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# Input–Output Models for Sustainable Industrial Systems

Implementation Using LINGO

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# Preface

Input–output analysis is a powerful and mathematically elegant framework for describing the networks of interdependent components. While originally developed for the analysis and planning of economic systems, over the past few decades, it has also been shown to apply to diverse types of systems. Its ability to reflect the interdependencies among system components is its most essential feature, as it allows input–output models to gauge ripple effects that may cause unintended, and potentially adverse, consequences if not predicted properly.

Sustainability considerations are now widely considered as integral to decision-making in business, engineering, and public policy. This book is intended to provide a concise treatment of different extensions of the input–output analysis as they apply to the planning of sustainable industrial systems. The first two chapters of the book give an introduction to the conceptual and mathematical foundations of the input–output analysis. A unique feature is the use of the commercial optimization software, LINGO, whose equation-based interface is ideal for learning the input–output models. Thus, the third chapter is dedicated entirely to a description of this programming environment. The next six chapters describe different extensions of the input–output model for various industrial systems at different scales, including industrial complexes, infrastructure systems, and supply chains. Further extensions delve into the use of the framework for plant design, operational optimization, human resource planning, and life cycle assessment. All these chapters provide ample illustrative case studies, accompanied by LINGO code to allow the reader to duplicate the results and even to use these models as starting points for their own case studies. In the final chapter of the book, we discuss some research prospects that we consider to be important directions for the future input–output analysis research.

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# Acronyms

ADB	Asian Development Bank
AF	Annualizing factor
AHP	Analytic hierarchy process
ANNs	Artificial neural networks
CE	Circular economy
CHP	Combined heat and power
CIS	Critical infrastructure systems
CRF	Capital recovery factor
DEMATEL	Decision-Making Trial and Evaluation Laboratory
EIP	Eco-industrial park
EU	European Union
FLP	Fuzzy linear programming
GDP	Gross domestic product
IE	Industrial ecology
IIM	Inoperability input–output modeling
I–O	Input–output
IS	Industrial symbiosis
ISO	International Standards Organization
LCA	Life cycle assessment
LCI	Life cycle inventory analysis
LCIA	Life cycle impact assessment
LP	Linear programming
MILP	Mixed-integer linear programming
MOLP	Multiple-objective linear programming
OECD	Organisation for Economic Co-operation and Development
PNS	Process network synthesis
RDU	Resource depletion units
REPA	Resource and environmental profile analysis
SAW	Simple additive weighting
SETAC	Society of Environmental Toxicology and Chemistry