CLC Briefing Paper 6

New Methodology for Modelling Population Change

Introduction

Since John Graunt's initial studies of human mortality in 1662, empirical demographers have held sway over the study of population change. While the early days of 'political arithmetics' have ultimately, over the course of the centuries, given way to modern techniques of event-history analysis, multilevel analysis and microsimulation, the core question remains the same: how can we understand population change scientifically and make the best use of the data available?

In recent years demographers have been paying ever more attention to the different levels of analysis in population sciences and to the uncertainty and complexity inherent in the study of human populations. This has resulted in the development of multilevel modelling approaches, and most recently the adoption of agent-based modelling methodologies in demography. Care Life Cycle project researchers and European collaborators have proposed a *system-based* modelling framework for population studies that combines the recent focus on complexity and multilevel approaches with the traditional empirical strengths of demographic research. We propose that these methods will allow for the development of more sophisticated, policy-relevant simulations of human populations.

The Complexity of Human Populations

Attempting to understand population change has never been straightforward, and the history of population science is punctuated by significant methodological advances as social science has adopted ever more complex modelling methods. From cohort analysis techniques to contemporary multilevel modelling, population scientists have worked tirelessly to incorporate new sources of population-level and individual-level data.

Even now, some of these techniques are reaching their limit. Social processes are understood to be the result of complex, interrelated webs of interactions between individuals, households, societal institutions, governments – each inextricably tied to the other. Traditional statistical methods struggle to capture the effects of these interactions, and thus simulation approaches – particularly agent-based modelling – have grown in prominence in response to these challenges.

Key Points

- Social processes are highly complex and investigating them in detail requires a new approach.
- Traditional statistical methods are useful but lack the ability to capture social complexity.
- A new research methodology called *system-based modelling* has been proposed to address these significant challenges.

Limitations of Agent-Based Models

Agent-based models allow the population scientist to represent the complex networks and feedback loops that underlie social processes. Substantial difficulties remain, however, in that formalising these elements is far from straightforward. Social processes cannot be clearly differentiated into a hierarchy of processes, given their interrelatedness, and the data available is often not easily translatable into useful simulation parameters. This makes agent-based modelling in population science a rather theory-dependent exercise, in practice; the modeller must devise behavioural theories to drive individual agent behaviour in the simulation, often in the absence of data to confirm these assumptions.

A Functional-Mechanistic View of the Social World

Our contention is that agent-based models can be seen as belonging to a larger class of *system-based models*, or models which are intended to specifically analyse systems composed of interacting elements. This broader category includes other approaches in addition to agent-based methods, such as models of higher-level social organisation. Moving in this direction marks a substantial shift in the scientific focus in this area: the object of study becomes not the *individual*, nor the *group*, but instead the *interaction* between elements of the system.

Taking this perspective forward and retaining the traditional strength of population science – namely its strong connection to real-world data – we must also adjust our means of constructing models of populations. We propose that this should consist of a *functional-mechanistic approach*, in which the modeller seeks to induce the functional structure of a system which generates some property of interest. For example, Émile Durkheim's interest in the social process which leads to suicide, and his resultant intensive analysis of empirical data for late 19th century Europe, led to his inference of the *integration theory*, in which the social integration of various groups is found to be most critical. Similarly, the system-based modelling process should start with a collection of all relevant empirical data about the social property under investigation, which would then provide the basis on which to infer the formal structure underlying that property.

Benefits of the System-Based Approach

Viewing social processes through the system-based lens helps us to avoid several major pitfalls of the existing approaches: complexity is reduced by focusing our enquiry on specific social properties; theory-dependence is reduced by following inductive rather than deductive methods; and the modelling process provides insight into how future data collection might be improved to facilitate faster and more effective model-building. Following the 350-years old demographic tradition, the system-based approach is not a total replacement for current methods, of course, but is intended to complement them and to produce more useful insights into complex social processes.

Future research

Further work on system-based modelling techniques will begin with investigations of methods of inductive agent-based simulations. Collaboration between demography experts and simulation researchers will allow for the development of this new paradigm, and for the wider adoption and investigation of these techniques across different fields and in different research contexts. Please contact us if you would like further information on the Care Life Cycle project, via email to clcproj@soton.ac.uk or telephone 023 8059 8981.

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