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ScienceDirect
Int. J. Production Economics 108 (2007) 100–110
international journal of production economics
www.elsevier.com/locate/ijpe

Coordinating ordering/shipment policy for buyer and supplier: Numerical and empirical analysis of influencing factors

Peter Kelle[a,*], Pamela A. Miller[b], Asli Y. Akbulut[c]

[a]*Louisiana State University, USA*
[b]*Northwestern State University, USA*
[c]*Grand Valley State University, USA*

Available online 23 January 2007

Abstract

The deficiencies in previous quantitative models for buyer–supplier coordination in a just-in-time (JIT) environment are corrected. An expanded model incorporating additional factors is developed and the factors are ranked through a detailed numerical analysis. Factor ranks are then compared with results of a series of semi-formal interviews with supplier and purchasing representatives.
Published by Elsevier B.V.

Keywords: Supply chain management; Buyer-supplier relationships; JIT; Optimal order/shipment policy; Policy coordination

1. Introduction

Managers widely agree that efficient supply chain management requires the cooperation of buyer–supplier partners throughout the whole supply chain from raw material suppliers to the final customer. Collaborative planning and cost reduction initiatives are based on the value chain principle. Alignment of the supply chain by optimizing the relationship and processes between manufacturers and distributors can provide a win–win environment.

In the spirit of buyer–supplier cooperation and coordination, Banerjee (1986) developed a model that finds the order quantity that minimizes the total relevant costs for the buyer and the supplier called the joint order quantity. Goyal (1988) adjusted this model to allow the supplier to produce in lot sizes that are a multiple of the purchaser's order quantity. Other quantitative results were published later in this area by Golhar and Sarker (1992) and Banerjee and Kim (1995). Miller and Kelle (1998) extended these models by including the shipping cost, multiple deliveries, and an adjustment of the supplier's holding cost to reflect multiple deliveries. Hill (1997) considered a more general type of policy based on successive shipments to the buyer. In Kelle and Miller (1998), a safety stock factor is added to combat the uncertainty that can occur in transition to just-in-time (JIT). The optimal batch sizes and raw material purchasing policies are determined in Khan and Sarker (2002). Quantitative support for negotiation is provided in Kelle et al. (2003).

Several quantitative and qualitative results have been published recently on the coordination and cooperation between the two parties suggesting

*Corresponding author.
E-mail addresses: millerp@nsula.edu (P. Kelle), qmkell@lsu.edu (P.A. Miller), akbuluta@gvsu.edu (A.Y. Akbulut).

0925-5273/$ - see front matter Published by Elsevier B.V.
doi:10.1016/j.ijpe.2006.12.005

joint channel-optimal ordering/shipment policies. These include the qualitative, managerial studies of González-Benito et al. (2000), Buvik and Halskau (2001), Dong et al. (2001), Frohlich and Westbrook (2001), White and Prybutok (2001), Barlow (2002), Fullerton et al. (2003), Yasin et al. (2003); and the quantitative studies of Hoffman (2000), Gavirneni (2001), Lee (2001), David and Eben-Chaime (2003), Kim and Ha (2003), Lovell (2003), Cao and Schniederjans (2004), Meca et al. (2004), and Wang et al. (2004).

In this paper, we extend these results in two directions: (1) by presenting the results of a detailed numerical analysis on the influencing factors and their effects and (2) by summarizing semi-formal interviews with purchasing professionals and supplier representatives on their perceptions about these factors.

We use analytic expressions for inventory related cost comparisons and examine the effect of parameter changes where they can be applied. In the analytic expressions, we correct some deficiencies of the previously published models and introduce a new cost factor. In cases where the analytic expressions are not applicable due to integer properties and other complexities, we use numerical comparisons based on several sets of full experimental designs.

This analysis is applied to the following:

- the optimal shipment quantity, q_B, and order quantity, $Q_B = nq_B$ for the buyer,
- the loss of buyer due to forced shipment size by a dominating supplier,
- the optimal shipment quantity, q_B, and lot size $Q_S = mq_S$ for the supplier,
- the loss of supplier due to forced shipment size by a dominating buyer, and
- the potential net improvement for buyer and supplier by accepting the joint optimal shipment size.

We consider the following five parameters for the buyer:

D	annual demand with known constant rate
A_B	the buyer's ordering cost, which is the cost of preparing and closing the contract
h_B	the buyer's annual inventory carrying cost ($h_B = r_B C_B$, where C_B is the selling price, and r_B is the buyer's annual inventory carrying cost rate)
Z_B	the receiving cost for the buyer, the fixed cost of receiving a shipment
L_B	the cost rate of losing flexibility for the buyer (explained later in Section 3). Further, we consider the following four parameters for the supplier:
P	the production rate
A_S	the supplier's fixed setup cost
h_S	the supplier's annual inventory carrying cost ($h_S = r_S C_S$, where C_S is the production cost and r_S is the supplier's annual inventory carrying cost rate)
Z_S	the supplier's fixed cost related to each shipment to buyer (independent of the shipment size)

We fix the production rate, P, and set different low and high values for each of the remaining eight parameters in different full experimental design settings. The major tendencies based on analytic results and several eight parameter full factorial numerical experiments are summarized.

Based on these sensitivity and factor analysis results, we prepared questions for purchasing and sales experts and conducted semi-formal interviews concerning their practices and perceptions. The key questions focus on the factors that purchasers and suppliers actually consider in decisions on ordering (contract) length, lot size, and shipment frequency, as well as which factors influence the loss the buyer (supplier) company incurs due to a forced shipment policy of a dominating partner. We also asked under which circumstances they believe a buyer (supplier) has greater benefits from the coordination of the policies. We compared the practitioners' responses to the quantitative modeling results. A large-scale survey will be planned based on the results of this paper.

2. The buyer's optimal shipment size

2.1. Analytic results

The buyer in JIT supply requires small, frequent shipments. We assume that the buyer's order (contract quantity), Q_B, is delivered in n shipments of size $q = Q_B/n$. The optimal shipment size for the buyer can be expressed in a form similar to the classic EOQ expression used to determine the optimal order size for the buyer in the traditional non-JIT environment:

$$q_B = \sqrt{\frac{2DZ_B}{h_B}}. \quad (1)$$