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Coordinating Supply Chains in Competitive Environments through Wholesale Price Contracts under Uncertainty

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ABSTRACT

The coordination of supply chains is a critical challenge faced by managers in the competitive market. Addressing this concern becomes paramount in the context of rivalry between production and distribution chains. The paper delves into the coordination analysis of a dual monopoly, where two manufacturers and two retailers collaborate to distribute goods, with the two products substituting each other. The chains engage in pricing competition to determine the selling price, and a wholesale price contract is employed for coordination analysis. The research demonstrates that supply chain coordination is achieved when the producer's profit margin is zero, implying that the product's price offered to the retailer equals the producer's production costs. However, achieving this balance might be challenging since manufacturers typically aim for a profit. Consequently, fluctuations in wholesale prices become instrumental in evaluating the distribution channel's efficiency. The study further explores the impact of factors such as product substitution and chain competitiveness on the efficiency of the supply chains.

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1. Introduction

In a supply chain, each member may seek to optimize their own decisions and work towards their own goals, which can lead to misalignment and conflicts of objectives between members. To integrate and align the objectives of supply chain members, the policy of supply chain coordination can be utilized. Coordination leads all members to make decisions in one direction, increasing supply chain efficiency and market share. Factors such as information sharing, information systems among members, simultaneous optimization, decision-making, and contracts contribute to supply chain coordination (Kanda & Deshmukh, 2009). In practice, contracts have extensive applications for supply chain coordination.

Coordination contracts deal with the aspects of profit and risk sharing among members. Coordination contracts encompass revenue-sharing contracts, quantity discount contracts, quantity flexibility contracts, buyback contracts, wholesale price contracts, and sales reward contracts (Cachon, 2003). The issue of competition plays a prominent role when there is more than one member in each layer of the supply chain. In such cases, each of them seeks to optimize decisions and gain maximum market share.

Jeuland & Shugan (1983) was among the first researchers to address the issue of competition in supply chain channels. Factors such as price, quality, delivery time, and order quantity lead to competition among members of each layer of the supply chain. These factors exert their impact on the demand function, which may have a positive or negative effect depending on their nature. Extensive research has been conducted by researchers on simultaneous coordination and competition, in each of which demand may be random or deterministic, and member competition is also over price. Such structures can include two manufacturers and one retailer, two retailers with one manufacturer, or two separate and parallel channels. In many cases, competitive factors cause supply chains to deviate from a Nash equilibrium, which is a coordinated solution to optimize total chain profit.

The main issue in such balances is which of the coordination contracts has greater efficiency and which contract members of the supply chain tend to conclude. Li et al. (2013) examined a supply chain with two manufacturers and two retailers with deterministic demand. In this article, two products with different brands are produced by manufacturers and provided to retailers. Therefore, each retailer faces the issue of pricing the products of each manufacturer. Thus, there is competition at both the retailer and manufacturer levels.

To analyze the coordination of this structure, first, the retailer, supply chain, and manufacturer problems are solved, and the optimal points are compared to examine the possibility of coordination. For the supply chain to be coordinated, the optimal points of each member must be equal to the overall optimal point of the supply chain. In the following, we first review the existing literature on coordination and competition. In Section 3, we refer to the mathematical modeling of the stated structure. Afterward, coordination analysis is performed, and finally, a numerical example is solved for this model, and the obtained results are presented. The objective of this study is to analyze the coordination of competitive dual supply chains using wholesale price contracts under demand uncertainty.

In this regard, a mathematical optimization model is developed for maximizing the profit of members and the whole supply chain, and coordination conditions are examined. Coordination of supply chains is a critical challenge faced by managers in the competitive market. Failing to coordinate leads to separate and conflicting decision-making by supply chain members, reducing the overall efficiency of the chain. Moreover, intra-chain competition adds to this challenge. This research aims to study coordination in competitive dual supply chains with two manufacturers and two wholesalers.

2. Literature review

2.1. Supply Chain Coordination: Approaches And Challenges

Nowadays, the main concern of the supply chain members is the level and alignment of goals. Because the existing conditions may cause each member to seek to optimize their decisions. In the realm of supply chain cooperation, diverse methodologies have been explored. (Adabi & Mashreghi, 2019; Li & Huo, 2008) argue that supply chain coordination becomes apparent when manufacturers operate with narrow profit margins while merchants bear the cost of manufacturing. In contrast, Boyaci & and Gallego (2004) emphasize the inherent challenge in this scenario, as manufacturers naturally seek profitability.

However, this collaboration paradoxically enhances competition and consumer satisfaction. Thorstenson & and Ramani (2020) examined how two rival producers can effectively coordinate the sale of competing goods to a single retailer. In a complementary case study by Abanavaz & and Bafruei (2020), we observe the collaboration between a producer and multiple retailers, all working in harmony to enhance supply chain profitability.

In summary, these scholarly works contend that supply chain coordination acts as an optimization mechanism for quality, price, profit, and overall customer satisfaction by aligning the interests of producers and retailers. Often, traditional profit-centric objectives must be adjusted to facilitate effective coordination.

2.2. Supply Chain Coordination Strategies

Efficient supply chain coordination is essential, particularly in volatile supply and demand scenarios. While wholesale price contracts are a common means of promoting collaboration, they can introduce conflicts of interest among supply chain participants. Jun et al. (2009) illustrated how two-part contract auctions can effectively coordinate supply chains and enhance profitability for all participants, even in the face of demand unpredictability.

In parallel, Giri & and Bardhan (2014) demonstrated that buyback agreements between suppliers and retailers can streamline the supply chain and boost profitability, even in the face of potential supply disruptions. Asian & Nie (2014) explored coordination under uncertainty and advocate for option contracts between buyers and backup suppliers to ensure responsive capacity and risk-sharing. In contrast, Zhao et al. (2021) suggested that production cost uncertainty can amplify conflicts in supply chains and diminish expected profits under decentralized decision-making. They proposed incomplete contracts, allowing for the renegotiation of wholesale prices and order quantities post-cost realization, to achieve optimal outcomes.

Supply chain competition further complicates coordination. Wu et al. (2011) delved into the realm of competing supply chains, making collective determinations on quantity and price amidst demand volatility. They fount that, in contrast to manufacturer Stackelberg leadership or price negotiations over wholesale prices, vertical integration yields a distinctive Nash equilibrium within a single timeframe. Liao & Lu (2020) extended this exploration to a three-level supply chain marked by yield uncertainty, unpredictable demand, and spot price fluctuations. Their research emphasized that option contracts, rather than wholesale pricing contracts, are better suited to coordinate the chain and yield Pareto improvements. However, the stringent prerequisites for coordination, particularly when addressing spot market volatility, require a higher option exercise price.

Lastly, Giri and Bardhan (2016) delved into a two-echelon supply chain vulnerable to disruptions in demand, yield, and supply. Their findings suggest that, under specific circumstances, allocating backup capacity and deploying contract mechanisms can effectively coordinate the chain. Nevertheless, it's crucial to acknowledge that the coordinated model may falter when disruption probabilities surpass predetermined thresholds.

2.3. Alignment of goals in Contemporary Supply Chains

In the dynamic and multifaceted landscapes of contemporary business environments, aligning objectives among supply chain stakeholders is of paramount concern. The existing conditions often tempt each stakeholder to prioritize their optimization, potentially jeopardizing the collective endeavor. In this context, supply chain coordination emerges as a pivotal factor for success, holding the potential to significantly enhance overall supply chain performance (Cai et al., 2019).

Effective coordination can facilitate equitable distribution of benefits and risks among supply chain members (Wang et al., 2021; Chen et al., 2018). Their research unequivocally demonstrates that, when demand hinges on pricing decisions, coordinated efforts within the supply chain yield substantial enhancements in overall performance. Additional investigations, such as those undertaken by Mahmoodi and Eshghi (2014), delved into the dynamics of competitive supply chains contending with linear uncertain demand. These studies reaffirm the premise that competition among supply chain members can promote equitable income distribution and mitigate risks.

Recent research endeavors broaden their scope to encompass supply chain configurations featuring numerous suppliers and retailers. Huang et al. (2017), for example, conducted a comprehensive study scrutinizing the intricacies of relationships between multiple suppliers and a solitary retailer within the supply chain framework. These studies systematically investigated the interplay between competition and coordination within supply chain structures governed by stochastic demand conditions, underscoring the importance of this dynamic interrelationship.

In this research, we reaffirm our commitment to examining the nuanced interplay between competition and coordination within a supply chain comprising two suppliers and two retailers, all operating within an environment characterized by stochastic demand patterns. Our study aims to elucidate the influence of competition on supply chain coordination when confronted with the inherent unpredictability of demand. Our assumptions encompass a supply chain featuring two manufacturers and two wholesalers, with a focus on retailer price contracts as a means to examine coordination (Figure 1).

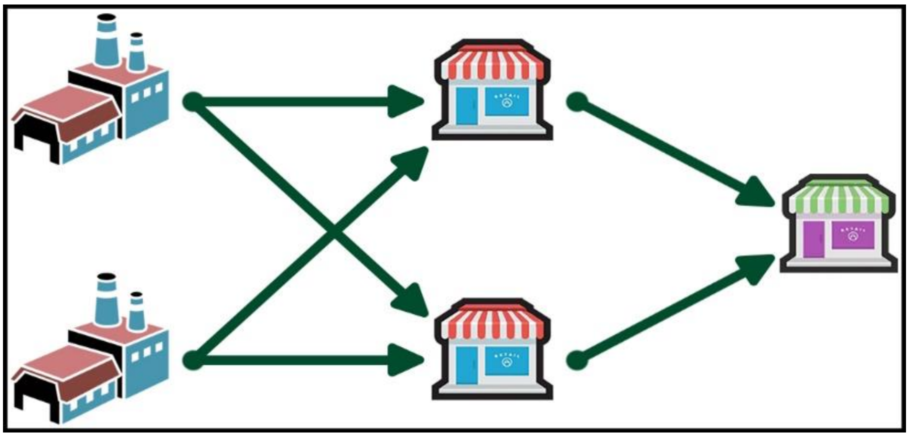

Fig 1. Competitive structure of supply chain with two manufacturers and two common retailers.

3. Methods

3.1. Mathematical Modeling

In this study, we examine a two-level supply chain comprising two manufacturers and two retailers. We assume that at each level, members engage in price competition. Additionally, we consider that the two products produced by the manufacturers can serve as substitutes for each other. The intensity of competition between the manufacturers can serve as an indicator of the extent to which these two products are interchangeable.

3.2. Assumptions

The main assumptions of the model are as follows:

- Demand is considered stochastic and price-dependent.
- At the end of the planning period, surplus products are auctioned off at a price lower than the wholesale price.
- In case of product shortage, retailers will incur lost sales costs.
- Each manufacturer offers its product at a fixed wholesale price.
- The retail price of each product may differ across retailers.

In this article, we followed a structured approach. Initially, a mathematical model was constructed to optimize the profit functions of supply chain participants, encompassing two manufacturers and two wholesalers, formulated as objective functions. Subsequently, by applying optimality conditions, we derived the optimal values for pricing and inventory decisions. We proceeded to identify the essential conditions for coordination by comparing the optimal points of manufacturers, wholesalers, and the entire supply chain.

Next, we investigated the impact of implementing a wholesale price contract on supply chain coordination. To validate our model and its findings, we solved a numerical example and engaged in a comprehensive discussion of the results obtained. The parameters and variables of the model are introduced in Table 1.

Table 1. The parameters and variables of the model.

Parameters	**Description**
D_{ij}	Demand for product i by retailer j
a_{ij}	Price-independent demand for product i at retailer j
v_{ij}	Surplus product liquidation value at the end of the selling season for product i at retailer j
g_{ij}	Shortage cost for product i at retailer j
c_i	Production cost for product i
b_{ij}	Price elasticity of demand for product i at retailer j (between 0 and 1)
Variable	**Description**
Sq_{ij}	Sales quantity of product i at retailer j
Lq_{ij}	Lost sales quantity of product i at retailer j
Iq_{ij}	Excess inventory quantity for product i at retailer j at the end of the period
x_i	Degree of competition among manufacturers (between 0 and 1)
θ_i	Degree of competition among retailers (between 0 and 1)
q_{ij}	Order quantity of product i from manufacturer at retailer j (random variable)
p_{ij}	Retail price of product i at retailer j (random variable)
w_i	Wholesale price of product i (random variable)
ε_{ij}	Stochastic demand for product i at retailer j with a specified distribution

4. Profit Functions of Supply Chain Members under Uncertain Demand

In this section, we delve into the modeling of profit functions for each constituent of the supply chain, encompassing manufacturers, retailers, and the supply chain as a whole, all within the context of uncertain demand. Initially, we formulate a demand function that takes into account the influences of pricing strategies and competitive dynamics among the participants. Subsequently, utilizing this demand function, we compute the profit functions for each participant.

Furthermore, we establish optimality conditions for pricing and inventory decisions, aimed at the maximization of profits. It is important to note that this section lays the foundation for subsequent calculations and analyses about the coordination of the supply chain.

4.1. Demand Function and Price Effect

Given that demand typically exhibits a negative correlation with price, we represent the retail price with a negative coefficient in the demand function. In simpler terms, when the price of a product rises, it tends to result in a decrease in demand. Furthermore, we account for the positive influence of the price of a product produced by another manufacturer on the demand function. The formulation of the demand function is expressed as follows:

$$D_{ij} = a_{ij} - b_{ij}p_{ij} + (1-\theta_i)x_i p_{i,3-j} + \theta_i(1-x_i)p_{3-i,j} + \theta_i x_i p_{3-i,3-j} + \varepsilon_{ij}. \quad (1)$$

4.2. Modified Variables for Simplification

Modifications have been made to the demand function using the variables y_{ij} and z_{ij} to simplify the model. These modifications are aimed at streamlining the model. The new variables are defined as follows:

$$D_{ij} = y_{ij}(p) + \varepsilon_{ij}, \tag{2}$$

$$z_{ij} = q_{ij} - y_{ij}(p). \tag{3}$$

4.3. Retail Profit Function

The retail profit function is formulated based on the modified variables in the demand function. This function demonstrates the impact of revenue, expenses, and other factors. The retail profit function is represented as follows:

$$E\left(\pi_{Rj}\left(\left(z_{ij}, p_{ij}\right)\right)\right) = \left(p_{ij} - w_i\right)\left[y_{ij}(p) + \mu_{ij}\right] - \left(w_i - v_{ij}\right)\Lambda_{Rj}\left(z_{ij}\right) - \left(p_{ij} - w_i + g_{ij}\right)\Theta_{Rj}\left(z_{ij}\right). \tag{4}$$

4.4. Calculating Surplus and Shortage

The surplus and shortage values during the planning period are calculated using the functions Λ_{Rj} and Θ_{Rj}. These values indicate the excesses and deficits within the supply chain. The following equations are associated with these calculations:

$$\Lambda_{Rj}\left(z_{ij}\right) = \int_{A_{ij}}^{z_{ij}} \left(z_{ij} - u_{ij}\right) f(u)\,du, \tag{5}$$

$$\Theta_{Rj}\left(z_{ij}\right) = \int_{z_{ij}}^{B_{ij}} \left(u_{ij} - z_{ij}\right) f(u)\,du. \tag{6}$$

4.5. Optimal Retail Price Calculation

To determine the optimal retail price, we employ the derivative of the retail profit function. This equation represents the price optimization under various circumstances. The following equation is associated with the calculation of the optimal retail price:

$$p_{ij}^{*} = \frac{\begin{bmatrix} a_{ij} + \mu_{ij} + (1-\theta_i)x_i p_{i,3-j} + \theta_i(1-x_i)p_{3-i,j} + \theta_i x_i p_{3-i,3-j} \\ + b_{ij}w_i + \Theta_{Rj}\left(z_{ij}\right) \end{bmatrix}}{2b_{ij}}. \tag{7}$$

4.6. *Optimal Inventory Level Calculation*

Likewise, the optimal inventory level is computed using probability distribution functions. This calculation signifies the optimization of inventory levels over a specific period. The following equation is relevant to the calculation of the optimal inventory level:

$$1 - F\left({z_{ij}}^{*}\right) = \frac{\left(w_i - v_{ij}\right)}{p_{ij} - v_{ij} + g_{ij}}. \tag{8}$$

4.7. Producer's Profit Function

Lastly, the manufacturer's profit function is defined, taking into account costs and revenues. This function represents the profit obtained from producing goods by the manufacturer. The equation below represents the manufacturer's profit function:

$$\pi_{Mi}(q_{ij}) = \sum_{j=1}^{2} (w_i - c_i) q_{ij}. \quad (9)$$

In this section of the article, we delve into the profit functions of supply chain members in the context of uncertain aggregate demand. These functions play a pivotal role in the analysis and improvement of supply chain performance when confronted with demand uncertainty.

5. Coordination Analysis

To conduct a thorough analysis of coordination, it is imperative to determine the optimal points for the retail price and inventory level of both the retailer and the supply chain as a whole. Coordination within the supply chain is deemed achieved when these optimal points of its constituent members align with the overall optimal point of the entire supply chain, a concept established by (Graves & de Kok, 2003). The synchronization of these optimal points signifies effective information sharing and the presence of a robust information system among the supply chain members.

The results of comparing these optimal points reveal that coordination is attained when the manufacturer's marginal profit reaches zero. This condition prompts the manufacturer to accept the coordination terms and raise the wholesale price. Consequently, the minimum wholesale price for the manufacturer equates to the production cost. Additionally, there exists a linear and ascending relationship between the manufacturer's profit and the wholesale price. Thus, the higher the wholesale price chosen by the manufacturer, the more favorable conditions it can secure.

In essence, the conditions of the wholesale price contract incentivize the manufacturer to increase the wholesale price to a level where the retailer incurs no loss and maintains a positive profit. Consequently, the manufacturer's highest wholesale price is established at the point where the retailer's profit turns negative beyond that threshold. This approach defines a range within which the manufacturer's wholesale price can fluctuate. By varying the wholesale price within this range, we can assess how supply chain efficiency, essentially represented by the profit ratio concerning the wholesale price in its current state compared to the optimal and ideal state (a coordinated supply chain), evolves.

6. Numerical Study

In this section, we have streamlined the problem-solving process by assuming that all parameters for both retailers and manufacturers are equal, denoted as follows:

$t_i = t, x_i = x, w_i = w, c_i = c, g_{ij} = g, v_{ij} = v, b_{ij} = b, a_{ij} = a, p_{ij} = p, z_{ij} = z.$

This assumption is a common practice in supply chain-related problems and is made for numerical analysis purposes (Chakraborty et al., 2015). With this assumption, the following parameter values are considered for the problem:

$a = 5000, c = 500, v = 450, g = 700, \varepsilon \in U(0,100), x = 0.5, t = 0.5.$

Based on the uniform demand function, the optimal points in a Stackelberg game are obtained by solving the related equations in MATLAB software. As mentioned before, when the relationship w = c = 500 holds, the supply chain is coordinated. Therefore, the results obtained from profit functions and variable values in a coordinated state and with changing b in the range [0.1, 0.7] are shown in Table (1). The reason for considering b in this range is that for values greater than 0.7, irrational results are observed, which is practically due to the existence of the following constraint between the parameters b, x and t:

$$b < x + t - tx \tag{10}$$

This constraint essentially indicates that the demand function decreases as the price increases.

Table 2. Results of changes in profit function values and variables with changing b in a coordinated state (w = c = 500).

b	p^*	z^*	q^*	π_R	π_M	π_{SC}
0.1	3634.6	98.71	2736.22	16843613.8	0	16843613.8
0.2	4340.9	98.91	2711.41	20447889.4	0	20447889.4
0.3	5361.1	99.1	2686.61	25637401.7	0	25637401.7
0.4	6964.28	99.3	2661.8	33770925.1	0	33770925.1
0.5	9849.99	99.5	2637	48381273.5	0	48381273.5
0.6	16573.3	99.7	2612.2	82422097.7	0	82422097.7
0.7	50249.99	99.9	2587.4	252476254.9	0	252476254.9

According to the above table, as the price sensitivity of demand (b) increases, the retailer chooses a higher price but the order quantity decreases with increasing b, which is due to costs related to excess inventory. On the other hand, the supply chain profit and retailer's profit increase due to the increase in selling price. Since the manufacturer has zero marginal profit in a coordinated state, it will not make any profit, which is due to the poor performance of the wholesale price contract for coordination. Therefore, the manufacturer tends to increase the wholesale price. Given the optimal conditions of the retailer, the manufacturer increases the wholesale price to increase its profit. Therefore, the manufacturer is allowed to increase the wholesale price to the extent that the retailer makes a positive profit. The minimum wholesale price is 500, which is the production cost. To analyze the sensitivity to increasing b, the wholesale price is increased until the maximum wholesale price is obtained given the positive retailer profit. The table below shows the upper bound of wholesale price and supply chain efficiency along with increasing price sensitivity demand (b).

In Table 3, for each level of b, the maximum wholesale price that the manufacturer can choose is specified. The results of Table 3 show that the best supply chain efficiency at each level of b occurs at a wholesale price of 500, because with increasing wholesale prices, efficiency is less than one. Therefore, it can be said that the coordinated supply chain has the best efficiency. On the other hand, according to Table 2, increasing *b* at a fixed wholesale price has increased the profitability of the supply chain.

Table 3. The effect of b changes on supply chain efficiency.

b	p^*	z^*	q^*	w_{max}	π_R	π_M	π_{SC}	*Ef*
0.1	2584.03	24.98	3345.36	2576	1048.69	13889936.47	13890985.16	0.82
0.2	3094.71	21.21	3319.12	3085	9123.59	17159885.93	17169009.53	0.83
0.3	3831.97	17.39	3293.00	3822	7695.61	21878720.36	21886415.97	0.85
0.4	4990.58	13.54	3266.83	4981	1964.90	29277383.15	29279348.06	0.86
0.5	7077.05	9.70	3240.44	7066	8334.78	42553466.76	42561801.55	0.87
0.6	11945.30	5.83	3214.03	11934	6668.80	73498603.83	73505272.64	0.89
0.7	36288.27	1.94	3187.53	36277	3199.45	228080740.34	228083939.79	0.90

In Table 4, at each layer of b, the efficiency of the supply chain was calculated by changing the wholesale price between the maximum and minimum values. This procedure shows the overall behavior of the manufacturer in a rational profit state. Consequently, the results of b changes in the supply chain efficiency (Ef) must be analyzed.

Table 4. Investigating the changes in supply chain efficiency with changes in wholesale price at each level of b.

b	*W*	p^*	z^*	q^*	π_R	π_M	π_{SC}	*Ef*
	500	3634.6	98.71	2736.22	16843613.8	0	16843613.8	1
0.1	1500	3130.90	68.9	3033.85	9761681.56	6067709.07	15829390.64	0.93
	2576	2584.03	24.98	3345.36	1048.69	13889936.47	13890985.16	0.82
	500	4340.9	98.91	2711.41	20447889.4	0	20447889.4	
0.2	2500	3325.97	42.67	3213.38	5232956.10	12853555.59	18086511.69	0.88
	3085	3094.71	21.21	3319.12	9123.59	17159885.93	17169009.53	0.83
	500	5361.1	99.1	2686.61	25637401.7	0	25637401.7	1
0.3	3000	4140.13	41.91	3178.85	7160188.96	15894276.14	23054465.11	0.89
	3822	3831.97	17.39	3293.00	7695.61	21878720.36	21886415.97	0.85
	500	6964.28	99.3	2661.8	33770925.1	0	33770925.1	1
0.4	3500	5545.80	64.83	2959.11	12576189.44	18638063.95	31214253.39	0.92
	4981	4990.58	13.54	3266.83	1964.90	29277383.15	29279348.06	0.86
	500	9849.99	99.5	2637	48381273.5	0	48381273.5	1
0.5	4000	8229.94	58.13	3000.64	25109958.65	2100454.15	46114507.80	0.95
	7066	7077.05	9.70	3240.44	8334.78	42553466.76	42561801.55	0.87
	500	16583.33	99.7	2587.4	82422097.7	0	82422097.7	1
0.6	5000	14561.95	69.28	2884.98	54488295.32	25964890.91	80453186.24	0.97
	11934	11945.30	5.83	3214.03	6668.80	73498603.83	73505272.64	0.89
	500	50249.99	99.9	3187.53	252476254.9	0	252476254.9	1
0.7	20000	42361.53	54.12	2936.04	130066548.32	114505705.96	244572254.28	0.96
	36277	36288.27	1.94	3187.53	3199.45	228080740.34	228083939.79	0.90

The values presented in Table 4 reveal a consistent trend: as the value of b increases at each layer, raising the wholesale price leads to a decrease in supply chain efficiency. This outcome underscores that when the manufacturer chooses to increase the wholesale price, it moves the supply chain further away from coordination. Consequently, increasing the wholesale price primarily benefits the manufacturer, but it comes at the expense of the retailer's profit and, subsequently, the overall supply chain profit. This reduction in profits is largely attributed to the resulting decrease in the selling price of the product.

In summary, the findings suggest that a careful balance must be struck between wholesale pricing and supply chain coordination to optimize overall profitability.

7. Discussion and Conclusion

This study delved into profit optimization for each member of the supply chain and the supply chain as a whole, taking into account stochastic demand and the competitive nature of supply chain members at both the manufacturer and retailer levels. Coordination was analyzed by comparing the optimal points of the retailer and the supply chain to establish coordination conditions. The results indicate that supply chain coordination occurs when the wholesale price equals the minimum value, which is the production cost. Consequently, the manufacturer does not accept a zero marginal profit and increases the wholesale price to maximize its own profit. However, the manufacturer can raise the wholesale price to a level where the retailer still maintains a positive profit.

In the numerical example section, the study investigated the impact of changes in the parameter b within a specific range on profit functions and variable values. Furthermore, at each level of b, the study determined the maximum wholesale price that the manufacturer could choose. Subsequently, by keeping b constant, the wholesale price was altered between its minimum and maximum values, leading to a reduction in supply chain efficiency due to the decrease in the selling price and, consequently, the total supply chain profit.

An examination of the wholesale price contract as a coordinating mechanism for the supply chain suggests that this contract has limited effectiveness in achieving coordination. Future research could explore alternative coordinating contracts such as revenue sharing and quantity discount contracts within the desired supply chain structure.

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