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The impact of the net present value on the assessment of the dynamic performance of e-commerce enabled supply chains

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Abstract

This paper shows the impact of using the net present value (NPV) on parameter selection in the ordering policy of a production planning and control system. Using a well understood and documented systems dynamics model of a supply chain, the NPV is used as an objective function to determine the discounted future variance costs resulting from the model's dynamics. The NPV of the Variance (NPV_v) is defined and applied to the model under three scenarios; traditional, electronic-point-of-sales enabled and vendor managed inventory. It is shown that the resulting management implications are sensitive to the selection of the NPV_v parameters.

Keywords: System simulation; Dynamic modelling; Financial performance

1. Introduction

E-commerce has led to potential for information transparency in the supply chain. New novel forms of supply chain structures have been enabled such as collaborative planning, forecasting and replenishment (CPFR) and vendor managed inventory (VMI). Such structures may have a positive impact on the dynamic behaviour of supply chains leading to reduced total logistics costs.

Although the benefits of supply chain management (SCM) strategies are often promoted actual bottom-line cost benefits are not always cited. This may be due to the complexities associated with determining actual costs and revenues throughout an actual supply chain (Tan et al., 2002). Researchers propose alternative approaches to measuring supply chain performance, such as balanced score cards (Bullinger et al., 2002), bullwhip (Towill and McCullen, 1999), uncertainty (Childerhouse and Towill, 2002) and multivariate techniques (Tan et al., 2002; Kim and Narasimhan, 2002). But as all SCM decisions ultimately have monetary consequences research on novel and robust forms of cash flow analysis have been proposed such as Net Present Value (NPV) (Grubbström, 1999), cash-to-cash (Farris and

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Hutchison, 2002) and target costing (Lockamy and Smith, 2000).

In this paper the NPV is investigated as a financial measure of the dynamic behaviour of supply chains. The NPV ascertains the time value of money invested in a business. Grubbström (1967) has shown that where the economic consequences of production planning decisions need to be known then the NPV may be applied.

The raison d'être for this paper are:

- to utilise a financial measure to assess the dynamic behaviour of supply chains,
- determine the impact of NPV on parameter selection,
- extend "hard engineering" know-how into the financial arena,
- apply NPV via system dynamics simulation,
- develop a single unified measure of performance that amalgamates a number of key dynamic characteristics.

While Wikner (1994) has undertaken some analysis of applying the NPV to a systems dynamics model of a production and inventory control system, Naim et al. (2004) have shown that the standard NPV is not a sufficient criterion for analysing the dynamic behaviour of such a closed-loop form of system. There is a need to extend the NPV criterion to encapsulate costs associated with the variances that occur in the system variables. This paper describes the development of the new criterion and how it may then be applied within a supply chain context.

This paper uses the automatic pipeline, inventory and order-based production control system (APIOBPCS) as a benchmark to determine the impact of using the NPV in assessing "on costs". The APIOBPCS archetype has been shown to model decision making heuristics as given in the MIT Beer Game (Sterman, 1989) and has led to insights on the impact of information transparency (Mason-Jones and Towill, 1997).

The paper next reviews literature on supply chain dynamics highlighting some recent developments on simulating the impact of information transparency as well as other SCM strategies. The paper then describes the simulation method adopted and the model used. This is followed by a presentation of the NPV formulae and its application. Next the need to use an alternative form of the NPV is justified, which is then applied to e-commerce supply chains as replicated by the MIT Beer Game. Finally, the results are discussed and managerial implications considered.

2. The construct of supply chain dynamics

Much of the pioneering work into aspects of supply chain dynamics was undertaken by Forrester in the late 1950s (Forrester, 1958), using a simple but representative simulation model of a production distribution system, more commonly referred to now as a supply chain. Originally developed as a detailed case study to highlight the principles of industrial dynamics, that is, that structure causes dynamic behaviour, Forrester's work has been widely quoted in business and academic literature on SCM. Based on a series of simulation experiments, Forrester revealed a number of important behavioural features of the production–distribution model that were concluded as having relevance to real world supply chains:

1. Demand in the marketplace becomes a delayed and distorted order pattern moving upstream through a supply chain.
   - 1.1. At any one point in time, processes in various companies in the chain may be moving in different directions to each other and to the market.
   - 1.2. Supply chain designs tend to "amplify" marketplace variations. The magnitude of the variations in orders placed on the factory is greater than the variations in marketplace demand.
   - 1.3. Supply chain designs can introduce "periodicity", or rogue seasonality which can be misinterpreted as a consequence of seasonal variations in the marketplace, rather than a property of the supply chain design.
2. Attempts to reduce poor supply chain dynamic behaviour can exacerbate the problem. Counter-intuitive behaviour often occurs because the