Available online at www.sciencedirect.com

ScienceDirect

European Journal of Operational Research 184 (2008) 793–796

EUROPEAN JOURNAL OF OPERATIONAL RESEARCH

www.elsevier.com/locate/ejor

Short Communication

A note on channel performance under consignment contract with revenue sharing

Sijie Li, Zhongsheng Hua *

School of Management, University of Science and Technology of China, Hefei, Anhui 230026, People's Republic of China

Received 20 May 2005; accepted 2 November 2006
Available online 2 January 2007

Abstract

Wang et al. [Y. Wang, L. Jiang, Z.J. Shen, Channel performance under consignment contract with revenue sharing. Management Science 50 (2004), 34–47] indicate that a decentralized supply chain cannot be perfectly coordinated. This note provides a cooperative game model that implements profit sharing between the manufacturer and the retailer to achieve their cooperation. When the manufacturer and the retailer are assumed to be risk-neutral, under a very mild restriction on the demand distribution function, the cooperative game model can achieve its unique equilibrium solution in iso-price-elastic or linear demand case. Under the revenue sharing agreement attached with the equilibrium payment scheme, the decentralized supply chain can be perfectly coordinated.

Keywords: Supply chain management; Consignment contract with revenue sharing; Coordination; Cooperative game

1. Introduction

Consignment contract with revenue sharing has been widely applied in many industries, especially in online marketplaces, such as Amazon.com, etc. Coordination mechanism is an important issue in designing a contract for a decentralized supply chain. If the decentralized decisions result in channel profit that is equal to those achieved under a centralized supply chain, the decentralized supply chain is perfectly coordinated [1,2]. Wang et al. [3] study a consignment contract with revenue sharing. They model the decision making of the two firms as a non-cooperative game, and indicate that the decentralized supply chain cannot be perfectly coordinated. Cachon and Lariviere [4] study a VMI contract with revenue sharing, which is similar to the consignment contract with revenue sharing. They demonstrate that the decentralized system provides less capacity than the integrated system.

Utilizing the cooperative bargaining theory initiated by Nash [5], we propose a cooperative game model to describe the payment bargaining process between the manufacturer and the retailer, and determine a new consignment contract with revenue sharing, i.e., the revenue sharing agreement attached with the equilibrium payment scheme. We show that the decentralized supply chain can be perfectly coordinated under the new consignment contract.

* Corresponding author. Tel.: +86 551 3607792; fax: +86 551 3600025.

E-mail address: zshua@ustc.edu.cn (Z. Hua).

0377-2217/$ - see front matter © 2006 Elsevier B.V. All rights reserved.
doi:10.1016/j.ejor.2006.11.003

2. Problem formulation

We first provide a short problem description. A two-echelon supply chain with one manufacturer and one retailer is considered. It is assumed that the price-sensitive demand D has the functional forms of $D(p) = y(p)\cdot\varepsilon$ in the multiplicative demand case, and $D(p) = y(p) + \varepsilon$ in the additive demand case. $y(p)$ is a deterministic and decreasing function of the retail price p. It takes the forms of $y(p) = ap^{-b}$ ($a > 0$, $b > 1$) and $y(p) = a - bp$ ($a > 0$, $b > 0$) in the multiplicative and additive cases, respectively. ε is a random variable with PDF $f(\cdot)$ and CDF $F(\cdot)$, and is supported on $[A, B]$ with $B > A \geqslant 0$.

The manufacturer produces q units of the single-period product at a constant cost c_{M}, and the product is sold at a retail price p per unit. The retailer incurs a constant cost c_{R} per unit at the retail stage. $c \equiv c_{\mathrm{M}} + c_{\mathrm{R}}$ is defined as the total supply chain cost per unit, out of which $\alpha = c_{\mathrm{R}}/c$ portion is incurred by the retailer at the retail stage, and the rest, i.e., $1 - \alpha = c_{\mathrm{M}}/c$, is the manufacturer's cost share incurred at the production stage. It is also assumed that the unsold units bear no salvage value or disposal cost, and the unsatisfied demand incurs no loss-of-goodwill cost at the end of the selling season.

Denote $\overline{F}(\cdot) = 1 - F(\cdot)$. Assume that F is strictly increasing, differentiable on $[A, B]$, $F(A) = 0$, and $F(B) = 1$ (i.e., there is always some demand in market).

Wang et al. [3] provides the optimal decision $(p_{\mathrm{c}}^*, z_{\mathrm{c}}^*)$ for the centralized supply chain with iso-price-elastic demand. For the centralized supply chain with additive demand case, following the similar proof procedures, we obtain the unique optimal decision under a certain condition, shown in Table 1. In Table 1, the stocking factor of inventory is defined as $z \equiv q/y(p)$ in the iso-price-elastic demand case, and as $z \equiv q - y(p)$ in the linear demand case; $\Lambda(z) = \int_A^z (z - x) f(x)\,\mathrm{d}x$.

As shown in Table 1, if F is IFR/IGFR (increasing failure rate/increasing general failure rate), the centralized supply chain has a unique optimal decision in the additive/multiplicative demand case. IGFR is implied by IFR condition, which captures most common distributions, such as the normal, uniform, as well as the gamma and Weibull families, subject to parameter restrictions.

3. Cooperative game models and supply chain performance

In the decentralized supply chain, a manufacturer produces the product and then sells it to consumers through a retailer under a consignment contract. The retailer offers the manufacturer a revenue sharing contract, the retailer keeps r share of the revenue for per unit sold, and remits the rest, i.e., $1 - r$, to the manufacturer.

Denote the manufacturer's and the retailer's expected profit functions in non-cooperative situations as $\Pi_{\mathrm{d,M}}$ and $\Pi_{\mathrm{d,R}}$, respectively; and denote those in the cooperative situations as $\Pi_{\mathrm{e,M}}$ and $\Pi_{\mathrm{e,R}}$, respectively. Denote by $(p_{\mathrm{e}}, z_{\mathrm{e}}, r_{\mathrm{e}})$ and $(p_{\mathrm{d}}, z_{\mathrm{d}}, r_{\mathrm{d}})$ the decisions at cooperation and non-cooperation, respectively. We add superscript "*" to relative variables to represent their corresponding optimal values.

The purpose of the cooperation is actually to determine a channel profit allocation scheme between the manufacturer and the retailer. It should be noted that not all optimal profit sharing schemes are acceptable, neither the manufacturer nor the retailer would be willing to accept less profit at cooperation than at non-cooperation. A payment scheme $(\Pi_{\mathrm{e,M}}^*, \Pi_{\mathrm{e,R}}^*)$ is called acceptable if $\Delta\Pi_{\mathrm{e,M}}^* = \Pi_{\mathrm{e,M}}^* - \Pi_{\mathrm{d,M}}^* \geqslant 0$, and $\Delta\Pi_{\mathrm{e,R}}^* = \Pi_{\mathrm{e,R}}^* - \Pi_{\mathrm{d,R}}^* \geqslant 0$, then the acceptable decision set Z can be defined as follows:

$$Z = \{(p, z, r) : \Delta\Pi_{\mathrm{e,M}}(p, z, r) = \Pi_{\mathrm{e,M}} - \Pi_{\mathrm{d,M}}^* \geqslant 0,\ \Delta\Pi_{\mathrm{e,R}}(p, z, r) = \Pi_{\mathrm{e,R}} - \Pi_{\mathrm{d,R}}^* \geqslant 0\}. \tag{1}$$

Table 1
The optimal decisions for the centralized supply chain

	Multiplicative case (Wang et al., 2004)	Additive case (our conclusion)
Condition	If $h(z) + z\,\mathrm{d}h(z)/\mathrm{d}z > 0$, i.e., F is IGFR	If $2h^2(z) + \mathrm{d}h(z)/\mathrm{d}z > 0$
z^*	$\overline{F}(z_{\mathrm{c}}^*) = \frac{(b-1)[z_{\mathrm{c}}^* - \Lambda(z_{\mathrm{c}}^*)]}{bz_{\mathrm{c}}^*}$	$F(z_{\mathrm{c}}^*) = \frac{a + z_{\mathrm{c}}^* - \Lambda(z_{\mathrm{c}}^*) - bc}{a + z_{\mathrm{c}}^* - \Lambda(z_{\mathrm{c}}^*) + bc}$
p^*	$p_{\mathrm{c}}^*(z_{\mathrm{c}}^*) = \frac{bcz_{\mathrm{c}}^*}{(b-1)[z_{\mathrm{c}}^* - \Lambda(z_{\mathrm{c}}^*)]}$	$p_{\mathrm{c}}^*(z_{\mathrm{c}}^*) = \frac{a + z_{\mathrm{c}}^* - \Lambda(z_{\mathrm{c}}^*) + bc}{2b}$