LogDynamics
International Graduate School

Learning Labs for Inventory Control: An Approach for Reducing Order and Inventory Oscillations

Motivation

Schedulers in production networks, like people in general life conditions, are rationally-bounded, limited by the magical number seven whenever they process information, and confined by a definite capacity of memory. Mental models determine what and how people see and are behind people's actions. However, in the meantime mental models are imperfect, tacit and deficient because of their open-loop structures. This suggests a linear description of cause-and-effect relationships between variables in mental models. Accordingly, the chance that people generate decisions that could reduce to its smallest expression order and inventory oscillations in highly dynamic systems is rather small.

The bullwhip effect may be defined as the variability of demand which gains in magnitude as the demand signal propagates from the retailer to the factory in a typical four-sector supply chain made up of a retailer, wholesaler, distributor and factory. By magnitude, it is meant the three cardinal features of (i) oscillations or fluctuations of demand and inventories; (ii) amplification as when the factory's production rate greatly exceeds the retailer's sales rate, and (iii) phase lag. These three properties of the bullwhip effect are salient in Figure 1. This phenomenon is characterized as demand distortion in a supply chain.

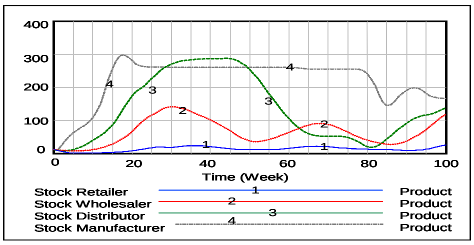

Figure 1: The bullwhip effect in a linear supply chain

The bullwhip effect gains in intensity due to two drivers of change, namely the globalization of world economies and technology. A manufacturing unit within the production network can create and propagate boom and bust cycles, overshoot & collapse, and instabilities of markets when it ignores the feedbacks, time delays and nonlinearities inherent to the system. The worldwide financial crises of previous decades which occurred in Asia and South America are believed to belong to this symptomatic mechanism of economic life. Most recently, the American real-estate sector was shaken by a crisis due to the difficulty of households in paying off loans, which generated heavy losses not only for American banks but also for European ones.

Approach and Methodology

The research objective focuses on analysis of the effects of learning laboratories (labs) on inventory oscillations. Learning laboratories aggregate a simulation game; such as the supply net game developed in this project, and a systems thinking intervention based upon mental model elicitation methods, for instance the left-hand column method conceived by Argyris and Schön. Learning labs are based upon the theory of organizational learning and systems thinking. The purpose lies in the examination of how decision makers perform the deterministic task of inventory control within controlled experiments thanks to the introduction of these learning labs. The sources of difficulty in performing this task are two-fold. The first is that customer orders are exogenous and uncertain. The second glitch is that the actual deliveries from the supplier(s) are not instantaneous.

Learning is measured on different scales with regard to (i) the answers to the questionnaire about systems thinking, (ii) the inventory costs generated during the implementation of the simulation game (supply net game); and finally, (iii) knowledge transfer from the simulation game, supply net game, to the beer game. The skills promoted by the learning lab are classified into hard and soft competences. While hard skills explicitly concern inventory control and regulation and necessitate the trial of strategies for the

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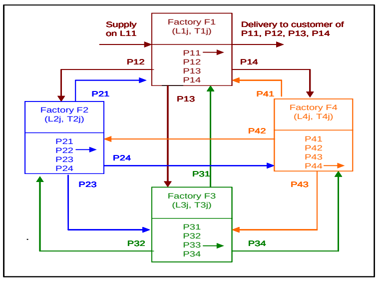
definition of appropriate policies, soft skills consider the more subtle competencies of collaboration and co-operation.

This project endeavors to investigate the effects of learning labs on cognitive misperceptions responsible for the creation, persistence and propagation of the bullwhip effect. This work fits into the structural frame of experimental and evaluative research which seek the determination and comparison of causal relationships between variables with the help of experimental design. Furthermore, the production network is modeled by means of the system dynamics methodology and, hence, the model is continuously simulated.

The task of inventory control is a common example of a stock management problem that consists in the decision maker's attempt to maintain a stock within an appropriate interval. Some further instances are the management of cash assets, air heating or water temperature regulation, adjustment of human relationships in groups, information disclosure rate, etc.

Structure of the Model

- Four-factory production network (Figure 2)
- Reentrant structure
- Replenishment of inventories: Anchoring and adjustment heuristic (Figure 3)



Pij is the product j manufactured by factory Fi

Lij is the production line of Pij

Tij is the min lead time on Lij

i, j = 1..4

Figure 2: Structure of the production network

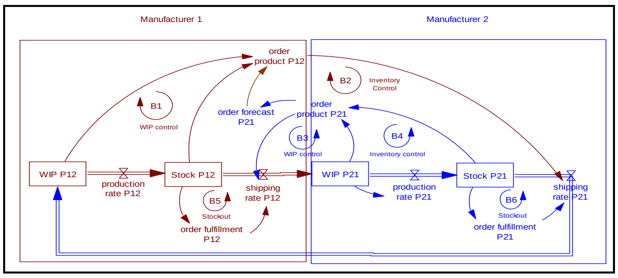


Figure 3: System dynamics policy diagram of the anchoring and adjustment heuristic adapted to the production network

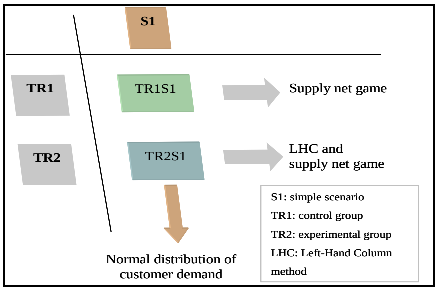


Figure 4: Design of the experiment

Practical Application

In summary, since all decisions are left to the discretion of decision makers, the significance of and genuine need for gaming environments embedded in learning labs is underpinned in complex logistic and production networks. A large number of supply chains encounter heavy oscillations of orders and inventories such as semiconductor & high-tech, commodities like beer and pampers; automobile, leather-shoe production, shipping & distribution, real-estate, chemicals or the aviation industry. Hence, the simulation game, supply net game (see Figure 5), can practically benefit many supply chains and not only those cited above; the list is not exhaustive. Moreover, innovative application of the simulation game, for instance by being linked to the online ordering system of an organization, could save a lot of costs, and hence be an economical training tool for controlling inventories and making decisions in hazardous environments.

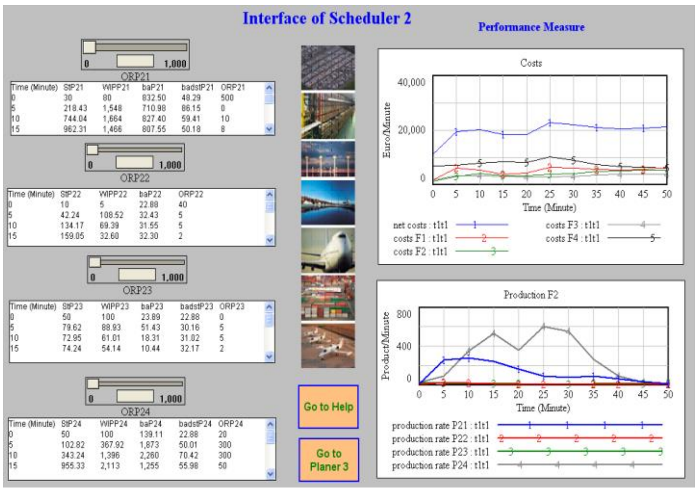


Figure 5: Interface of the simulation game

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