DEMOGRAPHIC ANALYSIS

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Keywords : demography, analytical tools, Lexis diagram, reproduction rates

Contents

1. Introduction

The word *demography* was coined in 1855, but demography was born two centuries earlier, when a London citizen, John Graunt, empirically developed simple and rigorous techniques for drawing out of a large amount of individual data on deaths and their causes the quantitative and qualitative features of the biosocial phenomenon of mortality.

His *Natural and Political Observations upon the Bills of Mortality* (1662) deal with a number of topics related with birth, marriage and death, as well as the size and structures of a population. By inventing simultaneously descriptive statistics and demographic analysis, Graunt showed not only his genius, but also some temerity, since most of his contemporaries deemed blasphemous his claim to "scientifically" unveil the mysteries of life and death.

Among his followers who improved the methods of observation, measurement and analysis of population processes, let us name a few 17th and 18th century "political arithmeticians": E. Halley (first life table), G. King, W. Kersseboom, N. Struyck, J.-P. Süssmilch, P. Wargentin, L. Muret, J.-B. Moheau. Great mathematicians such as Bernouilli, Laplace, Euler, De Moivre, Gompertz, contributed to the formalization of tools that were first made up empirically, and cleared a way for modelling. In the 19th and 20th centuries, A. Quetelet, M. Duncan, J. Bertillon, R. Kuczynski and A. Lotka paid noticeable contributions to the progress of a methodological body that does not show any sign of numbing.

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2. Basic concepts

2.1 Population and demography

Demographers study populations. So do ethnologists, sociologists and geneticists… Specifically, the demographic approach aims at describing and explaining the process of continuous change experienced by a population with the passing of time. *Demographic analysis* is an integrated body of principles and methods particularly fit to that approach. It is not, as one might suppose, a question of merely applying the basic techniques of statistical description to mortality and fertility, since those demographic phenomena exhibit specific features that deserve the settling of appropriate tools, some of which reach a high degree of refinement.

Thus a *population* can be analysed from a *demographic* point of view from the moment it is, at least potentially, *subject to a continuous process of change as time goes by*. We will examine later the nature of that process of change, but let us first look into the concept of population. For demographers, a population is a set (in the mathematical sense of the word) of elementary units (*individuals*), homogenous as regards some characteristics (*inclusion criteria*), and evolving under the effect of a more or less complex mechanism of change.

In order to be dealing with a real "population", it is necessary that, all the time, any "individual" (any being about which it is not absurd to wonder if it is in or out of the population under study) be in an only definite position regarding each inclusion criterion. For instance, "the resident population of Ireland as of 1st January 2000" is composed of all the individuals who, on the 1st of January 2000, fulfill simultaneously the three following conditions of inclusion:

- (*a*) he/she is a human being;
- (*b*) he/she is alive;
- (*c*) he/she enjoys legal resident status in Ireland (tourists and illegal immigrants are excluded).

It goes without saying that, in order to be a member of that population, one must comply with all the inclusion criteria, but that if you do not fulfill just one of them, you are out of the population.

2.2 Population dynamics: entries, exits, internal transitions

Time elapses… The resident population of Ireland as of 31st December 2000 will certainly be different from that of 1st January 2000. Between these two dates:

- A number of persons maintained their position regarding the three inclusion criteria; so they are still in the population;

- A number of persons went out of the population because they stopped complying with at least one criterion: some died (criterion *b*), others emigrated and thus lost legal resident status (criterion *c*);

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- A number of persons entered the population by obtaining the inclusion characteristic(s) they were missing: birth of a child in a family of legal residents (simultaneous fulfillment of the three criteria), attribution of legal residence to an immigrant (fulfillment of criterion *c* by someone who already complied with conditions *a* and *b*).

So, a population is a set into which one enters from the moment one fulfills all the inclusion criteria, and out of which one exits from the moment one does not comply with at least one of these conditions. Entries and exits are among the mechanisms by which the population changes with the passing of time. They alter at least one fundamental dimension of the population: its *size*. Every time a person enters (exits from) the population, the size of the latter increases (decreases) by one unit. This accounting is reflected in the "integral equation of population dynamics":

$$P(t_1) = P(t_0) + \text{Entries}\ (t_0, t_1) - \text{Exits}\ (t_0, t_1)$$

where P is the size of the population, t_0 and t_1 are two dates, and (t_0, t_1) is the time interval between these two dates.

Entries and exits are the only mechanisms that, being connected with the criteria of inclusion, alter the *size* of the population. But they also impact on many other aspects of the population. Let us imagine that an immigrant enters the population. He not only adds one unit to the size of the population, but he also brings into it all his personal characteristics: his sex, his age, his educational level, the colour of his eyes, his political opinion, etc. By so doing, he alters the statistical pattern (the *structure*) of each one of these characteristics in the population. Every entry and every exit impact on the structures of the population by a host of variables.

Some of these structures can also change by means of individual events (*internal transitions*) that are neither entries nor exits: when some member of the population remains in it but changes one of his/her characteristics, the structure of the population by that characteristic changes. For instance, when two members of the population marry, the size of the population is not modified, but there are henceforth one single person less and one married person more among both sexes; thus the structure of the population by marital status changes. One must pay special attention to a category of characteristics whose structures change in a perfectly steady and continuous way: *durations.* Without any event occurring, the mere passing of time uniformly increases all durations. In the demographic field, the most typical duration is age (time elapsed since one's birth), but also of interest are durations elapsed since other kinds of *events-origins*: marriage, death of spouse, immigration, birth of second child, last move, etc. Thus, the ageing of individuals continuously alters the structure by age of the population, and more generally all the structures by duration variables.

Those are all the components of what we called "the continuous process of population change".

Depending on the kind of population under study, the mechanisms of change (other than the passing of time) can differ: for instance, in the population of a country, entries are provided by fertility and immigration, whereas in the population of a company, they

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result only from hiring. Of course, the demographic analysis of these various phenomena must be adapted to their specific nature, but it is easy if one leans on the general principles that we will now describe. Below, we will deal with the typical case of a country's human population; the ways of entry and exit will then be birth, death and migration.

Entries, exits and internal transitions are demographic *events* (births, deaths, marriages, migrations…), individual expressions of general entry, exit or transition processes called demographic *phenomena* (fertility, mortality, nuptiality, migration…).

3. The key variable: time

3.1 Dates, durations, cohorts

Since the primary objectives of demographic analysis are to describe the size and structures of a population at a given time and to describe its change in size and structures between two dates, *demographic situations and events must be dated*. It even proves relevant to locate them on two or three time scales: for instance, when studying divorce, it is interesting to record not only the date of occurrence of every divorce (because of the influence the period of occurrence can have on the probability of divorce), but also the ages of the divorcing persons and the duration of their marriage (because these two variables are known to be important determinants of the risk of divorce). Usually, three time coordinates are relevant to explanatory analysis in demography:

- The *date* of observation or of occurrence. The probability of occurrence of a given event (birth, marriage, death, migration) can be strongly influenced by current period characteristics: for instance, all other things being equal, demographic behaviours are not the same in peacetime and in wartime, or before and after some legislative reform. This coordinate allows to bring to light "period effects".

- The *duration* elapsed since a relevant event-origin at the occurrence of the event under study. The probability of occurrence of an event can largely depend on the amount of time passed since a specific initial event: the risk of dying closely depends on age (duration of one's life, or time elapsed since one's birth), the probability to give birth to one's second child also depends on the duration elapsed since the birth of the previous one. The most often considered duration in demography is age, and it naturally is used to highlight "age effects".

- The *cohort*, group of persons who experienced the same event-origin at the same time, usually identified with the period when that event-origin occurred. It is frequently observed that the probability of experiencing a given event is shared by all the members of a cohort, and varies from one cohort to another. For instance, with the changing of habits, the behaviours of recent birth cohorts are different from those of older ones; another example: in Europe, the persons who got married immediately after the Second World War (marriage cohorts 1945-1949) have had, during the rest of their lives, procreational attitudes different from those of their predecessors. These are "cohort effects".

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