Decomposition Methods in Demography

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Conclusions

11.1 Introduction

This final chapter summarizes the research presented in the previous ten chapters. It includes three sections, beginning with this introductory part which reviews both Part II and Part III of the book. Based on the studies of all these methods we have drawn some conclusions about desired *Properties of Decomposition Methods,* which are included in the following section. Finally, the last section presents some concluding remarks on future prospects of decomposition methods.

The word decomposition in demography is not restricted to separations of changes over time. It is used in simple cases for defining an addition as well as in complex cases where derivatives with respect to different variables are found. In this book we have used decompositions for analysis of changes of demographic variables over time.

When decomposing social change over time, it is important to keep in mind that this is a form of data reduction whose objective is to summarize the effects of the components of change.

This has been the concern of many researchers. In demography the studies of decomposition date back to the 1950s when Kitagawa proposed a simple technique that separates the difference in demographic rates. This study inspired further research questions on how to allocate components when numerous variables are involved in the rates of study. Some methods are general decomposition techniques while others are particular applications to demographic variables. In Part II we studied applications of decompositions to measures of mortality, fertility and population growth rates. Finally, we introduced some methods used when analyzing demographic variables with parametric models.

This review of the methods of decomposition set a framework to introduce Part III and *The Direct Versus Compositional Decomposition.* This core part of the book presents Vaupel's (1992) general method of decomposition and this author extensions of Vaupel's method that

can also be used in particular areas of demography, such as the study of life expectancy and population growth. We claim and prove in this book that this decomposition technique deals effectively with demographic variables that have different types of changes over time.

The greatest advantage of this direct vs. compositional decomposition is its simplicity. If $\bar{v}$ denotes a demographic average and $\dot{\bar{v}}$ its change over time, then this is simply decomposed as

$$\dot{\bar{v}} = \bar{\dot{v}} + C(v, \acute{w}).$$

The change in an average is expressed as the sum of the average change of the variable of interest and the covariance between this variable and the intensity of its weights. In this way, the change over time in the crude death rate is separated into the average change in the death rates and the covariance between the death rates and the age-specific growth rates. Similarly, the change in the average life expectancy of the world is the average of the changes in the country-specific life expectancies and the covariance between these life expectancies and the population growth rates of the countries. The change in the population growth rate of the world is the average change in the countries' population growth and the variance of the growth rates. The average age of the population can be taken as an average of average ages over subpopulations. Its change is due to a change within each of these subpopulations and a change between the subpopulations. This is the average over subpopulations of the covariances between age and age-specific growth rates, and the covariance between the subpopulations' average age and their total growth rate, respectively. The intensity of the crude birth rate is decomposed into terms on the intensity in age-specific fertility rates, intensities of the female ratio and a difference between two average growth rates. Many other applications are possible. By using direct vs. compositional decomposition, the user knows the components that account for the change and the way these components are inter-related.

We have supplied some extensions of direct vs. compositional decomposition here, namely an age, categorical and cause-specific decomposition, and a multidimensional decomposition. These are some of the options that are of interest for demographers. Further extensions are suggested in the book such as the possibility to use this methodology for cases with samples instead of population totals. Another extension could be to examine second derivatives which allow us to study the contribution of the speed of the changes and the contribution of the components to this change.

A final contribution of this method is the possibility of implementing assumptions on the change over time of the demographic variables involved in the decomposition. This flexibility arises when considering the use of continuous change which can be interpreted as linear, exponential, logistic or another type.

From reviewing previous methods and comparing them with direct vs. compositional decomposition we gained more insight into the desired properties of a decomposition method. In the next section we list the most important properties.

11.2 Properties of Decomposition Methods

Several properties are desirable for a decomposition method. The following lists the most relevant properties.

- The decomposition method should allow the study of changes over any parameter: time, populations, sexes, ages, ethnicity, education attainment, etc. For example, when studying the decompositions of the age-specific growth rates we also included changes over age and cohorts.

- The method should also separate the total change into independent terms and avoid interaction effects. For example, when studying demographic averages, changes occurring in the variable of interest and those in the structure of the population should be separated into independent terms. Also residual terms are inconvenient for interpretation and, when present, if they have an important contribution in the change they are also a clear sign of the method's inefficiency.

- The components of the decomposition should represent meaningful demographic terms. This is a key issue in decomposition theory. The aim of this theory is to explain the total change into parts that have a clear interpretation and that explain the dynamics among the variables involved.

- The decomposition should have a simple mathematical expression which is easy to remember. A basic consideration in the use of any method is a formulation that immediately draws attention to its elements. The fewer and simpler these components are, the easier it is to use the method.

- The method should allow further decompositions for age, categorical and for cases of numerous compositional components, among others. For example, when decomposing life expectancy it should allow for a cause of death decomposition. Another example is the case of numerous compositional components. The decomposition should allow the user to choose whether there is a certain hierarchy between the components, or if they are all equally balanced.

- The methodology should be related to other decomposition methods. As in any other theory, decomposition methods are built on previous efforts in this area. The steps in the development of a new general decomposition have to relate to the questions that other, earlier decompositions have aimed at answering. It should study how these previous methodologies have answered the questions and permit implementations of the previous methods in the new technique.

- The decomposition should explicitly show the relations between the variables involved in the dynamic process under study. We are interested in studying the parts that explain the phenomena as well as in examining how these parts relate to each other.

- A decomposition method should have an expression for the relative change, relative to time, to a population, to one of the sexes, to an ethnic group, or to a similarly designated group, depending on the change under study. In the case of changes over time this is the intensity of the demographic average or its growth rate.

- The method should be flexible and allow the change of variables over time to be of different types: linear, exponential, logistic, and others. In many cases this entails suggesting a

particular type of change for each of the variables involved in the decomposition, though the change is not necessarily equal change for all.

These are the properties that have become evident during the present study. Additional desired attributes could be listed for every one of the challenges that demographers have solved by using decomposition methods.

The direct vs. compositional decomposition of Part III has proved to fulfill all the properties listed above and, therefore, contributes to a greater understanding of population dynamics.

11.3 Concluding Remarks

Which decomposition method is to be preferred?

This question has been of interest to numerous researchers, including those mentioned in this book. The criterion for choosing the most suitable decomposition technique depends on the demographic phenomena of study and the time of study.

As noted earlier, many methods complement each other by focusing on new aspects of the change that have not been revealed by other methods. A second conclusion, which involves more calculations, is the advice to apply all possible methods. By doing this the analysis will benefit from studying several factors associated with the phenomena being measured. Please note that we have used the word association for the relation between the demographic average and the components, or factors. This is to avoid the misunderstanding of causal relationship. Underlying unobserved heterogeneity of the components can actually be responsible for these associations.

Initially the decomposition methods were used to study the difference in demographic measures between two periods of time. This is an interesting aspect of population dynamics. However, it is important to analyze changes from a wider perspective. The era of the computer and the revolution of information have accelerated the collection of data and thus the amount of demographic information available. Consequently, new information will allow us to modify the assumptions of trends over time in demographic variables so that they become more similar to the real observed paths. The direct vs. compositional decomposition, then, is likely to become the leading methodology for studying change over time in demographic variables, because of its flexibility and ability to effectively capture change over time.