Manufacturing Supply Chain Analysis using System Dynamics and modeFRONTRIER

Amos H.C. Ng
Tehseen Aslam
Ingemar Karlsson

Virtual Systems Research Centre
University of Skövde
Högskolevägen 1
SE-54128, Skövde, SWEDEN

ABSTRACT

Modeling is an effective way for designing, understanding or analyzing real-world processes and systems. A model facilitates a decision maker to gain a better understanding of the complexity of a process/system and evaluate/predict its performance under various circumstances. A supply chain incorporates the integrated processes where products are transformed from raw material, e.g. from the suppliers, to finished products delivered to end customers. Typically, these processes include different business functions in a company, e.g., procurement, production, logistics, etc., need to collaborate, coordinate and interact with each other in order to produce the commodity of the supply chain. Hence, supply chains can be seen as good examples of such complex systems which require the modeling of processes in the presence of multiple autonomous entitles (i.e. suppliers, manufacturers, distributors, retailers, etc.), multiple performance measures and multiple objectives, both local and global, which together constituent very complex interaction effects.

Over the years, supply chains have been depicted with many different modeling approaches, ranging from process models, statistical models, optimization models, analytical models as well as simulation models, which include various simulation techniques like agent-based modeling, discrete event modeling and system dynamics modeling. The modeling method for supply chain proposed in this talk is based on system dynamics (SD), which is an approach based on information feedbacks and delays in the model in order to understand the dynamical behavior a system. A SD model facilitates the representation, both graphically and mathematically, of the interactions governing the dynamic behavior of the studied system or process as well as the analysis of the interactions and their emergent effects. Modeling with SD enables users to take a causal view of reality and implements quantitative means to investigate the behavior of the system and its response to various polices. Sterman (2000)[1] points out that a supply chain, being a system containing multiple autonomous entitles, is characterized by a stock and flow structure for acquisition, storage, converting inputs into outputs as well as the decision rules governing these flows. The existing flows in the supply chains such as information, material, orders, money, etc., create important feedbacks among the members of the supply chain, thus making SD a well-suited approach for modeling and analyzing supply chains.

Despite the increase in research within the domain of utilizing SD for supply chain management issues, there are relatively few articles in the literature that are related to the integration of simulation-based optimization (SBO), particularly multi-objective optimization (MOO), with SD models. The aim of this talk is therefore to introduce an integration of MOO and SD for manufacturing supply chain analysis. This is done by implementing a simple interfacing module for connecting modeFRONTIER (mF) and a Vensim SD model developed for the well-known Beer Game (BG) originally developed by MIT. The talk will introduce the integrated MOO and SD study for the BG. Data visualization methods like Parallel Coordinates (PC) in mF have been found to be very useful for gaining new insights in manufacturing supply chain analysis.

[1] Sterman J.D., 2000. Business Dynamics: Systems Thinking and Modeling for a Complex World, Boston: Irvin McGraw-Hill