Preface

Purpose and Content of the Book

This book offers an introduction to structural dynamics and disruption risk management in the supply chains for larger audiences. It covers recent developments in supply chain risk management and resilience from the position of structural dynamics focusing on the disruption propagation and the ripple effect.

Structural dynamics in a supply chain results both from planned redesign actions and from disruptive events such as natural catastrophes, strikes, piracy, and man-made disasters. This book explores supply chain structural dynamics and control, with an emphasis on global network design with disruption consideration, distribution planning, and dynamic (re)scheduling. Based upon the triangle, "management problem–mathematical model–technology," the book derives practical recommendations for management decision-making with disruption risk consideration for the following areas:

- What is the impact of the disruption on operational and financial supply chain performance?
- What parts of the supply chain are affected by the disruption, i.e., what is the scope of disruption propagation?
- Is stabilization or recovery needed? If yes, what changes and at which stages in the supply chain are needed?
- When does one failure trigger an adjacent set of failures?
- Which supply chain structures are particularly sensitive to ripple/domino effect?
- What are the typical ripple effect scenarios and how to react in each of these scenarios in the most efficient manner?
- How to estimate the impact of possible disruptions on performance in the proactive stage
- How to estimate the impact of real disruptions on performance in the execution stage
- How to generate efficient and effective stabilization and recovery measures

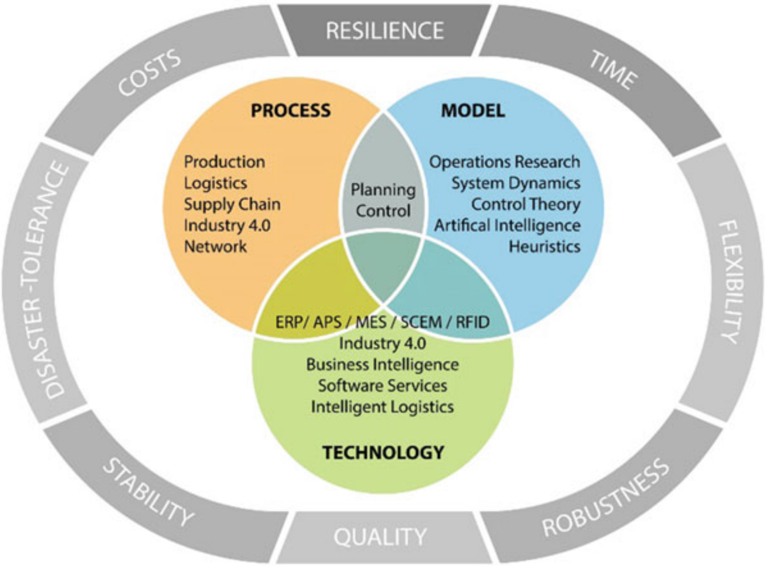

Fig. 1 Research philosophy behind this book

Among others, this book considers the ripple effect in the supply chain (also known as the "domino effect," "cascading effect," and "snowball effect"). It examines examples from both industrial and service supply chains and reveals decision-making recommendations for tackling disruption risks in proactive and reactive domains.

Based upon the triangle, "process–model–technology," this book investigates the dynamics of complex networks in production, logistics, and supply chains (Fig. 1).

In the management section, without relying heavily on mathematical derivations, the book offers state-of-the-art concepts and methods to tackle supply chain disruption risks in a simple, predictable format to make it easy to understand for students and professionals with both management and engineering background. This part of the book conceptualizes supply chain structural dynamics domain and disruption risks in verbal format.

In the technical section, the book constitutes structural dynamics control methods for supply chain management. Subsequently, real-life problems are modelled and solved with the help of mathematical programming, discrete-event simulation, optimal control theory, and fuzzy logic (Fig. 2).

The ultimate objective of this book is to comprehensively present an original multidisciplinary view of supply chain structural dynamics control developed by the author during the last 15 years. Providing supply chain risk managers and analysts with working models for contemporary decision-making problems at supply chain design, planning, and control levels, this research also aims at

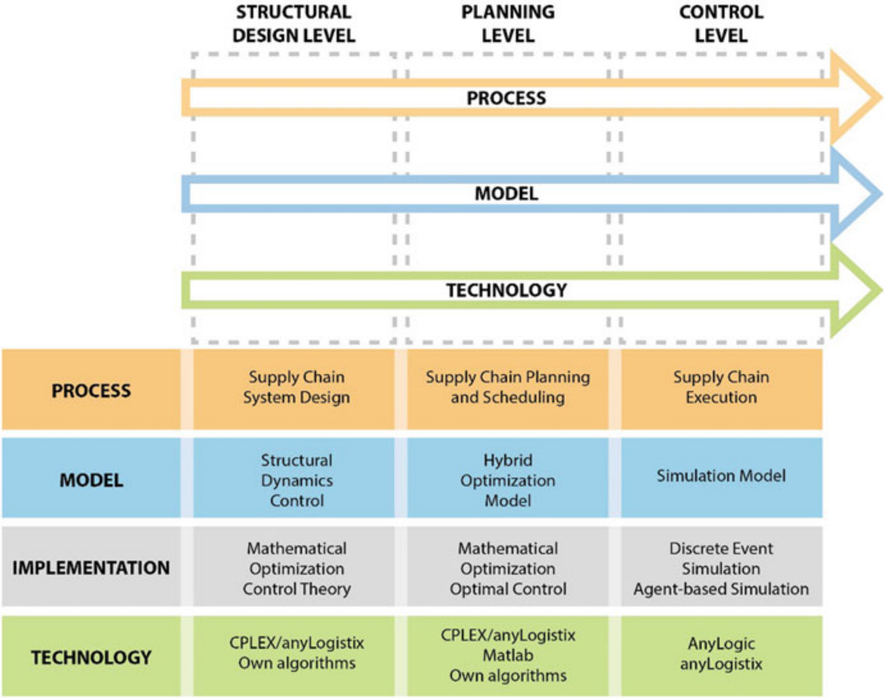

Fig. 2 Book structure

contributing to fundamentals of structural dynamics control in complex systems in general.

Chapter 1 first delineates the fundamentals of structural dynamics control in complex systems. Subsequently, the reader is introduced to the supply chains and their structural dynamics. Finally, the technical description of supply chain structural dynamics control is elaborated.

Chapter 2 introduces the reader to supply chain risk management as the application area of the structural dynamics control theory. Major definitions with regard to uncertainty and risks are followed by differentiating operative and disruptive risks. Subsequently, bullwhip and ripple effects are described. The latter is analyzed in more detail since the ripple effect is closely related to supply chain structural dynamics.

Chapter 3 defines the resilience concept in the framework of supply chain management. Major definitions with regard to resilience, robustness, stability, and flexibility are followed by a control theoretic supply chain resilience framework. Subsequently, a fuzzy theoretic approach to supply chain robustness estimation in the presence of structural dynamics is presented. The chapter concludes by presenting verbal and formal algorithms for supply chain structural and parametric adaptation.

Having described the structural dynamics control theory and the supply chain risk management domain as the application area, Chaps. 4 and 5 delineate methodical aspects. In Chap. 4, basic principles and methods of model-based decision-making such as mathematical optimization, simulation, control theory, and heuristic algorithms are described. Building upon Chap. 4, the state of the art in application of model-based decision-making methods to supply chain structural dynamics analysis and control is analyzed. Recent contributions from mathematical optimization, simulation, and control theory are summarized and analyzed in regard to the created knowledge and still existing research gaps.

Chapters 6, 7, 8, and 9 present applications of mathematical optimization, simulation, and control theory to solutions of supply chain design, planning, and scheduling models with structural dynamics consideration.

Chapter 6 considers a multistage supply chain reconfiguration problem. It develops a hybrid multi-objective mathematical optimization–optimal control model for proactive supply chain recovery planning and illustrates its application on numerical examples. The particular feature of the technical approach is the separation of design and control variables into a static (i.e., linear programming) and dynamic (i.e., optimal control) models. The management problem statement is original with regard to simultaneous decisions on supply chain redesign and replanning in the case of severe disruptions.

Chapter 7 is devoted to multistage supply chain scheduling. It develops control theoretic models and algorithms for supply chain scheduling with capacity disruption and recovery considerations. In this chapter, an original approach to flow shop and job shop scheduling with the help of optimal control theory blended with mathematical optimization is presented. Supply chain scheduling models are based on a dynamic interpretation of job execution processes. The computational procedure implies transformation of the optimal control problem to a boundary problem and Hamiltonian maximization with the help of maximum principle. The formulation of the scheduling problem in terms of optimal control allows for the utilization of a variety of control theoretic tools such as attainable sets and feedbacks to scheduling theory and practice. In addition, continuous time and state variables allow for modelling detailed operation execution dynamics with nonstationary considerations as well as modelling continuous flow production systems.

Chapter 8 elaborates on the simulation applications to supply chain structural dynamics control. The chapter presents three models with different application areas in industrial, retail, and service supply chains. The objective of this chapter is to reveal and depict advantages of simulation modelling as a dynamic approach to supply chain disruption management. The models developed provide evidence that simulation techniques are powerful tools that allow extending optimization methods. On the technical side, models are developed as discrete-event simulation models with multi-agent elements in AnyLogic and anyLogistix.

Chapter 9 considers a system theoretic concept of entropy with regard to supply chain complexity and adaptability analysis. A new concept of supply chain adaptation potential is presented and illustrated in the numerical examples. The application of this new method to the selection of the supply chain design method is also depicted.

Chapter 10 concludes the book. It starts with four case studies which illustrate practical handling of supply chain structural dynamics in risk management of the companies. Subsequently, it elaborates on new drivers of supply chain structural dynamics. The focus is directed herewith in the Industry 4.0 and cyber-physical systems. The adaptive supply chain management concept concludes this chapter.

Target Audience

Management and engineering graduate and PhD students, supply chain and operations management professionals, supply chain risk managers and analysts, industrial engineers, control engineers, and operations and supply chain researchers.

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