

# An Integrated Approach to Supply Chain Simulation

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## INTRODUCTION

Simulation can be a valuable tool for supply chain analysis, planning, optimization, evaluation, and risk management. Computer simulation and simulation models can be used to model intricate supply chains close to real systems, execute those models, and observe system behavior. The goal of simulation is to evaluate existing supply chain configurations, as well as to aid in design of the new supply chains. Supply chain simulation matters both supply chain design and supply chain control. In other words, it helps resolve different supply chain management (SCM) problems which can be grouped into the following categories:

- Infrastructure configuration that implies defining of the manufacturers, distribution centers, wholesalers, retailers and their locations (nodes).
- Planning and design of supply networks.
- Defining strategy related to processes at the nodes.
- Coordination between processes and activities with the purpose of their alignment and fulfillment of performance goals on global supply chain level.
- Information integration so that processes can exchange all necessary information.
- Risk mitigation in supply chain implementation both at the strategic and process levels.

- Supply chain validation through performance measurement which involves defining metrics at different supply chain levels.
- Validation through performance monitoring which involves defining metrics at different supply chain levels.
- Optimization by means of what-if analysis and application of best practices for improvement.

Modeling and simulation approach is the only practical option for exploring performance of the complex business networks such as supply chains. Furthermore, the modeling and simulation approach facilitates the design of the new supply chain configuration and policies, as well as the redesign of existing systems (Thierry et al., 2010). There are different supply chain modeling methods and types of simulation. Supply chain simulation can be performed with different goals. This can be analysis of supply chain dynamics, structure, or cash flow, risk mitigation, design, learning, etc.

In this chapter, the modelling approach and the simulation software which has integrative features capable to unify these various needs for different user groups are presented.

The background section gives definitions and explanations of key terms and concepts, as well as literature review with main contributions related to supply chain simulation. Simulation software integrates different models, entities and modules that function cooperatively. Its construction and



functioning principles are described and examples of supply chain simulations are given. The key contributions and benefits of the presented simulation solution are presented. Finally, the main future research directions and opportunities are examined.

## BACKGROUND

By examining well designed simulation models, organizations can reinforce their decisions regarding supply chain processes. They can study and analyze effects of different supply chain initiatives and improvement programs through sensitivity analysis (such as what-if or goal seek) before investing huge amount of money or disrupting their operations.

Computer simulation and simulation models can be used to model intricate supply networks close to real systems, execute those models, and observe system behavior.

The main advantages of the supply network computer simulation are (Stefanovic et al., 2009):

- The simulation is relatively clear and flexible.
- It can be used for analysis of the complex real systems such as supply networks.
- With the simulation, it is possible to include real-world influences, for example uncertainty factor in demand or lead time.
- “Time compression” is possible. Effects of a certain business policy over a long period of time (months, years), can be obtained in a short time.
- The simulation enables “what-if” analysis. Managers can test the results of different decisions.
- The simulation does not interrupt real systems. For example, experimenting with different supply network configurations can be done without disruptions and significant investment.

- With the simulation, the effects of the individual components, parameters and variables can be studied at the global level.
  - The main disadvantages of the supply network computer simulation can be summarized as:
- Quality simulation models can be expensive and time consuming to develop and validate.
- This is “modify-try” approach. Typically, it does not generate optimal solutions.
- It is necessary to model and define all relevant data in order to produce valid results which can be very difficult in complex supply network scenarios.
  - Simulation models can be classified into several categories and based on more than a few ways. Kleijnen (2005) classifies simulation models into four types:
- **Spreadsheet Simulation:** Used in corporate modeling usually by managers;
- **System Dynamics (SD):** Organizations are viewed as systems with six types of flows: materials, goods, personnel, money, orders, and information;
- **Discrete-Event Dynamic Systems (DEDS) Simulation:** Incorporates uncertainties and is usually part of the ERP systems;
- **Business Games:** Interactive simulation where managers operate within the simulated ‘world’.

During the past few decades, a number of papers have been published that deals with different aspect of supply chain modeling and simulation.

Some of them are purely mathematical models using the linear or mixed integer programming (Ettl et al., 2000), which are not fully applicable in a complex and volatile business environment. Those mathematical models have quite limited modeling power because they are based on simplifying assumptions and typically do not support

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