ABSTRACT

This article presents analysis of the behaviour of a model of a centralised supply chain. The research was conducted within the manufacturing sector and involved the breathing equipment manufacturer Draeger Safety, UK. A simplified model of the Draeger Safety, UK centralised supply chain has been developed and validated. Simulation and analysis have been performed using System Dynamics, non-linear dynamics and control theory. The findings suggest that destructive oscillations of inventory could be generated by internal decision making practices. A management microworld has been developed allowing managers to experiment with different decision policies and learn how the supply chain performs.

Keywords: control theory; non-linear dynamics; supply-chain management; system dynamics

INTRODUCTION

The contemporary business environment is characterised by an acceleration of the process of change due to the communication and analytical capabilities supported by modern Information and Communication Technologies (Sterman, 2000; Terzi and Cavalieri, 2004; Ortega and Lin, 2004). This poses an ever increasing demand for periodical review of strategies and organisational processes, and for faster and effective learning to deal with problem situations quicker. Furthermore, companies increasingly need to react quickly to customer requirements (Hong-Minh, Disney and Naim, 2000). Naylor et al (1999) suggested the principle of agile manufacturing, i.e. responding to customer requirements with very short lead-times can be applied to supply-chains. Global companies are realising that the efficiency of their businesses is dependent on the collaboration with...
their suppliers and customers (van der Zee, 2005; Yusuf, Gunasekaran, 2004; Adeleye and Sivayoganatahn, 2004; Cox et al, 2004). The concept of supply chain management (SCM) is concerned with the strategic approach of integrating producers, suppliers and customers in a collaborative network with the objective of improving the overall responsiveness of the network, but at the same time preserving the organisational autonomy of each unit (Terzi and Cavalieri, 2004). More accurate data and better information available to all nodes of the supply chain are considered crucial in improving its performance. Thus, companies invest heavily in intra-company information and communication platforms and E-collaboration tools, as data warehouse or Enterprise Resource Planning systems (ERP) and Manufacturing Resource Planning systems (Lyneisa, 2005; Li & Li, 2005; Marquez, Bianchi and Gupta, 2004).

Contemporary Manufacturing Resource Planning (MRP) is a structured approach to manufacturing management in which a suite of integrated computer software covering the main operational business functions is used to assist the planning of materials, capacity and cash flow, in accordance with company policy, to meet customer delivery requirements (Ackermans & Dellaert, 2005). It is a total approach to managing a business (Li & Li, 2005). It includes inventory control data, purchasing and accounts payable, suppliers’ data, master schedules, production schedules, resource capacities, manufacturing orders, etc. MRP systems are developed under the assumption that more data and better information lead to better decisions. The quality of this data is believed to be accurate or at least good enough to be reliable (Ackermans and Dellaert, 2005). However, even with the introduction of resource planning systems, the performance of the supply chain remains problematic (Lyneisa, 2005; Fowler, 1999). The weakness of such systems is that when used on their own they fail to address the complexity of management situations for two reasons: firstly, they do not take into account the inherent ‘messiness’ of situations that contain human decision making within the process that is considered problematic (Maturana & Varela, 1987; Beer, 1979, 1994); secondly, such tools do not promote learning (Senge, 1984, 1996; Venix, 1994; Morecroft, 2007) or effective decision support as they do not include the powerful technique of simulation to allow for what-if analysis of alternative strategies (Terzi and Cavalieri, 2004).

After reviewing more than eighty scientific papers on the role and application of simulation in the supply chain, Terzi and Cavalieri (2004) show how simulation is successfully adopted in different studies of logistic networks. Their findings ascertain that simulation allows evaluation of performance prior to the implementation of the system since: 1) it enables companies to perform powerful what-if analyses leading to learning and improved planning decisions; 2) permits the comparison of alternative strategies in a safe virtual world, without interrupting the real system; 3) permits time compression that allows for timely policy decisions to be made. These findings are also supported by Chang and Makatsoris (2001).

The suitability of simulation as an approach to studying supply chains does not guarantee its adequate decision support (van der Zee, 2005) as simulation relies on an heuristic search for good decisions strategies led by people. The success of the simulation study depends on the joint work of the analyst and the chain managers and actors, as well as the facilities offered by the modelling and simulation tools. Van der Zee (2005), Sterman (2000) and Senge (1996) suggest that it is important to consider the simulation model as a communicative tool between analysts and chain actors. System Dynamics (Forrester, 1961; Sterman 2000) as a modelling and simulation framework has been developed to such a purpose.

This research uses a combination of System Dynamics and control theory analyses to address the issues of decision support and learning in the supply chain. It acknowledges the insights of non-linear dynamics and chaos theory in exploring the system’s behaviour (Sice & French, 1998; Mosekilde, 2002).