Outline

The child-women ratio

Child-women ratio

We need some definitions to quantify fertility. A first attempt is just having an idea of how many kids there are per fecund woman. Let's define the following:

- **Kids**: those whose age is in $[0, 5)$
- **Fecund women**: those whose age is in $[15, 50)$.

$$\text{CW} = \frac{\text{Children aged in } [0,5)}{\text{Women aged in } [15,50)}.$$

The given definitions may be debatable, but they are a starting point. Also, they can be adjusted depending on the purpose of the study.

The child/women ratio

A CW example

Based on historical data, the CW ratio for Bangladesh in 1974 was

$$CW_{Bangladesh} = \frac{14649}{14952} \approx 0.98;$$

- Analogously, for England and Wales in 1985, the CW ratio was 0.29[a].
- In Bangladehs 1974, the CW ratio says that there are 0.98 kids aged $[0, 5)$ per fecund woman. It's almost a 1:1 relationship.
- An about England and Wales 1985, it was just 0.29, or approximately, almost 1 kid aged $[0, 5)$ per 3 fecund woman. It's almost a 1:3 relationship.

[a] It's important to consider the **same definitions for kids and fecund women**, so the ratio are **comparables.**

The child/women ratio

Remarks

The CW ratio is useful for having a broad idea of the level of fertility.

- Notice that no data on births are needed, just information about the age and sex structure of the population! This is particularly useful when using data from the census.
- It's also an extremely crude measure, but in general, **when fertility is high, so do the CW,** and viceversa.

The child/women ratio

Some risks

It is, however, very sensitive to reporting errors and to the level of infant mortality; i.e, it is not wise to compare levels of fertility between countries having very different conditions on those aspects.

- In the last example, it's risky to compare fertility levels this way because **mortality and reporting levels were certainly very different** in Bangladesh and England and Wales back in those days. The comparison has to be taken carefully.

The Crude Birth Rate

The Crude Birth Rate (aka, Crude Fertility Rate)

Another way of measuring fertility is the so called Crude Fertility (or Birth) Rate[a], defined as

$$\text{CBR} = \frac{\text{Births in a year}}{\text{Population at mid year}}.$$

- As it happens with other measures,the CBR is usually multiplied by 1000, for easy reading and interpretation.

[a] In Spanish, this is translated as "Tasa bruta de natalidad"

The CBR

Some drawbacks

There are still some drawbacks with the CBR.

- It includes all ages and both sexes in the denominator.
  - It doesn't relate births to women at risk of having those births. Thus, it's not a measure of fertility, strictly speaking.
  - Indeed, according to the definition, it's not a true rate, but just a ratio.

The CBR

Somehow it might work

However, it still gives some good numbers for understanding fertility in a broad sense. For example:

- Throughout the Demographic Transition, CBRs have gone from 35 per thousand to a minimum of 10 per thousand.
- During the Second Demographic Transition, it is expected (it is observed) that they fall below 10 per thousand.
- In 2000, Hong Kong, Japan and several European countries (Germany, Italy, Spain) they had CBR of less than 10 per thousand.

The CBR

- So to speak, the CBR for Bangladesh 1974 was around 48 births per 1000 people. That was quite high.
- On the other hand, the CBR for England and Wales 1985 was around 13 births per 1000 people.
  - As a reference, the whole UK in 2016 had a CBR around 12.
  - The CBR has decreased not that much partially due to immigration.
  - Immigrants come from countries with other fertility habits or traditions, so fertility among them is usually higher than in natives.

The CBR

Country	1960	2016 ▲	
Japan	17	8	
Italy	18	8	
Monaco		8	
Korea, Rep.	42	8	
San Marino		8	
Hong Kong SAR, China	35	8	
Portugal	24	8	
Greece	19	9	
Spain	22	9	
Andorra		9	
Croatia	18	9	

Figure: 4. CBR comparison between 1960 and 2016. Source: data.worldbank.org

The CBR

Country	Most Recent Year	Most Recent Value ^	
Korea, Rep.	2020	5	
Puerto Rico	2020	6	
Hong Kong SAR, China	2020	6	
Monaco	2018	6	
San Marino	2020	6	
Japan	2020	7	
Italy	2020	7	
Andorra	2019	7	
Spain	2020	7	
British Virgin Islands	2020	7	

Figure: 5. (2020) Top countries with the lowest CBRs around the world. Source: *https://data.worldbank.org/indicator/SP.DYN.CBRT.IN?most_recent_value_desc=*

The CBR

Country	1960	2016
Niger	58	48
Somalia	48	43
Chad	46	43
Mali	50	43
Congo, Dem. Rep.	47	42
Burundi	48	42
Uganda	50	42
Angola	55	42
Gambia, The	49	39
Mozambique	50	39
Burkina Faso	47	39

Figure: 6. CBR comparison between 1960 and 2016. Source: data.worldbank.org

The CBR

Country	Most Recent Year	Most Recent Value
Niger	2020	46
Somalia	2020	44
Chad	2020	44
Congo, Dem. Rep.	2020	42
Central African Republic	2020	42
Mali	2020	42
Angola	2020	39
Nigeria	2020	37
Uganda	2020	37
Benin	2020	37

Figure: 7. (2020) Top countries with the highest CBRs worldwide. Source: data.worldbank.org

The CBR

Remarks

Numbers show that the CBR may range typically from 10 up to 50.

- However, the CBR shows a (somehow alarming) decreasing trend over the past decades and few years.
- Still, the problem with the CBR is that it's greatly affected by the population structure, like age and sex composition.
  - It can be misleading for comparing fertility levels among populations, whether now or in the past.
- Still, it's very popular since requires few data and is easy to calculate.

The General Fertility Rate

The General Fertility Rate

A step further in getting a more precise measure of fertility is the General Fertility Rate[a]

The **General Fertility Rate (GFR)** is defined as

$$\text{GFR} = \frac{\text{Births during a year}}{\text{Women aged } [15, 50) \text{ at mid year}}.$$

- As before, it is typically multiplied by 1000.

[a] In Spanish, this is "Tasa General de Fecundidad"

The GFR

Advantages over the CBR

The main advatage of the GFR, is that, unlike the CBR, it does (kind of) control for age and sex structure. Also, it relates births just to women at risk of having them.

- However....**it does not contol entirely for age structure**
  - This is because there may be great variations between populations within reproductive ages, and the denominator includes all women from $[15, 50)$![a]
- Also, as seen before, **fertility is not the same throughout the women's reproductive age**
  - The GFR requires further refinements.

[a] This is a hint for constructing a new index...one that takes into account the women fertility within age intervals.

The Age Specific Fertility rate

Going further into refinements

A more refined measure of fertility is the so called **Age Specific Fertility Rate** (ASFR)[a]:

$$\text{ASFR}_{x,h} = F_{x,h} = \frac{B_{x,h}}{W_{x,h}}, \tag{1}$$

where $B_{x,h}$ are the number of births in a year to women aged $[x, x+h)$, and $W_{x,h}$ are women aged $[x, x+h)$.

- As before, the $\text{ASFR}_{x,h}$ is usually multiplied by 1000.

[a] In Spanish, this is "Tasa de Fecundidad Específica por Edad".

The ASFR

Remarks

As for the value of h in Eq.(1), this can be different depending on the study. However, $h = 1$ or $h = 5$ are typical values.

- Notice there is a big jump in data requirements over the measures considered.
  - Now it's necessary to have births by age of mother.
  - Sometimes, in some places, that could be not available or not reliable.

The ASFR

Remarks

When available, **ASFRs can be plotted, and they tend to show regular features.**

- In traditional societies, women have children at early ages and more or less high levels during their fertile years.
- In modern societies, the level of fertility decreases and the calendar of maternity is delayed.

The ASFR

Age	[1968] 1966-1970	[1978] 1976-1980	1986	1996	2006
15-19	0.044	0.030	0.018	0.014	0.009
20-24	0.175	0.116	0.093	0.075	0.060
25-29	0.165	0.121	0.129	0.136	0.127
30-34	0.099	0.062	0.074	0.107	0.123
35-39	0.049	0.022	0.022	0.041	0.052
40-44	0.014	0.004	0.004	0.007	0.009
45-49	0.001	0.000	0.000	0.000	0.000

Figure: 8. ASFRs for Norway. Source: https://www.ssb.no

The ASFR

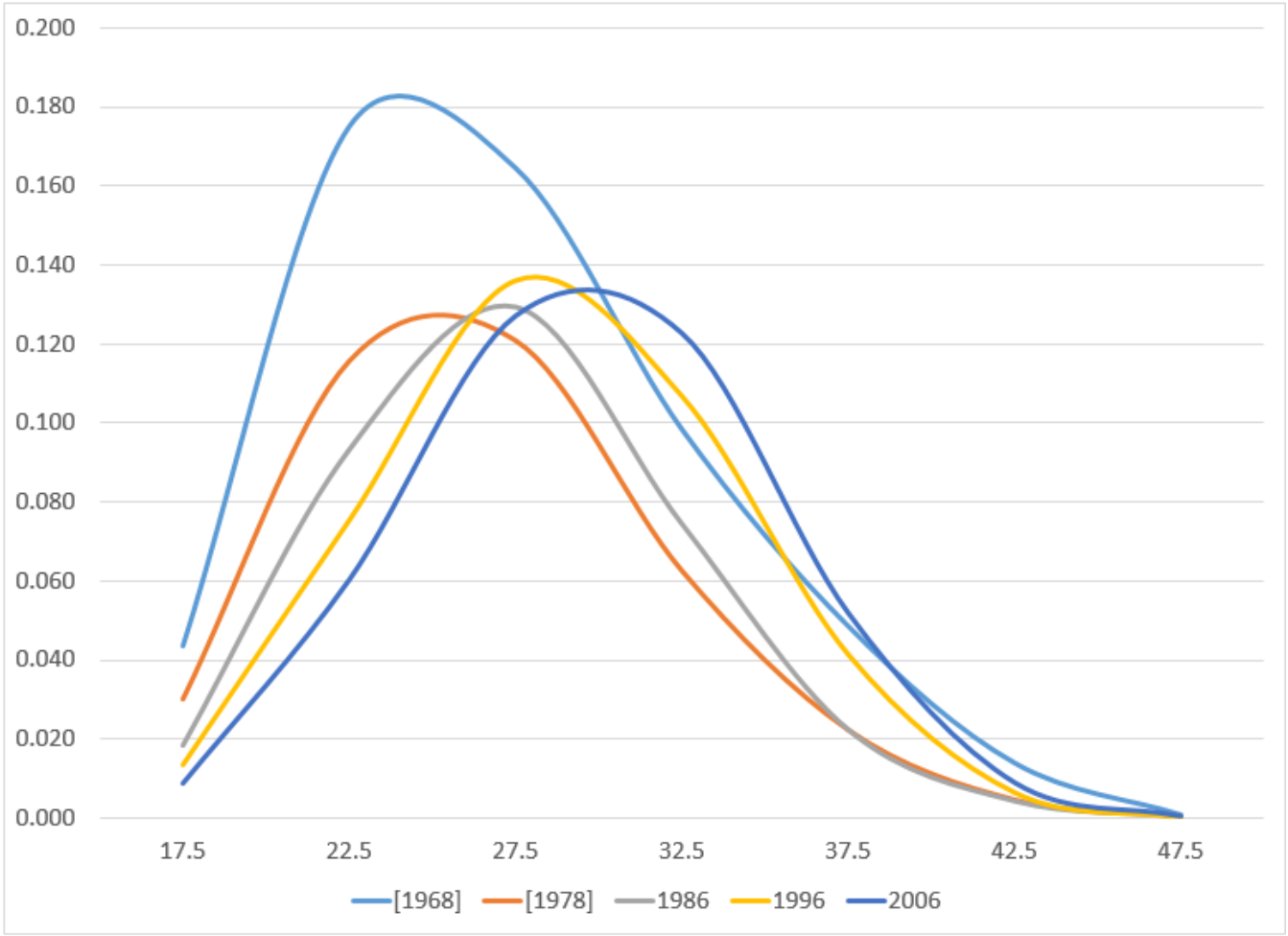

Figure: 9. ASFRs (from Figure 8), Norway.

The ASFR

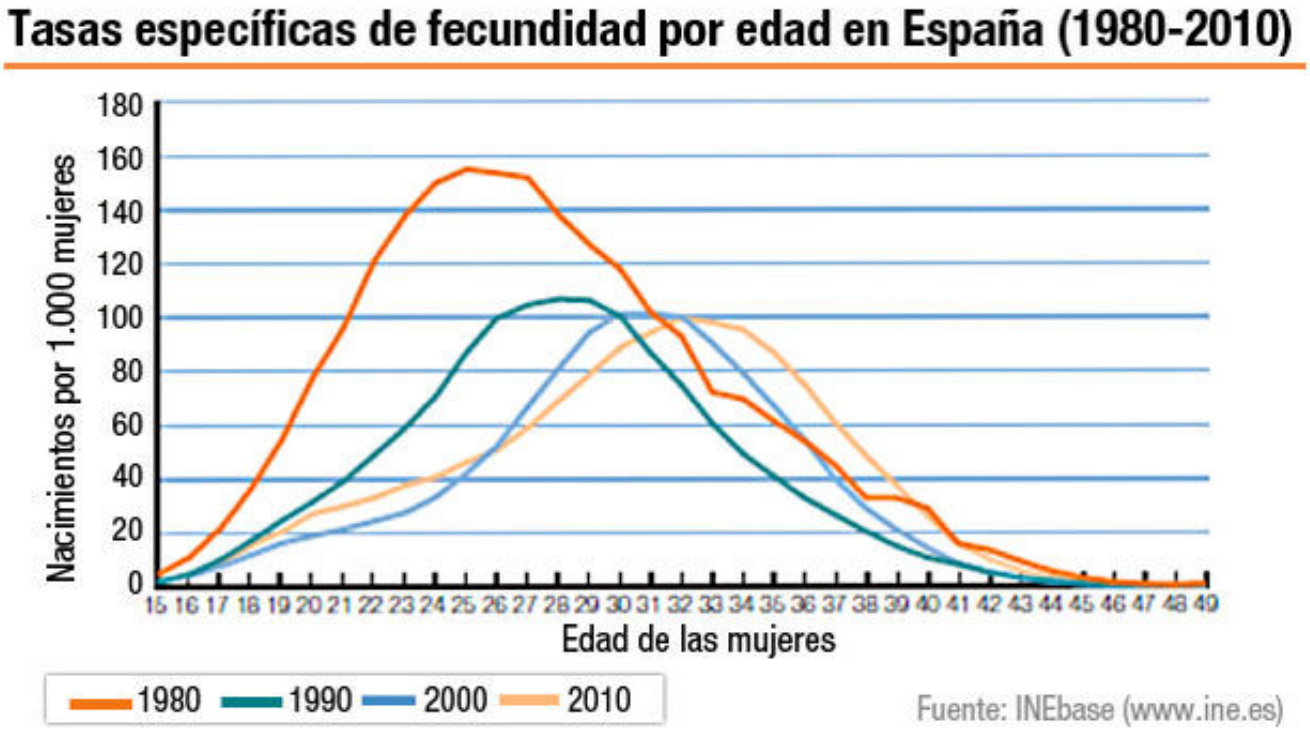

Figure: 10. ASFRs, Spain.

The ASFR

Remarks

Highlights:

- Fertility rates rise rapidly, peaking in the mid-twenties—or, in some developed countries, even in the early thirties.
- After age 40, fertility gradually declines to low levels.
- These regular patterns make ASFRs well-suited for mathematical modeling (Coale, Trussel, 1974) (Brass, 1981).

The ASFRs

Fertility level and calendar

In the case of Norway, we see that the curve of ASFRs (as a whole) has decreased in "altitude" over time.

- We say that the **fertility level has decreased.**
- We also see that the peak of the curve is reached later
  - In 1968, the peak was reched at around 24 or 25 years of age.
  - By 2006, the peak was reached at around 30 years.
  - We say that **the calendar of fertility has shifted.**

The ASFRs

Remarks

We can assess fertility levels and trends by examining the ASFR curves. However, there is a major drawback:

- We still don't have a single number to measure fertility levels; instead, we have at least seven different numbers, which are then converted into plots.
- This makes direct comparisons more challenging.

The Total Fertility Rate

Total Fertility Rate (TFR)

Perhaps, the most widely measure of fertility among demographers is the **Total Fertility Rate**[a]:

$$\text{TFR} = h \sum_{i=a}^{b} F_{i,h}. \tag{2}$$

- a is the age at which we consider fecundity has started.
- b is the age at which the last fecund interval starts.
- h is the length of the intervals.
- If $h = 5$, then $a = 15$ and $b = 45$.

[a] **In Spanish: "Tasa Global de Fecundidad"**

The TFR

Age	1966-1970 [1968]	1976-1980 [1978]	1986	1996	2006
15-19	0.044	0.030	0.018	0.014	0.009
20-24	0.175	0.116	0.093	0.075	0.060
25-29	0.165	0.121	0.129	0.136	0.127
30-34	0.099	0.062	0.074	0.107	0.123
35-39	0.049	0.022	0.022	0.041	0.052
40-44	0.014	0.004	0.004	0.007	0.009
45-49	0.001	0.000	0.000	0.000	0.000
TFR	2.729	1.776	1.709	1.898	1.901

Figure: 11. ASFRs and TFRs, Norway. Source: https://www.ssb.no.

The fertility structre

Fertility structure

In studying mortality, having a set of ASDRs means to have a mortality structure. In fertility studies, having a set of a calendar year ASFRs means to have a fertility structure.

- For example, in the last figure, for the year 1986, the set of ASFRs is the fertility structure in that calendar year.
- Notice that this fertility structure encompasses the fertility patterns of different generations: youngsters at 15 and mature women at 49 years of age.

The TFR

TFR interpretation

The great value of the TFR consist of being **a single number independent of age structure.** Notice the GFR only partially controls for age structure, while the CBR doesn't do so at all.

- Formally, the Total Fertility Rate (TFR) can be understood as **the number of children a woman would have** if:
  - 1) She survives to age 50, and
  - 2) She spends her reproductive years having children according to the fertility structure of a specific calendar year (i.e., the set of Age-Specific Fertility Rates (ASFRs) for that year).

The TFR

TFR interpretation

Notice that the TFR is a somewhat artificial measure.

- Its interpretation implies assuming that, during all her fertile years, a woman's reproductive behavior is according to the fertility structure of a certain calendar year.
- For example, in the last figure: *if a single woman went through her entire reproductive life according to the 1986 fertility structure, at the end of her reproductive life she would have 1.709 children.*
- Although the calendar-year fertility structure encompasses many different generations, we can somehow verify that in general, the fertility trends are changing in time.
- In the case of Norway, fertility went from 2.7 children per woman in 1968, to 1.7 in 1986. Over the next two decades, fertility went a bit up, but still below replacement levels.

The TFR

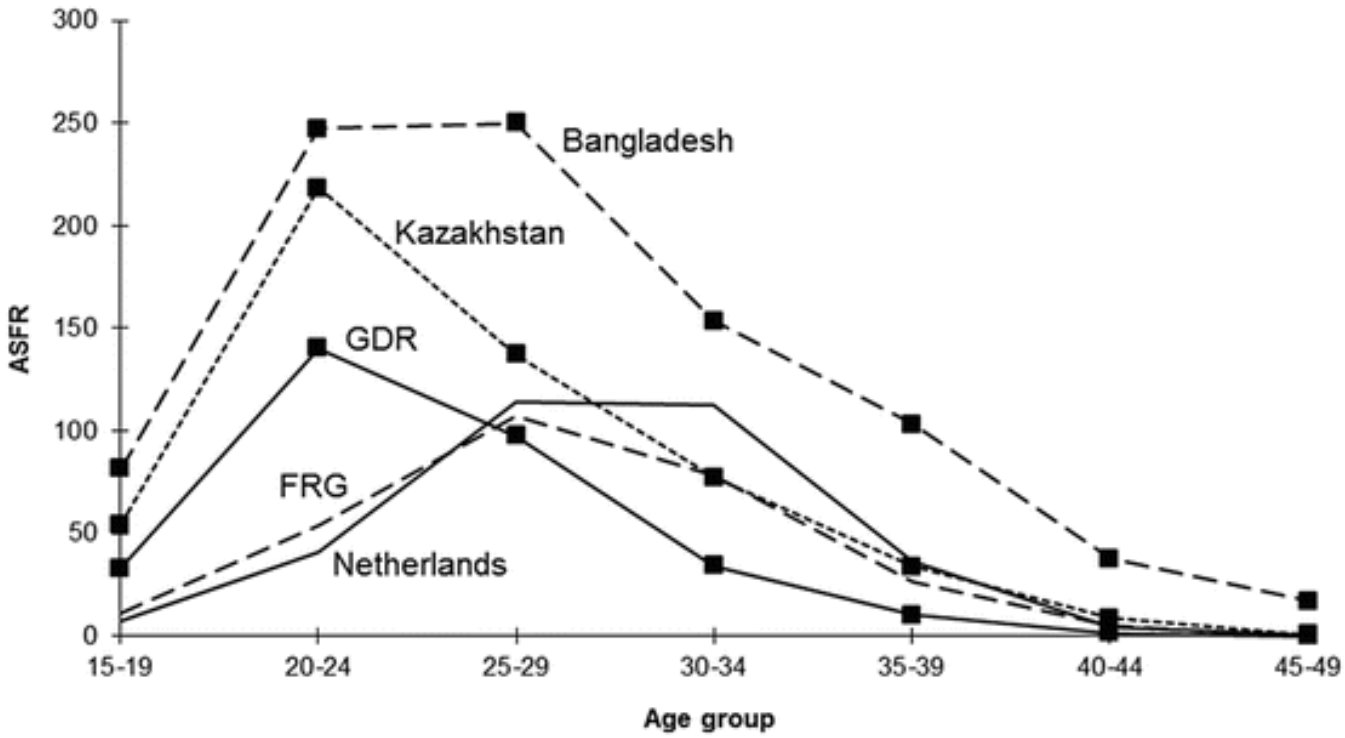

Figure: 12. ASFRs curves $[F(t)]$ for different countries in the early 1990s (Source: United Nations demographic yearbook, 1994)

The TFR

Measuring the calendar of fertility

Just as it is defined, note that the TFR is an approximation of the area under the curve of $F(t)$ (where t is age).

- This approximation is done by means of rectangles, each of area $hF_{i,h}$.
- Thus, it is the area under the curve of $F(t)$ which gives us a measure of the fertility level!

The TFR

Measuring the intensity (level) and calendar of fertility

- By means of the TFR we have a measure of the fertility level, but still *we need a way of measuring the calendar of fertility.*
- A way of measuring the **fertility calendar** is by calculating a central point for the set of ASFRs.
  - We can measure that by calculating the **average age at motherhood**
- Whenever we detect the average age at motherhood increases, *that shifts to the right the fertility structure*, meaning that the fertility calendar delays.

The TFR

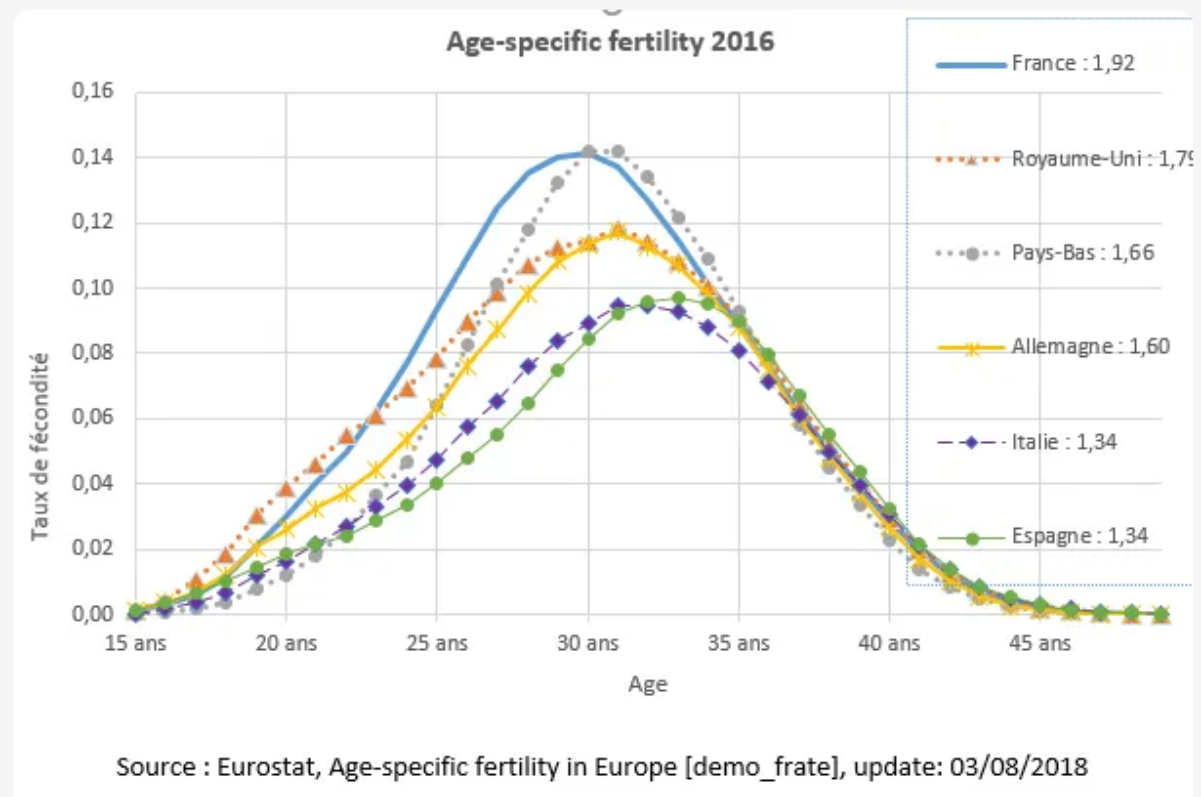

Figure: 13. ASFRs for selected european countries, 2016. Notice that the TFR, as defined in Eq. (2), is just an approximation to the area under the curve of the (hypothetical) continuous ASFR curve. Source: https://www.ined.fr/en/everything_about_population/graphs-maps/interpreted-graphs/fecondity-europe/

The average age to motherhood

Average age to motherhood

The **average age to motherhood** can be calculated by

$$\bar{a}_m = \frac{\sum_{x=a}^{b} F_{x,h} \left[\frac{1}{2}(2x+h)\right]}{\sum_{x=a}^{b} F_{x,h}}.$$

- Notice that factor $0.5 * (2x + h)$ is the midpoint whithin each interval
- Note that $\bar{a}_m$ is a weighted average of the mid points ages at each interval, weighted by the specific fertility rates.

The TFR

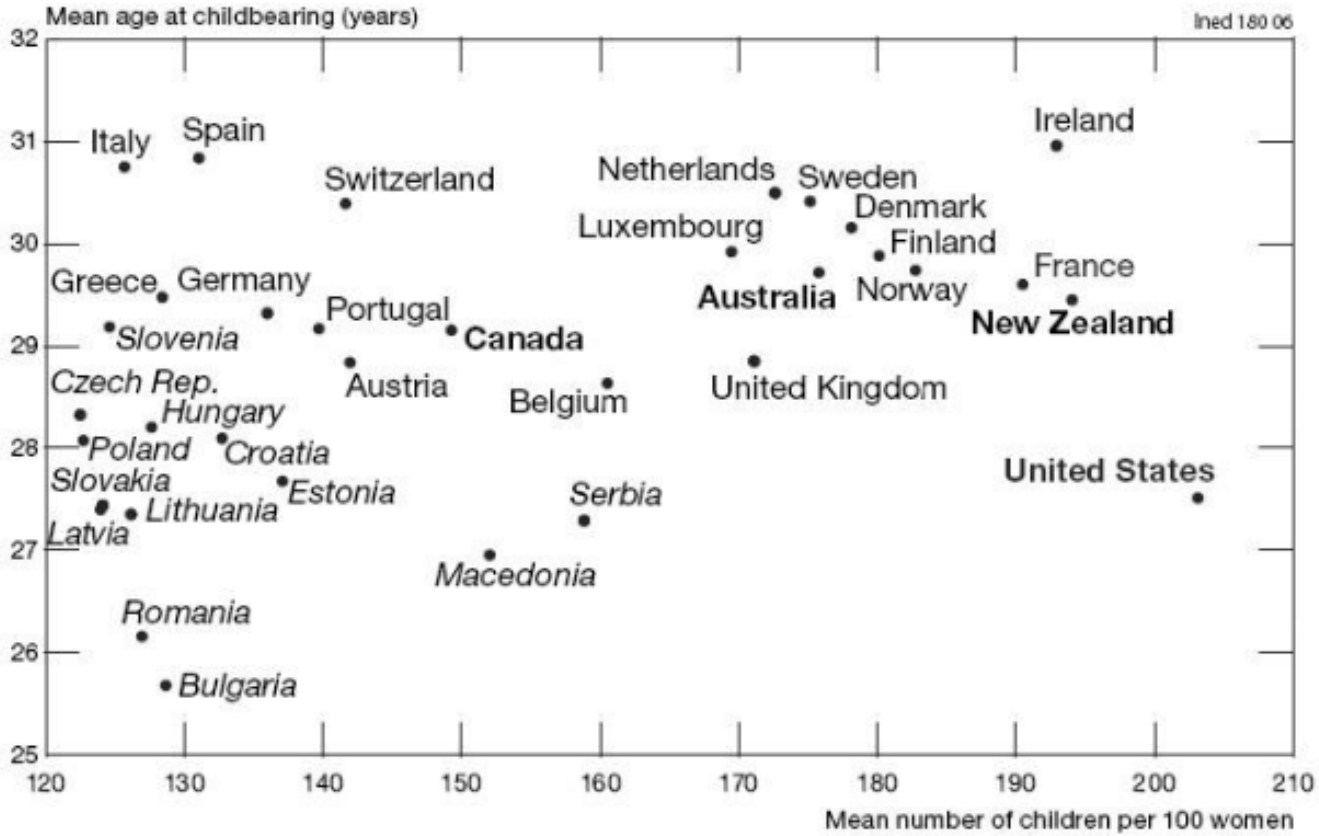

Figure: 14. Vertical: the calendar of fertility. Horizontal: TFR (per 100 woman). Source: Sardon, J. (2006). La fécondité dans les pays anglophones développés hors d'Europe: Canada, États-Unis, Australie et Nouvelle-Zélande. Population, 61, 301-328. https://doi.org/10.3917/popu.603.0301

The TFR

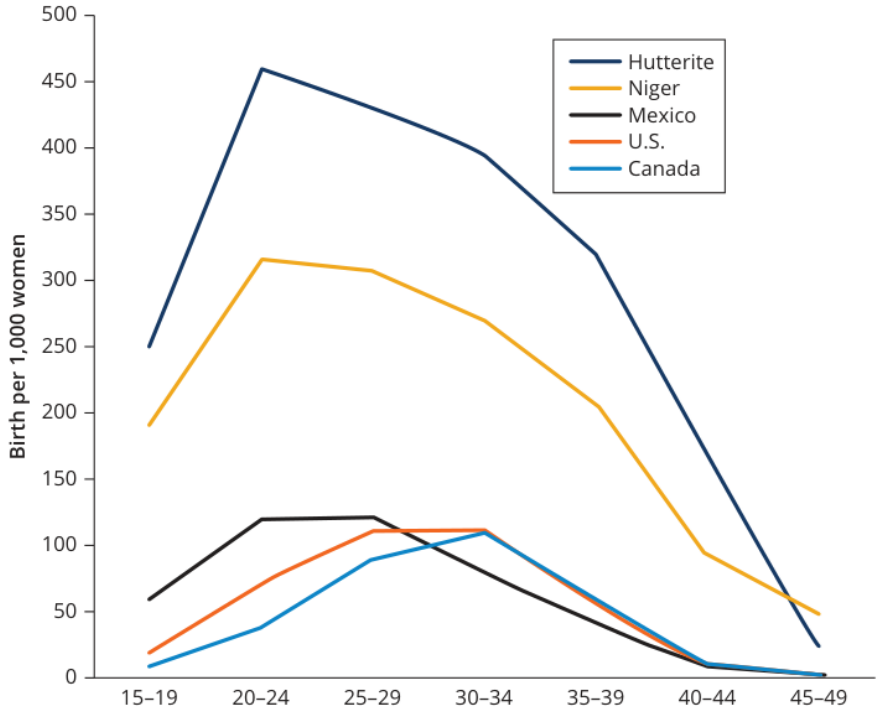

Figure: 15.Hutterite "Natural" Fertility Compared with Fertility Levels in Contemporary Niger, Mexico, the United States, and Canada. Hutterite data are from 1986, and the data for Niger, Canada, Mexico, and the United States are from United Nations Population Division (2017). Weeks, J. R. (2021). Population: An introduction to concepts and issues (13th ed.). Cengage Learning.

Activity

Example (activity)

Consider the data in the Excel file regarding fertility in Italy in 1961 and 1991.

- Calculate the level of fertility for both years by means of the TFR
- Calculate the calendar of the fertility for both years.
- Plot the curves of ASFRs for both years as well as the average age to motherhood.

Tables and plots

Age-specif fertility rates and total fertility rates for Italy, 1961 and 1991 (pop in 10^3)								
	Births		Women		ASFR		ASFR (per 1000 women)	
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 =	**2.4**	**1.3**		

Figure: 16. Source: United Nations 2000. Demographic Yearbook, Historical Supplement 1948-1997

Tables and plots

	ASFR			
Mid Point	1961	1991		
A	B	C	AB	AC
17.5	0.0187	0.0081	0.3273	0.1411
22.5	0.1113	0.0497	2.5047	1.1183
27.5	0.1572	0.0907	4.3230	2.4935
32.5	0.1127	0.0718	3.6637	2.3345
37.5	0.0611	0.0293	2.2901	1.0979
42.5	0.0227	0.0052	0.9641	0.2191
47.5	0.0017	0.0002	0.0815	0.0083
SUM =	0.4854	0.2549	14.1544	7.4126
		AVG age =	29.2	29.1

Figure: 17. Source: United Nations 2000. Demographic Yearbook, Historical Supplement 1948-1997

Fertility levels and calendars

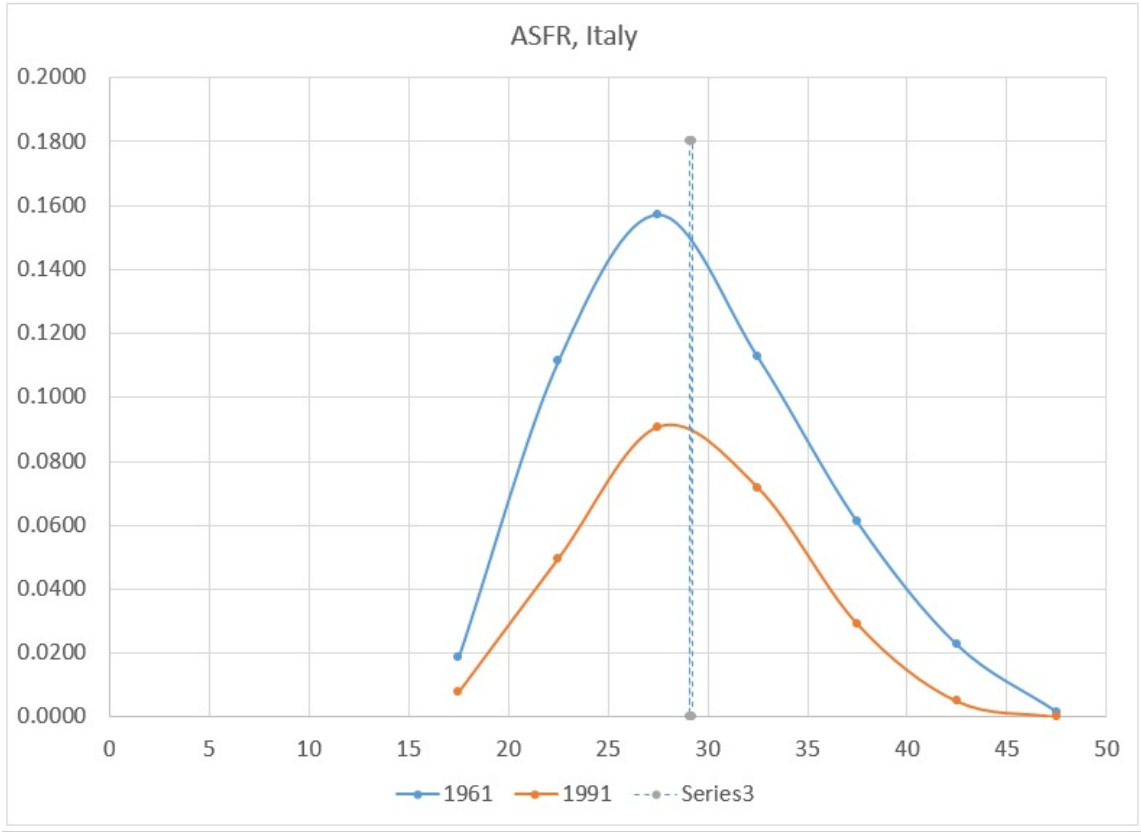

Figure: 18. Fertility levels and calendars for Italy, 1961 and 1991. Notice that the average age to motherhood didn't change that much. What changed was the level of fertility.

Marital and non-martial ASFRs

Marital status as a fertility factor

We have already noted that in the study of fertility, it is essential to differentiate between married and unmarried women, as this factor significantly influences their reproductive behavior.

- One of the most important distinctions between these groups is the exposure to and frequency of intercourse.
- However, with the rise of cohabitation without formal marriage, a more relevant factor to consider might be "married or in some form of cohabitation as a couple".

Marital and non-martial ASFRs

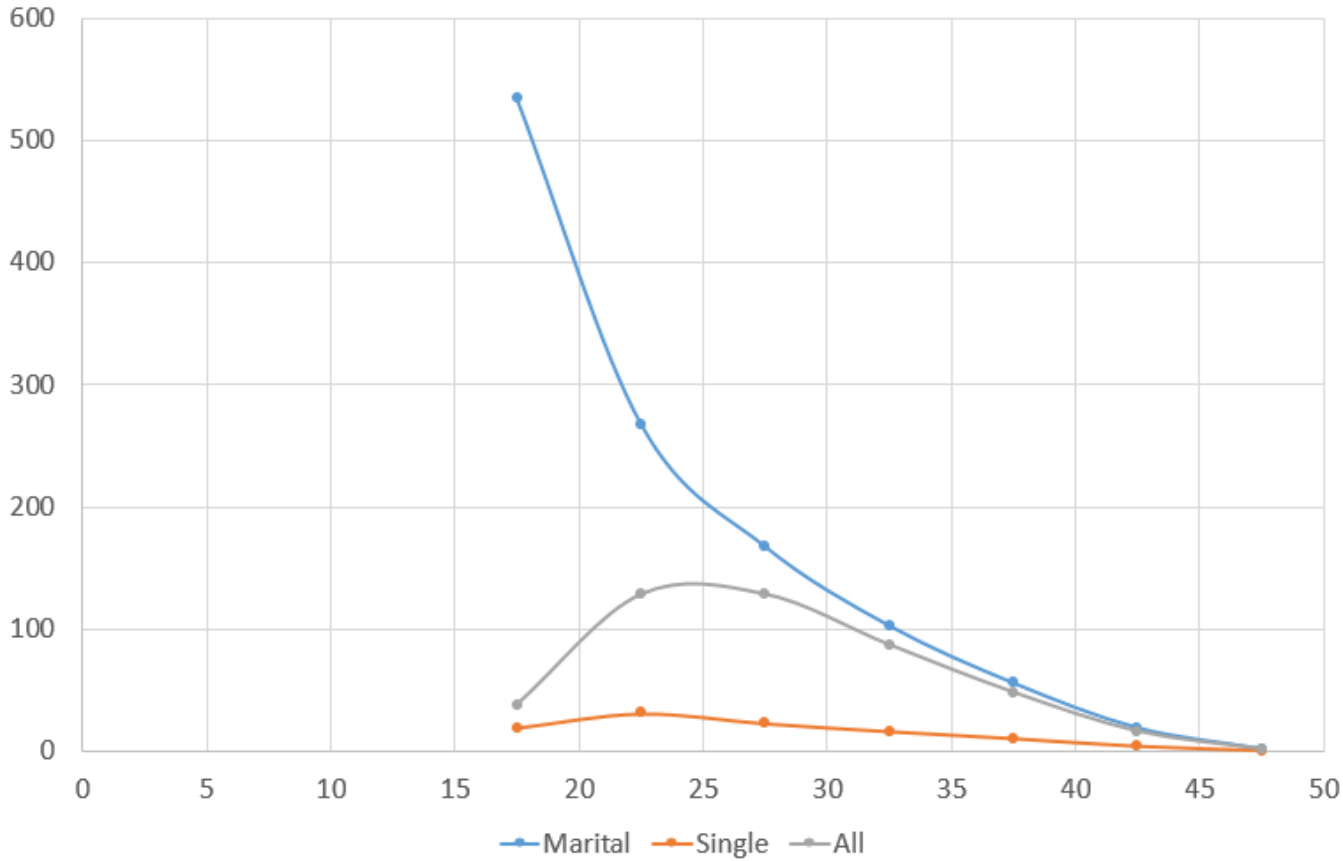

Figure: 19. ASFRs (per 1000) by marital status. Note that the overall ASFRs are the combined effect of the ASFRs of married and not married women. Sweden, 1951-1955.

Marital and non-martial ASFRs

Age	Marital	Single	All
15-19	543.0	19.0	38
20-24	268.0	31.0	128
25-29	167.0	23.0	128
30-34	103.0	16.0	87
35-39	56.0	10.0	48
40-44	19.0	4.0	16
45-49	2.0	0.2	1

Figure: 20. Marital, single and all ASFRs: Sweden 1951-1955, per 1000. Source: Statistics Sweden, 1985.

Marital and non-martial ASFRs

Question

- If the ASFRs are an average of the reproductive behavior of married and unmarried women, Could you explain why the average fertility behavior is so attracted to single women at younger ages, and so attracted to married women at older ages?
- Consider the age bracket 15-19. Calculate the corresponding weights for the $ASFR_M$ (*Marital*) and $ASFR_S$ (*Single*) so that the weighted average between both gives the global ASFR.