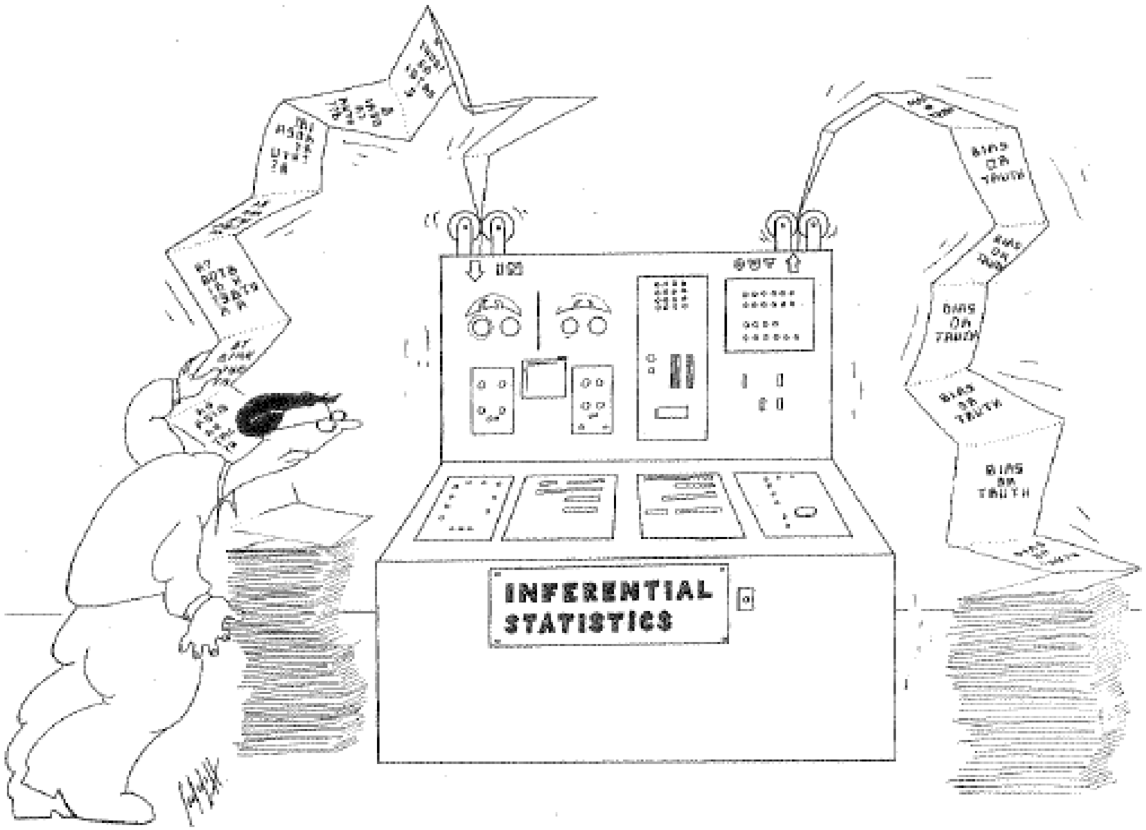
Population Projections:

Projecting Fertility and Mortality

United States Census Bureau
U.S. Department of Commerce
Economics and Statistics Administration
U.S. CENSUS BUREAU
census.gov

USAID
FROM THE AMERICAN PEOPLE

The process of developing cohort component population projections can be overwhelming!



But there are projection tools to help make the job easier, and fun!

Projecting Mortality and Fertility

- You have already determined mortality and fertility for the year around the base year population.

NOW

- Two aspects of mortality have to be projected: the level and the pattern by age and sex.

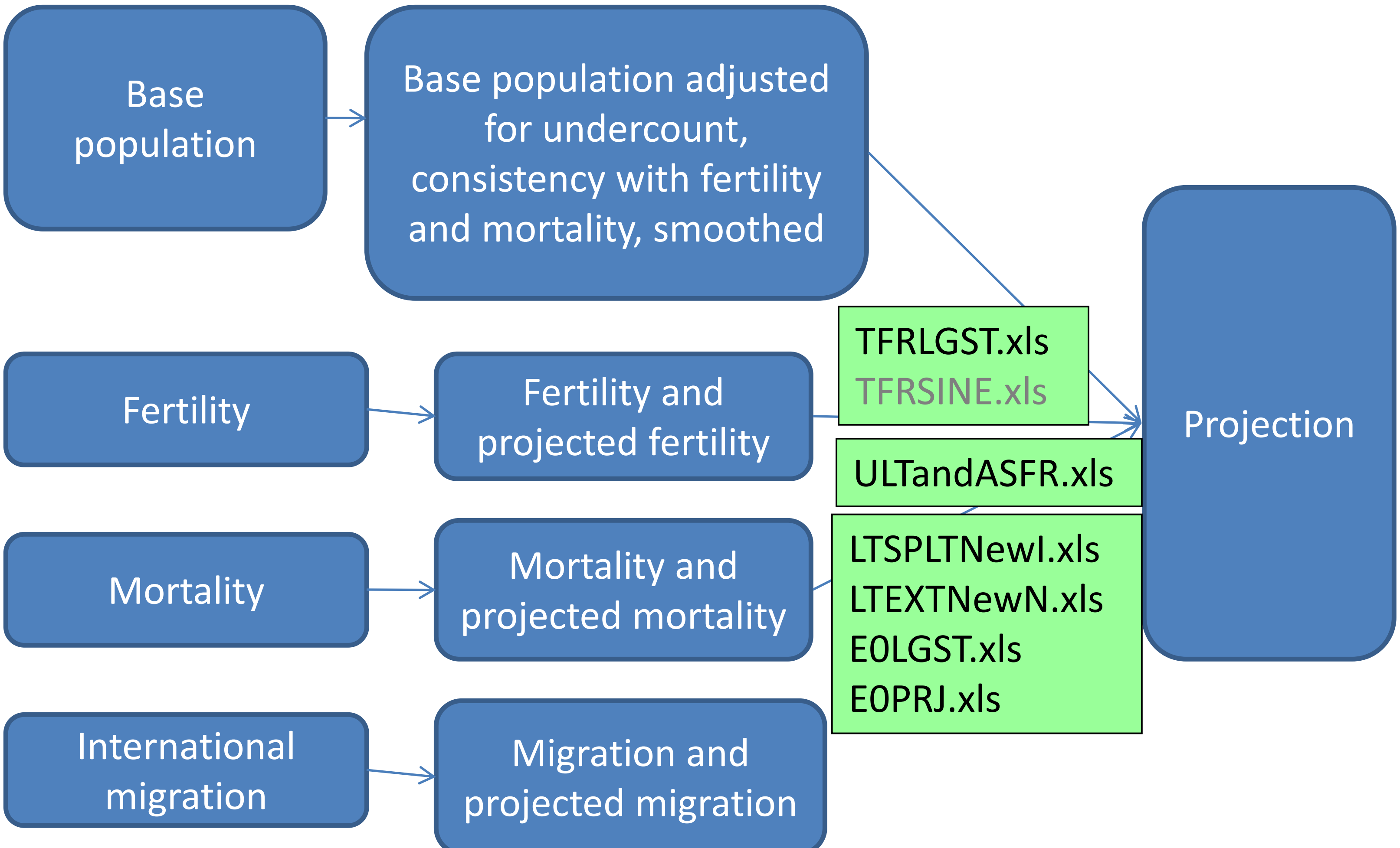
- Two aspects of fertility have to be projected: the level and the age pattern.

Projecting Mortality and Fertility Levels

Some general options for projecting overall levels (e_o and TFR)

1. Add no more information – the base year assumptions will then be held constant.
2. Choose a levels of e_0 and TFR in one or more future years. RUP will interpolate (linearly) between the values that you choose.
3. Choose logistic options, which tend to better represent future patterns of change.

Software for Logistic Projections of E(0) and TFR



From Excel help: Linear Trend

Linear

A linear trendline by using the following equation to calculate the least squares fit for a line:

$$y = mx + b$$

where *m* is the slope and *b* is the intercept.

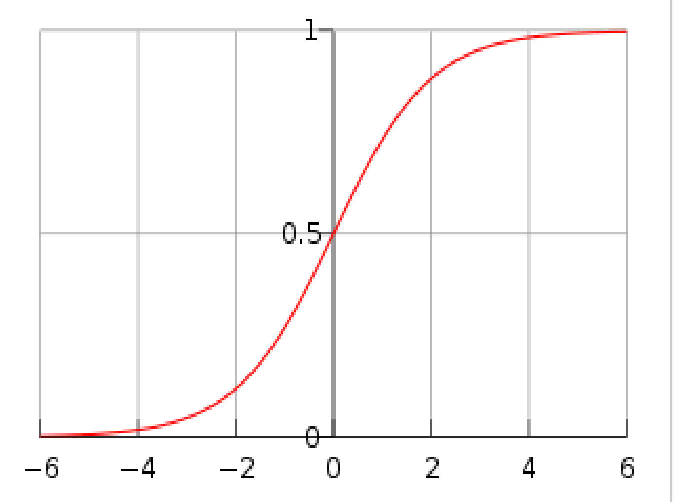
The Logistic function

Logistic function

From Wikipedia, the free encyclopedia

For the recurrence relation, see logistic map.

A **logistic function** or **logistic curve** is a common sigmoid curve, given its name in 1844 or 1845 by Pierre François Verhulst who studied it in relation to population growth. It can model the "S-shaped" curve (abbreviated S-curve) of growth of some population *P*. The initial stage of growth is approximately exponential; then, as saturation begins, the growth slows, and at maturity, growth stops.



Standard logistic sigmoid function

A simple logistic function may be defined by the formula

$$P(t) = \frac{1}{1 + e^{-t}}$$

where the variable *P* might be considered to denote a *population* and the variable *t* might be thought of as *time*[1]. For values of *t* in the range of real numbers from −∞ to +∞, the S-curve shown is obtained. In practice, due to the nature of the exponential function e^{-t}, it is sufficient to compute *t* over a small range of real numbers such as [−6, +6].

Logistic Curve

- **Particularly appropriate when you expect an S-shape, where there is an upper limit and/or lower limit on the trend:**
  - **Lowest TFR**
  - **Highest life expectancy**
  - **Percent Urban (maximum 100%)**

Projecting TFR and e_0 With Logistic Curves

Fertility (TFR) and mortality (e_0) can be projected beyond the reference date of the last available empirical data point using a logistic curve.

The logistic is appealing as a model for projection of fertility and mortality indices because it forces the index time series to approach an asymptote, which is consistent with available evidence and because its flexibility allows fitting to index values that are both further from as well as closer to the asymptote.

Base Population Consistency With Projected Fertility, Mortality, and Migration

In addition to establishing consistency between current and past fertility and mortality with the base population data, it’s important that fertility and mortality in the years following base year, are consistent as well.

Sidebar

How long can *individuals* live?

http://en.wikipedia.org/wiki/Oldest_people

Oldest people ever

Main article: List of the verified oldest people

Systematic verification of longevity has only been practiced in recent decades and only in certain parts of the world.

Living persons are given in *italics*.

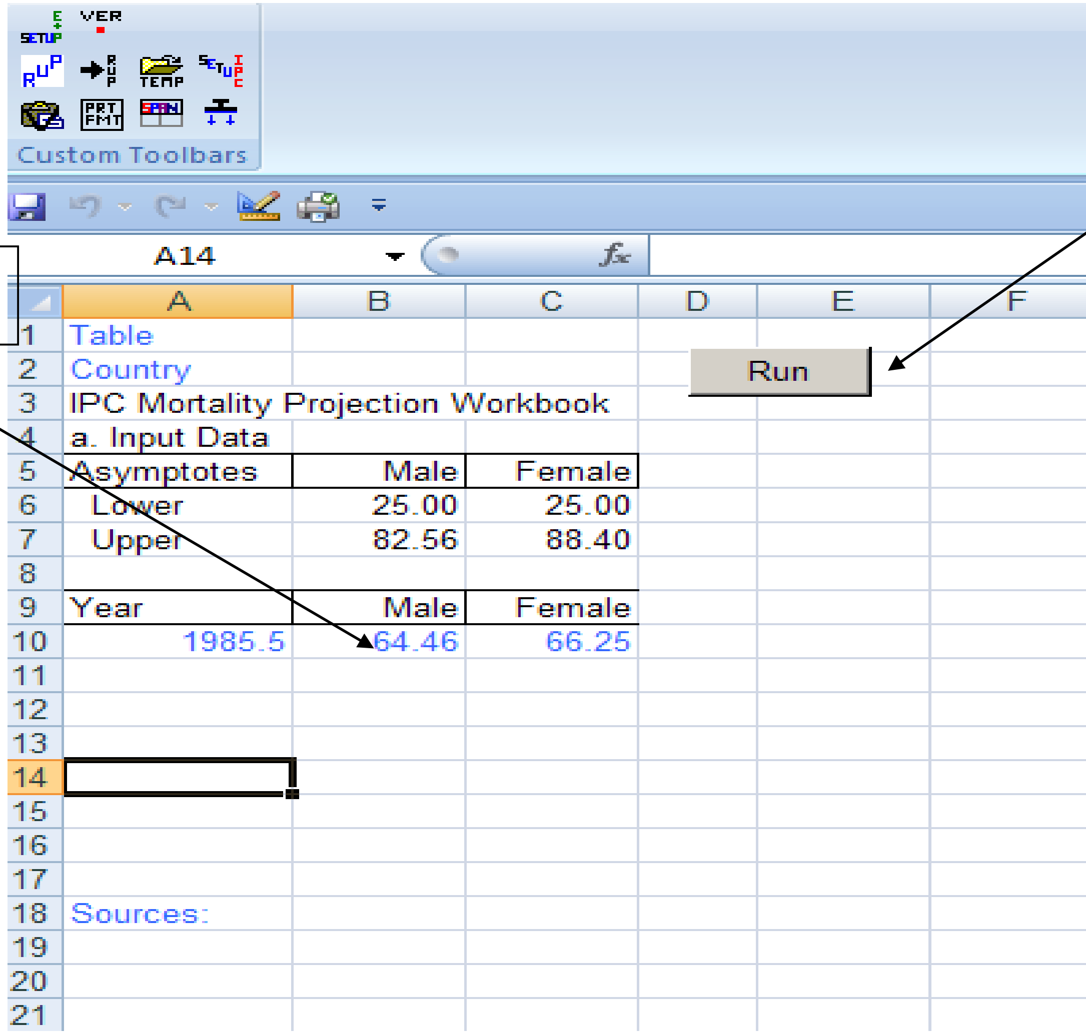
†^ denotes age at death, or, if living, age as of 19 November 2015

Rank	Name	Sex	Birth date	Death date	Age [†]	Place of death or residence
1	Jeanne Calment	F	21 February 1875	4 August 1997	122 years, 164 days	France
2	Sarah Knauss	F	24 September 1880	30 December 1999	119 years, 97 days	United States
3	Lucy Hannah	F	16 July 1875	21 March 1993	117 years, 248 days	United States
4	Marie-Louise Meilleur	F	29 August 1880	16 April 1998	117 years, 230 days	Canada
5	Misao Okawa	F	5 March 1898	1 April 2015[4]	117 years, 27 days	Japan
6	María Capovilla	F	14 September 1889	27 August 2006	116 years, 347 days	Ecuador
7	Gertrude Weaver[5]	F	4 July 1898	6 April 2015	116 years, 276 days	United States
8	Tane Ikai	F	18 January 1879	12 July 1995	116 years, 175 days	Japan
9	*Susannah Mushatt Jones*[6]	*F*	*6 July 1899*	*Living*[6]	*116 years, 136 days*	*United States*
10	Elizabeth Bolden	F	15 August 1890	11 December 2006	116 years, 118 days	United States

Projected e_0 with E0PRJ.xls

Press Run button

Input e(0)

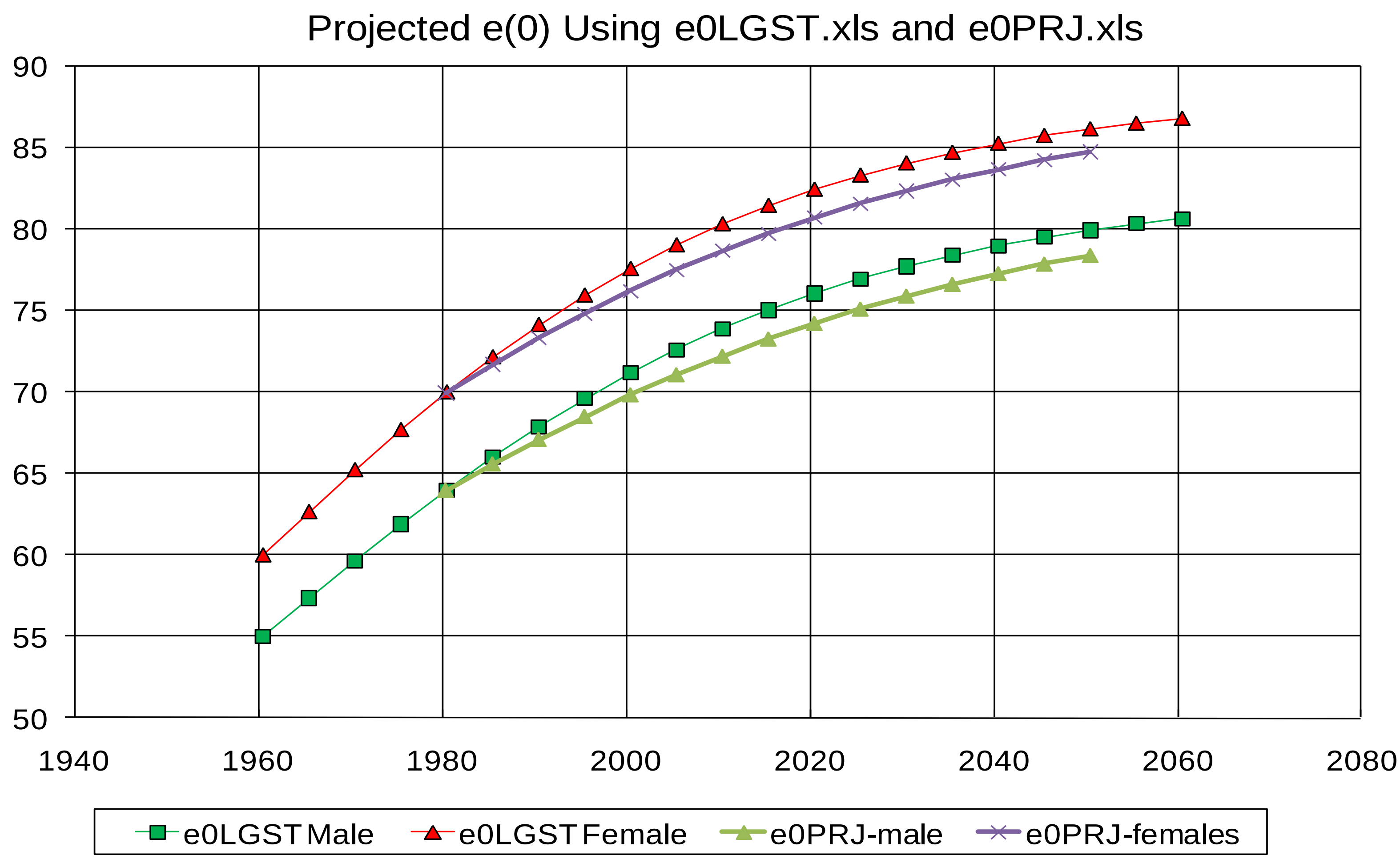


E0PRJ.xls Fixed Slope Output

I21

	A	B	C	D	E	G	H	I
1	Table							
2	Country							
3	c. Fixed Slope Logistic Life Expectancy Model							
4	Parameter	Male	Female		Create MXM			
5	Slope	0.0258	0.0271					
6	Intercept	-50.447	-53.185					
7								
8								
9		Model e0		Observed e0		e0 deviation		
10	Year	Male	Female	Male	Female	Male	Female	
11	1985.5	64.46	66.25	64.46	66.25	0.00	0.00	
12	1990.5	66.02	68.16					
13	1995.5	67.50	69.98					
14	2000.5	68.89	71.70					
15	2005.5	70.19	73.31					
16	2010.5	71.39	74.81					
17	2015.5	72.51	76.21					
18	2020.5	73.54	77.48					
19	2025.5	74.47	78.65					
20	2030.5	75.33	79.72					
21	2035.5	76.11	80.69					
22	2040.5	76.81	81.56					
23	2045.5	77.44	82.34					
24	2050.5	78.01	83.05					
25								
26								

e_0 by Sex Projected from 1960 with Logistic Functions



Projected e_0 : Our Guidelines

Mortality level is projected forward using E0PRJ.xls, a spreadsheet that fits Johnson's "fixed-slope logistic model" to one or more data points.

- Either a fixed or fitted slope may be used, but the fixed slope is strongly recommended.

- Unless the time series of e_0 values is erratic, use the last estimated e_0 alone. If the time series is erratic, select several (say, 3 to 5) values to be entered and fitted. E0PRJ will take an average of these values as its starting point.

continued .....

Projected E(0): Our Guidelines (continued)

- Use the standard asymptotes, including standard upper asymptotes of 82.56 for males, 88.40 for females. These are the e_0 values from the "ultimate life tables" which will be further explained. Use the standard lower asymptotes of 25 years.
- For purposes of interpolating or extrapolating backwards in time, even for short periods of time, the PAS spreadsheet E0LGST.xls may be used.

Projected TFR: Our Guidelines

Fertility level is projected in one of several ways, depending on the value of your TFR estimates.

- If your most recent TFR exceeds the assumed lower bound of 1.7, extrapolate TFR using the PAS program TFRLGST or, if a plateau in TFR is followed by a decline, using the PAS program TFRSINE, plus two or more estimates of TFR.

Projected TFRs with TFRLGSTNew.xls

Adjust Asymptotes, as needed

Input reference dates

Input TFRs

H21

Create RUP input data

	A	B	C	D	E	F
1	Table					
2	COUNTRY: YEARS					
3	Interpolation and Extrapolation of the Total Fertility Rate Using a Logistic Function					
4	Item/	Input	Output values			
5	date	values	Date	TFR	Date	TFR
6	Asymptotes:		1960.50	7.34	1960.50	7.34
7	Lower	2.00	1961.50	7.32	1965.50	7.25
8	Upper	7.43	1962.50	7.31	1970.50	7.08
9			1963.50	7.29	1975.50	6.77
10			1964.50	7.27	1980.50	6.26
11	Input TFR's		1965.50	7.25	1985.50	5.51
12	1979.00	6.4340	1966.50	7.22	1990.50	4.61
13	1985.00	5.5950	1967.50	7.19	1995.50	3.73
14			1968.50	7.16	2000.50	3.04
15			1969.50	7.12	2005.50	2.58
16			1970.50	7.08	2010.50	2.31
17			1971.50	7.03	2015.50	2.16
18			1972.50	6.97	2020.50	2.08
19			1973.50	6.91	2025.50	2.04
20			1974.50	6.84	2030.50	2.02
21			1975.50	6.77	2035.50	2.01
22			1976.50	6.68	2040.50	2.01
23			1977.50	6.59	2045.50	2.00

Projected TFR: Our Guidelines

Fertility level is projected in one of several ways, depending on the value of your TFR estimates.

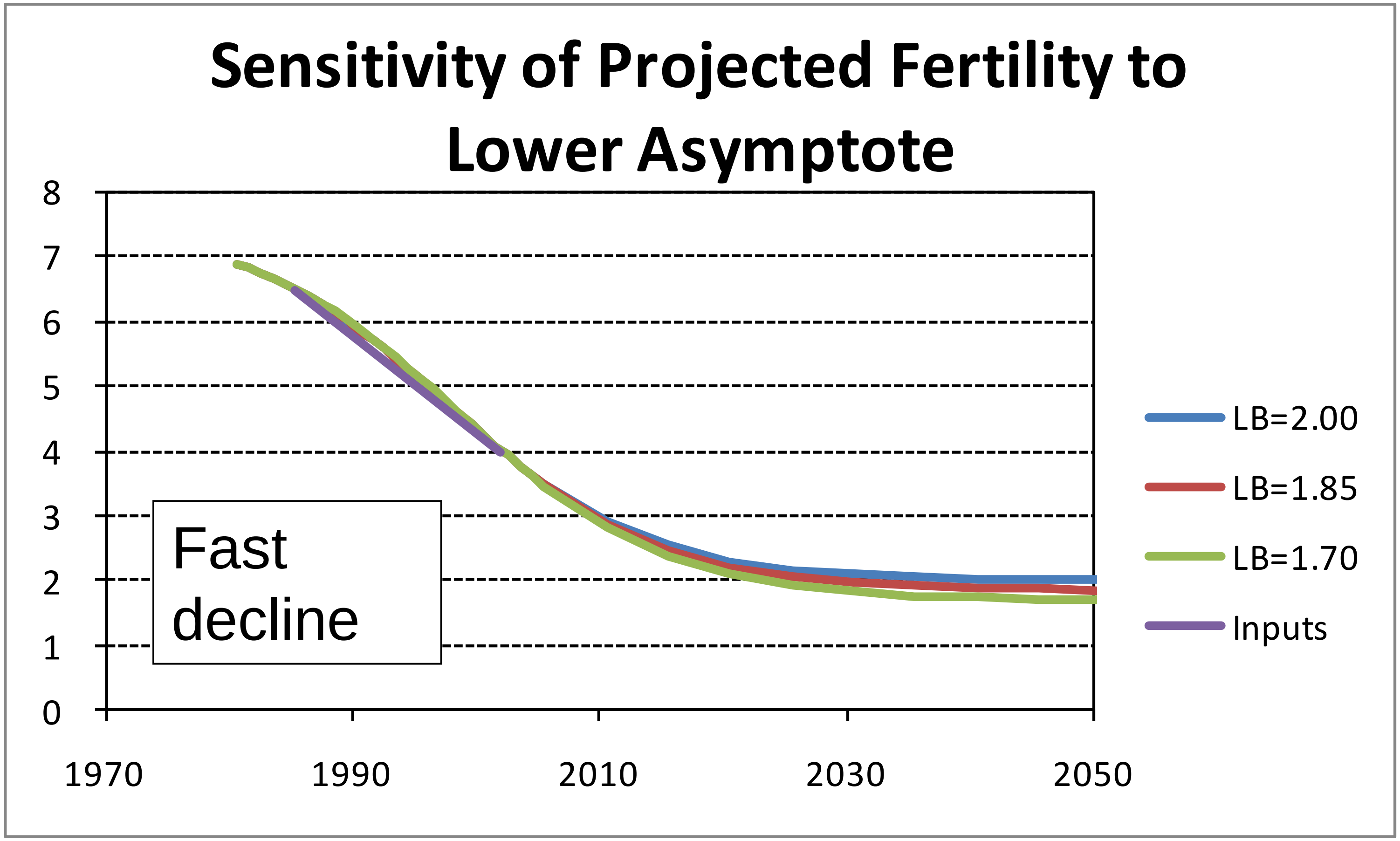
- If lowest (normally the most recent) estimated TFR is 3 births per woman or higher, use TFRLGST and set the asymptotes at the following levels.
  - lower asymptote = 2.0
  - upper asymptote = 1 birth higher than the highest TFR being used, but not lower than 6 births per woman

Projected TFR: Our Guidelines

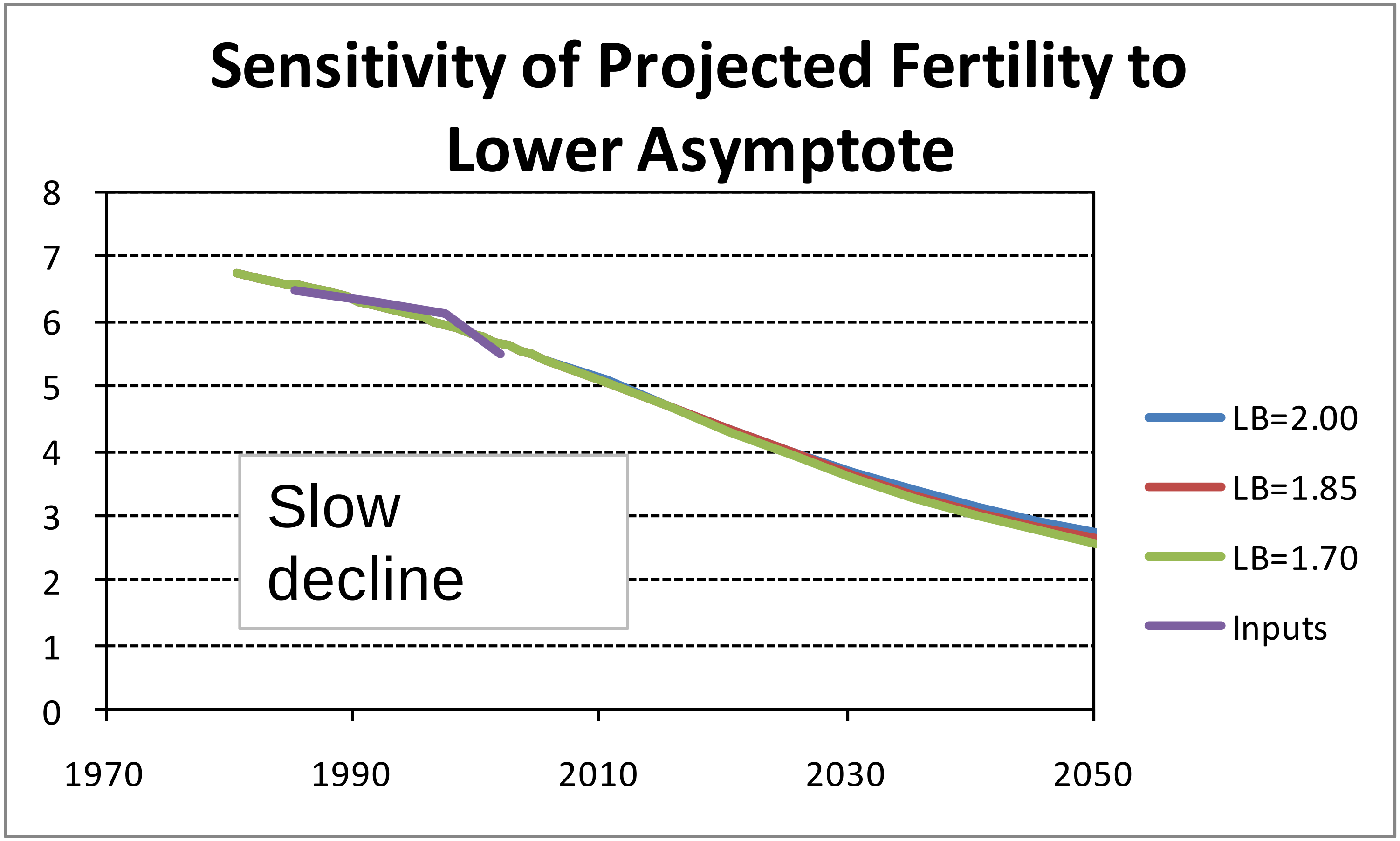
- If lowest (normally the most recent) estimated TFR is greater than or equal to 2.0 and less than 3 births per woman, use TFRLGST and set the asymptotes at:
  - lower asymptote = 1.7
  - upper asymptote = 4.0

- If most recent estimated TFR is less than 2 births but more than 1.7 births per woman, assume a linear change to 1.7 by the year 2050.

TFRs Projected with a Logistic Function



TFRs Projected with a Logistic Function



A Note About Our Guidelines: The Exceptions

- There will be some cases where the Guidelines don’t apply to your data, such as in cases where there have been extreme increases or decreases in e_0 or TFR.

- In those cases, re-select an asymptote with care, and where possible check your results with those produced by other researchers, analysts, and statistical organizations.

Projecting TFR

The PAS workbook TFRLGST often used. It allows for entering several years of estimates of TFR and then fitting the logistic curve to those points.

The PAS workbook TFRSINE can also be useful. It tries to fit a SINE curve to some data, but in a different way. One of the problems with the logistic curve is that the values never really “hit” the asymptotes. TFRSINE, however assumes that the TFR is constant up to a certain date then declines, also in an S shape, until it reaches a lower bound and then stays constant.

"Ultimate" M_x and ASFR Patterns

In addition to E0PRJ and TFRLGST or TFRSINE (which set future overall levels of mortality and fertility), …

a final, or "ultimate," set of m_xs and ASFRs are typically used to linearly interpolate **age patterns** of mortality and fertility from the last data point to the end of the projection period.

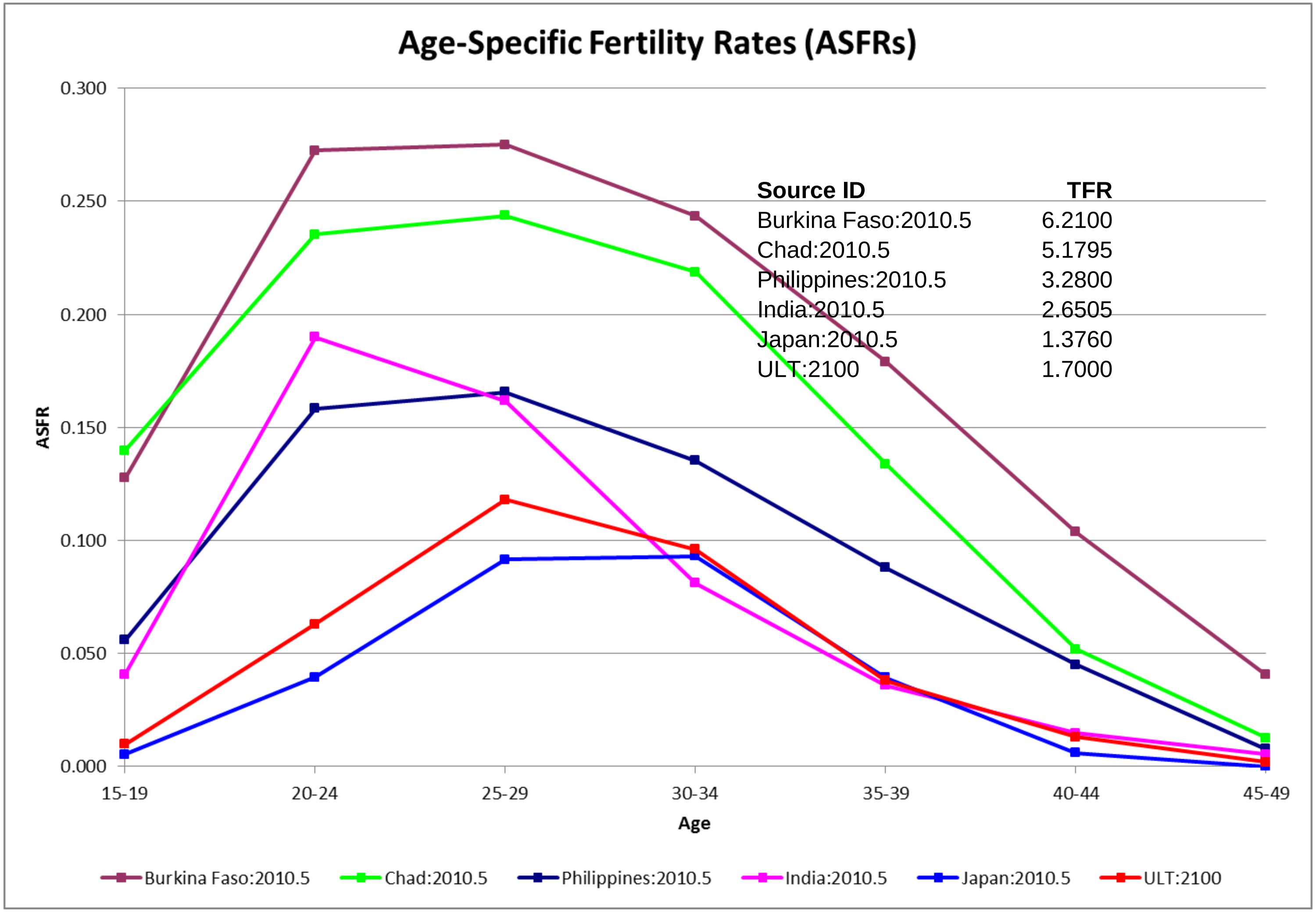
Census Bureau "Ultimate" M_x

The "Ultimate Life Table," composed of m_x by age and sex, is based on countries with the lowest observed death rates for each of several causes of death in each age/sex group.

Based on these m_x values, the life expectancy of this ultimate life table is 82.6 for male and 88.4 for females (which matches the upper asymptote we use in E0PRJ.xls).

You can also use MORTPAK/MATCH to generate model life tables with desired life expectancies at birth.

Shifting Patterns of Fertility By Level



Projections of Mortality and Fertility

Spreadsheets for preparing components for projection		
Data required	Spreadsheet	Procedure
Life expectancies at birth	**PAS>E0LGST.xls** **NewPAS>E0PRJ.xlt**	E0LGST interpolates and extrapolates e(0)s at birth using a logistic curve. E0PRJ extrapolates e(0)s using a fixed-slope logistic function or an estimated slope (like E0LGST).
Total fertility rates	**PAS> TFRLGST.xls** TFRSINE.xls	TFRLGSTnew interpolates and extrapolates TFR using a logistic curve. TFRSINE extrapolates TFR using a sine curve.
Ultimate ASFRs and M_x values	NewPAS> ULTandASFR.xls	Possible “ultimate” age patterns of fertilty and mortality