Effects of Discount Scenarios on Chaotic Behavior of Inventory Level Under Price-Dependent Demand

Iman Nosoohi, Department of Industrial Engineering& Systems Analysis, Isfahan University of Technology (IUT), Isfahan, Iran

Jamshid Parvizian, Department of Industrial Engineering& Systems Analysis, Isfahan University of Technology (IUT), Isfahan, Iran

ABSTRACT

In competitive conditions, demand depends on the price and retailers with lower prices sell more. In this paper a dynamic model is developed in which demand is price-dependent and the price is determined by the retailer based on its inventory level. The retailer can offer discounts to customers, regarding its inventory level, based on different scenarios such as linear, total or increasing scenarios. Simulations show that each scenario has different effects on the long-term chaotic behavior of the inventory level, and is able to control aperiodic behavior of inventory level under specific initial conditions. It is established that in order to secure inventory stability, the discount scenario should consider the incoming shipments to the retailer and the potentially maximum demand, instead of the inventory level.

Keywords: *Chaotic Behavior, Discount Scenario, Dynamic Model, Inventory Stability, Simulation*

INTRODUCTION

One of the major problems of supply chains is the proper management of the inventory in each level of the chain. Retailers need to *stabilize* their inventory at a *minimum level*. Fluctuations of the inventory level make decisions on orders and inventory planning important since it may lead to lost sale and finally dissatisfaction of customers. Such fluctuations are usually supposed to be caused by exogenous random factors, such as uncertainties in lead-times or market demand (Hwarng & Xie, 2008). However, studies have shown that inventories may exhibit significant fluctuations even if market demand and lead-times are deterministic (Hwarng & Xie, 2008). Fluctuations under deterministic situations are known as “Chaos”.

Though lacking a universal definition, Strogatz (1994) defines “Chaos” as an aperiodic long-term behavior in a deterministic system that exhibits sensitive dependence on

DOI: 10.4018/ijsda.2013070104

initial conditions. The origin of chaos theory goes back to Lorenz in the literature of weather forecasting. Feigenbaum and Mandelbort also have contributed to further development of the chaos theory (Strogatz, 1994).

A large number of real systems have chaotic behavior. For instance, there is chaotic behavior in epidemic spreading, heart beats, propagation of the avalanches, climate evolution, lasers, and electronic circuits. Little changes in such systems can lead to complex and erratic behavior. Chaos models can better simulate the natural phenomena by providing an alternative approach to explain the apparently random behavior of the complex and nonlinear systems (Vlad et al., 2010).

Fluctuations of the inventory level can be significantly aperiodic and unstable, especially in the long term and even in deterministic conditions. It is important to investigate major causes of chaotic behavior of inventory level and provide some strategies to control the chaotic behavior. Thus, in this research we investigate the dynamics of inventory level from a chaos perspective. The inventory model considered is based on a model presented by Wu and Zhang (2007). The difference between our model and theirs is that in our model the demand is price-dependent and the retailer offers discounts to customers based on its inventory level. Several scenarios can be considered to offer discount. Each scenario induces nonlinearities in the model. Different conditions, in which each scenario can cause chaotic behavior of the inventory level, are investigated in this paper. To reveal the behavior of inventory level graphical and simulation analysis are used since analytical methods are hard to apply for nonlinear systems.

The rest of the paper is organized as follows: first, we review the relevant literature. Next, the problem, including mathematical model and assumptions, is defined. After that we devote some sections to simulate the model under several discount scenarios and investigate if the scenarios can control chaotic behavior of the model under different parameter settings. Finally, we present major findings, some practical points for decision making and conclusions.

LITERATURE REVIEW

In this section, we first review research papers that relate to chaotic behavior of supply chains. Then, we review studies with the assumption of price dependent demand and discount policies.

Several studies have investigated supply chain management through different simulation approaches such as spreadsheet simulation, system dynamics, discrete-event simulation and business games (see for example Ingalls et al., 2005; Jain & Errin, 2005; Kleijnen, 2005; Rong et al., 2008; Kim, 2011). However there are limited studies on simulation of supply chain's from the view of chaotic behavior.

Mosekilde (1988) noticed that the classical beer distribution model shows a great variety of complex dynamic behaviors, including limit cycle oscillations and deterministic chaos. Wilding (1998) investigated internal systems within the supply chains can result in oscillations in demand and inventory, as orders pass through the systems. He defined deterministic chaos, in this field, and explained how the supply chains can demonstrate some of the key characteristics of chaotic systems such as sensitivity to initial conditions or generating patterns. Larsen et al. (1999) referred the wide variety of dynamic behaviors to the cascaded structure of the distribution chains. He found that nonlinearities and time delays of the systems can produce complex behavior including stationary periodic, quasi-periodic and hyper-chaotic motions. Further studies on ordering decisions and their effects on the nonlinear behavior of supply chains can be found in Thomsen et al. (1992) and Sosnovtseva and Mosekilde (1997). The effects of demand pattern, ordering policy, demand-information sharing, and lead time on the chaotic behavior of supply chain are studied by Hwrang and Xie (2008). Sipahi and Delice (2010) focused on the effects of different delays, emerging from decision making, production and transportation time, on the stability mechanisms of the supply chain. Recently, Wang et al. (2012) modeled an inventory system where return of goods is not allowed. They found upper bounds for order and inventory oscillations and parameter

Parameter Identification Using ANFIS for Magnetically Saturated Induction Motor

Mohamed M. Ismail Ali and M. A. Moustafa Hassan (2012). *International Journal of System Dynamics Applications (pp. 28-43).*

www.irma-international.org/article/parameter-identification-using-anfis-magnetically/66886/