Harwood Fundamentals of Pure and Applied Economics

MODELING IN URBAN AND REGIONAL ECONOMICS

Alex Anas

Harwood Fundamentals of Pure and Applied Economics

MODELING IN URBAN AND REGIONAL ECONOMICS

REGIONAL & URBAN ECONOMICS II
In 4 Volumes

I	Modeling in Urban and Regional Economics	*Anas*
II	The Economics of Housing Markets	*Muth and Goodman*
III	Urban and Regional Economics	*Edel*
IV	Urban Transportation Economics	*Small*

MODELING IN URBAN AND REGIONAL ECONOMICS

ALEX ANAS

Routledge
Taylor & Francis Group

First published in 1987 by
Harwood Academic Publishers GmbH

Reprinted in 2001 by
Routledge
2 Park Square, Milton Park, Abingdon, Oxon, OX14 4RN

Transferred to Digital Printing 2007

Routledge is an imprint of the Taylor & Francis Group

The publishers have made every effort to contact authors/copyright holders of the works reprinted in *Harwood Fundamentals of Pure & Applied Economics*. This has not been possible in every case, however, and we would welcome correspondence from those individuals/companies we have been unable to trace.

These reprints are taken from original copies of each book. in many cases the condition of these originals is not perfect. the publisher has gone to great lengths to ensure the quality of these reprints, but wishes to point out that certain characteristics of the original copies will, of necessity, be apparent in reprints thereof.

British Library Cataloguing in Publication Data
A CIP catalogue record for this book
is available from the British Library

Modeling in Urban and Regional Economics
ISBN 0-415-26973-3
Regional & Urban Economics II: 4 Volumes
ISBN 0-415-26972-5
Harwood Fundamentals of Pure & Applied Economics
ISBN 0-415-26907-5

Modeling in Urban and Regional Economics

Alex Anas
Northwestern University, USA

A volume in the Regional and Urban Economics section
edited by

Richard Arnott
Queen's University, Canada

harwood academic publishers
chur · london · paris · new york · melbourne

Harwood Academic Publishers

Post Office Box 197
London WC2E 9PX
England

58, rue Lhomond
75005 Paris
France

Post Office Box 786
Cooper Station
New York, NY 10276
United States of America

Private Bag 8
Camberwell, Victoria 3124
Australia

Library of Congress Cataloging-in-Publication Data

Anas, Alex.
Modeling in urban and regional economics.

(Fundamentals of pure and applied economics,
ISSN 0191-1708; vol. 26. Regional and urban economics section)
Bibliography: p.
Includes index.
1. Urban economics—Mathematical models. 2. Regional economics—Mathematical models. I. Title. II. Series: Fundamentals of pure and applied economics; vol. 26. III. Series: Fundamentals of pure and applied economics. Regional and urban economics section.
HT321.A52 1987 330′.0724 87-27518
ISBN 3-7186-0467-1

Contents

Introduction to the Series vii

Introduction 1

1. Monocentric Models 9
   1.1. Income and urban location 9
   1.2. Congestion and the use of land for roads 14
   1.3. Other themes in general equilibrium simulation 23
   1.4. Computational techniques 30
   1.5. Dynamics 34
   1.6. Non-monocentric models 37

2. Non-Economic Beginnings 38
   2.1. Forrester's urban dynamics 40
   2.2. Hill's EMPIRIC model 44
   2.3. Lowry's model and extensions 45
   2.4. Wilson's entropy principle and discrete choice models 54

3. Mathematical Programming 61
   3.1. Traffic network and spatial price equilibrium models 62
   3.2. The network design problem 71
   3.3. The Herbert–Stevens linear programming model of land use allocation 73
   3.4. Mills' linear programming model and extensions 77
   3.5. The Koopmans–Beckmann quadratic assignment problem 80

4. Econometric Models 84
   4.1. The Urban Institute Model for housing market analysis 85
   4.2. The National Bureau of Economic Research Model 94
   4.3. The Chicago Area Transportation–Land Use Analysis System 101
   4.4. A model of regulated european housing markets 107
   4.5. A supply side simulation model 110

5. Regional and Interregional Models 110
   5.1. Regional and interregional input–output 111
   5.2. Regional econometric models 114
   5.3. Regional intra–metropolitan models 116
   5.4. Models of less developed nations 117

Conclusions 119

References 121

Index 131

Introduction to the Series

Drawing on a personal network, an economist can still relatively easily stay well informed in the narrow field in which he works, but to keep up with the development of economics as a whole is a much more formidable challenge. Economists are confronted with difficulties associated with the rapid development of their discipline. There is a risk of "balkanisation" in economics, which may not be favorable to its development.

Fundamentals of Pure and Applied Economics has been created to meet this problem. The discipline of economics has been subdivided into sections (listed inside). These sections include short books, each surveying the state of the art in a given area.

Each book starts with the basic elements and goes as far as the most advanced results. Each should be useful to professors needing material for lectures, to graduate students looking for a global view of a particular subject, to professional economists wishing to keep up with the development of their science, and to researchers seeking convenient information on questions that incidentally appear in their work.

Each book is thus a presentation of the state of the art in a particular field rather than a step-by-step analysis of the development of the literature. Each is a high-level presentation but accessible to anyone with a solid background in economics, whether engaged in business, government, international organizations, teaching, or research in related fields.

Three aspects of *Fundamentals of Pure and Applied Economics* should be emphasized:

—First, the project covers the whole field of economics, not only theoretical or mathematical economics.

—Second, the project is open-ended and the number of books is not predetermined. If new interesting areas appear, they will generate additional books.
—Last, all the books making up each section will later be grouped to constitute one or several volumes of an Encyclopedia of Economics.

The editors of the sections are outstanding economists who have selected as authors for the series some of the finest specialists in the world.

J. Lesourne *H. Sonnenschein*

Modeling in Urban and Regional Economics

ALEX ANAS

Northwestern University, Evanston, Illinois, USA

INTRODUCTION

Ideally, the development of a science follows a three-phase progression. The first phase is the formulation of theory. The second phase is the empirical testing of specific models which stem from the theory and the third phase is the application of the science to real problems. In the natural sciences, application is achieved by the creation of technology. In the social sciences, and in economics in particular, application consists of building a mathematical model capable of making predictions (or forecasts) of markets and able to analyze, evaluate and determine selected public decisions and aspects of public policy.

It is rare that the ideal progression described above occurs in just that way. Often, empirical models with little theoretical grounding are developed and applied in advance of the birth of a theory. Such activity can highlight and stimulate the arrival of the theory. Empirical work and application following a theory often leads to revised and more mature statements of the theory which then lead to additional rounds of testing and application.

It is also possible that application can occur without any prior theory or at least no prior empirical testing of a theory. Ships were invented much before Archimedes formulated his law of buoyancy and the Wright brothers could fly with only a rudimentary and poorly tested theory of aerodynamics. Similarly, in the social sciences a qualitatively formulated theory can inspire a jump to actual policy application or at least to practical decision making without any quantitative empirical testing of the theory or the development of models based on the theory.

In urban and regional economics the interplay among theory, empirical testing and application has been particularly interesting. In urban economics, forecasting and policy analytic tools emerged in the 1960's independently from the urban economic theory which was also being formulated at that time. Since then, theoretical urban economics has achieved maturity while empirical testing and application has remained separate and has lagged somewhat behind but has been growing and converging to the theory while shaking itself loose from the early non-economic influences.

In regional economics the trends have been less confirming of the "ideal progression." Forecasting and policy oriented applied tools date back to the birth of input–output models in the early 1950's. A formal theory of the regional and interregional economy has not yet been formulated, although there is a number of hypotheses and propositions that have found empirical testing.

In this volume we are concerned not only with theoretical formulations, but with those models which belong in the realm of numerical exploration, empirical testing and policy applications of the theory. In urban and regional economics, this realm is quite broad and covers a variety of modeling styles and purposes. These will be gathered under the term "urban and regional economic modeling" or "simulation models," since all of them are numerically computable paradigmatic characterizations of the underlying reality, albeit at very different levels of simplication or empirical detail.

Five classes or types of models are identified and discussed in this volume. The fifth class contains an evaluation of the approaches that have been used in regional and interregional modeling, while the first four classes deal with urban modeling. These are "monocentric models," "non-economic models," "mathematical programming models" and "econometric models." Because the literature surveyed within each class varies considerably in its mix of theory versus application and in the qualitative versus quantitative orientation of the models, a general set of criteria that can be applied to all four classes are difficult to determine. The discussion below, therefore, is aimed at identifying each type of model and suggesting the considerations which are relevant for an evaluation.

The first breed of models deals with the numerical solution of a theoretical model the analytical solution of which has proven intractable. Simulation has been used to obtain magnitudes when explicit analytical solution is not possible and also to determine the direction of change when the comparative statics are ambiguous. In such cases the model being solved is essentially a simplified and idealized representation of reality. In urban economics, for example, the theory has been developed in the context of the, so called, nineteenth century style city with nearly all employment concentrated within a core extending a few miles around a central port or rail terminal. Housing is then assumed to be located in a circular suburban ring around the central core. Placing this idealized urban form on a featureless plain, on which transportation in any direction is equally costly, results in a one-dimensional representation in which distance from the center is the only variable which distinguishes locations. In urban economics this one-dimensional representation has come to be known as the *monocentric* model (i.e. a model with a *single employment center*). The role of "distance from the center" in a monocentric model has been compared to the role of the variable "time" in simple models of neoclassical growth theory (see [129]). In some respects, the mathematics employed to solve these two classes of models is in fact the same or very similar.

The monocentric model is a minimal model of an urban economy in the sense that it encapsulates the minimum amount of detail necessary to introduce the concept of location. As such, the monocentric model has served as a powerful parsimonious framework for building theory. Simple monocentric models have been solved analytically allowing full qualitative characterization of the solution space without any need for numerical explorations of it. The standard case capable of such solution is the long run equilibrium of land use in the suburban residential ring. For this partial equilibrium case, a full comparative static analysis has been possible (see [176, 77, 136]). Our ability to obtain full analytical solutions quickly diminishes with the introduction of additional complexity into the standard monocentric model. Some of these complexities are: (a) several classes of households which differ in preferences (utility functions), (b) presence of an externality such as traffic congestion, (c) general equilibrium versions encompassing several sectors such as production in the core, housing production in the suburban ring, transportation etc. (d) several employment locations, (e) effects of policy instruments such as the property tax.

The need to resort to numerical simulation to investigate some of these problems was recognized in the early seventies. This quickly gave rise to a style of analysis in which it became routine to select certain specialized functional forms and representative coefficient values and then proceed to obtain specific solutions. Despite some efforts to provide an empirical basis for the selected coefficients, the justification for this type of simulation is theoretical. In most cases the investigators used simulation to build qualitative results in a monocentric context, rather than claim more general empirical discovery. There has been, however, a tendency to draw broad-brush empirical generalizations. In some cases such attempts have been convincing, pointing the way for more realistic and larger scale empirical studies of the underlying questions.

There are, of course, some difficulties with this simulation style. An attempt to generalize results must be supported by tedious sensitivity testing whereby coefficient values are varied systematically. This is not only difficult to perform but also cumbersome to report in published form reducing the ability of the investigators to confirm and reproduce each others' results. These difficulties have been potentially mitigated by the development of numerical solution algorithms applicable to monocentric simulations (see [100, 101, 116, 117, 141, 142]). However, the actual application of these algorithms has been rather limited, perhaps because interest in monocentric models has declined toward the early eighties. Also, the numerical solution of these models still requires a lot of work because canned numerical algorithms are not available. Finally, since such models are not realistic they are used primarily to develop theoretical insight. But most theorists prefer to do purely theoretical work. They consider, not always wisely, that simulation is a poor substitute for theory. In part one of this article, we survey the problems examined by means of monocentric simulation and the contributions thus made to theoretical understanding on the one hand and to empirical discovery on the other.

The second type of applied research refers to a genre of large scale urban development models applicable on the computer. These are surveyed in part two of this article. These models are dissimilar.