P25 LAT3072-1 Demography

Actuarial Sciences

Dr. Miguel Reyes

miguel.reyes@udlap.mx

Universidad de las Américas Puebla

1. Introduction

P25 13/01 - 09/05

Outline

1. Introduction
   - Formal demography and population studies
   - Historical background
   - Demographic measures
   - The basic demographic equation
   - Data collection
   - Some current demographic indicators
   - Demographic transition

Outline

1. Introduction
   - Formal demography and population studies
   - Historical background
   - Demographic measures
   - The basic demographic equation
   - Data collection
   - Some current demographic indicators
   - Demographic transition

Definition

As a matter of a definition

Multilingual demographic dictionary (MDD) (United Nations and the IUSSP[a]): http://www.demopaedia.org

- Demography is the scientific study of human populations, focusing on their size, structure, and development.
  - Size refers to the total number of individuals within the population.
  - Structure involves the composition of the population, including the distribution of individuals by gender and age groups.
- Demography intersects with various disciplines, including sociology, anthropology, medicine, geography, economics, biology, ecology, and mathematics, providing a comprehensive understanding of human populations and their dynamics

[a] International Union for the Scientific Study of Population

Formal demography

DTT + a 'toolkit'

- Demographic Transition Theory (DTT) is often considered a central theoretical model in demography. It describes the changes in a population's demographic structure as it progresses through different stages of socioeconomic development.
- Originally, the DTT emerged as a description of the population dynamics observed in what are now called developed countries, documenting their progression from an initial state characterized by high birth and death rates to a final state with lower rates of both.

Formal demography

DTT + a 'toolkit'

- Additionally, a diverse array of techniques is employed to describe, summarize, and analyze demographic data.
- These techniques are applied to information collected from various sources, including surveys, vital records, and censuses, and encompass data on age, sex, births, deaths, migrations, marriages, and other demographic variables.
- Both the Demographic Transition Theory (DTT) and these analytical techniques are the components of what is referred to as formal demography.

Population studies

Distinguishing between Demography and Population Studies

Formal demography and population studies are closely related fields, but they differ in focus and methodology.

- Formal demography is primarily concerned with the quantitative analysis of demographic data, employing mathematical and statistical methods to study population structures and trends.
- Population studies adopt a more interdisciplinary approach, exploring the social, economic, and cultural factors that shape population dynamics.

Formal demography and population studies

More on distinguishing demography and pop. studies

- Formal demography is fundamentally **descriptive** or analitic, **rather than explanatory**.
  - It is concerned with demographic phenomena **in isolation** (not in interaction with economic or social phenomena).
- In other words:
  - Formal demography tries to answer questions like: "What is..."
  - Population studies tries to answer questions like: "Why..."

Formal demography and population studies

An example

Here is an example showing the difference between formal demography and population studies:

- Formal Demography: Researchers are analyzing birth rates in a specific region over a period of 15 years. They collect data on the number of births each year, calculate crude birth rates, age-specific birth rates, and other quantitative measures. They use mathematical models and statistical techniques to analyze the data and identify trends, patterns, and relationships. The focus here is on analyzing demographic data using formal methods and statistical tools.

Formal demography and population studies

An example

Following the example, the population studies' approach would be like:

- Population Studies: Researchers are exploring factors affecting birth rates in a region by examining not just quantitative data on births but also social, economic, and cultural influences such as education, healthcare, and employment. They use surveys and interviews to understand attitudes and beliefs about childbirth, focusing on the broader context and multiple dimensions of population dynamics.

Outline

1 Introduction
- Formal demography and population studies
- Historical background
- Demographic measures
- The basic demographic equation
- Data collection
- Some current demographic indicators
- Demographic transition

Europe in the 17th Century: Mercantilism and Early Demography

Europe, England and Mercantilism

In 17th-century Europe, mercantilism was the dominant economic doctrine.

- This system focused on maximizing national wealth by accumulating precious metals and developing colonies to extract resources.
- Nations promoted trading monopolies, especially concerning precious metals, and prioritized exports over imports to boost national wealth.
- There was also a strong emphasis on increasing population and reproduction rates to ensure a growing labor force! It was considered essential for economic development and colonial expansion.

Europe, 17th century

John Graunt

John Graunt (London, April 24, 1620 – London, April 18, 1674) was an English statistician considered the first demographer, the founder of biostatistics, and a precursor to epidemiology.

- His primary profession was as a haberdasher and textile merchant, which was far from the scientific world, his social activities in London allowed him access to the Bills of Mortality.
- By the end of the 16th century, these mortality records, alongside baptismal lists, provided Graunt with crucial demographic data[a].
- These records served as the documentary foundation for his statistical, actuarial, and demographic research.

[a] Specifically, these sources covered a population of approximately half a million people and included data on mortality (deaths) and fertility (number of newborns via baptized babies), forming the foundation for Graunt's research.

William Petty

William Petty

Alongside Graunt, Sir William Petty (1623-1687) is a significant figure in the history of demography.

- Petty, a close friend of Graunt, is considered a pioneer in the field, founding what he called Political Arithmetic.
- This term described the quantitative and statistical analysis of population and economic data. Petty's interdisciplinary approach laid a solid foundation for future demographic studies.

Advances in the 19th Century: The Evolution of Life Tables

Life Tables

In the 19th century, demography continued to evolve with figures like Achille Guillard, a French demographer born in 1805.

- Guillard made important contributions to understanding life expectancy and mortality patterns through the development of life tables.
- In 1855, he coined the term Demography to describe the systematic study of populations.
- Although not in the 19th Century, Edmund Halley (1693) was also instrumental in this field as well, as he calculated the first life table based on actual numbers of deaths by age.

Advances in the 19th Century: The Evolution of Life Tables

Life Tables

To summarize, the development of life tables began with John Graunt's pioneering work in 1662 and was further advanced by Edmund Halley's calculations in 1693.

- In 1815, Milne formalized the presentation of modern life tables, and by the early 20th century, Alfred Lotka and others had developed the mathematical framework for stable populations.

Advances in the 19th Century: The Evolution of Life Tables

Sweden as a pioneer nation

William Petty, with his "Political Arithmetic", envisioned a world where every nation had a statistical office. He understood the power of data in understanding social and economic trends, enabling informed decision-making.

- Sweden took the lead and in 1748 was the first nation establishing a statistical office, in Stockholm.
- This was achieved through a royal decree, demonstrating the importance of systematic data collection for intelligent governance.

Developments on Fertility Analysis

Fertility Analysis

In fertility analysis, early studies by Thomas Malthus in the 18th and 19th centuries, and previously John Graunt's studies, laid the foundations for this discipline.

- Concepts like Total Fertility Rate and Net Reproduction Rate were developed by German demographers in the late 19th century. In 1935, Kuczynski's *Die natürliche Fruchtbarkeit des Menschen* (The Natural Fertility of Man) examined fertility patterns.
- Mid-20th-century cohort fertility analysis was further shaped by researchers like Frank Lorimer, Kingsley Davis, Judith Blake, and Whelpton, contributing to our understanding of fertility dynamics.

Malthus: Arithmetic vs. Geometric Growth Rates

Malthus

Thomas Robert Malthus (1766-1834) made significant contributions to demography with his Essay on the Principle of Population (1798).

- Malthus argued that population growth tends to outpace the growth of resources, leading to a struggle for existence.
- He suggested that while population grows exponentially, resources, especially food, grow arithmetically. This perspective emphasized the need to study population dynamics and their impact on resources.

Malthus: Arithmetic vs. Geometric Growth Rates

Population Theories

It is well-known the concept of the Malthusian Catastrophe, a potential crisis where population growth exceeds the capacity of resources to sustain it.

- According to Malthus, such a situation would lead to famine, disease, and other forms of population control, ultimately reducing the population to a level that could be sustained by available resources.
- This concept highlighted the potential for severe consequences when population growth is unchecked.

Demographic Theories

Population Theories

Karl Marx (1818-1883) challenged Malthusian views by arguing that there is no natural population law.

- Marx shifted the focus from population growth to the economic system, claiming that poverty and inequality were results of capitalism rather than merely population expansion.

Demographic Theories

Population Theories

Ester Boserup (18 May 1910 – 24 September 1999) was a Danish economist, known for her theory on agricultural intensification.

- In her work "The Conditions of Agricultural Growth" (1965), Boserup argued that population growth can drive innovations in agricultural technology. She proposed that the pressures of an expanding population stimulate improvements in farming methods, allowing food production to increase to meet demand. Thus, rather than being a threat, population growth can be a catalyst for progress and agricultural development.

Demographic Theories

Population Theories

In the 20th century, the French demographer Alfred Sauvy (1898-1990) made significant contributions to population theories.

- Sauvy is known for coining the term "Third World" and for his extensive work on general population theories.
- His work provided a broader perspective on demographic issues, emphasizing the social and economic dimensions of population dynamics. Sauvy's insights continue to influence contemporary discussions on population and development.

Recent Developments in Demographic Models

Recent Developments in Demographic Models

In the latter half of the 20th century, several demographic models emerged. These include:

- The United Nations model life tables (1955-56), the Princeton regional model life tables by Coale and Demeny (1966, 1983), and models of nuptiality and marital fertility developed by Coale and others.
- Brass' relational models of mortality (1971) and fertility (1981) further advanced the field, leading to contemporary microsimulation models that simulate individual-level behaviors and decision-making processes to understand population dynamics.

Reflections on Population Theories

Reflections on Population Theories

The study of population has evolved from early observations of mortality and fertility to sophisticated models analyzing modern demographic dynamics.

- Theories and models continue to develop, reflecting the need to understand the complex interactions between populations and resources, and their implications for policy and social planning.

Outline

1. Introduction
   - Formal demography and population studies
   - Historical background
   - Demographic measures
   - The basic demographic equation
   - Data collection
   - Some current demographic indicators
   - Demographic transition

Rates, ratios and proportions

Three basic indexes

There are three basic tools used to analyze demographic data:

- Ratios
- Proportions
- Rates

These tools allow for meaningful comparisons by adjusting for differences in population size.

Ratios, proportions and rates

Ratios and Proportions

- Ratio: A ratio compares two quantities by dividing one by the other.
  - Example: The Sex Ratio, which is the number of males per 100 females.
- Proportion: A proportion is a specific type of ratio where the numerator is part of the denominator. It is expressed as $p = x/(x+y)$
  - Example: The proportion of males in a population, calculated as the number of males, x, divided by the total population of females and males, $x+y$.
  - Note: Proportions always range from 0 to 1.

Rates, ratios and proportions

Rates

The term 'rate' is often used loosely in demography, which can lead to confusion. Let's clarify it:

- Numerator: In the strictest sense, the numerator of a rate represents the number of events (such as births or deaths) that occur within a specific period.
- Denominator: The denominator refers to the number of person-years (PY) of exposure to risk experienced by the population during that time frame.
  - For a clearer understanding of person-years, **please refer to the accompanying Excel file**.

Rates, ratios and proportions

Aproximating person-years

In demography, rates are typically calculated for one-year periods.

- The total number of person-years of exposure to risk is often approximated by the average population during that year. This average can be further estimated by taking the mean of the population at the start and end of the year.
- Government statistical services usually provide annual population estimates based on the mid-year point, rather than the beginning or end of the year.

Rates, ratios and proportions

Be careful!

Many measures in demography are often referred to as rates, but they are not always true rates. Sometimes, they are merely ratios or proportions (or even more complex indices).

- Example: The so-called Literacy Rate.
  - It is not actually a rate; it's simply the proportion of the population that is literate.
- Example: The so-called Crude Birth Rate.
  - This is not a true rate but a ratio, as the numerator includes the number of live births during the period, while the denominator includes the entire population—including those not at risk of giving birth, such as men, children, and the elderly.

Outline

1. Introduction
   - Formal demography and population studies
   - Historical background
   - Demographic measures
   - The basic demographic equation
   - Data collection
   - Some current demographic indicators
   - Demographic transition

The demographic equation

Population change

The basic demographic equation is one of the most fundamental relationships in formal demography:

$$P_T = P_0 + B(0,T) - D(0,T) + I(0,T) - O(0,T). \quad (1)$$

- This is: the population of an area at certain time T depends on the population at time 0 plus
  - the amount of births B between 0 and T
  - (minus) the amount of deaths D between 0 and T
  - the amount of immigrants I between 0 and T
  - (minus) the amount of emmigrants O between 0 and T.

The demographic equation (DE)

Splitting up the DE

The difference $B - D$ is called **natural increase**

- The difference $I - O$ is called **net migration.**
- The difference $\Delta P = P_T - P_0$ is called **population change.**
- Thus,

$$\Delta P = \text{Natural Increase} + \text{Net Migration} \tag{2}$$

Demographic equation

What term dominates the most?

When expressing ΔP by Eq.(2), it becomes clear that, technically speaking, there can be three scenarios:

- In some parts of the world, ΔP is dominated by the (rate of) natural increase.
- In others, Net Migration is more important.
- In some they are basically equally important.

Demographic equation

Social population growth

Regions of the world where ΔP is driven primarily by migration include:

- 1. Western Europe: Countries like Germany, Spain, and Italy have low birth rates and aging populations. Population growth in these countries is largely driven by immigration, as natural growth is either negative or close to zero.
- 2. Gulf States: Countries such as the United Arab Emirates, Qatar, and Kuwait experience significant population growth due to the influx of migrant workers. In these nations, the majority of the population is foreign, and social growth far exceeds natural growth.

Demographic equation

Social population growth

Regions of the world where ΔP is driven primarily by migration include:

- 3. North America: In the United States and Canada, migration has been a key factor in population growth. While the U.S. has a relatively high birth rate compared to other developed countries, social growth through immigration has been crucial to population increase.
- 4. Australia and New Zealand: Both countries have active immigration programs that have been responsible for much of their population growth in recent decades. Here, social growth has played a more important role than natural growth.
- 5. Singapore: With a low birth rate, Singapore's population growth heavily depends on immigration. The country has implemented policies to attract foreign workers, resulting in significant social growth.

Demographic equation

Natural increase

In some countries, such as Nigeria, India, Pakistan, Ethiopia or the Philippines, population growth is primarily driven by natural growth rather than migration.

- A common characteristic among these nations is their status as developing or emerging economies, which often face challenges related to high birth rates and limited access to healthcare and education. These factors contribute to higher fertility rates and a younger population, making natural growth the dominant factor in their population dynamics.

Demographic equation

Error of closure

Sometimes the basic demographic equation is called **Balancing Equation,** although, in practice, it rarely balances exactly.

- The difference between the left hand side and right hand side of Eq. (1) is called **error of closure.**
- The error of closure is an indicator of the quality of demographic data: The greater the error, the worst the quality of demographic data.

Demographic equation

The DE in terms of rates

The demographic equation can also be expressed in terms of rates dividing it by the person-years lived during 0 and T.

- In practice, it is a convention to approximate the person-years lived during 0 and T using the **mid-year population**, MYP.
- The MYP is approximated by the average of the population at the begining and the end of the year.

Demographic equation

The DE, in terms of rates

Theoreticaly:

$$\frac{P_T - P_0}{PY(0,T)} = \frac{B(0,T)}{PY(0,T)} - \frac{D(0,T)}{PY(0,T)} + \frac{I(0,T)}{PY(0,T)} - \frac{O(0,T)}{PY(0,T)},$$

- The difference $\frac{B}{PY} - \frac{D}{PY}$ is called the Rate of Natural Increase (Crude Birth Rate - Crude Death Rate) [CBR - CDR]
- The difference $\frac{I}{PY} - \frac{O}{PY}$ is called the Net Migration Rate (Crude Rate of Immigration - Crude Rate of Outmigration) [CRI - CRO]
- The term $\frac{P_T - P_0}{PY}$ is called the Crude Growth Rate [CGR].

Demographic equation

The DE, in terms of rates (Spanish)

Be careful when translating the aforementioned terms! In Spanish we say:

- "*Tasa Bruta de Natalidad*" for the CBR
- "*Tasa Bruta de Mortalidad*" for the CDR
- "*Tasa Bruta de Inmigración*" for the CRI
- "*Tasa Bruta de Emigración*" for the CRO
- "*Tasa Bruta de Crecimiento*" for the CGR