Final exam DEMO2002 "Population Analysis"

Instructions:

i. On Wattle, students have access to the exam and data used at 9am.
ii. In the exam there are 10 questions each with equal value.
iii. Calculations will be needed to solve the exam and students can use any software for that. Please do NOT include excel files or R code in your answers, just the final output, either a Table or a Figure.
iv. Students should submit a PDF of their exam/answers in turnitin by noon (12pm). Late submission 5% rate applicable each hour late.

Name: __Sreehari P Sreedhar__
.

ANU u-ID: __u7322074__**.**

1) Transition theories:

Briefly describe the three transitions discussed in class, emphasizing their different stages and if some of the theories are included on the others (maximum 300 words).

Stage 1: High Fertility, High Mortality

Stage 2: High Fertility, Low Mortality

Stage 3: Low Fertility, Low Mortality

Demographic transitions can generally be classified into three stages, as listed above. Greater granularity in the division is possible, exploring the periods of changes in demographic rates. A general rule of procreation under matrimony can be observed.

In the second demographic transition, we see sustained low (sub replacement) levels of fertility, with the possibility of reproduction outside the confines of traditional matrimony.

The third transition explored would be on the basis of population health. Similar to the three stages in the first transition model, we observe changes in population with respect to the type of diseases.
The earlier stages were impacted by pandemics and communicable diseases, with the population in the later stages being impacted by lifestyle conditions and man-made conditions such as cancer.

2) Family formation:

In Wattle you are given data "Marriage.csv" including Australian 2021 age-specific marriage rates for females, males, and same sex partners (females and males) from ABS.

2.1) Present a Table with the mean age at marriage for the four groups and describe your findings. Would you conclude that one group has less/more marriages than the other? Or will you do further analysis for that, and which measure would you use for that? Explain your answer (maximum 300 words).

Table 1 Mean age at Marriage (Years)

	Female	Male
Heterosexual	31.1	33
Homosexual	34.7	36.6

The above table presents the mean age at marriage (MAM) for the four given groups. It is seen that homosexual people of both sexes generally get married later than their heterosexual peers. The data also conforms to the observed trend in heterosexual couples where the male partner is older than the female partner.

In its computation, the following values were used as the midpoints for each age group.

	Age.group	Mid.points
1	16-19	17.5
2	20-24	22.0
3	25-29	27.0
4	30-34	32.0
5	35-39	37.0

6	40-44	42.0
7	45-49	47.0
8	50+	75.0

For the first 7 groups, the arithmetic mid-point was used. However, for the 50+ years age group, an assumption was made regarding the upper limit – an upper limit of 100 years was chosen. I assume that people above the age of 100 years do not get married, in our population.

From the data given, it would not be possible to compare marriage rates. The marriage rates given are computed as

$$Mx^{s,i} = \frac{Number\ of\ Marriages\ of\ Sexuality\ s\ at\ Age\ Group\ i}{Persons\ Years\ at\ Age\ Group\ i}$$

Given that the number of people opting for same sex marriages are disproportionately small in the population, and that males and females generally do not have proportional parity in the population, the derived marriage rate cannot be compared.

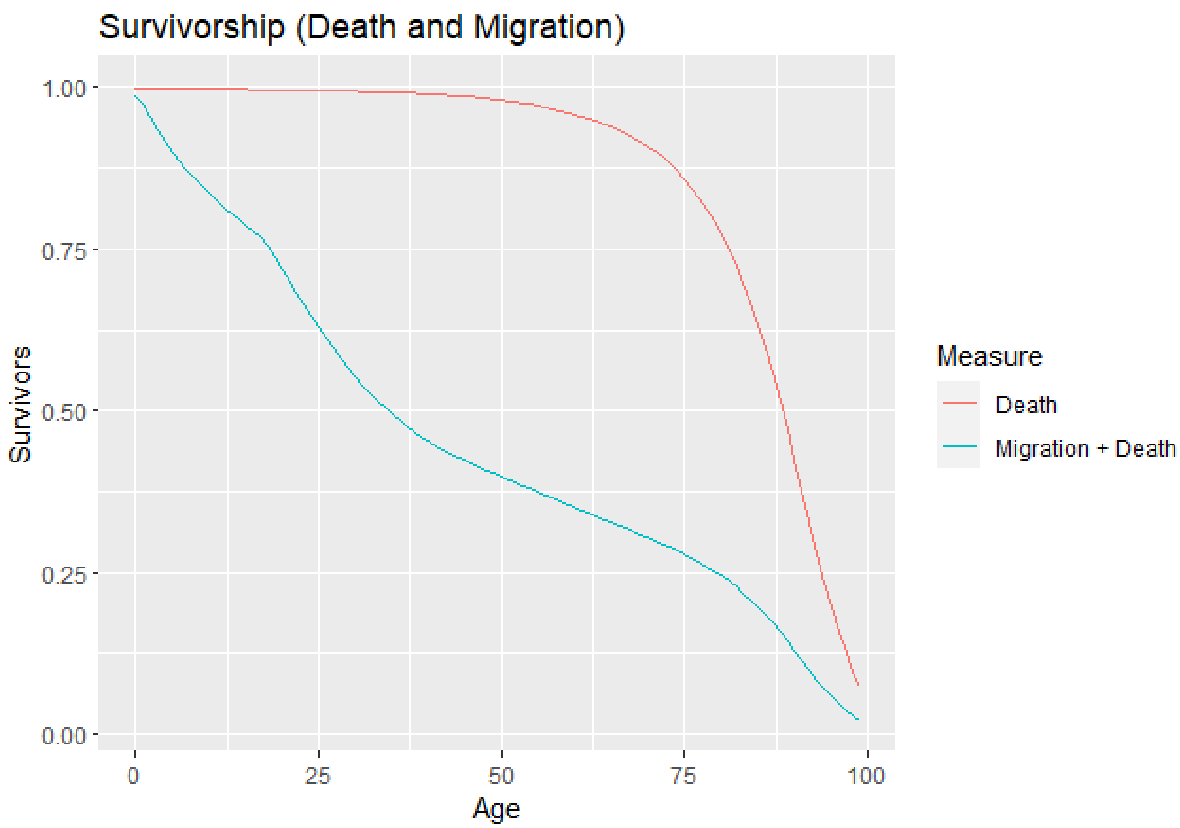
Comparable marriage rates can be derived with the following equation.

$$Mx^{s,i} = \frac{Number\ of\ Marriages\ of\ Sexuality\ s\ at\ Age\ Group\ i}{Persons\ Years\ of\ Sexuality\ s\ at\ Age\ Group\ i}$$

3) Migration & life table:

In wattle you can find the data “femalesNSW2018.txt” corresponding to single-age counts of women in NSW (Population), their mortality (death rates, Mx), and out migration rates from NSW to the rest of the country (NSW.to.RAU) and their life table ax in the year of 2018 (data from ABS).

3.1) Construct two life tables: i) based on the death rates (Mx); and ii) based on the death and migration rates (Mx + NSW.to.RAU). Present a Figure showing the survivors for each of those life tables in (i) and (ii), and describe the results (maximum 200 words).



The above graphic shows the proportion of females from the initial population surviving at each age level.

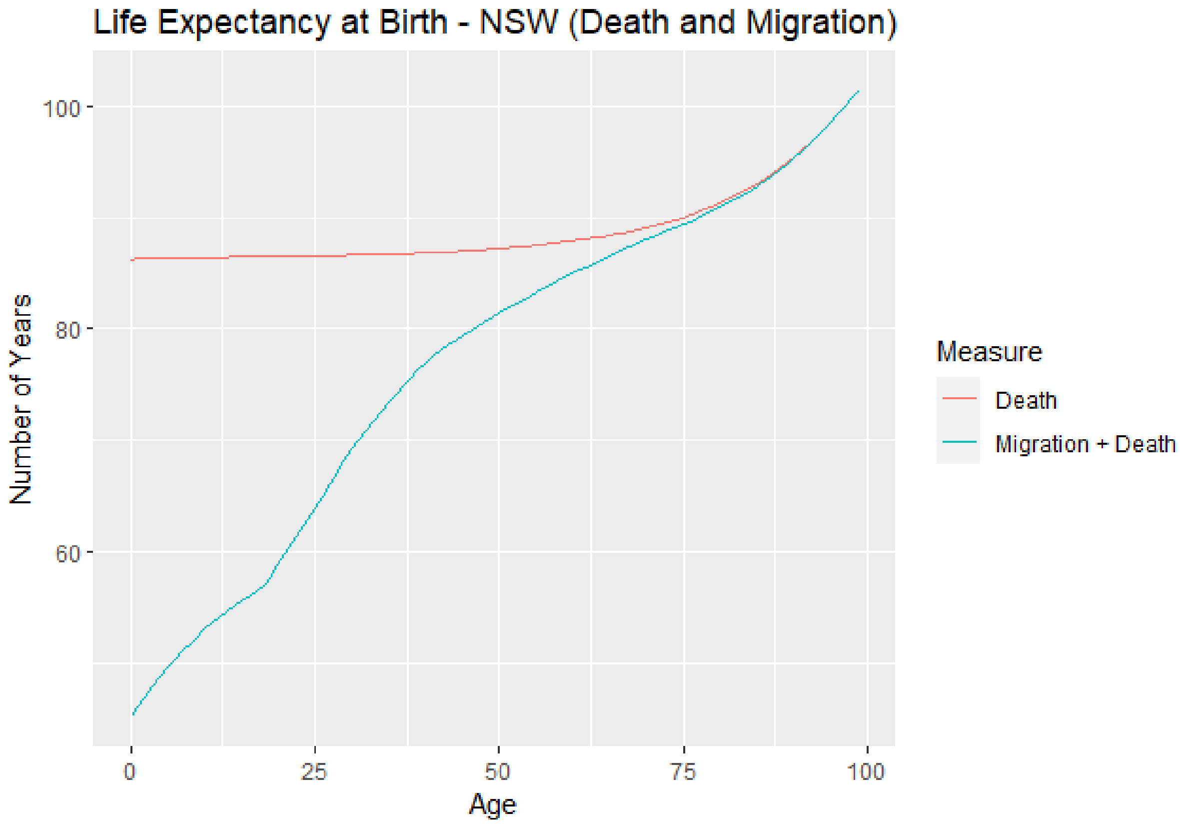
Looking at the line representing mortality in New South Wales, it is seen that there is very little mortality till about the age of 50, as is generally observed in modern countries with good healthcare and standard of living.

The survivorship function computed using the joint migration and death rates can be considered as the number of females in New South Wales from the initial population who still remain in New South Wales, i.e., they were born in New South Wales and live there throughout their lives.

The line representing the joint rates sees an initial sharp descent till about the age of 20, possibly corresponding to the employment-based migration of middle aged parents, and a second descent from 20 years to about 40 years, corresponding to individual migration for education and employment.

It can be understood that a large portion of women leaving the population till about the age of 50 can be attributed to migration. After the age of 50 years, mortality also becomes an influencing factor.

3.2) Based on the calculations in (3.1) show the life expectancies at birth for each of those life tables (i) and (ii), and discuss those values and what could you do to improve this model (maximum 200 words).



The above graphic presents the "life expectancy at birth" computing using the two given rates.

It is seen that the older women have a generally higher life expectancy at birth, even when only the death rates are considered. This is an odd effect of the use of period data instead of cohort data. One can generally expect the younger population to have a larger life expectancy at birth.

The line representing the joint rates can be thought of as the number of years a person at a specific age can be expected to live in NSW – a girl baby born in 2018 can be expected to live about 45 years in NSW, while older women still living in NSW are likely to have lived out their entire lives there. We assume that out-migrants do not return to the population.

This model can be improved through the use of cohort data instead of period data. With the use of cohort data, one can expect the older women to have shorter life expectancies than was observed in the figure.

3.3) Why is migration important for Australia and what are the migration challenges that covid19 has created for the country? (maximum 200 words).

Australia, like most developed countries, has a low birth rate and a low death rate. As the population size reduces and ages, the economy must depend on migrants for supporting growth.

Furthermore, with increased fertility rates among migrants, Australia can expect to see improvements in its fertility rates.

With the onset of COVID19 came border restrictions. For a period of two years, Australia imposed strict immigration rules and reduced the number of foreign migrants entering the country. Students and unskilled foreigners found it challenging to immigrate, while the highly skilled and economically forward (and generally older) population found it easier to enter the country.

4) Forecasting:

In wattle you are given the data “AUSfertilityRates1975.txt” including the fertility data for Australia in 1975 from ABS (ages 15 to 49, so you will need to adapt that first row of the matrix for that), and in the Human Mortality Database you can find the population, births and life table data for the country (single-year, single-age).

4.1) which steps are to be followed to construct the cohort component method? Particularly elaborate on the estimation of the projected first age-group. I would also be interested to see some values from the Leslie matrix based on data for the year of 1975: a) survival ratio for females and males from age 10 to 11; b) value for the first row of the matrix for females and males at age 15. (maximum 200 words)

a) Survival ratio (10 – 11) Females = 0.9997662

Survival ratio (10 – 11) Males = 0.9996733

b) Leslie Matrix First Row, Age 15 Female = 0.005598177

Leslie Matrix First Row, Age 15 Male = 0

4.2) Create a forecast for the year of 2020 based on the fixed values of Australian fertility, mortality, migration and population in 1975. Present two population pyramids for 2020 (real from HMD and the one with the projection based on data for 1975). Describe them and explain why they are different? (maximum 200 words)

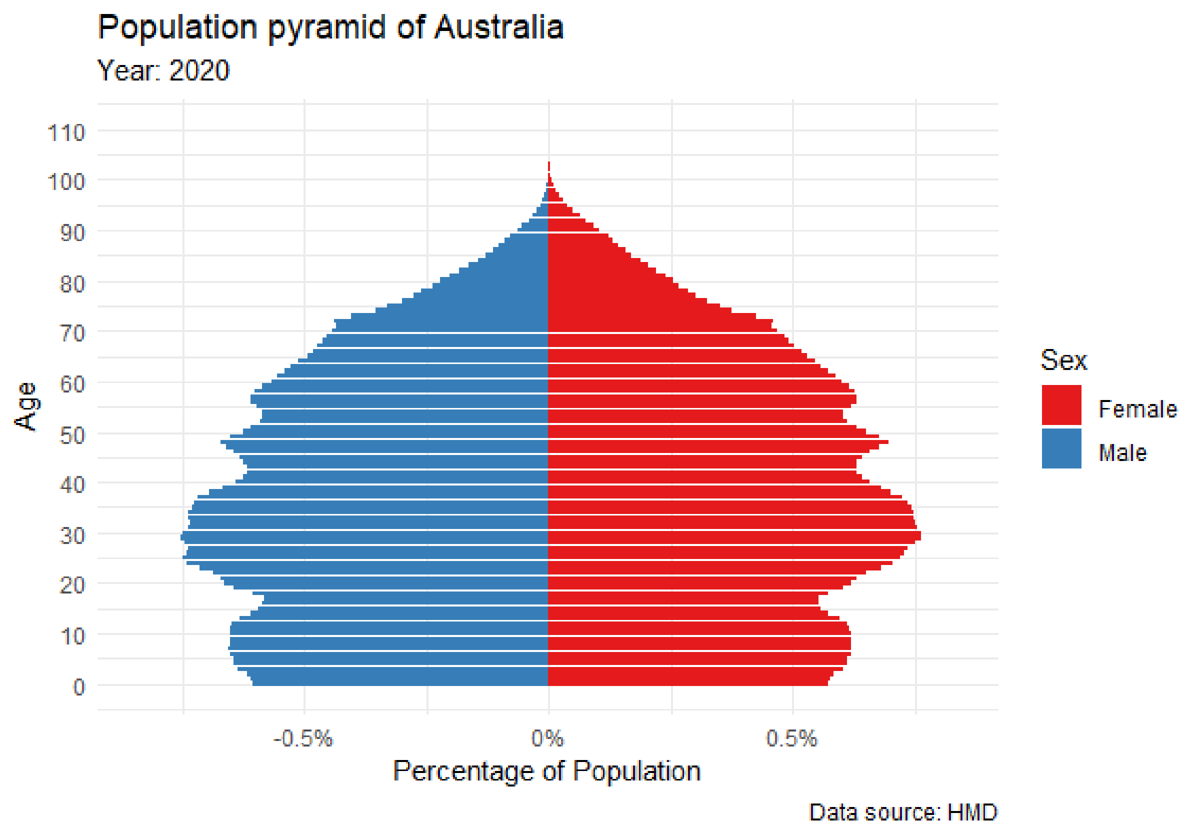


Figure 1 Observed Population

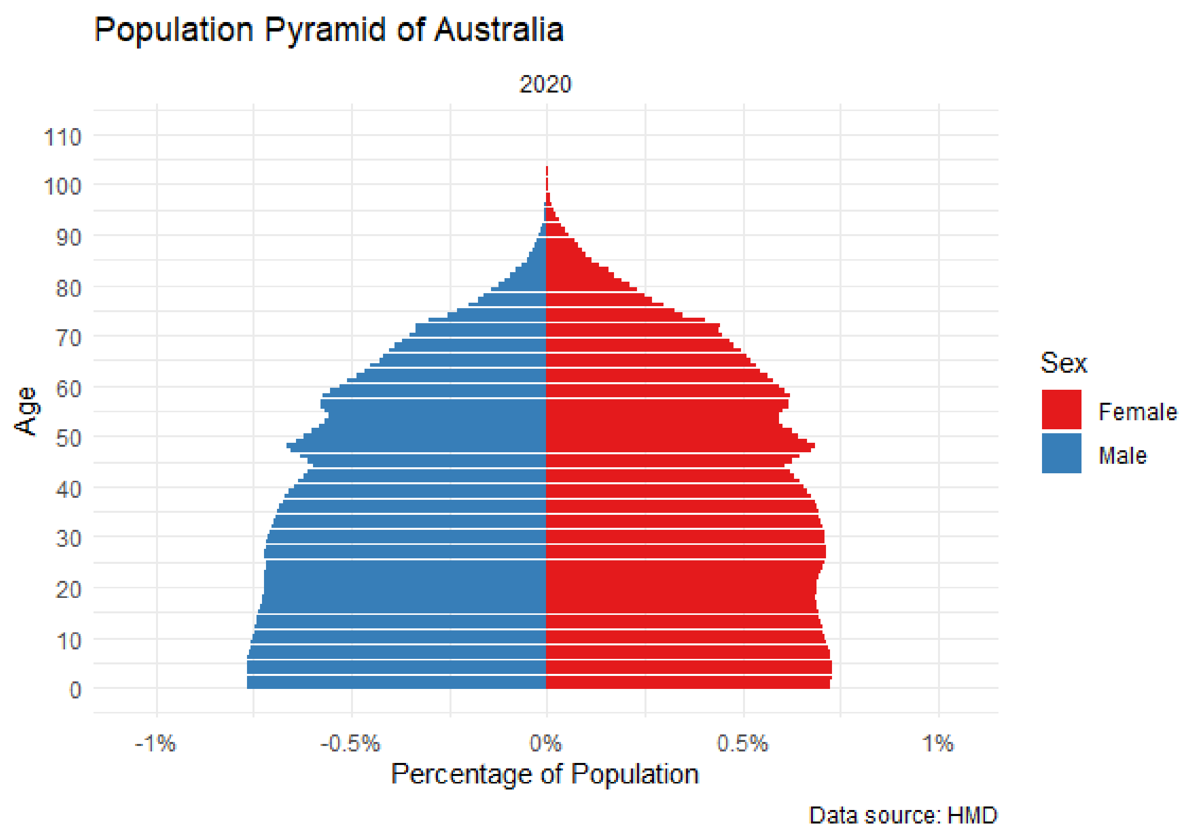


Figure 2 Projected Population

The above graphics present the observed and projected populations for Australia (2020).

In Figure 1, we can see a spindle shaped population distribution with a large middle-aged population. There is not a lot of observed variation between that male and female distributions.

The distribution in Figure 2 describes the projected population with a large fertility rate. The resulting distribution is seen to be bell shaped, with a larger male infant population, i.e., the female babies either had a higher mortality rate or the sex ratio at birth is skewed.

The two main differences between the observed and projected populations are

- In the projected model, we see a larger baby population than is observed. This is because the model does not account for falling fertility rates in real life.
- The observed middle-aged population is larger than the projected one. As a consequence of the falling fertility rate, we find that the Australian population is aging.
- The large middle aged population could also be a result of foreign migrants who have moved to Australia for employment.

4.3) Similar to (4.2), now create a new forecast for the year of 2020 based on the fixed values of Australian mortality, migration and population in 1975; but let's assume the fertility in each age group decreases by 20% from the 1975 level and remains constant at this level during the projection. Present a population pyramid for 2020 (for the forecast based on the 20% fertility decline). Describe it and explain why it is different than that observed in 2020 in the HMD? (maximum 200 words)

Figure 3 Observed Population

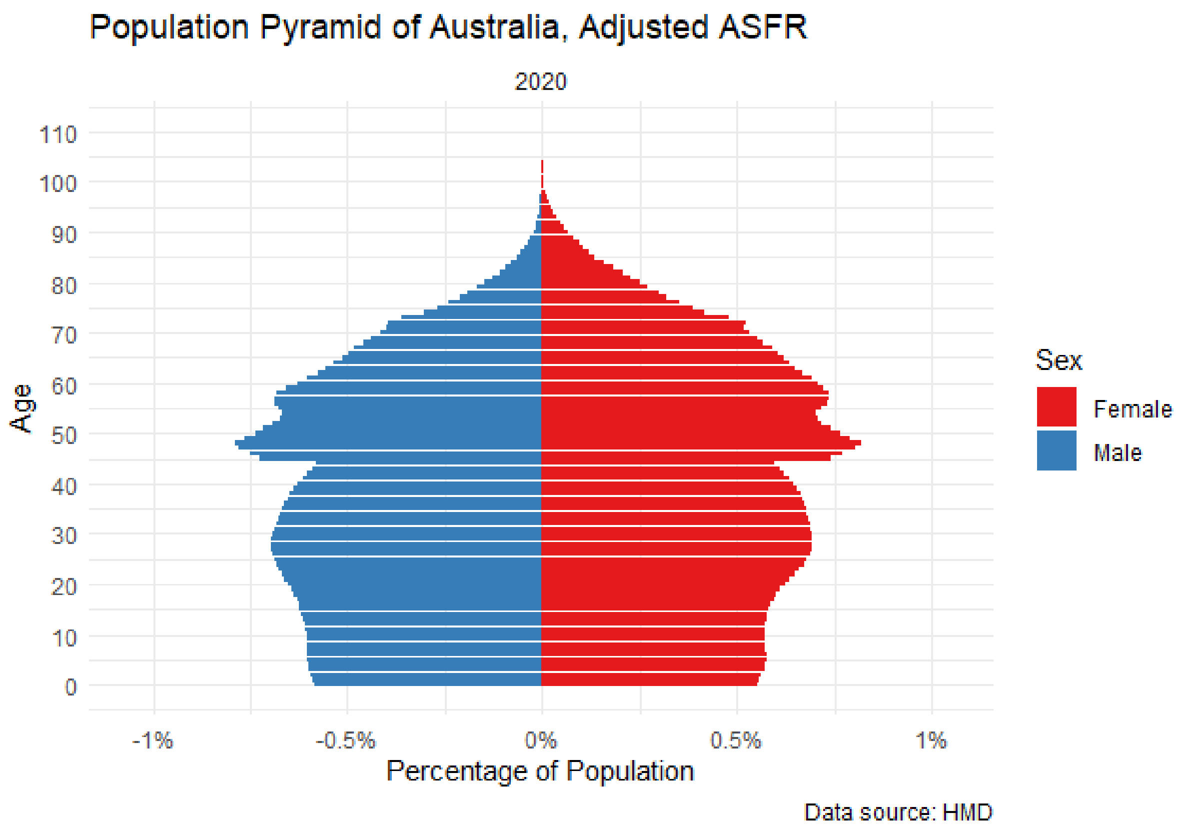


Figure 3 Projected Population

The above graphic presents the projected population of Australia (2020) with lowered fertility rates.

This distribution is seen to be more similar to Figure 1 than Figure 2, with the spindle shape characteristic of an aging population.

In contrast to the observed distribution, we see a larger aging (50-60 years) population in the projected distribution. This is the cohort of people that were children in 1975, whose population was not affected by the adjusted ASFR.

4.4) Present a Table of total population of females and males in 2020 based on i) HMD, ii) forecast with 1975 data (as in 4.2), and iii) forecast with 1975 data with fertility decline of 20% (as in 4.3). Describe the Table. (maximum 200 words)

	Males	Females
Observed (HMD)	12655057	12841836
Projected	9916602	10357727
Projected (ASFR Adj.)	8276535	8791104

Table 2 Total Population, Australia 2020

The above table presents the total observed population of males and females in Australia (2020), along with two projected populations.

We observe that in the observed population and the two counterfactuals, Australia has a larger female population than male.

It is seen that neither of the projections come close to the observed values, with the projection with adjusted ASFR being further away from the observed distribution due to the falling fertility rates.

Though fertility rates in 2020 are low, the observed population is possibly larger due to the presence of foreign migrants.

In the derivation of the projections, we do not explicitly add empirical migration data, and hence do not account for changing economic conditions and living standards around the world.

4.5) Why would we want to do the procedures of 4.2 and 4.3 before actually doing a forecast into the future? (maximum 200 words)

In 4.3, we added a constant multiplier (0.8) to ASFR in the calculation of population projections.

The model used here is static and does not account for changing demographic rates. With advancements in healthcare, Australia has seen generally consistent low death rates between 1975 and 2020.

However, in the same period, the fertility rate has been consistently decreasing. The static model used in 4.2 assumes that the fertility rate is constant across the years and that 2020 sees the same rates as 1975. In order to account for the tempo effects of reduction in ASFR, we scale down the 1975 fertility rate while holding it constant over the years.

Though this method is not an ideal solution, in the absence of empirical data for future predictions, it is generally effective.