

Manufacturer vs. Retailer: Who Should Manage Returns in Revenue-Sharing Contracts under Multiplicative Demand?

Milena Bieniek

`milena.bieniek@umcs.lublin.pl`

Maria Curie-Skłodowska University

Jarosław Banaś

Maria Curie-Skłodowska University

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Abstract

This article investigates pricing and ordering decisions in a two-echelon supply chain facing price-sensitive, multiplicative stochastic demand in the presence of product returns and exchanges. Using a Stackelberg game with the manufacturer as the leader, we analyze four contract scenarios that combine revenue sharing or cost-revenue sharing with manufacturer- or retailer-managed returns. We show that revenue-sharing contracts do not fully coordinate the supply chain when return handling costs are not shared. Cost-revenue sharing contracts can coordinate the channel when the wholesale price is set at the coordinating level below the production cost. Theoretical findings show that multiplicative demand introduces a structural singularity in the induced pricing functions, contrasting with the continuous outcomes under additive demand. Numerical and sensitivity analyses show that decentralization causes only a small loss in channel profit but a much larger reduction in order quantity. Furthermore, we find a critical sharing ratio threshold. Above this value, letting the retailer handle returns becomes better for both parties than if the manufacturer manages them. These findings offer practical guidelines for designing contracts in e-commerce and electronics supply chains.

Keywords: revenue sharing, returns, exchanges, Stackelberg game, supply chain coordination

MSC Classification: JEL , EconLit: L14 , C44 , C61

1 Introduction

Product returns are a major challenge in many industries, particularly in e-commerce [1]. Product returns can generate considerable losses because both retailers and manufacturers may be responsible for handling them. The manufacturer accepts consumer returns mainly for reasons such as warranty and take-back compliance [2]. In particular, costs associated with the returns of electronics can be substantial [3]. It has been reported that 41% of consumers have returned a non-defective electronic product and that 92% would buy again from a brand if the return process were easy [4]. In the electronics industry, contracts between manufacturers and retailers play an important

role in supply chain (SC) management. [5]. These contracts often incorporate revenue sharing (RS) mechanisms under sales revenue is shared between parties according to an agreed sharing ratio.

This paper studies how RS contracts can be designed to improve decisions and outcomes for both manufacturers and retailers. Contracts specify expectations regarding the values of variables and ensure that both parties adhere to the terms. At the Stackelberg equilibrium, the retailer chooses its best response to the manufacturer's decision, while the manufacturer chooses its decision anticipating this response. Any unilateral deviation from these equilibrium decisions leads to a lower profit for the deviating party. This requirement can be represented as an equilibrium point in the Stackelberg game with the manufacturer as the leader [6].

In the study RS contracts for non-defective product (false failure returns (FFR) [7]) returns are evaluated. Consumers may return non-defective products and exchange them for new items. Any surplus inventory can be salvaged without capacity constraints. The handling of returns is divided into two strategies: R or M. Under strategy R, consumers return products to the retailer, who handles the returns. Under strategy M, consumers return products directly to the manufacturer. Both strategies maintain identical forward channels. After choosing the return handling strategy, the manufacturer selects either an RS or a CRS (Cost-Revenue Sharing) contract. Under the RS contract, revenue is shared between the manufacturer and the retailer according to the negotiated sharing ratio. Under the CRS contract, the retailer shares both revenue and return handling costs with the manufacturer. Furthermore, in each scenario, the consumer demand is stochastic, multiplicative and dependent on the retail price. Consequently, in the decentralized channel, four contract scenarios are identified. Together with the multiplicative case, they are summarized in Table 1.

Table 1 Setup of contract scenarios

Strategy	M	R
Sharing policy		
Revenue sharing	RS-M	RS-R
Cost-revenue sharing	CRS-M	CRS-R

Before the Stackelberg game begins, the manufacturer selects one of the four contract scenarios. The Stackelberg game then proceeds with the manufacturer as the leader and the retailer as the follower. Initially, the manufacturer sets the wholesale price w , maximizing their expected profit. Subsequently, the retailer determines the retail price p and order quantity q , aiming to maximize their own expected profit. The manufacturer then produces and delivers the product to the retailer before the selling season. Upon the occurrence of seasonal demand, products are returned and exchanged based on the mismatch rate, and transfer payments are executed between the firms as per the agreed contract terms.

The article examines optimal decisions and determines which party should handle the returns, and under what conditions. Both multiplicative and additive demand models are widely applied in the literature [8–11]. While in [12] RS contracts under

additive demand are considered, this study examines RS contracts under multiplicative. The demand functions for a wide variety of products including food and electronic items, are often estimated to be multiplicative. This study also extends [13] and [14], which consider wholesale-price contracts under multiplicative demand. To achieve these objectives, the following research questions are formulated:

- RQ1. How do RS and CRS contracts affect the analytical structure of the Stackelberg game under multiplicative demand?
- RQ2. Which optimal decision variables: price, wholesale price, or order quantity distinguish the contract scenarios, and how are they affected by return handling costs and the sharing ratio?
- RQ3. Which contract strategy is preferred by the manufacturer and which by the retailer under different sharing ratios?
- RQ4. Which contract mechanisms achieve full SC coordination under multiplicative demand?

The model is based on a scenario describing relationships among SC members introduced in [15] and further developed in [13] and [12]. Liu et al. [15] consider wholesale or buyback transactions with price-free stochastic demand and retail price being the exogenous variable. In [13] and [14] the model of [15] with endogenous price and additive or multiplicative demand is supplemented but the wholesale price contract is still considered. In the paper [12] four contract scenarios based on RS agreement under additive demand are introduced, and optimized. In this paper we concentrate on the results of the multiplicative demand case, namely we formalize and optimize RS-M, RS-R, CRS-M, CRS-R contract scenarios with the stochastic and multiplicative form of demand assumed. The study makes four contributions. First, it shows that the form of demand uncertainty affects not only the analytical solution of SC contracts but also the economic properties of the resulting contract. Under multiplicative demand, the pricing functions have a boundary that is absent under additive demand, limiting the feasible decisions. Second, the study shows that the party handling returns does not always bear the full cost of them. When the manufacturer handles returns, higher return costs lead to a higher wholesale price. When the retailer handles returns, it increases the retail price, while the manufacturer lowers the wholesale price to reduce the negative effect on demand and order quantity. Third, the study shows how CRS can coordinate the SC. When revenue and return costs are shared in the same proportion, the decisions of the firms can match those of the centralized channel. However, the wholesale price that gives full coordination may differ from the price chosen by the manufacturer in the Stackelberg game. Fourth, the numerical analysis shows that a small loss in total profit may be linked to a much larger reduction in order quantity. It also shows when retailer-managed returns create a conflict between the manufacturer and the retailer, and when they benefit both parties. These theoretical insights give managers a basis for designing effective returns policies suited to different product demands, which is especially relevant because of the widespread use of RS contracts and the growing problem of product returns, particularly in electronics industry.

2 Related literature

This study is related to the literature on RS contracts and SC contracts with product returns. We describe findings concerning those issues focusing our attention on the most relevant and recent research. The pure RS contract determines the distribution of profits and losses between members and therefore can coordinate the SC [6, 16]. To achieve coordination, an RS contract should clearly specify how revenue is measured and shared [17]. The challenge of reducing non-defective returns through SC coordination is addressed in [7]. The target rebate contract which leads to a Pareto improvement is considered. This contract could substantially enhance the profit for both parties involved, and for the whole SC as well. In [18] a model of consumer returns policies is proposed in which consumers face valuation uncertainty. Consumers' decision is to purchase and return the product, while the seller's decision is to establish the price, quantity, and refund amount. The impact of full and partial returns policies on the SC performance is investigated and the proposition of strategies of the SC coordination is offered.

In [19] a coordination contract resolving a profit conflict between the manufacturer and retailer resulting from reducing FFR is presented. A quantity discount contract is introduced, which specifies a payment to the retailer with an amount decreasing in the number of returns. It was proved that the contract is Pareto improving and that it can discourage the retailer from accepting returns. Examining the principal-agent problem in handling FFR within a reverse SC featuring one manufacturer and two competing dealers, Sun et al. [20] design optimal incentive contracts under both symmetric and asymmetric information. They find that under the symmetric information, the dealers' effort levels align with those that maximize the expected overall profit of the SC. Considering the possibility of reselling FFR, Pingping et al. [21] investigate transshipment and inventory decisions in a dual-channel SC. They examine three scenarios with FFR, taking into account transshipment and consumer switch, and demonstrate that scenario choices significantly affect optimal quantities.

Khouja and Hammami [22] compare cash returns with refunds in the form of store credit or gift cards. Both policies benefit consumers who keep the product more than those who return it. In [15] and [13], a wholesale price contract with a returns handling strategy is considered. In [15], the retailer's order quantity, the manufacturer's returns handling strategy, and channel coordination are explored under FFR assumption. The study proves that a buyback contract in such SC is able to coordinate the SC. In [13], the endogenous retail price is additionally considered, with a discussion concerning the possibility of negative demand realizations, albeit only in the case of the manufacturer handling strategy. In [12], the RS contract in a similar model is investigated under additive stochastic demand linearly dependent on the retail price. The authors of [23] examine returns management strategies using a game theoretical model for a SC where the retailer faces customer returns. The manufacturer can pursue either a buyback or a wholesale price contract. The optimal returns management strategy is determined and it is shown that each strategy can lead to a Pareto improvement.

The existing literature does not fully address RS and CRS contracts with product returns under multiplicative stochastic demand [12, 13, 15]. In this paper mathematical modeling is conducted for four contract scenarios combining RS and CRS contracts

with exchange under two returns handling strategy. These contract scenarios are illustrated on schemes, and optimal quantities are derived. The assessment whether these contracts may coordinate the SC is undertaken. Finally, an extensive sensitivity analysis is conducted to determine which return handling strategy is preferred and how RS and CRS contracts affect the profits of the SC members and the whole channel.

3 Problem formulation

Consider a two-echelon SC consisting of an independent manufacturer and retailer. Within this distribution setup, the manufacturer introduces a fresh product, which is then channeled through the retailer. The retailer, in this arrangement, purchases the product at the wholesale price, while consumers pay the retail price directly to the retailer. The manufacturer faces a unit cost of producing the item. Table 2 outlines the parameters, assumptions, and decision variables pertinent to the model.

Table 2 Model parameters, notation and assumptions

Decision variables	
p	retail price per unit set by the retailer
$z(q)$	inventory factor (order quantity) set by the retailer
w	wholesale price per unit set by the manufacturer
Parameters and notation	
l	name of scenario $l \in \{RS, CRS\}$
k	name of strategy $k \in \{M, R\}$
Π_c^k	expected profit in the centralized channel
Π_m^{l-k}, Π_r^{l-k}	manufacturer's and retailer's expected profit in the decentralized channel
$\Pi_d^{l-k} = \Pi_m^{l-k} + \Pi_r^{l-k}$	expected profit of the decentralized channel
$\Delta \Pi_i^l = \Pi_i^{l-R} - \Pi_i^{l-M}$	the difference between respective profits i , $i \in \{m, r, d\}$, in strategy R and M
$r \in (0, 1)$	sharing ratio, in degenerate boundary cases $r = 0$ or $r = 1$
$c > 0$	unit production cost
v	unit salvage value $v < c$,
$h^k \geq 0$	$= H^k \alpha$ returns handling cost per unit sold H^k multiplied by the mismatch rate $\alpha \in (0, 1)$
$h_c^k \geq 0$	$= H_c^k \alpha$ consumer's average returns handling cost H_c^k multiplied by α
$a > 0, b > 2$	deterministic demand parameters [24]
ε	random variable with $E[\varepsilon] = 1$ and $\sigma^2[\varepsilon] < \infty$
$F(x), f(x)$	cumulative distributed function (cdf) and probability df (pdf) of ε with support $[A, B]$, $0 \leq A < B$ and $f(x) > 0$
$g(x) = \frac{f(x)}{F(x)}$	failure rate with $\bar{F}(x) = 1 - F(x)$
$u(x) = xg(x)$	generalized failure rate
$\Lambda(z) = \int_A^z (z - \varepsilon)f(\varepsilon)d\varepsilon$	$\frac{d\Lambda(z)}{dz} = F(z)$
$rv \leq w$	constraint on prices, $k \in \{M, R\}$
F is IFR	F belongs to increasing failure rate class of cdfs [25]
$eff^{l-k} = \frac{\Pi_d^{l-k}}{\Pi_c^k}$	the profit efficiency of the decentralized channel compared with that of a centralized one [26].

Within this SC, the manufacturer and retailer accept non-defective returns and allow consumers to exchange them for new product variants. The manufacturer proposes a contract to the retailer, who can choose to accept or reject it. At the start of the selling season, the manufacturer selects one of the two returns handling strategies: handling returns themselves (M) or leaving them to the retailer (R). The manufacturer also decides on the contract type: an RS contract, where revenue is shared, or a CRS contract, where both revenue and returns costs are shared.

The sharing ratio, denoted as r , remains constant in both contract types and is established in the course of negotiations between channel members. Based on this ratio, the retailer receives a r portion of the revenue or incurs a r share of the returns handling costs generated per unit, while the manufacturer's share amounts to $1 - r$ per unit. After the retailer agrees to the manufacturer's offer, the Stackelberg game begins with sequential decision-making among the firms involved. In economic theory, the Stackelberg game depicts a situation where one firm, the leader, makes the first move, and the other, the follower, responds subsequently. The leader understands that the follower observes its decisions, while the follower lacks the ability to commit to a different role in interactions. This dynamic requires the leader to carefully consider its actions, knowing they will influence the follower's decisions [27].

This research employs the manufacturer-dominant Stackelberg model, where both the manufacturer and the retailer tend to optimize their profits by setting prices and order quantities. As the Stackelberg leader, the manufacturer moves first and anticipates the retailer's response when setting the wholesale price. It's crucial to highlight that transactions only occur upon the sale of an item. Initially, the manufacturer establishes the wholesale price (w), and then the retailer, functioning as the follower, decides on the order quantity (q) and the retail price (p) for the product. We assume that the returns are sent back either to the manufacturer or the retailer. Subsequently, the returned product undergoes inspection or repackaging before it can be resold as a new item. The consumer's returns handling cost includes expenses such as reverse shipping fees, travel costs, time costs, and is influenced by factors such as responsiveness and convenience in the returns process. The sequence of events is shown in Fig. 1. We assume that demand is stochastic, multiplicative, and dependent on the retail price p . Namely, for $\varepsilon \in [A, B]$ being a random variable with cdf F independent of p and continuously differentiable pdf f , the demand is multiplicative denoted by $D^k(p, \varepsilon) = d^k(p)\varepsilon$, where

$$d^k(p) = a(p + h_c^k)^{-b} \quad (1)$$

is a deterministic demand, which gives

$$D^k(p, \varepsilon) = a(p + h_c^k)^{-b}\varepsilon \quad (2)$$

where a is the market size and b is the price elasticity of demand and $k \in \{M, R\}$ [28].

4 Profit functions

To begin, we present the schemes of the introduced contract scenarios showing the money and product flows in the SC (see Figure 2 and 3).

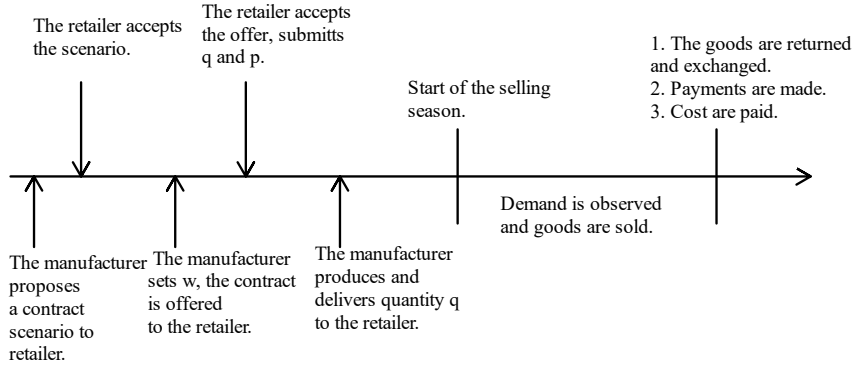


Fig. 1 The sequence of the events in the supply chain

Based on the schemes we will outline profit equations for the centralized channel and the decentralized channels, when employing strategies M and R. In the centralized channel both involve decision making by a central authority. Subsequently, we will present the expression for the expected profit in the centralized channel under strategy k :

$$\Pi_c^k(p, q) = (p - v - h^k)E[\min\{q, D^k(p, \varepsilon)\}] - (c - v)q, \quad k \in \{M, R\}. \quad (3)$$

The anticipated profits of the decentralized channel under strategy M and R, coupled with RS or CRS contracts, can be represented by the following expressions.

Then,

- under the RS-M scenario the manufacturer's expected profit is given by

$$\Pi_m^{RS-M}(w) = (w - c + (1 - r)v)q + ((1 - r)(p - v) - h^M)E[\min\{q, D^M(p, \varepsilon)\}], \quad (4)$$

- under the RS-R scenario the manufacturer's expected profit is equal to

$$\Pi_m^{RS-R}(w) = (w - c + (1 - r)v)q + (1 - r)(p - v)E[\min\{q, D^R(p, \varepsilon)\}]. \quad (5)$$

- under the CRS- k , $k \in \{M, R\}$ scenario the manufacturer's expected profit is given by

$$\Pi_m^{CRS-k}(w) = (w - c + (1 - r)v)q + (1 - r)(p - v - h^k)E[\min\{q, D^k(p, \varepsilon)\}]. \quad (6)$$

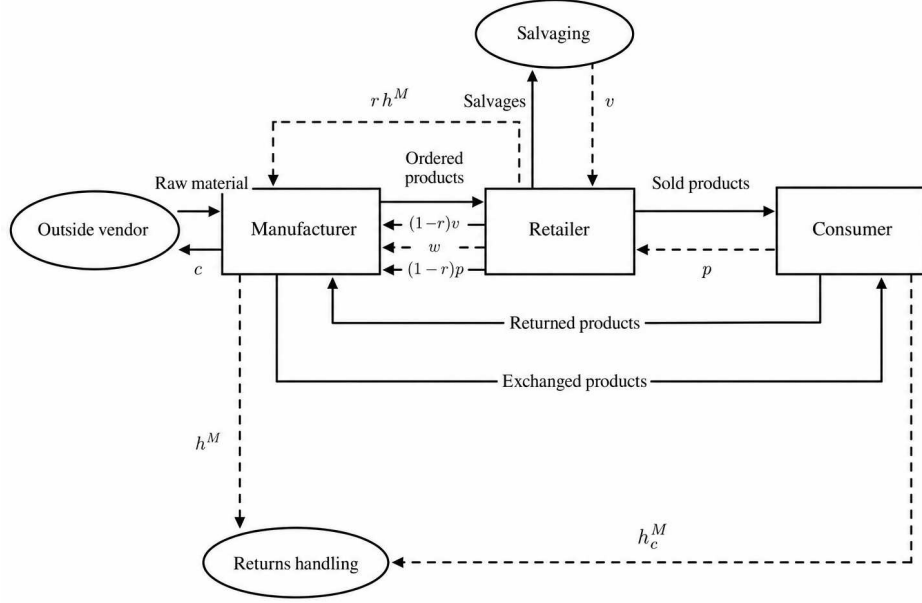


Fig. 2 The distribution channel in SC under CRS-M and RS-M scenario, product flow —, money flow ----, returns costs flow under CRS -.-.-.

Defining an inventory factor for multiplicative demand by

$$z = q/(a(p + h_c^k)^{-b}) = q/(d^k(p)),$$

we get

$$E[\min\{q, D^k(p, \varepsilon)\}] = d^k(p)(z - \Lambda(z)), \quad k \in \{M, R\}$$

[8], which lets us provide basic formulations of the expected profit functions of parties using the newsvendor frameworks in each scenario, noting that the retailer's expected profit is the difference between the centralized and manufacturer's profit. The resulting profit functions and optimization problems are presented below.

In the forthcoming analysis, we provide closed-form expressions for optimal quantities and address the question of whether the specific SCs are coordinated or not. A contract coordinates the SC if the decentralized and centralized channels yield identical pricing and ordering decisions [6]. The objective of SC coordination is to enhance the overall performance of the SC by aligning the plans and objectives of individual enterprises. Typically, it places emphasis on optimizing inventory management and ordering decisions within distributed inter-company settings [29].

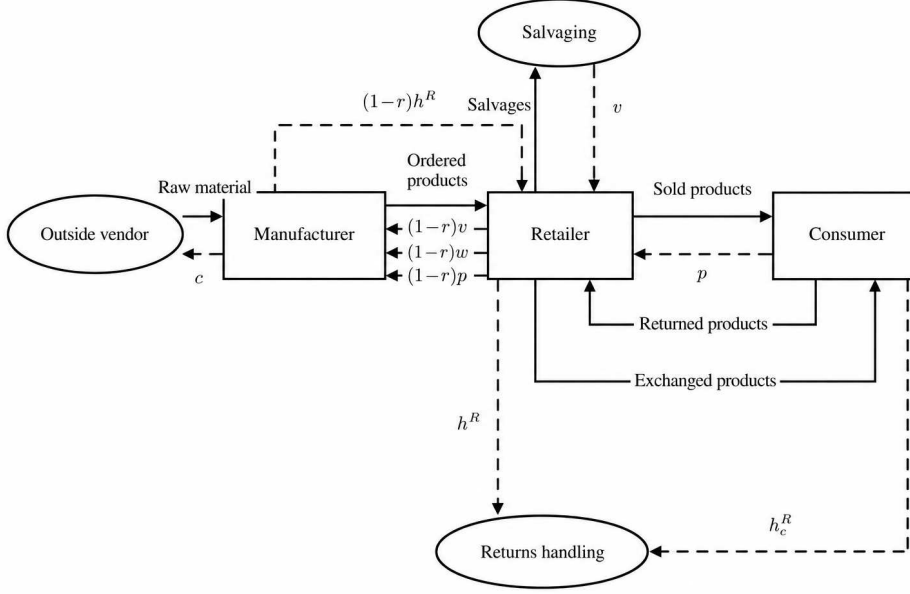


Fig. 3 The distribution channel in SC under CRS-R and RS-R scenario, product flow —, money flow - - - -, returns costs flow under CRS -.-.-

4.1 Optimal decisions in Centralized Channels

As a benchmark, we consider a centralized channel in which a central decision-maker chooses the retail price and order quantity to maximize the total expected SC profit. Generally, the centralized channel problem under strategy $k \in \{M, R\}$ is written as

$$\max_{p, z \in [A, B]} \Pi_c^k(p, z) = d^k(p) \{ (p - v - h^k)(z - \Lambda(z)) - (c - v)z \}. \quad (7)$$

We get the following theorem.

Theorem 1. *If assumptions hold, then for any $z \in [A, B]$, the central decision-maker's unique optimal price under strategy $k \in \{M, R\}$ is given by*

$$p_c^k(z) = \frac{bh^k + h_c^k + bv}{b - 1} + \frac{bz(c - v)}{(b - 1)(z - \Lambda(z))}, \quad (8)$$

and the unique optimal inventory factor $z = z_c^k$ is determined by

$$(p_c^k(z) - v - h^k)\bar{F}(z) - (c - v) = 0.$$

All proofs are relegated to the Appendix.

5 Optimal decisions in Decentralized Channels

5.1 Revenue Sharing Contract

Under RS-M scenario, using the backward induction method, first, the retailer's maximization problem is solved

$$\max_{p, z \in [A, B]} \Pi_{ret}^{RS-M}(p, z) = d^M(p) \{r(p - v)(z - \Lambda(z)) - (w - rv)z\}, \quad (9)$$

and then the manufacturer's optimization problem

$$\max_w \Pi_m^{RS-M}(w) = d^M(p) \{((1 - r)(p - v) - h^M)(z - \Lambda(z)) + (w - c + (1 - r)v)z\} \quad (10)$$

is considered. Similarly, under RS-R scenario, we sequentially solve the following problems

$$\max_{p, z \in [A, B]} \Pi_{ret}^{RS-R}(p, z) = d^R(p) \{r(p - v) - h^R)(z - \Lambda(z)) - (w - rv)z\}, \quad (11)$$

and

$$\max_w \Pi_m^{RS-R}(w) = d^R(p) \{(1 - r)(p - v)(z - \Lambda(z)) + (w - c + (1 - r)v)z\}. \quad (12)$$

The decisions concerning the decentralized RS problems formulated above are as follows.

Theorem 2. *If assumptions hold, then for any $z \in [A, B]$*

1. *under the RS-M contract scenario, the retailer's unique optimal price p_d^{RS-M} is given by*

$$p_d^{RS-M}(z) = \frac{bv + h_c^M}{b - 1} + \frac{bz(w - rv)}{r(b - 1)(z - \Lambda(z))}, \quad (13)$$

and the retailer's optimal inventory factor $z = z_d^{RS-M}$ is uniquely determined by

$$r(p_d^{RS-M}(z) - v)\bar{F}(z) = w - rv. \quad (14)$$

2. *under the RS-R contract scenario, the retailer's unique optimal price p_d^{RS-R} is given by*

$$p_d^{RS-R}(z) = \frac{bv + h_c^R}{b - 1} + \frac{bh^R}{r(b - 1)} + \frac{bz(w - rv)}{r(b - 1)(z - \Lambda(z))},$$

and the retailer's optimal inventory factor $z = z_d^{RS-R}$ is uniquely determined by

$$(r(p_d^{RS-R}(z) - v) - h^R)\bar{F}(z) = w - rv.$$

By anticipating the retailer's best response regarding the retail price and the inventory factor, the manufacturer determines the wholesale price that maximizes its

expected profit. The problem of optimizing the manufacturer's profit over the wholesale price can be transformed into the maximization over the inventory factor z after expressing the wholesale and retail price in terms of z which are derived from the formulas of the optimal quantities of the retailer's problem. Therefore, finally we solve the following optimization problems.

Let z_0 be defined by

$$(b-1)(z_0 - \Lambda(z_0)) - bz_0\bar{F}(z_0) = 0. \quad (15)$$

Under the RS- k contract scenario the optimal decisions to the problem can be obtained by solving

$$\max_{z \in [z_0, B]} \Pi_m^{RS-k}(z), \quad k \in \{M, R\}$$

1. where Π_m^{RS-M} is defined by (10) with

$$p := p_d^{RS-M}(z) = v + \frac{(z - \Lambda(z))(h_c^M + v)}{(b-1)(z - \Lambda(z)) - bz\bar{F}(z)},$$

and

$$w := w_d^{RS-M}(z) = r \left(v + \frac{\bar{F}(z)(z - \Lambda(z))(h_c^M + v)}{(b-1)(z - \Lambda(z)) - bz\bar{F}(z)} \right);$$

2. where Π_m^{RS-R} is defined by (12) with

$$p := p_d^{RS-R}(z) = \frac{rh_c^R(z - \Lambda(z)) + b(h^R + rv)(z - \Lambda(z) - z\bar{F}(z))}{r((b-1)(z - \Lambda(z)) - bz\bar{F}(z))}$$

and

$$w := w_d^{RS-R}(z) = rv + \frac{\bar{F}(z)(z - \Lambda(z))(h_c^R + rh_c^R + rv)}{(b-1)(z - \Lambda(z)) - bz\bar{F}(z)}.$$

Now, we need the following theorem.

Theorem 3. *Under RS- k scenario, $k \in \{M, R\}$, if $z \in [A, B]$ then the functions $p_d^{RS-k}(z)$ and $w_d^{RS-k}(z)$ have a vertical asymptote in a non-removable singularity point at z_0 defined by $(b-1)(z_0 - \Lambda(z_0)) - bz_0\bar{F}(z_0) = 0$. The function $p_d^{RS-k}(z) + h_c^k \geq 0$ if $z \in (z_0, B]$ and $p_d^{RS-k}(z) + h_c^k < 0$, otherwise.*

The theorem says that both the retail price and the wholesale price have a vertical asymptote at z_0 from the right side. As z approaches z_0 from the right, the order quantity and the manufacturer's expected profit tend to zero, so this boundary case is not economically meaningful. Moreover, for $p^k(z) + h_c^k < 0$ demand is not well-defined since the exponent b does not have to be an integer number. For the purpose of the existence argument, define the continuous extension of the profit function with $\Pi(z_0) = 0$ since $\lim_{z \rightarrow z_0^+} \Pi_m(z) = 0$. Then the profit is continuous on $[z_0, B]$, and the Weierstrass theorem applies. Therefore, the optimization could be limited to the interval $[z_0, B]$. Due to the complexity of the above optimization problems, they can be solved numerically. The objective functions are continuous on the closed interval, therefore, they obtain their extreme values by the Weierstrass extreme value theorem [30]. However,

these values do not have to be unique. Similar problems in the subsequent part of the article can be treated likewise.

5.2 Cost-Revenue Sharing Contract

Under CRS-k scenario, using the backward induction method, first, the retailer's maximization problem is solved

$$\max_{p, z \in [A, B]} \Pi_{ret}^{CRS-k}(p, z) = d^k(p) \{r(p - v - h^k)(z - \Lambda(z)) - (w - rv)z\}, \quad (16)$$

$k \in \{M, R\}$ and then the manufacturer's optimization problem

$$\max_w \Pi_m^{CRS-k}(w) = d^k(p) \{(1 - r)(p - v - h^k)(z - \Lambda(z)) + (w - c + (1 - r)v)z\} \quad (17)$$

is considered.

The decisions based on the decentralized problems are as follows.

Theorem 4. *If assumptions hold, then for any $z \in [A, B]$ under the CRS-k contract scenario the retailer's unique optimal price p_d^{CRS-k} is given by*

$$p_d^{CRS-k}(z) = \frac{bv + bh^k + h_c^k}{b - 1} + \frac{bz(w - rv)}{r(b - 1)(z - \Lambda(z))}, \quad (18)$$

and the retailer's optimal inventory factor $z = z_d^{CRS-k}$ is uniquely determined by

$$r(p_d^{CRS-k}(z) - v - h^k)\bar{F}(z) = w - rv. \quad (19)$$

Similarly, as under strategy M, the problems of optimizing the manufacturer's profit over the wholesale price can be transformed into the maximization over inventory factor. Finally, we solve the following optimization problems. Under the CRS-k contract scenario the optimal decisions can be obtained by solving

$$\max_{z \in [z_0, B]} \Pi_m^{CRS-k}(z),$$

where Π_m^{CRS-k} is given by (17) with

$$p := p_d^{CRS-k}(z) = \frac{h_c^k(z - \Lambda(z)) + b(h^k + v)(z - \Lambda(z) - z\bar{F}(z))}{(b - 1)(z - \Lambda(z)) - bz\bar{F}(z)},$$

and

$$w := w_d^{CRS-k}(z) = rv + \frac{\bar{F}(z)(z - \Lambda(z))(rh^k + rh_c^k + rv)}{(b - 1)(z - \Lambda(z)) - bz\bar{F}(z)}, \quad k \in \{M, R\}.$$

Remark 1. *The SC coordination of the studied RS contracts under multiplicative demand is similar to those given in [12] under additive demand or in [6] of RS contract*

with no returns considered. Namely for the set of CRS- k , $k \in \{M, R\}$, contracts with $w = rc$, $r \in (0, 1)$ we obtain, $\Pi_m^{CRS-k} = (1 - r)\Pi_c^k$. Then, the centralized channel decisions are identical as those for the decentralized channel, and CRS- k contracts coordinate the SC. Using the similar consideration, we obtain that the RS-M channel could be coordinated only if $h^M = 0$ or $r = 0$ and the RS-R channel if $h^R = 0$ or $r = 1$. The sharing ratio r is also the share of the SC profit and of the revenue and costs. Coordination under the CRS contract requires the wholesale price $w = rc$, which is below the production cost c . This lower wholesale price is compensated by the manufacturer's share of sales revenue and by sharing return handling costs with the retailer. The CRS contract has the ability to coordinate the SC by incentivizing the retailer to place larger orders and can enhance the overall efficiency of the SC more effectively than the RS contract.

6 Numerical example

To illustrate the results of the proposed Stackelberg game, we conduct a numerical study and sensitivity analysis. We use data from the electronics industry because electronics and clothing have the highest rate of product returns comparing to other industries. In electronics industry it is assumed that the return probability typically ranges from 5% to 15%. Production cost is assumed at 40–60% of the retail price. The return handling cost paid by retailer or manufacturer is estimated at 15–35% and those paid by consumer at 5% of the retail price. The salvage value is about at 40% of the retail price. Parameters of the multiplicative demand function are taken from standard benchmarks in the OR literature [31, 32]. For simplicity, costs are normalized such that 1 unit corresponds to 100EUR. To calibrate the baseline cost parameters, we initially set the retail price to $p = 2$. This value is used only for calibration, because in the optimization model p remains a decision variable and is determined endogenously. Therefore, in our problem it is assumed that $a = 100$, $b = 2.1$, $c = 1$, $v = 0.8$, $r = 0.4$. Moreover, let us suppose that $\alpha = 0.1$, $h^k = \alpha H^k = 0.04$, $h_c^k = \alpha H_c^k = 0.01$, $k \in \{M, R\}$. Finally, let us assume that ε follows a uniform distribution on $[0, 2]$.

According to the mathematical complexity of the optimal decisions we provide a numerical analysis of the performance of SC with respect to the return handling costs. Then, from (15) we get $z_0 = 1.2903$ and in consequence the profit functions are optimized on $[1.2903, 2]$. In the beginning we assume that both strategies use the same cost values. In such a case the difference between the strategy M and strategy R will come from the contract itself not from a difference in costs. Obviously, with equal costs, CRS-M and CRS-R contract scenarios give identical results.

The optimal solution to the centralized problem for the baseline parameter values gives $z_c^k = 1.7229$, $p_c^k = 2.2834$, $q_c^k = 30.15$ and $\Pi_c^k = 18.7425$, $k \in \{M, R\}$, under both strategies. Table 3 shows that decentralization reduces channel profit by about 4%, since the channel efficiency is approximately 0.96, while the order quantity decreases by roughly 37%. Although the CRS contract can achieve full coordination when $w = rc = 0.40$, the manufacturer chooses $w = 0.4626$ in equilibrium, so full coordination is not achieved.

Table 3 Optimal decisions and profits at the baseline

Scenario	z	p	w	q	Π_m	Π_{ret}	eff
Centralized	1.7229	2.2834	—	30.15	—	—	1
RS-M	1.6103	2.7514	0.4721	19.08	11.9750	5.9949	0.95878
RS-R	1.6568	2.7772	0.4489	19.25	12.0080	5.9866	0.96009
CRS-M,R	1.6288	2.7611	0.4626	19.16	11.9901	5.9938	0.95953

The most distinct patterns in wholesale price appear in Figures 4 and 5. Under RS-M, the wholesale price rises with h^M , while under RS-R, it falls with h^R . These two trends move in almost opposite directions, whereas under CRS, the wholesale price curve is nearly flat. The reason lies in the profit functions. Under RS-M the returns cost appears only in the manufacturer's objective. The retailer's problem and best response do not depend on h_M , so only the manufacturer reacts by increasing the wholesale price w . Under Theorem 2, in contract scenario RS-R the retailer pays the cost and raises the retail price by $bh^R/(r(b-1))$ per unit of h^R . This is $1/r = 2.5$ times more than the centralized channel raises it with the term $bh^R/(b-1)$ by Theorem 1. The retail price thus exceeds the optimal level for the channel. To prevent excessive retail markups and protect order quantity, the manufacturer responds by lowering the wholesale price.

For the parameter values considered in Figures 6 and 7, the retail prices satisfy $p_d^{RS-R} > p_d^{CRS-k} > p_d^{RS-M}$, $k \in \{M, R\}$. The retail price increases with the return handling cost in all scenarios, although the mechanism differs across contracts. Under RS-M, the manufacturer reacts to a higher h^M by increasing the wholesale price, which leads the retailer to increase the retail price. Under RS-R, the return cost h^R directly affects the retailer's decision and increases the retail price, while the manufacturer responds by lowering the wholesale price. Consumer cost enters the demand function through $p + h_c^k$ and is not included in the sharing rule, its effect is similar across the scenarios and does not by itself explain the differences between them.

The inventory factor is below the centralized value z_c^k in every case which is shown in Figures 8 and 9. This is the usual under-ordering in a decentralized channel. Its reaction to h^k separates the strategies: z_d^k falls under RS-M, rises under RS-R and is almost flat under CRS. Under RS-R, the lower wholesale price allows for a lower retail price, which stimulates demand and pushes order quantities toward the centralized level. At the same time under RS-M the higher price does the opposite.

Figures 10 and 11 show that channel efficiency changes only slightly with the return handling cost and remains close to 0.96. For the baseline parameter values, and the values of efficiency in specific contract scenarios in Table 3 we observe that, RS-R has the highest efficiency in the baseline case, although the differences between the scenarios are small.

For the baseline value $r=0.4$, Table 4 shows that the manufacturer prefers strategy R, while the retailer prefers strategy M. Since the manufacturer is the Stackelberg leader and chooses the return strategy, RS-R is selected, although the retailer would prefer RS-M. The conflict depends on the sharing ratio r .

For the values of r considered in Table 4, the manufacturer benefits from changing from strategy M to strategy R. In the baseline numerical example, below the threshold

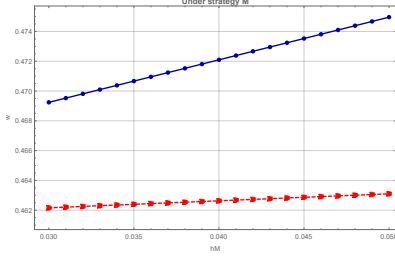


Fig. 4 Wholesale price, CRS-red, RS-blue

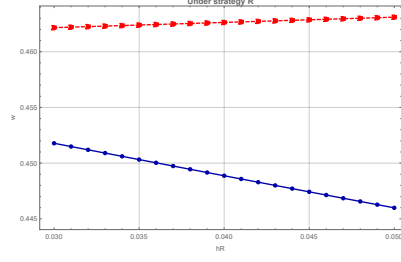


Fig. 5 Wholesale price, CRS-red, RS-blue

$r^* = 0.475$, the retailer loses, leading to a conflict of interest. Above r^* , both parties gain, so strategy R Pareto-dominates strategy M. Under RS-R, the retailer incurs a cost of $h^R = 0.04$ per unit sold and receives a lower wholesale price in return. Because the manufacturer sets this discount to maximize profit, it grows slowly with r . Below r^* , the discount does not cover the retailer's additional cost.

Table 4 Impact of changing the return handling strategy under the RS contract

r	Π_m^{RS-M}	Π_m^{RS-R}	$\Delta\Pi_m$	Π_{ret}^{RS-M}	Π_{ret}^{RS-R}	$\Delta\Pi_{ret}$	Verdict
0.400	11.9750	12.0080	0.0330	5.9949	5.9866	-0.0084	manufacturer prefers R, retailer prefers M
0.475	10.8783	10.9077	0.0294	6.7727	6.7726	-0.0000	- conflict R indifferent
0.500	10.5249	10.5529	0.0281	7.0074	7.0097	0.0023	R Pareto-dominates M

Table 5 Effect of the sharing ratio under RS-R

r	Π_m^{RS-R}	Π_{ret}^{RS-R}	Π_d^{RS-R}	eff^{RS-R}	q_d^{RS-R}
0.2	15.1823	3.3337	18.5160	0.9879	24.3924
0.4	12.0080	5.9866	17.9946	0.9601	19.2493
0.7	7.9348	8.4613	16.3960	0.8748	12.5342

An interesting case occurs when the retailer has a higher handling cost but provides a more convenient return process for consumers. In Table 6 we see that although the retailer has a higher returns handling cost, RS-R scenario gives a higher total channel profit because the lower consumer return cost partly compensates for this disadvantage. However, at the same time the retailer's profit slightly decreases. Thus, the return strategy that is better for the whole channel need not be preferred by the party responsible for returns, which may create a need for contractual compensation.

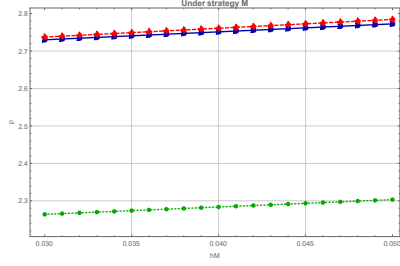


Fig. 6 Retail price, CRS-red, RS-blue

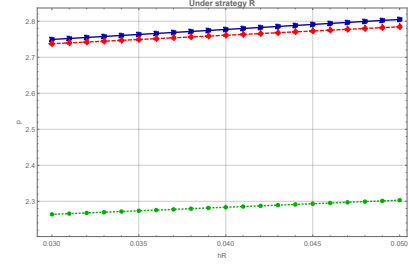


Fig. 7 Retail price, CRS-red, RS-blue

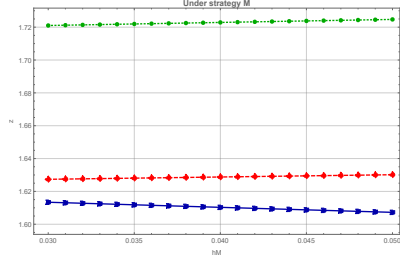


Fig. 8 Inventory factor, CRS-red, RS-blue

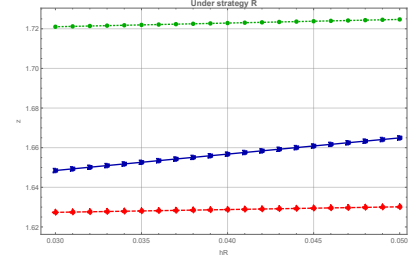


Fig. 9 Inventory factor, CRS-red, RS-blue

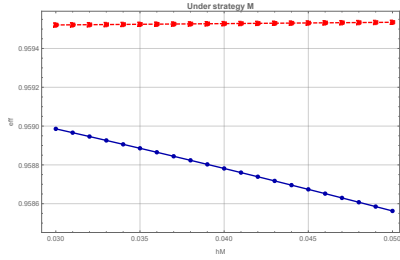


Fig. 10 Efficiency, CRS-red, RS-blue

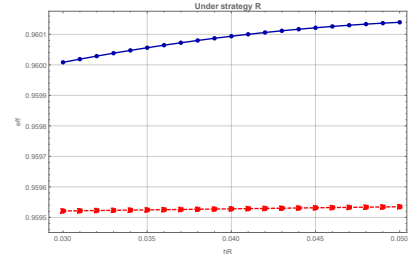


Fig. 11 Efficiency, CRS-red, RS-blue

7 Discussion and managerial implications

The main question of this study is whether product returns should be handled by the manufacturer or by the retailer. The results show that there is no single strategy that is always better. An important part of this study is therefore a broad numerical comparison of strategies M and R. We examine their effects on prices, inventory factors, profits, and channel efficiency for different values of the sharing ratio and return costs. Compared with the previous models discussed in this paper, the present study places greater emphasis on the numerical comparison of the two return handling strategies. This study is related to the models considered in [15], [13], [12], and [14]. The model

Table 6 Expected profits under asymmetric return costs with $h^M = 0.04$, $h_c^M = 0.01$, $h^R = 0.045$, $h_c^R = 0.005$

Strategy l	Π_m^{RS-l}	Π_{ret}^{RS-l}	Π_d^{RS-l}
M	11.9750	5.9949	17.9700
R	12.0098	5.9852	17.9950

in [15] investigates a wholesale-price contract with stochastic demand independent of price. The articles [13] and [14] consider price-dependent demand under a wholesale-price contract. In [12], RS and CRS contracts with returns are studied under additive demand. In the present paper, the previously mentioned two contracts are considered under multiplicative price-sensitive demand which changes the analytical form of the problem. In particular, the retail and wholesale price functions have a vertical asymptote, which does not occur in the additive-demand model considered in [12]. Therefore, the feasible range of decisions in the manufacturer's problem has to be restricted. This result answers RQ1 and shows that the form of demand affects the structure of the optimization problem.

The optimal wholesale price, retail price, and inventory factor depend on both the contract and the return handling strategy. Under RS-M, a higher return handling cost leads the manufacturer to increase the wholesale price. Under RS-R, the retailer bears the return cost and increases the retail price, while the manufacturer responds by lowering the wholesale price. Thus, the return cost affects the channel differently depending on which party handles returns. These results address RQ2.

The numerical analysis also shows that the manufacturer and the retailer may prefer different return handling strategies. For the baseline value $r = 0.4$, the manufacturer prefers strategy R, while the retailer prefers strategy M. At $r^* = 0.475$, the retailer is approximately indifferent between the two strategies. Above this value, strategy R benefits both parties and Pareto-dominates strategy M. Therefore, the sharing ratio affects not only the division of revenue but also the conflict between the channel members. These results answer RQ3.

The results for coordination answer RQ4. The RS contract does not coordinate the SC when return handling costs are not shared. The CRS contract can coordinate the channel when revenue and return handling costs are shared in the same proportion and the wholesale price is set at $w = rc$. However, the manufacturer may choose a different wholesale price in the Stackelberg equilibrium. In the baseline example, the coordinating price is $w = 0.4$, while the manufacturer chooses $w = 0.4626$. Therefore, the CRS contract can provide full coordination, but the equilibrium decisions do not necessarily lead to it.

The numerical results also show that profit efficiency alone may not fully describe the effect of decentralization. In the baseline case, decentralization reduces total channel profit by about 4%, while the order quantity decreases by about 37%. Thus, a relatively small loss in profit may be accompanied by a much larger change in the order decision. This may be important for firms concerned with capacity use, sales volume, or market share.

The analysis of asymmetric return costs gives another result concerning the choice of the return handler. The party with the lower direct handling cost is not always the better choice. A party with a higher handling cost may still be preferred if its return process is more convenient for customers and the consumer return cost is lower. In the numerical example, retailer-managed returns give a slightly higher total channel profit even though the retailer has a higher direct handling cost. However, the retailer's own profit decreases. This shows that the strategy that is better for the whole channel may not be preferred by the party responsible for returns.

Several managerial implications follow from these results. First, the choice between manufacturer-managed and retailer-managed returns should be considered together with the sharing ratio and return costs. Second, managers should consider not only the direct cost of handling returns but also the cost faced by consumers. A more convenient return process can support demand and may compensate for a higher direct handling cost. Third, if the strategy that increases total channel profit reduces the profit of one party, compensation may be needed to make this strategy acceptable to both parties. The results also show that sharing return costs can improve coordination because the division of costs becomes consistent with the division of revenue. However, the sharing rule alone is not sufficient. Full coordination also requires an appropriate wholesale price. Therefore, the sharing ratio, return cost allocation, and wholesale price should be considered jointly when the contract is designed.

Summarizing, the study shows that the decision whether the manufacturer or the retailer should handle returns depends mainly on the contract type, the sharing ratio, and the return-related costs. Retailer-managed returns may be preferred when they improve total channel profit or make returns easier for customers, but they may also create a conflict between the channel members. Manufacturer-managed returns may be preferred when the retailer's return costs are high or when the retailer does not receive enough benefit from taking responsibility for returns. Therefore, the return handling strategy should be evaluated from both the channel and individual firm perspectives.

Future research could extend the model to SCs with multiple retailers, different bargaining structures, or a dynamic setting. It could also use empirical data on return costs and consumer return convenience to examine the results in different industries.

Appendix A Proofs of theorems

Proof of Theorem 1. By using $\frac{d}{dp}d^k(p) = -\frac{bd^k(p)}{p+h_c^k}$, we get

$$\frac{d\Pi_c^k(p, z)}{dp} = \frac{d^k(p)}{p + h_c^k} \{(z - \Lambda(z))((1 - b)p + (bv + bh^k + h_c^k)) + bz(c - v)\}.$$

By the first order condition $\frac{d\Pi_c^k(p, z)}{dp} = 0$ we obtain the formula (8) for optimal price $p_c^k(z)$. The solution $p_c^k(z)$ is unique since the gradient of the linear function of p equal to $(z - \Lambda(z))(1 - b)$ is negative. Hence the function of p is decreasing, and, $\frac{d\Pi_c^k(p, z)}{dp} > 0$ for $p < p_c^k(z)$ and $\frac{d\Pi_c^k(p, z)}{dp} < 0$ for $p > p_c^k(z)$.

Now, let us find the optimal z . Note that $\frac{d\Pi_c^k(p,z)}{dz} = \frac{\delta\Pi_c^k(p,z)}{\delta z} + \frac{\delta\Pi_c^k(p,z)}{\delta p} \frac{dp}{dz} = \frac{\delta\Pi_c^k(p,z)}{\delta z}$. Next, substituting formula (8) into formula (7) we get $\Pi_c^k(p,z)$ only in terms of z . Namely, $\Pi_c^k(p_c^k(z), z) = \Pi_c^k(z)$, which is a continuous and smooth function of z . Then, the optimal decision z_c^k is determined by the first order condition $\frac{d\Pi_c^k(z)}{dz} = 0$, which implies $(p_c^k(z) - v - h^k)\bar{F}(z) - (c - v) = 0$. The last equation determined the ordering decision. Let us observe that $\text{sgn}\{\frac{d\Pi_c^k(z)}{dz} |_{z=A}\} = \text{sgn}\{p_c^k(A) - c - h^k\} > 0$ and $\text{sgn}\{\frac{d\Pi_c^k(z)}{dz} |_{z=B}\} = \text{sgn}\{-(c - v)\} < 0$. Moreover,

$$\frac{d\Pi_c^k(z)}{dz} = \frac{d^k(p)}{(b-1)(z - \Lambda(z))} H(z), \quad (\text{A1})$$

where $H(z) = (h_c^k + h^k + v)(z - \Lambda(z))\bar{F}(z) + bz(c - v)\bar{F} - (b-1)(c - v)(z - \Lambda(z))$. Hence, to prove the uniqueness of z_c it suffices to show that the function $H(z)$ has only one z -intercept. We have $H'(z) = \bar{F}(z)\{(h_c^k + h^k + v)(\bar{F}(z) - g(z)(z - \Lambda(z))) + c - v - b(c - v)u(z)\}$ and

$$H''(z)|_{H'(z)=0} = -\bar{F}(z)\{(h_c^k + h^k + v)(2f(z) + g'(z)(z - \Lambda(z))) + b(c - v)u'(z)\} < 0,$$

by IFR property. Therefore, $H(z)$ is unimodal, first nonnegative and then negative, and crosses the z -axes only once. Since the first factor in A1 is positive, $\Pi_c^k(z)$ increases at A and decreases at B then there exists a unique maximum of $\Pi_c^k(z)$. The proof is complete. $\square$

Proof of Theorem 2. The proof of that theorem is similar to the proof in the centralized case. $\square$

of Theorem 3. Let $L(z)$ be the numerator of $p_d^{RS-M}(z)$ and $M(z)$ be the denominator of it equal to

$$M(z) = (b-1)(z - \Lambda(z)) - bz\bar{F}(z).$$

Let z_0 be the solution to $M(z) = 0$. This solution is unique since:

$$M'(z) = \bar{F}(z)(bu(z) - 1),$$

and

$$M''(z)|_{M'(z)=0} = \bar{F}(z)bu'(z) \geq 0,$$

and, moreover, $M(A) = -A < 0$ and $M(B) = b-1 > 0$. Hence for $A > 0$ the function $M(z)$ is first negative up to $z = z_0$ and then positive. Additionally, the numerator is nonnegative since $L'(z) \geq 0$ and $L(A) = h_c A \geq 0$ which implies the second statement of the theorem. If $A = 0$ then $M'(A) = -1 < 0$ therefore is still only one zero of $M(z)$ on the interval $(A, B]$. Note that when $A = 0$ the point $z = 0$ is a removable singularity of $p_d^{RS-M}(z)$ rather than a point of discontinuity since $\lim_{z \rightarrow 0^+} p_d^{RS-M}(z) = -h_c^M$. Additionally, $L(z) + h_c M(z) \geq 0$ which implies that $p_d^{RS-M}(z) + h_c > 0$ for $z > z_0$ and $p_d^{RS-M}(z) + h_c \leq 0$ for $z < z_0$. The proof for the R strategy is similar. The proof is complete. $\square$

of Theorem 4. The proof of that theorem is similar to the proof in the centralized case. $\square$

References

- [1] Frei, R., Jack, L., Brown, S.: Product returns: a growing problem for business, society and environment. *International Journal of Operations & Production Management* **40**, 1613–1621 (2020) <https://doi.org/10.1108/IJOPM-02-2020-0083>
- [2] Li, M., Liu, Y.: Beneficial product returns in supply chains. *Production and Operations Management* **30**(11), 3849–3855 (2021) <https://doi.org/10.1111/poms.13519>
- [3] Lazar, R.: How to manage ecommerce returns in the electronics industry. *returngo* (2023). <https://returngo.ai/manage-returns-in-electronics-industry/>
- [4] Do you really need an automated returns and exchange solution? *Return Prime* (2025). <https://www.returnprime.com/return-and-exchange-solution-for-merchants-selling-electronics-audio-equipments-appliances>
- [5] Cohan, P.: Project vogue: Inside apple’s iphone deal with att. *Forbes* (2013)
- [6] Cachon, G.P., Lariviere, M.A.: Supply chain coordination with revenue-sharing contracts: Strengths and limitations. *Management Science* **51**, 30–44 (2005) <https://doi.org/10.1287/mnsc.1040.0215>
- [7] Ferguson, M., Guide, V.D.R., Souza, G.C.: Supply chain coordination for false failure returns. *Manufacturing & Service Operations Management* **8**(4), 376–393 (2006) <https://doi.org/10.1287/msom.1060.0112>
- [8] Petruzzi, N.C., Dada, M.: Pricing and newsvendor problem: a review with extensions. *Operations Research* **47**, 183–194 (1999) <https://doi.org/10.1287/opre.47.2.183>
- [9] Adnan, Z.H., Ozelkan, E.: Supply chain price variability under the buyback contract. *Journal of industrial and production engineering* **40**(4), 301–322 (2023) <https://doi.org/10.1080/21681015.2023.2194877>
- [10] Chiu, C.H., Choi, T.M., Tang, C.S.: Price, rebate, and returns supply contracts for coordinating supply chains with price dependent demands. *Production and Operations Management* **20**(1), 81–91 (2011) <https://doi.org/10.1111/j.1937-5956.2010.01159.x>
- [11] Huang, J., Leng, M., Parlar, M.: Demand functions in decision modeling: A comprehensive survey and research directions*. *Decision Sciences* **44** (2013) <https://doi.org/10.1111/deci.12021>

- [12] Bieniek, M., Szapiro, T.: Supply chain coordination and decision-making under revenue sharing and cost-revenue sharing contracts with returns. *Operations Research and Decisions* **33**, 15–39 (2024) <https://doi.org/10.37190/ord240302>
- [13] Bieniek, M.: Returns handling in e-commerce: How to avoid demand negativity in supply chain contracts with returns? *Electronic Commerce Research* **25**, 271–294 (2025) <https://doi.org/10.1007/s10660-023-09689-2>
- [14] Bieniek, M., Banas, J.: The multi-criteria nature of classical decisions in wholesale-price contracts with product exchange. *Multiple Criteria Decision Making* **19**, 5–23 (2025) <https://doi.org/0.22367/mcdm.2025.19.01>
- [15] Liu, J., Xiao, T., Tian, C., Wang, H.: Ordering and returns handling decisions and coordination in a supply chain with demand uncertainty. *International Transactions in Operational Research* **27**(2), 1033–1057 (2020) <https://doi.org/10.1111/itor.12542>
- [16] Cachon, G.P.: Supply chain coordination with contracts. In: *Supply Chain Management: Design, Coordination and Operation. Handbooks in Operations Research and Management Science*, vol. 11, pp. 227–339. Elsevier, Amsterdam (2003). [https://doi.org/10.1016/S0927-0507\(03\)11006-7](https://doi.org/10.1016/S0927-0507(03)11006-7)
- [17] Bart, N., Chernonog, T., Avinadav, T.: Revenue-sharing contracts in supply chains: a comprehensive literature review. *International Journal of Production Research* **59**(21), 6633–6658 (2021) <https://doi.org/10.1016/j.ifacol.2019.11.425>
- [18] Su, X.: Consumer returns policies and supply chain performance. *Manufacturing & Service Operations Management* **11**(4), 595–612 (2009) <https://doi.org/10.1287/msom.1080.0240>
- [19] Huang, X., Choi, S.-M., Ching, W.-K., Siu, T.-K., Huang, M.: On supply chain coordination for false failure returns: A quantity discount contract approach. *International Journal of Production Economics* **133**(2), 634–644 (2011) <https://doi.org/10.1016/j.ijpe.2011.04.031> . Towards High Performance Manufacturing
- [20] Sun, D., Ma, X., Wang, D., Li, J.: Principal agent problem for returns handling in a reverse supply chain with one manufacturer and two competing dealers. *Applied Mathematical Modelling* **66**, 118–140 (2019) <https://doi.org/10.1016/j.apm.2018.09.012>
- [21] Pingping, F., Tingdan, Z., Jian, C., Feng, W.: Research on inventory decisions in a dual-channel supply chain with false failure returns and transshipment. *Journal of Systems Science and Mathematical Sciences* **42**(11), 2973 (2022) <https://doi.org/10.12341/jssms21556>
- [22] Khouja, M., Hammami, R.: Optimizing price, order quantity, and return policy in the presence of consumer opportunistic behavior for online retailers. *European*

Journal of Operational Research **309**(2), 683–703 (2023) <https://doi.org/10.1016/j.ejor.2023.01.035>

- [23] Li, D., Chen, J., Chen, B., Liao, Y.: Manufacturer’s contract choice and retailer’s returns management strategy. *Transportation Research Part E: Logistics and Transportation Review* **165**, 102862 (2022) <https://doi.org/10.1016/j.tre.2022.102862>
- [24] Simon, H., Fassnacht, M.: Fundamentals of price management. In: *Price Management: Strategy, Analysis, Decision, Implementation*, pp. 1–28. Springer, Cham (2019). https://doi.org/10.1007/978-3-319-99456-7_1 . https://doi.org/10.1007/978-3-319-99456-7_1
- [25] Lariviere, M.A.: Supply chain contracting and coordination with stochastic demand. In: Tayur, S., Ganeshan, R., Magazine, M.e. (eds.) *Quantitative Models for Supply Chain Management. International Series in Operations Research & Management Science* vol. 7, pp. 233–268. Springer, Boston, MA (1999). https://doi.org/10.1007/978-1-4615-4949-9_8
- [26] Wang, Y., Jiang, L., Shen, Z.-J.: Channel performance under consignment contract with revenue sharing. *Management Science* **50**(1), 34–47 (2004) <https://doi.org/10.1287/mnsc.1030.0168>
- [27] Von Stackelberg, H.: *Market Structure and Equilibrium*. Springer, Berlin, Heidelberg (2011)
- [28] Ru, J., Wang, Y.: Consignment contracting: Who should control inventory in the supply chain? *European Journal of Operational Research* **201**(3), 760–769 (2010) <https://doi.org/10.1016/j.ejor.2009.04.006>
- [29] Sangal, I., Pareek, S., Shah, N.H.: Collaboration of single-manufacturer multi-buyer inventory status with credit option under fuzzy demand. *Handbook of Research on Promoting Business Process Improvement Through Inventory Control Techniques*, 34 (2018) <https://doi.org/10.4018/978-1-5225-3232-3.ch015>
- [30] Rudin, W.: *Principles of Mathematical Analysis*, (1953)
- [31] Team, R.: Returns management in 2024: Balancing cost and cx. Radial (2024). <https://www.radial.com/insights/returns-management-2024>
- [32] Franklin, S.: The true cost of ecommerce returns: Stats and best practices for minimising loss. bloom (2022). <https://www.letsbloom.com/blog/true-cost-of-ecommerce-returns/>