Teaching Demography:
Ten Principles and Two Rationales[1]

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Introduction

Livi-Bacci once spoke of the danger of demography becoming '…more a technique than a science…' [1984]. Caselli has noted that 'Demographers over the last decades…have largely focused on measures, on how to adapt ever more sophisticated methodologies to the issues at hand' [memo to IUSSP Working Group on Teaching Demography, 2000]. A recent call for papers from another IUSSP working group underlines a preoccupation with data and technique, speaking of '…papers that present innovative work based on macro- or micro-level data…' and '…a preference for work using new or recent data sets, or new methods of analysis.' Nothing is said about new ideas, or the development or testing of older theoretical ideas, except insofar as this might be implicit in the word *innovative.*

Demographers, individually and collectively, have a choice. We can rest content with being and being seen as technicians, doing 'demographic accounting.' We can leave many of the most important population problems of the day to others, accepting demography as a small sub-discipline of economics, sociology, or environmental science.' Or we can develop and promote demography as a distinct and autonomous science – an extensive, coherent, and empirically grounded body of knowledge about how populations work. To do this, we must give more weight to theory – as opposed to techniques and empirical data – since theory, properly considered, is nothing less than a summary of what is known. It codifies our understanding of how populations work in a way that data, technique, and description cannot. Nowhere is this more important than in the teaching of demography, where students and other non-specialists are first exposed to the discipline.

How then should demography be taught if it is to realise its full potential as a science? I offer ten principles for teaching demography – and by implication, for the design of texts. These are stated briefly and dogmatically, with a only a few comments or illustrations and little or no systematic attempt at justification. I then consider two sources of support for the approach suggested -- two rationales. The first is found in current pedagogy in other fields, particularly the physical sciences. These are disciplines

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of unquestioned scientific stature and effectiveness, with longer and broader experience in teaching courses on basic principles, and more highly evolved textbooks. But the approach in these disciplines is not accidental or arbitrary – it is founded on sound principles of scientific methodology, based in turn on a sound understanding of the nature of science.

I develop briefly the view that demography, like much of contemporary empirical social science, contains large elements of an *unsound* understanding of the nature of science and of scientific procedure. This is the view of logical empiricism, popularised in social science by Nagel [1961] and Hempel [1965] following World War II. I sketch an alternative and potentially more fruitful approach, found in the writings of several social scientists and contemporary philosophers of science.

Three qualifications:

1] Clearly the application of the principles will have to be modified depending on the character of the course and students – undergraduate or graduate, developed country or developing, specialist or generalist, etc. But in some sense they should apply to any demography course.

2] How demography actually is taught differs considerably within and across nations. But there is no adequate body of information on the details of actual practice. My impression is that European demography [especially the French school -- including Quebec -- but also the Italian, and, increasingly, the German] come closer to the ten principles in their teaching than does the British or North American schools. But this is a matter for further empirical study. Clearly, what follows assumes that demography generally is not taught as well as it might be.

3] My characterisation of demographic methodology is meant to apply to mainstream demography and social demography. It is less relevant to economic demography, whose scientific methodology and pedagogical practice come closer to the ideal sketched below, given an emphasis on mathematical theory and modelling. Economics has been hampered by other problems, however, notably its penchant for axiomatic theory based on what many see as a restrictive set of axioms. An adequate discussion of the role of economics in contemporary demographic methodology would require at least another paper.

Ten Principles for Teaching Demography

1] Put more emphasis on theory, that is, abstract models of population dynamics and demographic behaviour. Present demography as a body of theoretical knowledge, as well as a body of data, techniques, and descriptive findings. This assumes that one wants to present demography as a science.

2] Hold onto older and simpler -- even 'oversimplified' -- models insofar as they contain valuable insights and can help students begin to understand.

Judith Blake dismissed microeconomics of fertility with the question ‘Are babies consumer durables?’ We might as well dismiss classical mechanics with the question ‘Do falling bodies fall without air resistance?’

3] Put more emphasis on student activity in which they use theoretical models to analyse real-world – or at least realistic – problems and exercises. The problems will be of increasing orders of difficulty. The analytic tools used will be of increasing orders of complexity. The aim will be development of students’ ability to reason demographically, to explain, predict, or suggest policy interventions.

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. Some problems should suggest the need to add other variables to their models, or to relax one or more simplifying assumptions. Theory and theoretical models are presented as potential tools for understanding the real world, not as some sort of absolute truth.

5] Teach or require the tools students need to work rigorously with the theoretical models. The classic tool in physical science has been mathematics. A more flexible and accessible tool for many demography students [certainly in sociology departments] will be some form of computer modelling. The emphasis here is not so much on the rigor that comes with quantification as on the ability to perform complex logical inference correctly.

6] Integrate ‘formal demography’ [‘techniques’] and ‘population studies’ [‘substance’] rather than teaching so-called ‘technical demography’ in completely distinct courses or relegating it to an appendix, as is typical in many English-language demographic texts. The time-honoured distinction between formal demography and population studies, based on a sharp distinction between necessary and contingent relationships, is called into question by recent work in the philosophy of science. In a ‘model-based’ view of science, to be described later, a good theoretical model is based on relationships *assumed* as necessary. This is true of a ‘formal’ model such as the stable population model, but also of a ‘behavioural’ model such as the microeconomic theory of fertility. As theoretical models they share the same epistemological status. The relevant empirical question is not whether they are true or false, but whether they adequately represent some portion of the real-world, adequacy judged with reference to a specific analytic purpose.

7] Teach the basic principles of formal demography in every demography course, unless it can be assumed that students already know them. Otherwise, it is not a demography course. It may be a good course, but it is not demography. These principles represent a solid core on which behavioural demography must build. In North America especially, one sees many courses on the ‘sociology of population,’ courses taught by persons with little or no demographic training, and making little use of the central concepts of demography.

8] Emphasise the more general principles underlying many apparently disparate measures and models in order to make the teaching of formal demography more efficient. A large collection of demographic measures can be grasped quickly, for example, if students have a firm understanding of the notion of weighted sums and averages. These sums and averages in turn can be represented as functions of some area under the relevant curves. How often do we teach students that the life expectancy at birth, the total fertility rate, and Hajnal's singulate mean age at marriage are based on the same underlying measurement concept, differing only in detail?

9] For beginning student of demography especially, put less emphasis on data collection, errors in data, and precision in techniques. This is not a counsel of sloppiness, but rather a recognition that it is not sound pedagogy to immerse students in data-collection techniques and rather discouraging claims about errors. Similarly, it is inappropriate to introduce all the measurement refinements that have been introduced over the years. Students first have to grasp the basic concepts. In any event, there is some unresolved inconsistency in demography in the fact that, although we know errors tend to be large, we generally do not restrict ourselves to two or three significant digits, and generally avoid use of scientific notation. A mature science is comfortable with the use of approximations adequate to the task at hand. Precision is sought not for its own sake but only when it really is necessary.

10] Rely more heavily on visual representation of theoretical ideas and processes. Many of the relatively simple theoretical model emphasised in the above approach can easily be expressed in diagrams, in texts and lectures. These will be visual representations of ideas, in contrast to graphic representations of data., which has become fairly common in demographic writing. The basic demographic equation typically is presented as an equation, and often in the form of an accounting sheet giving a numerical example. But many students, especially beginners, do not think easily in equations or balance sheets. Why not give them the added help of a picture?[2]

Teaching in Other Some Other Disciplines

One source of ideas for the teaching of demography is to look at teaching and text-writing in other disciplines, especially those that are older and better known, and respected for their scientific maturity and achievements. This approach was used some years ago by Stephan and Massey [1982] with respect to the teaching of introductory sociology.[3] But their ideas also are relevant to demography.

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[2] Recent texts are instructive in this regard. Preston, Heuveline, and Guillot [2001] discuss the concept at several points, but give no diagram. Hinde [1998] gives the equation and then immediately introduces a corresponding multistate diagram. In her classic paper on 'Graphics in Demography' [1985], Watkins discusses the basic equation in the first two paragraphs, but ironcially nowhere presents a graphic representation.

[3] I am grateful for Frank Trovato for bringing this paper to my attention.

Stephan and Massey start from the assumption that '…the public's generally unfavorable perception of sociology is due in large part to the way in which sociology is presented in introductory courses.' They argue that the introductory course does not attract the right people into the field, and that it 'ill-prepares those who go on professionally.' The remedy they propose is to develop the introductory sociology course '…along the lines followed by more established scientific disciplines' [423].

They ask what introductory courses in other fields have in common, and how these common characteristics distinguish these courses from introductory sociology. Stephan and Massy list five common characteristics [424-425]:

1] The subject matter is *primary*, that is, the *earliest* material to become an established part of the field, and *basic* to much of the discipline.

2] Much of the material is relatively *simple*: 'Though there may be much of it, it is for the most part uncomplicated.' They add: 'Much of the subject matter can be pictured in one way or another, a particular help when learning about unfamiliar material.'

3] The subject matter is *consensual*, material on which most people in the field can agree.

4] Much of the material is *quantitative*, since the 'precision and nonambiguity characteristic of quantitative statements seems to lend itself to introductory presentations.[4]

5] Much of what is learned is *do-able* by the student: 'There is something for the student to perform as well as learn.' Thus most courses involve laboratory work.

The authors comment that the typical introductory sociology course manifests characteristics almost the exact opposite of the five listed.

A recent examination of some popular North American introductory physics texts leads to a similar list of characteristics [Burch, 2001b]. There are two basically different types of physics text, one designed for science majors with substantial mathematics background, and one designed for students in the arts and humanities and the social sciences. An important point is that the subject matter is much the same in both kinds of text. The differences relate primarily to matters of detail and of level, especially with respect to mathematics required. But the underlying assumption is that teaching physics is teaching physics: one doesn't present one set of topics to one type of student and a different set to the other. Both present material that Stephan and Massey label as *primary*.

[4] But non-quantitative statements also can be precise and nonambiguous, and physical science often deals in qualitative principles as well. Electromagnetic charges, for example, are positive or negative; and opposite charges attract, while like charges repel. Quantification comes only later. It is often pointed out by physical and biological scientists that much of the scientific value of mathematics lies not in the resulting quantification, but in its use as a tool of rigorous reasoning.

The text chosen is *Fundamentals of Physics* by Halliday, Resnick, and Walker [1997]. Now in its 5th edition , the work is available in a number of different formats, the largest, the so-called 'extended' edition running to forty-five chapters. The version considered here contains thirty-eight chapters, covering approximately one thousand pages.

One expects the general pedagogical quality of physics texts to be high, partly because it is such a well-developed science, and partly because it has been so widely taught for so long. The modern text is the result of a strong evolutionary process. Economics texts might also be useful in this regard. In demography, as we well know, the number of students taught and the level at which they are taught [seldom in first year of university] are such that textbooks are not economically attractive to publishers, and there have been correspondingly few.

Some noteworthy features of the above text include the following:

1] Emphasis on fundamental principles, including classical mechanics [Newtonian] and simple abstract models. Despite a popular impression to the contrary, physicists do not reject the older ideas as outmoded by relativity and quantum theory. The unreal models of classical mechanics [straight line motion, no friction or air-resistance, constant acceleration, etc.] are presented as valid knowledge when applied to appropriate parts of the real world.

2] Emphasis on developing the student's ability to reason; an active approach to the subject matter. '…[W]e have enhanced the applications that help students forge a bridge between concepts and reasoning. We not only *tell* students how physics works, we *show* them, and we give them the opportunity to show us what they have learned by testing their understanding of the concepts and applying them to real-world scenarios' [p.vii]. The aim is '…to establish a connections between conceptual theories and applications,' and to 'force a bridge between concepts and reasoning and to marry theory with practice' [p.vii]. To this end, the text contains 1,000 'checkpoints' and questions, and approximately 3,400 exercises. The checkpoint questions '…require decision making and reasoning on the part of the student; they ask the student to organize the physics concepts rather than just plug numbers into equations' [p.viii]. One is reminded of the adage: 'I hear and I forget; I see and I remember; I do and I understand.' [5]

3] Frequent use of illustrations. The authors write: 'Because the illustrations in a physics textbook are so important to an understanding of the concepts, we have altered nearly 30 percent of the illustrations to improve their clarity' [p.viii]. The number of illustrations is large, both in expository text and in problems and exercises. Chapter 2, for example, on straight-line motion, contains 31 illustrations in 25 pages, more than one per page. A few are photographs and a few are graphs of functions, but many are visual

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[5] This quote is from the first edition of *An Introduction to Computer Simulation Methods* by Harvey Gould and Jan Tobochnik. I no longer have the exact reference, and it is not repeated in the second edition [1996].

representations of objects or processes. Compare this with the infrequent use of visual representation and diagrams in demography, other than those used to graph data.

4] Relatively brief expository text. In many chapters, the expository text occupies only a fraction of the overall space. In the chapter on motion mentioned above, problems and exercises occupy nine of the 25 pages; in the remaining 16 or so, the basic text occupies at most 2/3 of the space, with the rest devoted to checkpoints, sample problems, illustrations, problem-solving suggestions, etc.

One way to summarise the above is that in each chapter *a few basic concepts and principles* are clearly stated and then *applied* to a wide variety of subject matters. In one sense, the amount of subject matter introduced is small. Emphasis is on the power of its application. By contrast, many 'population texts' [notably in North America] cover an enormous range of topics but in less depth and with less rigour. And application of basic ideas in the form of student exercises and problems are less common.

A Philosophical Rationale[6]

The shape of introductory courses in other disciplines is not accidental or arbitrary. It is the product of a long and strong evolutionary process. Introductory courses in physics, biology, chemistry, etc. are taught to thousands of students in virtually every university or in the world, as well as in secondary school science courses. The number of students have made it economical to write and publish many texts over the years. Demography, by contrast, is text-poor, if for no other reason than that it seldom is taught to first-year university students.

But the kinds of courses described above also embody a particular understanding of science and of scientific procedure. It is a view of science in which theory – understood as over-arching general systems but also as simple theoretical models – occupies central place. Theory, thus broadly conceived, is the codification of what is known in a field. And it provides the tools with which scientists explain and predict, which are the ultimate aims of science as science. Everything else is instrumental and secondary to the development of theory.[7]

There also is a distinctive view of what theory is, how it develops, and how it is used. This view is a odds with the view of theory that has permeated empirical social science for fifty years or more, the view of logical empiricism. According to this view, found in the writings of Nagel, Hempel, Popper and others], the aim of science is to discover 'scientific laws,' universal empirical generalisations arrived at through empirical research. When sufficient laws have been 'discovered,' they can serve as a foundation for theory, through a process of further generalisation. Several empirical regularities, for

6 For a fuller exposition of these ideas see Burch 2001a, 2001b.

7 An exception relates to the earliest years of a new scientific field, in which empirical description of subject matter is primary. An explanatory science must have well-documented empirical phenomena to explain. I would argue that demography now has a sufficient empirical base on which to build more and better theory than we currently have.

example, might be subsumed under a theoretical generalisation. Several theoretical generalisations might be subsumed under still more general propositions, in a hierarchical fashion. The criterion for the validity or truth of a theoretical proposition is its logical consistency with empirical data. A theory which is inconsistent with some substantial body of data is 'falsified,' to use Popper's term.

Explanation of a specific phenomenon, in this view, consists in showing that it follows logically from some theoretical generalisation, 'a covering law,' plus some relevant concrete facts. The central element in science, in the logical empiricist view, is the scientific law, induced from empirical regularities.

Contemporary philosophers of science have increasingly questioned the logical empiricist approach, whether applied to physics or more generally. An early work by Nancy Cartwright [1983] is entitled *How the Laws of Physics Lie*, the point being that many so-called laws are not literally true representations of reality, but abstract and oversimplified representations that fit the real world in some cases but not others. In a later work [1999], she speaks of theories and theoretical models as 'nomological machines,' the idea being that laws come from theoretical models, not the other way around.

In a similar vein, Ronald Giere [a philosopher with physics background], writes in *Science Without Laws* [1999] that most scientific laws are not universal, and that they are in fact not even true: '…understood as general claims about the world, most purported laws of nature are in fact false. So we need a portrait of science that captures our everyday understanding of success without invoking laws of nature understood as true, universal generalizations' [p.24]. The reason is that any law of nature contains '…only a few physical quantities, whereas nature contains many quantities which often interact one with another, and there are few if any isolated systems. So there cannot be many systems in the real world that exactly satisfy any purported law of nature' [p.24].

For Giere, the primary representational device in science is not the law but the *model* , of which there are three main types: physical models; visual models; and theoretical models. Models are inherently abstract constructions that attempt to represent only certain features of the real world. They are true only in the sense that definitions are true. The question of whether they are empirically true is irrelevant, since they cannot be. The relevant question is whether they correspond to some part of the real world in a] some respects b] to a sufficient degree of accuracy for c] certain well-defined purposes. Giere gives the example of the model for the earth-moon system, which is adequate to describe and account for the moon's orbit and perhaps for putting a rocket on the moon, but is inadequate to describe the Venus-earth system, and says nothing about whether, as the nursery rhymes would have it, the moon is made of cheese. The prototype of scientific knowledge is not the empirical law, but a model plus a list of real-world systems to which it applies.

A model explains some real-world phenomenon if a] the model is appropriate to the real-world system in the three respects noted above, and b] if the model logically implies the phenomenon, in other words, if the phenomenon follows logically from the model as specified to fit a particular part of the real world. It would never occur to most physical scientists to add the second condition. But in social science, including demography, we are so used to loose inference that its explicit statement is necessary.

Note that in this account of science, all models are *formally* true [assuming, of course, no logical errors or internal contradictions], that is, true by definition. The empirical question then becomes one not of empirical truth or validity, but whether a valid model applies to a particular empirical case.

Of course some models are more widely applicable than others, and, other things equal, science will focus on models with the widest applicability, but without necessarily discarding others. In demography, for example, the fundamental demographic equation is true by definition and applicable to every well-defined real population [neglecting error in data]. The exponential growth formula is true by definition, and, with respect to calculation of the average annual growth rate over a period is also applicable to every real-world population. With respect to describing a population's actual growth trajectory, however, the exponential growth formula applies more or less to some populations, but is not at all applicable to others.

A behavioural model such as the theory of demographic transition can be stated in such a way that it is formally true. Its applicability to the real-world has been a matter of debate for over fifty years. But it is worth noting, in terms of Giere's criteria of applicability, that it correctly represents a large number of actual cases of mortality/fertility decline, at least in qualitative terms.[8]

In my reading of Giere's and Cartwright's accounts of science, they come close to the what has long been the standard approach in the literature on mathematical modelling, and more recently of computer modelling. A model is an abstract construct that may or may not be useful for a certain purpose. In science, that purpose often will be explanation or prediction as opposed to practice. And in some schools of computer modelling, the emphasis is on less abstract models, trying to capture more of the complexity of the real world. But the central ideas are the same.

The model-based approach to science described above prefers not to make a sharp distinction between a model and a theory. Some authors distinguish the two on a general/specific axis; but then differences are in degree only not in kind. Giere speaks of 'theoretical models,' and sometimes describes a 'theory' as a collection of such models.

Note that this position does not agree with the view of post-modernists and others that science is totally a social construction. A model is the creation of a scientific mind, but it

[8] An interesting point about transition theory is that there has been a tendency to dismiss it as not fitting all cases or as not providing details of timing, pace, etc. There seems to have been relatively little effort to accept it as a valid model and work towards a more precise specification by defining functional forms for fertility or mortality decline as functions of 'development,' and parameters representing size of lags, slopes, etc., with different model specifications appropriate to different historical cases.

is not just a fantasy. A good model is good precisely because it captures some important aspects of the real world. In Giere's words, there is 'realism without truth.'

Similar ideas have occasionally been anticipated by social scientists, but they do not seem to have been taken seriously by empirically oriented researchers. Eugene Meehan, a political scientist, set forth a 'system paradigm' for explanation in social science that comes close to Giere's ideas in many respects. Explicitly rejecting logical empiricism, he advocates the construction of formal 'systems' [Giere would call them 'models'], logically consistent systems of relationships. Explanation consists in applying this 'formal calculus' to some empirical phenomenon. The phenomenon is explained if a] it follows logically from the assumptions of the system, and b] if the formal system is 'isomorphic' with respect to the real-world system in which the phenomenon occurs, that is, if the system fits the real world. Fit clearly is a matter of degree, and whether a fit is a good one depends very much on the purpose for which the analysis has been undertaken. An explanation or prediction based on a 'system' may be good enough for some purposes, but not others. Meehan considers the logical empiricists' failure to include purpose in its criteria for judging scientific theories a fundamental flaw.

In a 1975 paper, Nathan Keyfitz introduced such thinking into demography , but there is little evidence that we took it to heart. Asking 'How do we know the facts of demography?' Keyfitz replies: 'Many readers will be surprised to learn that in a science thought of as empirical, often criticized for its lack of theory, the most important relations cannot be established by direct observation, which tends to provide enigmatic and inconsistent reports' [267]. He illustrates his point with several examples, some from 'formal demography,' some from 'behavioural demography.' Methodologically, he does not draw a sharp line between the two.

In his conclusion he writes:

> The model is much more than a mnemonic device, however; it is a machine with causal linkages. Insofar as it reflects the real world, it suggests how levers can be moved to alter direction in accord with policy requirements. The question is always how closely this constructed machine resembles the one operated by nature. As the investigator concentrates on its degree of realism, he more and more persuades himself that his model is a theory of the real world [285].

Note the equation of model and theory in the final sentence. The general sense of the quote is such that it would be right at home in the works of Giere or Cartwright.

Concluding Comments

The ideas sketched above suggest a view of demography somewhat different from the view to which we are accustomed. Theory and theoretical models are center-stage, rather than subordinated to data, technique and descriptive findings. But the notion of theory is broadened such that a simple equation like the exponential or a complex algorithm like the cohort-component projection model can be viewed as theoretical models, valid substantive representations of how populations work. By the same token, behavioural models such as the microeconomic theory of fertility or transition theory can be seen as valid knowledge, even if they do not agree with all the facts.

Older models need not be discarded because they are old or simple, even over-simplified and 'unrealistic.' Most models contain some kernel of truth. Rather than discarded, they should be 'polished,' refined and stated in rigorous terms, and added to the demographer's toolkit of potentially useful models. If physicists rejected older, simpler, and 'unrealistic' models, a large portion of the standard introductory text would be discarded.

Rather than putting so much emphasis on 'testing' our theoretical models against specific data sets [statistical modelling], there could be more emphasis on using models to analyse and explain important demographic events, and to predict demographic futures. Often as not, our models will prove useful even if they are not 'true' in any absolute sense.

Arraying demographic knowledge in the manner suggested would yield a large and rich body of substantive ideas about how populations work, suggesting more and deeper understanding than demographers typically are given credit for – or than is apparent in many of our routine multivariate analyses, technical manuals or highly discursive undergraduate texts.

For students at all levels, especially for beginning students, such an approach to demography might be more demanding, both intellectually and psychologically. But in the long run, it could attract more and better students, and better prepare them for future work involving demographic analysis. What is more satisfying to a student than to know that the clear concepts they are learning are in some sense both valid and important? What is more satisfying than to know that these ideas enable the student to do something – namely to think in an organised way about important demographic developments, and to arrive at coherent explanations, grounded predictions, or well-reasoned policy advice? What is more reassuring than the feeling that one is learning a discipline, rather than a jumble of vague and often competing, if not contradictory ideas, or a set of measurement tools? What would be healthier than to learn in demography that science is a balanced process of continual exchange between empirical observation and theoretical reflection, and that theorising and model building are creative acts?

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