A Demography Model - Detailed Explanation

This model describes the evolution of a population over time, divided by age groups and sex. It captures the fundamental demographic dynamics - births, deaths, and migration - which together determine how the total population changes from one period to the next.

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1. List Definitions

>list ages = ages : age$_0 * age_1 1 > list sexes = sexes : female male / > fertile :$ 10

These lists define the model's structural dimensions:

- "ages" enumerates age groups, from age$_0 (newborns) up to age_1 1 (the oldest group). -$ "$sexes$" $distinguishes between female and male. - The$ "$fertile$" $flag marks whether a sex is fertile (1 for females,$

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2. Population Dynamics

The population is tracked at various stages within each period.

a. Primo Population

>doable [ages ages$_n ostart] pop_p rimo_{a = pop_{a\, b(-1)}}$

For all age groups except the youngest ('ages$_n ostart$' $excludes the start group), the beginning - of - period (primo) population in an age group is equal to the end - of - period (ultimo) population of the previous age g$ $people move from one age group to the next as time progresses.$

b. Population Before Death

For the youngest age group:

>doable [ages ages$_s tart] pop_b efore_d eath_{a = birth_{total_{sexes} + migration_a}}$

The youngest group's population before death depends on births of that sex in the current period and net migration for that age group. This reflects that new members of the population come from births and migration, since there is no prior age group for newborns.

For all other age groups:

>doable [ages ages$_n ostart] pop_b efore_d eath_{a = pop_p rimo_{a + migration_a}}$

Older groups' populations before death are determined by the primo population (those who aged into the group) and migration inflows or outflows.

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3. Mortality and Deaths

>doable [ages ages$_{e}nd]death_{r}ate_{a=1.0>doable<sum=total>death_{a=pop_{b}efore_{d}eath_{a}*death_{r}ate_{a}}}$

For the last age group, the death rate is set to 1.0, implying that everyone in this group dies within the period - a closure condition preventing population overflow beyond the oldest cohort. Deaths in all groups are computed as the product of the population before death and the age-specific death rate.

4. End-of-Period (Ultimo) Population

>doable <sum=total> pop$_{a=pop_{b}efore_{d}eath_{a}-death_{a}}$

The end-of-period population equals the population before death minus deaths. This is the surviving population that will age into the next group in the following period.

5. Births and Fertility

>doable <sum=total> [ages ages$_{n}ostart, sexesfertile]birth_{a=pop_{p}rimo_{a}*fertility_{a}}$

Births are generated by fertile females in each age group. Fertility rates (fertility$_{a})varybyage,andareinthedataframese$

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6. Sex Ratio at Birth

>birth$_{total_{female=FRAC_{B}IRTH_{female}*birth_{t}otal>birth_{t}otal_{m}ale=(1-FRAC_{B}IRTH_{f}emale)*birth_{t}otal}}$

The total births are split into female and male newborns using the fraction 'FRAC$_{B}IRTH_{female}$'$.Thisensuresabiologicallyrealisticsexdistributionatbirth.$

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7. Totals and Consistency Check

>migration$_{total=sum(ages,sum(sexes,migration_{a}))migration_{t}otalaggregatesmigrationflowsoverallagesandsexes.}$

>pop$_{total_{c}heck=(pop_{t}otal(-1)+birth_{t}otal+migration_{t}otal-death_{t}otal)-pop_{t}otal}$

pop$_{total_{c}heckservesasaconsistencytestforthemodel:Thechangeintotalpopulationshouldequalbirths+migrationdeaths.Anydeviation}$

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Summary

This demographic model captures the fundamental accounting identities of population dynamics:

Population_t^{age} = Population_{t-1}^{age-1} + Births_t^{age} + Migration_t^{age} - Deaths_t^{age}

For the youngest cohort ($age = 0$), there is no inflow from $age - 1$, so the equation simplifies to:

Population_t⁰ = Births_t + Migration_t⁰ - Deaths_t⁰

It distinguishes individuals by age and sex, allowing for realistic aging, fertility, and mortality processes. The model is modular and extendable - one could add features such as: - Age-dependent migration patterns - Variable mortality shocks (for example, pandemics) - Policy impacts on fertility rates - Regional or socioeconomic subpopulations