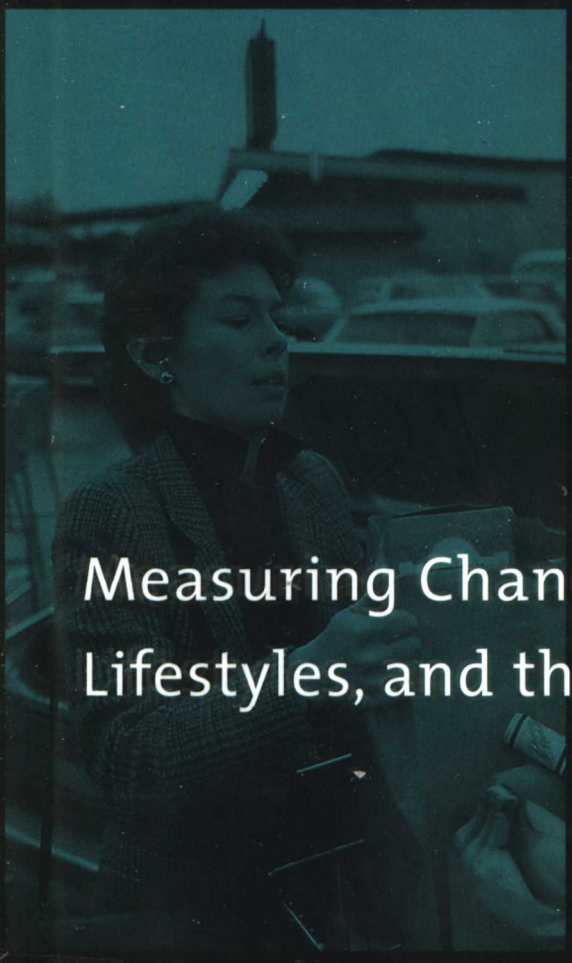
Structural Economics



Measuring Change in Technology, Lifestyles, and the Environment

FAYE DUCHIN

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Preface

Structural economics is a body of theory and methods relating changes in technology, lifestyles, and the environment, an approach that makes it possible to address, and begin to answer, some of the most challenging questions of our time. This volume brings together for the first time a full description of structural economics and provides new material that develops not only its technological but also its social dimension. The effort involves integrating qualitative understanding into a flexible quantitative framework intended for describing and analyzing how people live in households and earn their livings producing goods and services on farms, in mines, in factories, and, increasingly, in offices. The framework also deals with how technologies change and how the lifestyles of different kinds of households change in the process of development. The case of Indonesia has been used in this book both for illustration and to test and improve new concepts by applying them to factual information.

This work has in part been supported by the program in sustainable development of the United Nations University in Tokyo. The program sets out to explore how it might be possible to ensure adequate protection of the natural world while satisfying the objectives of accelerated economic development in industrializing countries and maintaining current standards of living in the developed world. A distinctive feature of this effort of the United Nations University is its focus on the perspectives, challenges, options, and active participation of developing countries, especially those in the Asia Pacific region.

Many dimensions of structural economics have been developed over a period of decades, in particular its power for analyzing the implications of technological change. A relevant body of work is described in some detail in this book. New research about the social dimension of sustainable development seeks to conceptualize and

describe different categories of households and their lifestyles and to develop a framework for analyzing scenarios about alternative prospects for lifestyle changes. This is achieved by extending existing concepts, databases, and models in ways that parallel the treatment of technological change.

The present volume consists of nine chapters written over the past five years. Each chapter is intended to be self-contained in the treatment of some part of the overall subject while touching on most of the other themes as well. The reason for this approach is that the different aspects—classifications, data, mathematics, scenarios—are highly interdependent to such an extent that the research itself has moved in an iterative fashion from one to the next. To the extent possible I wanted to avoid a highly technical treatment that would isolate the topics in separate chapters. While most chapters thus take up overlapping material, I have tried to avoid redundancy and to provide the flow and integration that a reader has the right to expect.

The book is addressed to the general reader who is concerned with the public good, believes that substantial changes in how we live and work may be in store, and is convinced that a deeper understanding of our options is needed if we are to make reasonable decisions. Yet, while I strive for a clear presentation and avoid jargon, the book is not light reading and includes some mathematics.

I have two reasons for aiming the exposition at a general reader. First, at a time of extreme specialization within mutually exclusive academic disciplines, one of the few ways to try to address a variety of social scientists is to write for a general reader. Second, this work is based on the conviction that specialists, generalists, and ordinary (that is, nonexpert) citizens are reliant upon each other in effecting social change. For this reason, I want to point out that there is a pathway through the book, simply skipping chapters 5 and 6, that tells a coherent story while bypassing the most technical material.

The mathematical formulation of chapter 6 recapitulates the entire story of structural economics in a succinct form that makes it possible to carry out experiments. The nonmathematical reader, who will already be familiar with the story, may not be interested in the equations but may want to peruse the list of variables to get an intuition about the formal representation.

While all chapters include references to a scholarly literature, many of the cited books and articles may well be of interest to a general reader. This is least likely to be true for the references to the

social accounting literature in chapter 5. That work is nonetheless included because it serves as a major stimulus, and also a point of comparison, for the somewhat different approach that I propose.

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This book marks a main turning point in my intellectual work. At the time I began the manuscript, I had no idea that the completion of the first draft would exactly coincide with my leaving the Institute for Economic Analysis at New York University, where I had been for twenty years, for a different kind of challenge.

In September of 1996 I moved to Troy, New York, to become the dean of the School of the Humanities and Social Sciences at Rensselaer Polytechnic Institute, a technological university and the home of the first school of engineering to be established in the United States (in 1824). The fresh perspective provided by this change, coupled with the detailed and incisive comments of Frank Ackerman of Tufts University, Bert Steenge of the University of Twente, and Reid Lifset of Yale University, informed a substantial revision of the scope of the manuscript. I am grateful to my editor at Island Press, Todd Baldwin, for his interest in this work and his substantial help in improving the text. The book is a synthesis of my work of the past twenty years and provides a point of departure for moving, with the collaboration of new colleagues, in fresh directions.

I want to thank Dr. Fu-chen Lo, deputy director of the Institute for Advanced Studies at the United Nations University in Tokyo, for his support of this project and his commitment, more generally, to the interplay of theoretical and empirical research. I gratefully acknowledge the collaboration of Glenn-Marie Lange in drafting an early version of chapter 5 and that of Karim Nauphal in carrying out the computations reported in chapter 8. I am extremely fortunate to have worked for two decades with Wassily Leontief, who shared with me his passion for understanding how economies function.

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Introduction

For twenty years I carried out detailed studies about changes in ways of producing steel, generating electricity, manufacturing cars, and growing rice. I supervised the construction of large databases from information collected mainly by national statistical offices and oversaw the development of mathematical models and computer systems to analyze the data. I was especially interested in the similarities and differences in production techniques among various societies, and in the effects of those techniques on employment, income, and the use of raw materials. Over the past decade I focused increasingly on the generation of pollution and ways of reducing wastes, use of materials and energy, and erosion. I wrote many technical reports and articles and a few books describing the results of various analyses. Finally, I realized (with the urging of a number of friends and colleagues) that it was time to give a name to this body of theory and methods and provide a systematic description of the approach, along with examples that would demonstrate its power. In this way, other researchers might take it up.

I chose the name structural economics because the theory and methodology emphasize the structure of an economy, the fundamental ways in which various industrial sectors relate—to one another, to the households that constitute the labor force and consume industrial products, and to the environment, which is both source for materials and sink for wastes.

I had come to see that while mainstream academic economists had different concerns, my basic approach was highly valued in other quarters. I had discovered strong common interests with engineers in life-cycle analysis and state-of-the-art technologies, with applied physical scientists in energy and materials, and with ecologists in the effects of human activities on the environment. But it was clear to me that structural economics needed to be rooted in eco-

nomics, the field that deals with what is produced and how, what is consumed and by whom. I thought that a department of economics at a technological university could be a hospitable home.

The central feature of a technological university, such as the one at which I now work, is its school of engineering, which makes use of the methods and results of science while imparting to the entire campus community a pragmatic, problem-solving orientation. The humanities and social sciences constitute the largest academic unit at a liberal arts college; at a technological university the school of the humanities and social sciences is relatively small and generally includes only a subset of the independent disciplines and departments that are within its scope. This fact makes for a looser affiliation for its researchers with the mainstream disciplines in which they received their formal training and far more readiness on their parts to cross disciplinary borders. The technological university provides a suitable setting for studying all aspects of life and work in a technological society.

At New York University I had found myself at a large, diversified institution, but one with a conventional department of economics and no school of engineering. I chose to move to a technological university after many years of trying to collaborate with engineers and other economists from a distance.

To throw more light on my motivation, I will describe the kinds of questions that have interested me in recent years. The major source of environmental degradation in an industrial society lies in the ways in which materials and energy are used. I have attempted to understand the extent to which it is realistic to reduce the scale of use of fuels and major materials or to substantially increase recycling of the latter. A serious examination of these prospects requires investigating the basis for people's lifestyle decisions—in the case of materials, particularly in terms of the items they use and discard. But it also requires understanding facts about the potential substitutions of reprocessed for virgin materials on the basis of their physical characteristics. This knowledge, which is in the domain of engineers and applied physical scientists, is necessary for evaluating the feasibility and economic viability of alternative strategies. Among materials, an especially difficult challenge is posed by the proliferation of nondegradable plastics. My work on plastics (discussed in chapter 2) benefited from collaboration with engineers.

Like other private and public institutions before them, American universities are now under substantial pressures for change.

The main reason is economic. There have been major shifts in the composition and needs of the population seeking university-level training. Many prospective students who are from modest socioeconomic backgrounds would not in past decades have aspired to a college degree. The need to supplement the limited financial means of a more diverse group of students is obviously costly.

Like corporations before them, financially pressed universities resort first to cutting costs across all functions, but economies achieved in this way generally prove inadequate. In response to changes in students' needs and in management practices, new kinds of institutions are proving popular. Nonresidential programs delivered via satellite or on the Internet, on-site corporate programs, and community colleges are among the alternatives that are vastly expanding the range of training and diplomas available. This environment poses a severe challenge to those attempting to create new programs within a university setting committed to maintaining a community of scholars.

In the twenty-first century, research universities that do not have enormous endowments will change in order to survive. Many institutions will combine departments rather than try to cover every discipline and subdiscipline. Economics and the other social sciences will move away from abstract theorizing and toward a more pragmatic, problem-oriented focus—in particular, they will use the communities in which they are located as their laboratories. Virtually all communities are preoccupied with economic development. Local officials, businesspeople, and community leaders are concerned about maintaining the tax base and municipal services and expanding employment, while preserving and improving the local quality of life. Meeting challenges like these requires an understanding of social realities, physical facts, and technological alternatives. In short, the strengths of a school of the humanities and social sciences at a technological university place it in a position today to pioneer the kinds of programs, especially in economics, that we are likely to see at many universities in the future.

University-based research agendas about social problems, such as those experienced in the local community, involve generalists, specialists, and people in their capacity as citizens. The generalists and citizens are well placed to formulate the problems but may need to work with experts to identify options for resolving them. A collaboration of social scientists, engineers, and citizens could develop solid waste or sewage treatment and disposal options that are well

suited to the population density and other characteristics of a particular community, for example. Or a study of where people live and work and shop could be conducted and used as a basis for replacing some use of the car with convenient public transportation.

It is legitimate to inquire as to whether this kind of approach, while it may be of both educational and social value, belongs to the tradition of theory-based science. There are, to be sure, approaches to problem-oriented analysis that have little to do with science. One can take positions of principle that are plausible but have no empirical support, or conduct empirical investigations that take on important questions but vastly oversimplify them. An example of the former is the declaration that "material throughput" in a community (or a nation or the global economy) should be minimized. This exhortation sounds prudent, economical, and environmentally sound, but it provides no basis for action: When you get down to specifics, like how to reduce the use of plastics, it will generally be necessary to increase the use of some materials in order to decrease that of others. An example of an oversimplified empirical study is one that concludes that waste plastics should be incinerated or, for that matter, that they should be recycled. A substantial body of work will be needed before questions of this scope can possibly be answered in such categorical terms. Most studies of this type simply reflect the a priori conviction of the analyst rather than the weight of evidence.

Depending on the degree of specificity, economic reasoning based on general principles has been called pure theory (abstract theorizing by critics), applied or policy analysis, or outright advocacy. All of these have their place. These analyses are able to deliver an enviably simple message. Especially the applied analysts also often exhibit great tolerance for different theoretical perspectives and methods.

This tolerance is called pluralism, and pluralists are reticent to criticize the work of their colleagues, a characteristic that makes for congenial social relations and enjoyable conferences. Furthermore, espousing pluralism is simpler than building a new theoretical framework. Nonpluralists, or researchers with an unwavering preference for a specific theoretical framework and methodological practice, are open to criticism for reductionism, rigidity, and a misplaced concern with rigor.

It is a mistake of historic dimensions, however, to forgo the power of science in addressing society's major challenges. A distinguishing characteristic of scientific inquiry is its openness to unex-

pected conclusions. By contrast, it is distressingly common among issue-oriented analysts to conduct a study in order to demonstrate their convictions. Advocates believe they know what needs to be done, but it behooves the scientist to be more skeptical and demanding of evidence.

I believe that the fundamental challenge facing civic society today is to figure out what our options are for dealing with social and environmental problems. This requires acts of imagination—the ability to describe novel, untried, but plausible solutions that could represent dramatic departures from present practices. The gift of this type of imagination is probably equally distributed among generalists, specialists, and citizens. Interestingly, the scientific tradition explicitly acknowledges the importance of curiosity about how things work, but not of imagination—the ability to conceive of how things might work differently.

Subsequently, the alternative options, based on imaginative scenarios, require systematic analysis to determine their feasibility and other characteristics. The scientific method is a demonstrated approach for formulating this kind of investigation.

The particular approach that I will develop in the course of this book, structural economics, involves the kind of inquiry that I have been describing. The first step is determining the scope of the inquiry, which I take to be the production and consumption of goods and services and the social and environmental issues surrounding those activities. Then the variables of interest are identified; these include quantitative measures of the amounts of production and consumption of specific goods and services in a particular economy. This specificity makes it possible to distinguish, for example, plastic from steel and uranium or coal from wood. Next a model, or symbolic representation, of the relationships among these variables is needed. Building a model is the familiar process of developing theory, in this case determining the relationships among the production and consumption of plastic, steel, wood, and other inputs and outputs. A mathematical, and therefore formalized and simplified, version of the conceptual model is then developed and used with a body of descriptive data to assess the implications of alternative scenarios about the future. Methodology is needed, as in other scientific endeavors, to assure quality control over the collection and manipulation of the data, which provide empirical content to an analysis. The scenarios are a translation of the acts of imagination about what could be done into the language of the model.

Structural economics bears a family resemblance to neoclassical

economics, but there are striking differences between them. In a hypothetico-deductive science like neoclassical economics, most research effort is devoted to stating and proving theorems and testing hypotheses. Hypothesis testing is a way of evaluating the truth or falsity of a more general theory from which the hypothesis is deduced. As a result of the test, it may be possible to reject the hypothesis, implying that the theory is false. In laboratory sciences, experiments are used for a similar purpose. This is not true for structural economics, which is more about constructing solutions than deducing proofs.

In structural economics each scenario about the future could (if one wished) be viewed as a hypothesis or an experiment. But the feasibility at issue is mainly that of the scenario itself, or perhaps of a family of related scenarios, rather than the validity of the theory or model. It is only after cumulative experience with interpreting the results of many such experiments that the researcher might be moved to change or extend the theory—and, in turn, the form of the model. Not only imagination but also inductive reasoning and intuition play a large and explicitly recognized role in the development of theory in structural economics. Research consists of bringing a broadening set of ideas and an expanding body of data into closer correspondence in the process of evaluating alternative prospects for action. This is what I mean by exploiting the power of science for issue-oriented research.

Structural economics represents an effort to apply the power of science to the social domain. It is rooted in economics but requires the participation not only of economists but also of engineers, sociologists, and anthropologists in addressing questions of common interest. At a time when the number of economics majors at universities is falling precipitously, I believe it can help interest young people in taking on these challenges.

Two societies are discussed in this book, those of the United States and, especially, Indonesia. This choice is consistent with the desire to create an analytic framework sufficiently general that it can be useful for both developing and developed countries. Indonesia is the fourth most populous country in the world (after India, China, and the United States) and has a resource-rich economy that was growing rapidly until the financial crisis that began in 1997. These facts, and its geographic location in Southeast Asia, account for its importance among developing countries. Information is available because the Central Bureau of Statistics of Indonesia collects