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The Dictionary of DEMOGRAPHY

Edited by
CHRISTOPHER WILSON

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Basil Blackwell Inc.
432 Park Avenue South, Suite 1505
New York, NY 10016, USA

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Contributors

John G. Blacker JGB
Centre for Population Studies, London

John Bongaarts JB
Population Council, New York

Mead T. Cain MTC
Population Council, New York

John C. Caldwell JCC
Australian National University

J. G. Cleland JGC
World Fertility Survey, London

Joel E. Cohen JEC
Rockerfeller University, New York

Tim Dyson TD
London School of Economics

Douglas Ewbank DE
University of Pennsylvania

Griffith Feeney GF
East-West Population Institute Honolulu

Allan Hill AH
London School of Hygiene and Tropical Medicine

Kenneth Hill KH
National Academy of Sciences, Washington

R. J. Johnston RJJ
University of Sheffield

Chris Langford CML
London School of Economics

Ronald D. Lee RDL
University of California, Berkeley

P. N. Mari-Bhat PNM-B
University of Pennsylvania

Michael Murphy MM
London School of Economics

Hilary Page HP
Interuniversity Programme in Demography, Vrije Universiteit, Brussels

Roland Pressat RP
Institut National D'Études Démographiques, Paris

Pat Quiggin PQ
Australian National University

Philip Rees PR
University of Leeds

Eve Roman ER
London School of Hygiene and Tropical Medicine

Roger Schofield RSS
Cambridge Group for the History of Population and Social Structure

Christopher Scott CS
World Fertility Survey, London

Richard Smith RMS
All Souls' College, Oxford

David C. Souden DCS
Emmanuel College, Cambridge

James Trussell JT
Princeton University

Helen Ware HW
Human Rights Commission, Canberra

Christopher Wilson CW
London School of Economics

E. A. Wrigley EAW
London School of Economics

Guillaume Wunsch GW
Université Catholique de Louvain

Basia Zaba BZ
UNECLA, Trinidad

ergodicity The property of having the present state of a population independent of its make-up in the remote past, and determined only by the birth and death rates recently experienced. It is a crucial element in the construction of mathematical models of demographic change.

Not all populations display ergodicity. Those that do are ergodic because births occur simultaneously to parents from different earlier cohorts, gradually smoothing the time series of births.

When the current state of a population is specified by a census solely according to age, it is determined by the age-specific rates of birth, death and possibly migration. When the present state of the population is specified by age, sex and characteristics such as geographical location or educational status, it is determined by birth, death and migration rates specific to age, sex and the other characteristics.

Ergodicity can be proved to be a property only of mathematical models of populations, and is imputed to a real population on the hypothesis that the real population is well described by some mathematical model that has been shown to be ergodic. Strong ergodic theorems assume that the vital rates of a population model are fixed over all time. The theory and applications of STABLE POPULATIONS are based on strong ergodic theorems. Weak ergodic theorems assume that populations experience a given deterministic sequence of possibly time-varying vital rates.

Stochastic ergodic theorems assume that the sequence of vital rates experienced by a population is not deterministic but is modelled by a stochastic process. A stochastic ergodic theorem asserts that in the long run the probability distribution of the population model will depend on the stochastic process that has been governing the vital rates and not on the initial state of the population model. JEC

Reading

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data on marital status often include visiting and common-law unions as well as the conventional categories. RP, CW

Markov chain models Stochastic or probabilistic models of the evolution of a process (here a demographic process). Markovian models are distinguished from other stochastic models by the special characteristic that, given the present state of the process, the probability distribution of future states is assumed to be the same regardless of the previous history of the process. The Markovian property is summarised by saying that the future is conditionally independent of the past, given the present.

A Markovian model is often said to be a Markov chain model when the number of states used to describe the process is finite or countably infinite and time is treated as progressing in discrete steps. In these cases the Markov chain can be completely described by the probabilities that the system is in each state when the process is first observed (these probabilities constitute the initial probability distribution) and by the TRANSITION MATRIX.

A concrete example of a Markov chain model in demography is a model for the reproductive history of a woman. In a simple version the states of the woman could be: susceptible to conception, pregnant, post-partum lactating but non-susceptible, and amenorrheic after a miscarriage or abortion. The time step might be the duration of one normal menstrual cycle. The transition probability matrix would specify, say, the probability that a woman susceptible to conception at one menstrual cycle would remain susceptible at the time of the next; the complement of that probability would be the probability that she would become pregnant. The equilibrium fraction of time that a woman would spend (during her fertile years) in each state and the mean inter-birth interval could be examined as a function of the conditional probability of remaining susceptible from one cycle to the next, which in turn would be affected by con-

traceptive practice. The Markovian assumption in this model implies that the woman's probability of conception during her next cycle, given that she is susceptible to conception now, is independent of her entire past: in particular, independent of how long she has been susceptible and how often she has been pregnant previously. Thus the Markovian assumption may limit the empirical relevance of the model.

Even in Markovian models that are more sophisticated than this simple example it is important to use longitudinal data on the history of the process being modelled to check the Markovian assumption as directly as possible.

Markov chain models fall between the extreme of dependence, or complete memory, in which the probability distribution of a future state depends on the entire present and past history of the process, and the extreme of independence, or no memory, in which the probability distribution of a future state is entirely independent of present and past states.

Markov chain models have been extensively developed for reproduction, multiregional migration, intergenerational and intraorganisational mobility, population genetics, morbidity and health. JEC

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transition matrix A tabular summary of the absolute or relative frequencies with which individuals move among states within a certain time period. ('Individual' may refer to a family or other unit.) For example, in studies of intergenerational mobility a transition matrix may tabulate the social class of a son as a function of the social class of the father. In this example, 'state' refers to a social class.

Assuming that individuals can occupy only one state at any given instant, one row of a transition matrix and one column of the matrix is assigned to each state. In the intersection of the row for state *i* and the column for state *j* is recorded the number of individuals who were in state *i* at an initial time and in state *j* at a final time.

Such a transition matrix of absolute frequencies may be converted to a transition matrix of relative frequencies by dividing each number in row *i* by the sum of the numbers in row *i* . The fraction in row *i* and column *j* then describes the proportion of individuals initially in state *i* who were finally in state *j*.

Transition matrices of absolute and relative frequencies are descriptive statistics. Theoretical transition matrices that specify probabilities in place of relative frequencies are frequently derived from MARKOV CHAIN MODELS. JEC