DOI 10.25336/csp29401
Canadian Studies in Population 45
no. 3–4 (2018), p. 139–40

REVIEW • FORUM

Thomas K. Burch's *Model-Based Demography*[1]

by Samuel H. Preston, University of Pennsylvania

Tom Burch has a lover's quarrel with demography. In his eyes, the field has a useful body of techniques designed to characterize a particular set of empirical observations. But it is deficient in theory and models, without which its status as a science suffers.

How to produce better theory and models? Burch suggests that one approach is to recognize that several classical demographic techniques can be used in broader and more imaginative ways, as effectively illustrated in one chapter on life tables and two chapters on cohort component projection. These should not be presented merely as techniques or measurement devices but should be repurposed as theoretical models that can be used to address a wide variety of issues.

Other models of demographic processes, he argues, should play a more prominent role in the field, including the exponential and logistic curves, the Lotka/Volterra predator/prey relationship, and the macro-level model underlying the "Limits to Growth" project. Model-building software should be more heavily exploited and simulation used more frequently. Hernes' model of the age-pattern of entry into first marriage receives the most ringing endorsement in the volume. One chapter is primarily devoted to it, and it makes prominent appearances in five other chapters. It is an ideal model for Burch's purposes, because it has clear-cut behavioural assumptions that can be expressed mathematically, while the resulting formula can be applied to data in order to estimate underlying parameters. An additional virtue is that it fits data well—although no better than the Coale-McNeil model, to which it is considered superior because of its somewhat stronger behavioural underpinnings.

The stable population model receives the acclaim it deserves, and the virtues of the Goodman/Keyfitz/Pullum model of kinship ties and of the Hammel/Wachter family simulation model are appropriately underscored. But in a volume entitled "Model-Based Demography," I would have expected a somewhat more complete accounting of the major models being used in demography. Any personal list of important models is necessarily arbitrary, but I would have expected discussion of the Sheps/Menken model of the interbirth interval and its powerful simplification by Bongaarts. Other valuable models that might have been cited include Schoen's increment/decrement models of marriage and divorce, Rogers' multiregional models, Vaupel's models of the age-pattern of mortality, Bayesian hierarchical models of population projection, and Lee's models of the age-pattern of consumption and production.

Burch's principal justification for making models and theory more prominent in demography is not so much to enhance its analytic capabilities as to make the field more attractive to students, while raising its scientific credentials. The principal goal is a better "presentation of self." The pedagogic goal is explicit in a three-chapter section entitled "Teaching Demography." Burch has thought a great deal about how best to present demography to undergraduates, and has many

1. *Model-Based Demography: Essays on Integrating Data, Technique, and Theory*. Demographic Research Monographs. Dordrecht: Springer, 2018. ISBN 978-3-319-65432-4. Hardcover C$59.99, 200 pp.; e-book DOI 10.1007/978-3-319-65433-1.

attractive suggestions. One that I found particularly appealing was a formal elucidation of the Easterlin/Crimmins framework for the adoption of contraception, from which many conceptual and analytic spin-offs can be developed.

In support of its assessments, the volume makes many references to epistemology and the philosophy of science. It is rare that demography is exposed to evaluative criteria emerging from those fields, and I found the encounter to be bracing and fruitful. The key distinction between logical empiricism ("empirical generalizations providing the foundation for theoretical propositions arrived at by a process of induction") and abstract theory is stressed, with the arc of history pointing in the latter directions while demography remains unduly tied to the former.

The emphasis on the philosophy of science at times leads to an evaluation of demographers in terms of whether they themselves are good philosophers of demography. Although his enormous disciplinary contributions are recognized, Ansley Coale is chided for not being self-conscious and explicit about the methodology of demography. So Burch spends a fascinating five pages rooting out Coale's methodological asides and characterizing the logic of his many inquiries. (In one passage that students of Coale's may find amusing, Burch expresses frustration that Coale uses the term "idea" instead of "theory.") Nathan Keyfitz, on the other hand, assumes an elevated status because he wrote a 1975 paper entitled "How Do We Know the Facts of Demography?" that convincingly illustrates the value of theory relative to empirical evidence. Burch notes that much of the writing about demography as a discipline has been done by Europeans and Canadians rather than the perhaps-too-practical Americans.

The reason why demography is not advancing faster as a science, in Burch's view, is that it is not attracting people who are strong in mathematics. This diagnosis seems accurate if somewhat tautological. Better mathematical preparation among demographers would certainly increase the likelihood that formal models would develop faster and deeper. A more general statement is that a field advances most rapidly when it attracts outstanding scholars. Non-mathematical behavioural models have also been of critical importance to the field—I think especially of John Caldwell's enormous contributions to the understanding of health transitions through close observation and creative reflection. Or consider the group of economists like Mark Rosenzweig and Jere Behrman, who have brought a more rigorous approach to identifying causal processes in demography by insisting on proper research designs for analyzing observational data.

Despite many major advances in the corpus of demography, I share Burch's view that demography is not advancing as rapidly as it should be, or as it was two or three decades ago. External pressures probably play a role. Socially conscious scholars may be less likely to be drawn to the field because rapid population growth is no longer considered a major social threat. Fertility analyses, in particular, seem somewhat moribund, at least when China is not the setting. On the other hand, studies of population health have become more sophisticated and more prominent, as illustrated by the growing frequency of their appearance on the annual meeting programs of the Population Association of America. Firm support for such studies by the US National Institutes of Health probably contributes to this trend.

A thorough assessment of the past, present, and future of demography would be a worthwhile undertaking. Tom Burch's lively and provocative *Model-Based Demography* provides one of the foundational documents for such an assessment.

DOI 10.25336/csp29382
Canadian Studies in Population 45
no. 3–4 (2018), p. 141–43

REVIEW • FORUM

Thomas K. Burch's *Model-Based Demography*[1]

by Daniel Courgeau, National Institute for Demographic Studies

The central concern of this book is with the role and status of theory in demography. It gives a very deep overview of the importance of model-based demography, compared with the usual logical empiricism followed in this discipline. While these papers were written during a long period of time (the past three decades), they develop a new, original, and coherent view of demographic research. Professor Burch constructs theoretical models here that consist of clear concepts, with well-specified relations among them. He rejects the heavy reliance on statistical models in mainstream demography, which have no place for unmeasured variables. For him, computer modelling is an essential tool for theoretical work in the twenty-first century.

This book appeared in the same year as the paper I published with Bijak, Franck, and Silverman (Courgeau et al. 2017), and their main titles are the same. This was not at all a casual coincidence, as during the preceding year we had conducted a thorough discussion with Burch on such a model-based demography. I will first give here the flavour of this exchange before proceeding further.

The first point is related to the use of agent-based models in demography. Burch's chapter 2 was written for the Billari and Prskawetz book on this topic (2003) . In their introduction to this book, they said that "agent-based computational models pre-suppose rules of behavior and verify whether theses micro-based rules can explain macroscopic regularities" (p. 2). Burch agrees with this definition, as he writes in this chapter: "A particularly promising genre of simulation is agent-based modelling, which promises to link individual demographic behaviors to aggregate patterns, and to explicate the social—as distinct from stochastic—mechanisms underlying demographics dynamics" (p. 40). Even in his chapter 14, Burch considers agent-based modelling as the final step among the methodological paradigms in demography: from *period analysis* to *multi-level analysis* to *agent-based models*.

We agree that agent-based modelling constitutes an improvement in demography, but feel that it may not necessarily constitute a *new paradigm* for this discipline. First, it does not give a new combination of concepts, like the cross-sectional, the longitudinal, the event-history, or the multi-level paradigms, but only a new way to treat them by computer simulation, even with some arbitrariness. We also agree with Holland's criticism when he writes that agent-based computational models offer "little provision for agent conglomerates that provide building blocks and behavior at a higher order of organization" (2012). Indeed, micro-level rules find hardly a link with aggregate-level rules, and it seems difficult to think that aggregate-level rules may be entirely modelled with a micro-approach, since they transcend the behaviours of the component agents. An emergent entity such as a social network has properties which its component parts—here, the individuals in this network—do not have. For instance, a multi-level analysis on the effects of an

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individual characteristic (e.g., being a farmer) and the corresponding aggregate characteristic (the proportion of farmers living in an area) on the probability of internal migration in Norway shows that the effects are contradictory (Courgeau 2003): it seems hard to explain a macro-characteristic acting positively by a micro-characteristic acting negatively.

The second point is related to the difference between a *semantic* and a *mechanistic* view of science. Burch tells us: "My understanding is that your basic approach to science would be similar to that of the 'semantic' school. Yet there is little if any reference to their work" (pers. comm.). So, let us see if the model-based view of demography developed in this book, and in our paper, covers the same philosophic content.

In his first chapter, the author clearly defines his view of model-based science: "This view of theory is known in philosophy of science circles as the 'semantic' view, or more recently and descriptively, the 'model-based' view of science" (p. 3). This semantic theory of models attacked the empirical explanatory models that had dominated the philosophy of science before the 1960s, and promoted formal explanatory models during the following decades. Even if various versions of this approach differ (among, for example, Frederick Suppe, Bas van Fraassen, Ronald Giere, etc.), it continues to be developed nowadays. In this approach, *models*, as abstract representations of some portion of the world, are the central element of scientific knowledge, which reject empirical laws. For the 21st-century researcher, computer modelling will permit the statement, manipulation, and evaluation of more and more complex theoretical models, which can be used to make claims about specific aspects of the world. But how in this case would one identify the relationship between the theoretical model and the empirical observations, and test the fit of a simulation model? There is a real danger in constructing a theoretical model without any relationship with observed data and no way to verify this relationship. As Burch says in chapter 3, " 'Correct' predictions can result from a model with incorrect assumptions and inputs" (p. 59).

In order to go further and to enrich this approach, we rely on *model-based science*, which is known in the philosophy of science as a *mechanistic view*, mainly developed for the biological sciences during the 1990s. Again, various versions of this approach exist (William Bechtel, Carl Carver, Stuart Glennan, etc.), but its development nowadays is increasingly not only for the biological sciences but also for the social sciences. In our case, we are working with the version given by Robert Franck (2002), the *functional-mechanistic* approach; and its application to demography we term *model-based demography*. As with the semantic view, the mechanistic theory of models rejects the empirical explanatory approach. This may be the main reason of Burch's confusion of the two approaches, which are in many aspects similar in their rejection of logical empiricism. But while for the semantic approach a theory is a *formal* system, empty of any empirical content, the mechanistic one infers, from the sustained observation of some property of nature, the *functional* structure—in classical terms, the *axiom, form, principle,* or *law*—which rules the process generating this property, and without which this property could not come about as it does. By focusing on the mechanism generating a social property, the functional structure is treated independently of the causal structure and may therefore be generalized. Although this approach has been successfully applied to some social sciences, like archaeology or communications (Pratt 2011), it has not yet been entirely applied to demography, even if the functions of fertility, mortality, and migration clearly delimit its parameter space—in other words, the principle of all demographic growth or decline.

We may conclude that our two model-based demographies cover the same philosophical content, permitting the dismissal of the "covering law" approach and the creation of a formal system from which the facts to be explained can be deduced. However, while the semantic view leaves unanswered the question of *realism* in science, the functional-mechanistic view permits us to introduce simultaneously a *formal* and an *empirical* explanation. As Franck said, "The formal (conceptual)

model is the form of the social mechanism, and the social mechanism is the matter of the formal model" (2002: 296).

Even if I did not tackle all the questions raised in our discussion with Professor Burch, I hope that this short review will permit readers to see its fruitfulness. Our views are quite similar in abandoning the "covering law" approach based on empirical regularities, and in discovering a system's principle from the study of its properties. I hope that these model-based approaches will bring about further opportunities for constructing and verifying their validity.

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DOI 10.25336/csp29383
Canadian Studies in Population 45
no. 3–4 (2018), p. 144–45

REVIEW • FORUM

Thomas K. Burch's *Model-Based Demography*[1]

by David A. Swanson, University of California Riverside

This open-access monograph by Tom Burch is a recent—and valuable—addition to a long-standing series of research monographs under the general editorship of James Vaupel that is produced by Springer in conjunction with the Max Planck Institute for Demographic Research (Rostock, Germany). It can accessed and downloaded in whole or part at:

https://www.demogr.mpg.de/en/projects_publications/publications_1904/monographs/model_based_demography_5983.htm

The monograph consists of 200 pages organized into four major parts, with chapters 1 through 5 in the first part (I. A Model-Based View of Demography), chapters 6 through 10 in the second (II. Some Demographic Models Re-visited), and chapters 11 through 13 in the third part (III. Teaching Demography). The Final Part (IV. Conclusion) consists of chapter 14, "Concluding Thoughts."

The first chapter, "Demography in a New Key: A Theory of Population Theory," opens Part I (A Model-Based View of Demography) by providing an overview of and introduction to Burch's primary argument, which is that a *model-based* view of science is the perspective that should be used in conceptualizing, researching, and teaching demography. In the second chapter, "Data, Models, Theory and Reality: The Structure of Demographic Knowledge," the author lays the groundwork for his argument, which is illustrated and supported in the three remaining chapters in Part I of the monograph, covering topics regarding the use of simulation and differential equations in demography.

In Part II (Some Demographic Models Re-visited), Burch looks at several important frameworks extant in demography, including the *cohort-component population projection model*. In regard to the latter, he observes that it embodies a sound theory of population dynamics and is a good theoretical model, noting that its drawbacks relate to the way it was perceived and used, as an exclusively valid approach to population forecasting, often applied and interpreted in a mechanical manner.

In chapter 11, Burch kicks off Part III of the monograph, Teaching Demography, with ten principles, which stem from his critique that contemporary social science labours under the burden of logical positivism, which provides a faulty view of the nature of science. It is worthwhile to list all ten principles here because they provide an insight into the monograph as a whole.

> 1. Put more emphasis on theory, that is, abstract models of population dynamics and demographic behaviour. Teach demography as a body of theoretical knowledge, as well as a body of data, techniques, and descriptive findings.
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> 2. Hold on to older and simpler—even 'oversimplified'—models insofar as they contain valuable insights and can help students begin to understand.

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3. Put more emphasis on student activity in which they use theoretical models to analyze real-world—or at least realistic—problems and exercises.

4. Set problems and exercises that will lead students to face the limitations of the analytic tools they have learned and encourage them to try to think of improvements.

5. Teach or require the tools students need to work rigorously with the theoretical models.

6. Integrate formal demography ("techniques") and population studies ("substance") rather than teaching so-called "technical demography" in completely separate courses or relegating it to an appendix, as is typical in many English language demographic texts.

7. Teach the basic principles of formal demography in every demography course, unless it can be assumed that students already know them.

8. Emphasize the general principles underlying many apparently disparate measures and models to make the teaching of formal demography more efficient.

9. For beginning students of demography especially, put less emphasis on data collection, errors in data, and precision in techniques.

10. Rely more heavily on visual representation of theoretical ideas and processes.

"Concluding Thoughts" is the tile of the single chapter 14 in Part IV (Conclusion) of the monograph. Here, Burch argues that a model-based view will provide a liberating and more fruitful approach to theory, modelling, and demographic explanation.

Tom Burch's monograph can be viewed as a summary of the thoughts that he has assembled on population theory after many years of careful consideration, and he ties them not only to theory but to modelling and explanation, as well as to teaching. This monograph is an important, seminal contribution to the field of demography that is extremely well-written and organized. You should read this liberating monograph, but beware that in so doing, your level of comfort with how the field is currently conceptualized, studied, and taught will be disturbed and, possibly, forever altered.

DOI 10.25336/csp29413
Canadian Studies in Population 45
no. 3–4 (2018), p. 146–48

REVIEW • FORUM

Reflections on reviews by Courgeau, Preston, and Swanson[1]

by Thomas K. Burch, University of Victoria

It is a privilege and a pleasure to have *Model-Based Demography* reviewed by three eminent demographers, all the more so because they represent different academic backgrounds and different intellectual traditions within demography. I value their expressions of appreciation for the book, but also their questions and criticisms, which will help others and me better understand the issues at hand.

Samuel Preston says that I have "a lover's quarrel with demography." I would emphasize the *lover* part. My quarrel is with those who would identify demography with "human bookkeeping," or view it simply as a branch of statistics. I prefer to think of demography as a complete and autonomous science, and a much better discipline than we sometimes recognize. But we must drop our logical positivist blinders and view our discipline from a different perspective. In my opinion, the semantic or model-based school of philosophy of science provides a fruitful perspective. I would say of demography what Ronald Giere has said of science in general: "The problem is not with current scientific theories of the world, but with current theories…of what it is to acquire good scientific theories of the world" (1999: 3). Demographers know much more about human population than we give ourselves credit for. Again, quoting Giere, "our collective self-knowledge lags behind our collective knowledge of the world" (1999: 3). But the totality of demographic knowledge has not been adequately codified and unified. This is less true of the technical/formal side of demography, and truer of the behavioural and theoretical side.

David Swanson quotes my ten principles for teaching demography "because they provide an insight into the monograph as a whole." In this context, I would take the opportunity to add two more:

> 11. In judging the worth of a model or theory, a central consideration is the purpose for which it is being used. A good model for one purpose may be a bad model for another. The life table stationary population model is good for many purposes. But many years ago, the use of a series of stationary populations to study population aging led to a partially wrong conclusion: declining mortality invariably was associated with population aging—that is, a larger proportion of the population over age 65 in the stationary population. Overlooked was the fact that stationarity in the face of declining mortality implies declining fertility. A good model was used for the wrong job.
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> 12. It follows that there may be many useful models of the same phenomenon, and that there is no perfect model that excludes all others (Teller 2001).

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And so, I agree with Preston when he notes that I have discussed only a few of the many excellent models in demography. But the models included are simply examples, chosen to illustrate a specific methodological or pedagogical argument. An inventory and synthesis of all or the most worthwhile demographic models would be a different and much larger task, perhaps a task beyond the ability of a single researcher. Such a compendium would include micro-behavioural models, such as Lee's model of migration decision making, but also microeconomic models of fertility, marriage, divorce, and migration. It would include macro-models, such as various demographic transition theories, or gravity models of migration or Stouffer's model of intervening opportunities, as well as mathematical models of age schedules of fertility, mortality, migration, etc. It would include models of the consequences of demographic change, such as Coale-Hoover on fertility decline and economic growth and other models of the "demographic dividends" of lowered fertility, and models of the labour force impact of population aging. It would include qualitative as well as quantitative models, and visual and conceptual models. Preston rightly cites the influential work of John Caldwell, much of which was non-quantitative. The possibilities seem almost endless and a bit overwhelming.

Nevertheless, it is to be hoped that someday there will be a volume—more likely, volumes—that codify *all* demographic models, formal and behavioural, as well as Preston and his colleagues have done for formal demographic models (Preston et al. 2001).

Daniel Courgeau disagrees with my view on the role of statistics in demography: "He rejects the heavy reliance on statistical models in usual demography." Presumably, something I wrote has given him this impression, but that is not quite my view. What I object to is *overreliance* on statistical models—especially multivariate models of census or survey data—to the neglect of other kinds of modelling, notably mathematical and computer simulation models of theory and systems. Demography will always rely heavily on statistics to describe demographic dynamics, to discover relationships that require further explanation, for putting error bounds on population forecasts, and for entirely new uses that are now coming into play—for example, statistical *meta-models* for understanding the inner workings of complex agent-based computer models (Grow and Van Bavel 2017: passim and esp. ch. 4). But ABM and other computer modelling approaches will focus more on modelling real-world systems rather than incomplete datasets relating to the real world. These will be more theoretical than empirical models, but often they will incorporate empirical data and relationships. Michael Wolfson has recently used the apt term *quasi-theoretical* to describe computer models of theory that are firmly anchored in empirical data (see Grow and Van Bavel 2017: 489–90).

In Courgeau's view, the semantic or model-based approach to science does not encompass mechanistic models. This is not my understanding. Giere, for example, explicitly lists a wide variety of models—physical, visual, large, small, mathematical, conceptual, and so forth (1999). The model-based approach takes an extremely broad view of what constitutes a model. That view certainly can include causal or mechanistic or functional models. Another member of the semantic school, Nancy Cartwright, attributes the behaviour of some part of reality to its "nature" (1999). To me, this comes close to Robert Francke's notion of a functional structure inferred from the behaviour of some system, although I may miss some of the subtleties in the formulations of Francke and Courgeau. And while it may be true, as Courgeau asserts, that "for the semantic approach a theory is a formal system empty of any content," this is true only of a model or theory as such. As soon as it is used for some specific scientific or practical purpose, it must be linked to empirical observations, to verify that it fits some portion of the real world closely enough for the purpose at hand, to paraphrase Giere. I would never argue that in demography as an empirical science there is a role for theoretical models that are totally untethered from observation.

Courgeau also objects to my reference to agent-based modelling as a new paradigm in demography. It may well be that I have use the word *paradigm* too loosely. All I wish to say is that ABM is a major new tool to relate behaviour at the micro level to macro-level demographic trends. And it does so in a way that subjects hypothetical individual actors to social norms and rules, and to pressures resulting from their positions in social networks, rather than only to random draws from probability distributions, as has been the case in earlier micro-simulations. This strikes me as a major advance in demographic analysis, even if it does not constitute a new paradigm in Courgeau's preferred meaning of the word.

Swanson ends his review with the suggestion that demographers reading the book may find that their "level of comfort with how the field is currently conceptualized, studied, and taught will be disturbed and, possibly, forever altered." That, of course, has been my aim all along. It is a modest aim and not original with me. Looking to the future, I'm only saying that demography, like any other empirical science, must make greater use of mathematical modelling and of the many kinds of modelling made possible by computers if it is to realize its full potential as a science. Looking to the past and present, I suggest—paradoxically, perhaps—that demography already has a wealth of good scientific models, including theoretical models, many of which we tend to devalue and ignore. We know more than we know.

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