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Bullwhip Effect Study in a Constrained Supply Chain

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Abstract

Well organized supply chains are one of the best ways to compete in today's marketplaces. For make-to-stock production systems the production plans and activities are based on demand forecasting, which is one of the key causes of the bullwhip effect (BE). BE is the inherent increase in demand fluctuation up the supply chain and produces excess inventory and poor customer service. In the paper we simulated a simple three-stage supply chain using seasonal (SM) and deseasonalized (DSM) time series of the market demand data in order to identify, illustrate and discuss the impacts of different level constraints on the BE. The results are presented for different overall equipment effectiveness (*OEE*) and constrained inventory policies. At higher *OEE* level manufacturers have less variability in production processes; the BE is stronger in DSM than in SM.

Keywords: Supply chain; bullwhip effect; simulation; capacity constraints

1. Introduction

Supply chain management (SCM) is one of the most important and developing areas. It includes basically demand fulfilment, demand planning and supply planning. It integrates internal and external logistics across many manufacturers, suppliers, distributors, retailers, and transportation providers to increase productivity and to obtain a competitive advantage for all parties involved. The objective of supply chain management is to provide a high velocity flow of high quality, relevant information that will enable suppliers to provide an uninterrupted and precisely timed flow of materials to customers. The idea is to apply a total systems approach to managing the entire flow of information, materials, and services from raw materials suppliers through factories and warehouses to the

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end customer. Design of supply chain networks includes network configuration and related operational decisions.

The original motive of SCM was “elimination of barriers between trading partners” in order to facilitate synchronization of information between them [1]. But in real business this idea became lost. Where is the main problem? Supply chain performance depends on the operation of all members in a supply chain, where each member's basic objective is the optimisation of its own performance. Such behaviour of members can lead to less optimal whole chain performance. Members of a supply chain are used to compete and not to co-operate; they don't share information about products, customers, inventories, production capacities, costs and other business processes. So the members don't know much about the real market situation and the efficiency in their chain. They just repeat five basic activities in their supply chain: buy, make, move, store and sell.

Simulation is a very powerful and widely used management science technique [2] for the analysis and study of supply chains. The most important types are: spreadsheet simulation, system dynamics, discrete-event simulation, and business games.

The bullwhip effect represents the phenomenon of demand distortion where orders to supplier tend to have larger variance than sales to the buyer and this distortion propagates upstream in an amplified form.

In the paper we are giving a brief literature review of publications dealing with the bullwhip effect (section 2), continued with the presentation of the data used in the model (section 3) and our analysis of the influence of level constraints in the modelled supply chain (sections 4 and 5). Finally, section 6 contains a conclusion of the work and the future work.

2. Literature review

Numerous studies focused on identifying the bullwhip effect in examples from individual products and companies, starting in '70s [3-5].

Alony and Munoz reviewed the various methods of modelling the dynamics of supply chains [6]. They examined the limitations of modelling methodologies (analytical, agent-based, simulation) and suggested a combined discrete event and continuous simulation modelling approach. Pujawan investigated how different supply chain policies and different operating environments affect schedule instability in a supply chain [7]. It is shown that schedule instability is propagated up the supply chain and is much affected by the degree of demand uncertainty from the end customers, and that safety stock policy applied by the buyer has much impact on schedule instability.

Disney reviewed a range of methodological approaches to solving the bullwhip problem [8]. Measures for the bullwhip are given. Different types of supply chains (traditional – Fig. 1, information sharing, vendor managed inventory) are described and as a whole it is a general overview including also replenishment policies, forecasting techniques, lead times, costs etc.

Ouyang and Li analysed the propagation and amplification of order fluctuations in supply chain networks (with multiple customers) operated with linear and time-invariant inventory management policies [9]. The paper gives analytical conditions to predict the presence of the bullwhip effect to any network structure and any inventory replenishment policy, using a system control framework for analysing order stability. It provides the basis for modelling complex interactions among suppliers and among customer demands.

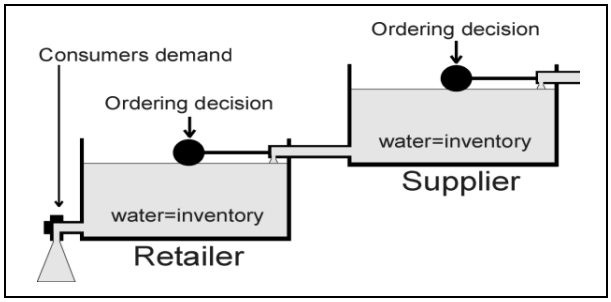

Fig. 1. Schematic of a traditional supply chain [8].