Canadian Studies in Population 38, No. 1–2 (Spring/Summer 2011):165–7.

A comment on Thomas K. Burch's paper "Does demography need differential equations?"

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I accepted with great deal of hesitation the editor's invitation to comment on Tomas K. Burch's paper. I do not feel I have any particular competence in the field. Rather, my comments, for whatever worth they may be, are inspired by "common sense" and by my experience, albeit selective, with modeling in demography—and maybe also, if I may say so, by my epistemological understanding of what demography should be if it is to claim the status of a full-fledged scientific discipline.

Tom Burch pleads for more mathematics in demography, and he points out specific examples where its application has contributed to advancements not just in technical but also in analytical and, more generally, in theoretical demography. Hardly anyone would disagree with Burch regarding the need to train demography students in higher mathematics, as well as encourage our researchers to make greater use of this supreme discipline (and not just differential equations) in demography beyond statistics, particularly in the realm of demographic theorizing.

Demography stands out as a field at the crossroads of *biological laws* and *social contingences*. Hence, I would argue, demography is amenable to mathematical expression more than any other social scientific discipline, even more so than economics (although the latter does possess an enviable mathematical arsenal). Mathematical demography has made significant headway, but there is plenty of room for further progress.

Having said this, we have to also be cautious of how far we shall and can push the formalization of the field of population studies. Let us be aware of the use, and also of the potential abuse, of mathematics. For instance, take any economics journal (not just *Econometrics*, which is understandably highly mathematical), but any of the other authoritative journals in economics. What do you find? Some would want us to write economics in mathematical terms, almost at the exclusion of words per se. Take, on the other hand, the great theoretical works which have revolutionized our way of thinking about economics and also its praxis. Adam Smith, David Ricardo, Karl Marx, and many other great thinkers in economics—there is hardly any mathematical formula in the works of these influential thinkers. The same could be said of the great economists of the 20th century, such as Joseph Schumpeter (though he did not avoid quantification); or take John Meynard Keynes (there are only a few formulas in his *The General Theory of Employment, Interest and Money*). Yet one cannot say that Keynes, with his contributions to probability theory, did not know mathematics. Closer to our profession, Thomas Malthus referred to *arithmetic* and *geometric* population growth, but without giving their formal mathematical expressions. I cannot help but wonder whether there would be room for these authors in today's leading journals in economics.

Of course, there are great names in what is called pure economics who made extensive use of mathematics. Leon Walras is one of them, whose general economic equilibrium theory (resting on such concepts as marginal utility, interdependence, and *tatônnement*) is couched largely in mathematical terms. One should not forget other pure mathematical economists such as Irving Fisher and Paul Samuelson, and before these, Vilfredo Pareto, who excelled in both sociology and mathematics.

A related topic is the typology in demography. We try, justifiably so, to express certain demographic processes and configurations as types, models. This is where mathematics finds its best application. But models, as useful as they no doubt are, are simplifications of reality, sometimes simplifications to such a degree that they have nothing to do with reality itself. Burch is conscious of that and cites as an example Forrester's *World Dynamics:* "The Forrester model, which was the basis for the *Limits to Growth* [study] is so complex that one wonders whether it is meaningful."

One should be mindful of the fact that mathematics in itself does not explain anything. Mathematics is an instrument of measurement—it measures magnitudes, changes, intensities, relationships—and in this capacity it is a tool without which progress in any science, including demography, would be impossible. Mathematics is also logic; and that is its strength. But this can also be its liability if we push too far inferences derived from certain models, notwithstanding their inherent internal logical coherence. Often, reality defies the logic of models; and in such cases the models will be of little help in explaining phenomena in the real world (e.g., the case of *The Limits to Growth* mentioned above).

The benefits that mathematics can bring to demography are many. Just think about Lotka's significant contributions, for example. It is intriguing that Lotka, as an American in the pragmatic world that Anglo-Saxon America was in his time (and still is) would come up with his mathematical theory of stable population, what seemed at that time a rather speculative endeavor. Lotka's model of stable population proved inspirational. It proved extremely fruitful in *applied demography;* just think of the stable population models developed at the Office of Population Research at Princeton (OPR) by Ansley Coale and Paul Demeny, and at about the same time at the United Nations by the distinguished French demographer Bourgeois-Pichat. Then came the so-called "quasi stable population models" which take into account the declining mortality while fertility remains still at its traditional level. Having been at that time associated with the OPR, I had first-hand experience in the application of these models. With only a few reliable pieces of information (e.g., proportion of children under age 5, combined with some good assumptions about the mortality level) one is able, through these models, to estimate basic demographic parameters such as fertility, mortality, population growth, and age distribution. Thus, we have here a clear case of a fruitful linkage between *theoretical demography* and *applied demography,* all this possible because of Lotka's mathematical theory of stable population.

I shall digress for a moment to my early days as a student of economics. My professor, the renowned Belgian economist Léon H. Dupriez, maintained that there are two roads to economics, one "narrow" and one "large." The former is to study the system, its internal functioning; the latter, to study its transformation. Professor Dupriez warned us students about the misuse of the mathematical approach in studying the transformational processes in economics at the expense of history, institutions, and human values. I believe this applies to demography, as well. We can speak of something like "core demography," in the first instance. Therein formalization is both appropriate and feasible. But once we move into interpretation, explanation of demographic processes, and causes and im-

plications, we then need to take the "large road," which means having to involve many other disciplines in order to gain a full understanding of demographic phenomena. Our principal preoccupation as demographers is to explain demographic processes in their complexity. Mathematics, specifically differential equations, can help us to do that. I agree with Burch. We need to strive for greater mathematical literacy in demography.

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