		

Figure: 20. ASFRs, TFR and GRR for Italy in 1961 and 1991.

The GRR

The GRR interpretation

That is to say: if a woman goes through all her reproductive years, $[15, 50)$, according to the fertility schedule given by the ASFRs, then:

- In 1961, a woman would have had 1.2 girls after her reproductive years.
- In 1991, a woman would have had 0.6 girls after her reproductive years.

The GRR

The GRR interpretation

- The GRR measures the replacement by the number of daughters that will replace each woman.
  - A GRR slightly greater than 1 guarantees the replacement of a generation of women by their daughters.
  - Note that in 1961, the replacement of women was guaranteed with a slight surplus (1.2).
  - In 1991, the replacement of the generation of women was no longer guaranteed, having a gross reproduction rate of less than one daughter per woman.

The Net Reproduction Rate

The Net Reproduction Rate

Finally, being realistic, not all women get to the end of their reproductive period. Thus, we need to somehow consider the probability of a woman to survive all along her reproductive years. It is the Net Reproduction Rate (NRR)[a] which takes that fact into account.

- For getting the NRR, we need information about the mortality schedule. We can get that in a period life table.

[a] In Spanish: "Tasa Neta de Reproducción"

The NRR

The NRR definition

The way the NRR considers survival information is by *potential and actual person-years lived*. The NRR is defined as:

$$\begin{aligned} \text{NRR} &= \frac{1}{2.05} h \sum_{i=a}^{b} \frac{L_{i,h}}{h l_0} F_{i,h} \\ &= \frac{1}{2.05} \sum_{i=1}^{b} \frac{L_{i,h}}{l_0} F_{i,h}. \end{aligned} \tag{3}$$

- NRR $= 1$ means an exact replacement, one daughter per woman.
- NRR <1 means that fertility is below replacement (fewer daughters than the mothers' generation).
- NRR> 1 indicates that fertility is above replacement (the future generation of potential mothers will be greater than the generation of current mothers).

The NRR

Age A	Number surviving at exact age x B l_x	Age-specific death rates C ${}_nm_x$	Probability of dying D ${}_nq_x$	Average number alive between exact ages E ${}_nL_x$	Total population aged x and over F T_x	Average life expectancy at exact age x G e_x
0	1000.000	6.04	6.01	995.19	80000	80.00
1	993.989	0.44	1.76	3969.85	79005	79.48
5	992.244	0.18	0.90	4958.76	75035	75.62
10	991.350	0.15	0.75	4954.96	70077	70.69
15	990.605	0.30	1.50	4949.45	65122	65.74
20	989.117	0.36	1.79	4941.32	60172	60.83
25	987.341	0.44	2.22	4931.44	55231	55.94
30	985.147	0.55	2.77	4919.19	50299	51.06
35	982.422	0.80	4.01	4902.65	45380	46.19
40	978.480	1.25	6.24	4877.75	40478	41.37
45	972.374	1.97	9.80	4839.00	35600	36.61
50	962.845	3.06	15.19	4779.12	30761	31.95
55	948.220	4.60	22.73	4689.36	25982	27.40

Figure: 21. West model life table, Level 25, females (life expectancy at birth, 80). Coale and Guo (1990:31)

The NRR

Survival conditions, 1991	
l_0=	**1000**

C	D	E		1961	1991
L_i,x	L_i,x/l_0	Estimate for 1961 (95% 1991)		EA	DB
4949.45	4.9495	4.7020		0.0880	0.0399
4941.32	4.9413	4.6943		0.5226	0.2456
4931.44	4.9314	4.6849		0.7365	0.4472
4919.19	4.9192	4.6732		0.5268	0.3533
4902.65	4.9027	4.6575		0.2844	0.1435
4877.75	4.8778	4.6339		0.1051	0.0251
4839.00	4.8390	4.5971		0.0079	0.0008
			SUM	2.2712	1.2555
			NRR	**1.11**	**0.61**

Figure: 22. Survival conditions for 1991 taken from Fig. (23). Survival conditons for 1961 were estimated assuming they were 95% of those from 1991.

The NRR

Age-specific fertility rates, TFRs, GRRs, NRRs for Italy, 1961 and 1991 (Pop. in 10^3)								
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				SUM	0.4854	0.2549		
				TFR	**2.43**	**1.27**		
				GRR	**1.18**	**0.62**		
				NRR	**1.11**	**0.61**		
				NRR/GRR	**0.94**	**0.98**		

Figure: 23. ASFRs, TFR, GRR, NRR and NRR/GRR for Italy, 1961 and 1991.

The NRR

Remarks

- According to the TFR, Italy had a decrease on the number of childs per woman from 1961 (2.43) to 1991 (1.27)
- According to the GRR, there were expected 1.18 daughters per woman in 1961 and 0.62 daughters in 1991.
- Considering the mortality levels in each year, the "net daughters" expected per woman in 1961 was 1.11 and in 1991, 0.61.
  - Thus, due to mortality, in 1961, we expected to have 6% less daughters (compared to not considering mortality at all)
  - In 1991, we expected to have just 1% less daughters (compared to not considering mortality at all)
  - That just shows that survival conditions had got better in Italy from 1961 to 1991.

Outline

Proximate determinants of fertility

Proximate Determinants of Fertility

Davis and Blake (1956) suggested two types of factors mainly affect fertility: the direct (or proximate determinants) and distal (or indirect determinants, also called background factors)[a].

- The proximate determinants (PD) of fertility are both biological and behavioral determinants that affect the fertility **directly.**
- The indirect factors such as socio-demographic and culture influence fertility through these proximate determinants but indirectly.

[a]Davis K, JB. *Social structure and fertility: an analytic framework.* Econ Dev Cult Chang. 1956 ;112–135.

Proximate determinants of fertility

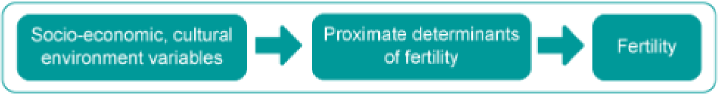

Figure: 24. Distal and proximate determinants of fertility. Proximate determinants have **direct effects on fertility**. Source: Bongaarts and Potter (1983)

Proximate determinants of fertility

Proximate Determinants of Fertility

- If a *proximate fertility variable*, such as the prevalence of contraception changes, then fertility necessarily changes (assuming the other proximate determinants fertility variables remain constant),
  - Notice this is not necessarily the case for an indirect determinant, such as income or education.
- If properly measured and modeled, proximate determinants can express fertility behavior with reasonable accuracy.

Proximate determinants of fertility

Underlying cases in action

Thus, the underlying causes operate through the proximate determinants (causes) affecting fertility.

- For example:
  - Underlying causes: Changes in the role and status of woman in society contributes to changing marriage patterns.
  - Proximate determinant: Changes in the age of marriage and the proportion of married women have a direct effect on fertility.

Proximate determinants of fertility

11 proximate determinants

In the mid-1950s, Davis and Blake proposed eleven proximate determinants of fertility. Later, Bongaarts, in the late 1970s, and Bongaarts and Porter (1983)[a] refined Davis and Blake's framework into 7 important factors.

- *1) The proportion of married women; 2) prevalence of contraception; 3) rate of induced abortion, 4) frequency of sexual intercourse; 5) sterility; 6) spontaneous intrauterine mortality; 7) and duration of the fertile period.*
- The degree at which these different intermediate factors affect fertility varies between societies.

[a]- Bongaarts, J. and Porter, R.J. (1983) *Fertility biology and behavior: An analysis of the proximate determinants of fertility.* Academic Press, New York.; Bongaarts J.(1978) *A framework for analyzing the proximate determinants of fertility.* Popul Dev Rev.; 4(1):105–132. doi: 10.2307/1972149

Proximate determinants of fertility

Classic Bongaarts and Porter model

There is debate about the nature and relative importance of the underlying causes.

- Partially because they are difficult to identify and measure, but also because their influence varies over time and from place to place.
- In contrast, proximate determinants are easier to identify and have been widely studied
- In this regard, there is the iconic work of Bongaarts (1982), who showed that 4 determinants are most important in terms of explaining variations in fertility levels of populations[a].

[a] Bongaarts J. (1982) *The fertility-inhibiting effects of the intermediate fertility variables*. Stud Fam Plann. Jun-Jul;13 (6-7): 179-89. PMID: 7112629

Proximate determinants of fertility

B & P's proximate determinants

Bongaarts' research suggests only four proximate determinants account for most of the variations in fertility in the world:

- 1) Marriage (or cohabitation)[a]
- 2) Contraception (contraceptive use and effectiveness)
- 3) Induced abortion
- 4) Postpartum infecundability

[a] i.e., proportions of women married or in sexual union as proxy of % of women exposed to sexual intercourse

Proximate determinants of fertility

B & P's proximate determinants

Those 4 proximate determinants are of most importance because they differ greatly between populations and because fertility is highly sensitive to changes in them. This led Bongaarts to imagine a model for computing the fertility rate as well as the contribution of each PD.

- However, with changes in population reproductive behaviors, some original assumptions have become less accurate over time and necessitate modification.
  - e.g., nowadays, sexual activities are often not confined only within marriage.
- These limitations of Bongaarts' model were later revised by John Stover (1998) and, in turn, Stover's work was updated with some modifications in 2015 on three of the four components[a].

[a]Bongaarts J. (2015) Modeling the fertility impact of the proximate determinants: time for a tune-up John Bongaarts. Demogr Res.; 33:535–560. doi: 10.4054/DemRes.2015.33.19

Proximate determinants of fertility

Bongaarts' aggregate model of the proximate determinants of fertility

- The marriage index, C_m , refers to the proportion of married women calculated according to age group
  - $C_m = 1$ if all are married
  - $C_m = 0$ if no one is married.
- The contraception index, C_c, considers the prevalence and effectiveness of contraception
  - $C_c = 1$ if there's no contraception or it is totally inefficient;
  - $C_c = 0$ if all fecund women use 100% effective contraception.

Proximate determinants of fertility

Bongaarts' aggregate model of the proximate determinants of fertility

- The induced abortion rate, C_a;
  - $C_a = 1$ if there are no induced abortions
  - $C_a = 0$ if all pregnancies are aborted.
- The postpartum infecundability rate, C_i,
  - $C_i = 1$ in the absence of breastfeeding and postpartum abstinence;
  - $C_i = 0$ if the post-partum infecundability is infinite (post-partum infecundability modifies the intervals between births).

Proximate determinants of fertility

Whta is that maximum fertility level?

Note that fertility is directly affected by the proximate determinants depending on the value those four indexes may take.

- When all indexes are 1, then there's no reduction in fertility
  - i.e., fertility is at its maximum.
  - The question is: what is that maximum?
- Recall that from a theoretical viewpoint, it's believed that the maximum fertility level a human population can reach is a $F_{max} = \text{TFR}_{max} \approx 15$.
  - If the proximate determinants take a value between 0 and 1, that affects (reduces) that maximum.
  - When all of them are 1, then we should observe just F_{max}!

Proximate determinants of fertility

Bongaarts' aggregate model of the proximate determinants of fertility

Thus, a way of mathematically express those conditions is the following:

$$\mathrm{TFR} = C_m C_c C_a C_i F_{max} \tag{4}$$

- What are the possibilities? Well...we may have different values for each coefficient, giving different final proportions of F_{max}.

Proximate determinants of fertility

Some possible scenarios

The following are some possibilities:

- When all indexes are 1:

$$\text{TFR} = 1 * 1 * 1 * 1 * F_{max} = F_{max}.$$

- If, say, marriage influence reduce to half:

$$\text{TFR} = 0.5 * 1 * 1 * 1 * F_{max} \approx 7.5.$$

- If marriage and contraception indexes are both 0.5:

$$\text{TFR} = 0.5 * 0.5 * 1 * 1 * F_{max} \approx 3.8.$$

- Note that if two populations have the same TFR, that can be due to a different combination of proximate determinants.

Proximate determinants of fertility

Bongaarts pros and cons

Bongaarts proximate determinants framework is theoretically strong, but of course, it is a simplification of reality.

- It does not intent to obtain an accurate estimate of total fertility rate. Rather, it is intended to aid the analysis and explanation of fertility differentials, by focusing on the links between the proximate fertility variables and various socio-economic and cultural 'background' factors.

Proximate determinants of fertility

Bongaarts pros and cons

- Be aware that the framework was developed in the 1970s when individual demographic data were scarce.
  - Information such as the data on abortion, effectiveness of contraceptive use and sexual activities, were hard to obtain accurately.
- Baschieri and Hinde (2007)[a] applied the model to explain the variations in birth intervals between the first and second children using individual's contraceptive calendar data from an Egyptian Demographic and Health Survey (DHS).

[a] Baschieri, A; Hinde, A (2007) The proximate determinants of fertility and birth intervals in Egypt: An application of calendar data. Demographic Research, 16. pp. 59-95. ISSN 1435-9871

Proximate determinants of fertility

Some improvements

In trying to improve the Bongaarts model, Stover (1998)[a] revisited and proposed a new version.

- The main changes of his revision are:
  - Instead of proportion of married, proportion of sexually active women are considered.
  - An index of pathological sterility is added.
  - Overlap between contraceptive use and infecundity is taken into account.
  - Overlap between contraceptive use and postpartum amenorrhea is adjusted.
  - Since sterility is added, then there's a change from Total Fertility F_{max} to Potential Fertility.

[a]Stover, J. (1998). Revising the Proximate Determinants of Fertility Framework: What Have We Learned in the past 20 Years? Studies in Family Planning, 29(3), 255–267. https://doi.org/10.2307/172272

Bottomline

Bottomline

- 1. The study of human behavior regarding fertility (and family) is essential to understand social changes.
- 2. Analizing fertility and family is more than calculating rates and indices, although they are key indicators.
- 3. To elucidate about possible trends and changes means doing research on the characteristics of individuals, the experiences of their life stories and the reasons behind their personal decisions.
- 4. The social context, including cultural practices, law and policies, is also important to explain the changes in fertility and family, due to the influence in the lifestyles of people and their opportunities and expectations in life .

John Bongaarts

John Bongaarts

John P. M. Bongaarts (born 1945) is a Dutch-American demographer. He serves as Vice-President and Distinguished Scholar at the Population Council, where he has worked since the 1970s.

- Bongaart has performed research in a diverse set of topics, such as population growth and aging, mortality, population-environment links and demography related to the epidemiology of HIV/AIDS. His most recognized work lies in the field of fertility, and has been a topic of interest throughout his career.

John Bongaarts

John Bongaarts

Figure: 25. John Bongaarts, a world renowned demographer with an unorthodox academic trajectory.

John Bongaarts

John Bongaarts

Bongaarts was born in Tegelen, the Netherlands, in 1945.

- He obtained a degree in electrical engineering from Eindhoven University of Technology in 1968.
- Later he studied physiology and biomedical engineering at the University of Illinois (US) and obtained his PhD in 1972, with a dissertation titled: "A Cybernetic Model of the Demographic Transition". He subsequently was a postdoctoral fellow at Johns Hopkins University.
- He started working as associate for the Center for Population Studies of the Population Council in 1973. By 1982 he had become senior associate. In 1988 he became deputy director. The next year he was promoted to vice president of the policy research division. Since 2007 he also serves as distinguished scholar.