

Preface

Supply chain networks, consisting of manufacturers, distributors, retailers, and consumers, provide the critical infrastructure for the production of goods, their distribution, and their ultimate consumption in today's globalized economies and societies. The reality of supply chain networks today includes not only competition but also cooperation since decision-makers in the supply chains must interact not only in terms of the product flows but also in terms of pricing in order to satisfy the consumers. At the same time, decision-makers in supply chains are characterized by their individualized objectives, which may include not only profit maximization, but also risk minimization, as well as the incorporation of environmentally conscious objectives, to various degrees. The concept of supply chain networks is as applicable to services as it is to goods.

This book provides the conceptual, analytical, and computational tools for the formulation and solution of supply chains from a network economics perspective. The approach is rigorous and of sufficient generality and detail to give added insight into the behavior and structure of these complex network systems, consisting of numerous decision-makers and their individualized behaviors.

This book builds the foundation for the modeling and analysis of the interrelationships among decision-makers in supply chains, ranging from the manufacturers/suppliers through the consumers. The models handle both competition as well as cooperation and yield the resulting product and material flows and prices in the chains. Network theory, optimization theory, as well as game theory, and the theories of variational inequalities and projected dynamical systems are synthesized and applied to scope out the statics and the dynamics of supply chain prices, flows, and the resulting profits. The network economics perspective provides a unique clarity to the conceptualization and visualization of supply chain problems as network problems, which enables the extension of the foundations to related application domains, ranging from energy supply chains through environmental supply chains, including reverse supply chain networks, as well as financial networks.

This book consists of three parts, with a total of twelve chapters. Part I establishes the theoretical foundations and includes both static and dynamic supply chain network models, including a model with supply-side and demand-side risk. In addition, the recently unveiled double-layered dynamics theory is described, which helps to scope out both adjustment processes and the evolution of the product flows and prices as demand varies over time. The importance of pricing in the supply chain network in order to satisfy the underlying optimality conditions of the decision-makers is clearly spelled out. Structural relationships between supply chain networks and transportation networks are identified and exploited to provide new interpretations of supply chain network equilibria as well as appropriate computational procedures. A new interpretation of the extended Braess paradox is provided through an evolutionary variational inequality formulation.

Part II of this book then applies and extends the theory developed in Part I to energy supply chains in the form of electric power generation and distribution networks. Both static and dynamic models of electric power supply chains are developed, along with qualitative analysis, and numerous examples. The last chapter of Part II focuses on the incorporation of alternative power plants into electric power supply chain networks, coupled with environmental policy instruments. The relationships between electric power supply chains and transportation networks are vividly captured through the theoretical results and the solution of practical examples. A conjecture postulated fifty years ago is resolved when electric power generation and distribution networks, that is, electric power supply chain networks, are shown to be transformable into transportation network equilibrium problems.

Part III of this book explores environmental supply chain networks and financial networks with intermediation, which are interpreted as supply chains. The environmental supply chain component of this book includes a formalism for the modeling, analysis, and solution of reverse supply chain management problems in the case of electronic recycling. Electronic waste is a huge environmental problem today and, hence, a framework for addressing this problem is of recognizable value. Financial networks with intermediation are shown to be transformable into transportation network equilibrium problems and also solved as such. A question asked over fifty years ago as to whether money flows like water or electricity is now answered in that money is shown to flow like transportation as is also the case for electricity.

The book is accompanied by two appendices, the first of which provides the basic level of optimization, variational inequality, and projected dynamical systems theory for the understanding of the results in this book. The second appendix consists of problems to accompany the chapters for self-study and/or pedagogical purposes. Some of the problems are research-oriented whereas others reinforce the material in the various chapters.

The intended audience for this book includes students, researchers, and practitioners in economics, business, and logistics, in engineering, notably,

in transportation science, in computer science, and in operations research and management science, who are interested in supply chain networks from the formulation and qualitative analysis stages through the computation of solutions and the application of the results.

Research on which this book is based was conducted over the past decade. The writing of this book took place while the author was a 2005-2006 Science Fellow at the Radcliffe Institute for Advanced Study at Harvard University in Cambridge, Massachusetts, while she was on sabbatical leave from the Isenberg School of Management at the University of Massachusetts at Amherst. The author would like to thank all the Radcliffe Institute Fellows for their incredible support, friendship, and wonderful conversations not only during numerous lunches, oftentimes, accompanied by laughter, but throughout the entire fellowship year. She would also like to acknowledge the outstanding intellectual stimulation provided through the Radcliffe Institute's seminar program. The fellowship year at the Radcliffe Institute sustained and enriched the author through many drafts of this book. The sharing of stories among the fellows, coupled with the seminars, provided a wonderful backdrop for the writing of this book, as well as for incredible memories, and invaluable advice. The author is eternally grateful to the Radcliffe Institute administration and staff for a very special year!

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This book is dedicated to my family, to the Fellows of the Radcliffe Institute, and to all my students and collaborators.