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Research Article

Are Online and Offline Bargaining Profitable for the Retailer, Manufacturer, and Customer in A Green Supply Chain Management?

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ABSTRACT

Online and offline bargaining play one of the most important roles for attracting customers, increasing sales, and overall profit in the green supply chain management. Nowadays, it has attracted the attention of both manufacturers and retailers after dealing with their contracts. In this paper, the manufacturer invests in green innovation to produce green products after receiving orders from retailers through a dual channel. The retailer sells products to customers through a bargaining policy in the dual channel, whereas there is a contract, namely, revenue-sharing between the retailer and manufacturer. The selling price and green innovation-dependent demand are considered. The problem is solved through the game policy. The numerical experiment shows that without offline bargaining, the retailer's profit decreases to 5.41%, whereas the profit of the manufacturer and the whole supply chain decreases by 25.69% and 10.48%, respectively. If this business continues only in the offline channel, the profit decreases by 40.89%, 42.22%, and 41.45%, respectively. Without online bargaining, the retailer's profit decreases to 3.99%, whereas the profit of the manufacturer and supply chain decreases by 18.91 % and 13.62 %, respectively. From this numerical result, it is found that online and offline bargaining increase the sales and overall profit.

Keywords: Green innovation; Bargaining; supply chain management; dual channel retailing

INTRODUCTION

Bargaining and dual channel (DC) strategies acquire increased importance in modern supply chains and retail markets. Bargaining (Matsumoto et al., 2024) is negotiation among agents, typically manufacturers and retailers, on significant terms such as price (Kumar et al., 2025) and profit sharing, typically game theory-based to capture their strategic interactions (Matsui, 2022). Simultaneously, DC systems (Nematollahi et al., 2024) allow manufacturers to sell products through traditional retail intermediaries and direct-to-consumer channels, e.g., internet stores. DCs (Yang et al., 2024) expand market coverage and offer greater flexibility to consumers, but may create channel conflict via price competition and demand cannibalization (Nair et al., 2022). To balance such issues, bargaining mechanisms (Euler et al., 2024) are used to coordinate incentives and reach mutually acceptable agreements, inducing coordination and profitability down the supply chain (Yao et al., 2023). In addition, there are several ways to enhance online and offline bargaining in green supply chain management (GSCM) (Li et al., 2024). As time progresses, customers are becoming heavily dependent on green items (Li et al., 2018). Major companies are trying to reduce the harmful influence of smart manufacturing on the environment. But green products are expensive, and customers always want to buy a green product at her/his satisfied retail price of that product. Due to this issue, nowadays online and offline bargaining has become too popular for customers (Sarkar et al., 2025b; Guchhait & Sarkar, 2025). Many researchers work in green innovation and bargaining, but online and offline bargaining in DC retailing has not been considered previously.

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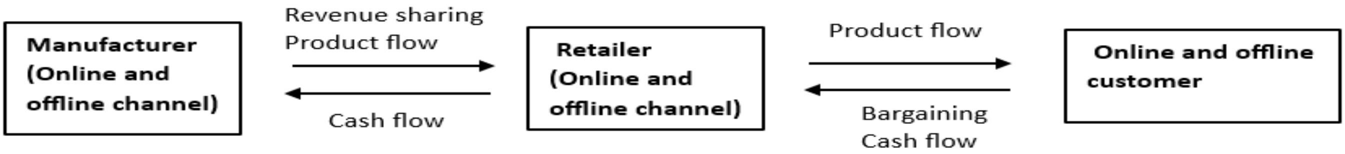

Fig 1 Diagram illustrating the proposed model

OBJECTIVES

Customer satisfaction with selling prices is the most important factor in the business industry. To satisfy the customer, bargaining can play a pivotal role. So the motive is to satisfy the customer by introducing a bargaining policy in an DC retailing. In the present time, the buying tendency of old customers is in the offline channel, and young customers are in the online channel. In this model, DC bargaining is considered for all types of customers. So every type of customer will be satisfied.

LITERATURE REVIEW

This paper is developed based on green innovation, bargaining, DC (Hu et al., 2024), transportation, and supply chain management. Some needed literature is discussed based on keywords. The effect of bargaining on GSCM was discussed by Davoudi et al. (2023). This research paper investigated the principle of bargaining with some type of revenue-sharing agreement and marketing expenditure in the traditional channel. However, this study forgot to explain the DC retailing (Mahapatra et al., 2025). Dilm et al. (2023) introduced a bargaining approach in a small dynamic bazaar. In this model, traders may enter and exit over time, with only a small number typically active at any specific point. Xing et al. (2023) examined a bargaining policy that consisted of a recompose mechanism to hold up consensus in a social group. The empirical experiment of a theoretical model in a bargaining method was discussed by Vetschera et al. (2023). This study examined the connection between negotiation processes and their outcomes through a model that focuses on the decisions made at each stage of bargaining. Fanfani (2023) explained that Italian collective bargaining positively impacts wages while significantly reducing employment. Yang and Xiao (2017) explained a decision-making strategy for green items in a GSCM by using fuzzy uncertainties. This model proposed the influence of channel leading and governmental intermediation on the green level and pricing decisions of GSCM and its profit. Caramia and Stecca (2024) investigated a programming approach in a GSCM. This paper introduced a new programming policy to minimize CO_2 emissions in a three-echelon GSCM.

PROBLEM DEFINITION, NOTATION, AND ASSUMPTIONS

Problem definition: A two-echelon GSCM model has been developed (**Fig 1**) with the manufacturer and retailer as supply chain members, where the DC is considered from both members. The manufacturer produces green products and the retailer opens a bargaining policy for customers and sells those products in the DCs.

Notation: All notations are expressed in **Table 1**

Table 1 Notation of this study

Decision variables	Description
p_i, w_i, θ_i	Selling price, wholesale price, and investment for green innovation, respectively
Parameters	Description
α_i, β_i V_i, G_i, F_i, and H_i c_i, and I_i m_i, and k_i	Customer sensitivity of the selling price and green innovation, respectively, $\alpha_i > \beta_i + 1$ Manufacturer's and retailer's variable and constant transportation cost, respectively Manufacturing cost and investment parameter of green groduct, respectively Retailer's margin and the total population of potential customers, respectively
Index	Description
i	1 , 2 (1 for online channel and 2 for offline channel)

Assumptions: The following assumptions are considered.

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1. An GSCM model is considered in this model, where the manufacturer makes green products and both members use DC for selling products.
2. The demand is depending on green innovation and price, which is expressed as $\sum_{i=1}^{2} k_i\, p_i^{\alpha_i}\, \theta_i^{\beta_i}$, where $\alpha_i > \beta_i + 1$. The retailer's marginal price is $m_i = p_i - w_i$.
3. The manufacturer invests $I_i\theta_i^2$ for green innovation and a revenue-sharing contract between retailer and manufacturer is also considered in this study.
4. The manufacturer and retailer invest money in variable and fixed transportation, including some maintenance policies such as durable packaging cost, pre-shipment Inspection cost, post-delivery Inspection cost, labour cost, labour training cost, documentation cost, and monitoring tools cost.

MODEL AND METHOD

Model: In this model, bargaining occurs between the retailer and the consumer before buying an item. That's why the retailer deals with a revenue-sharing ratio with the manufacturer. It is considered that λ_i and $1-\lambda_i$ are the profit rates of retailer and manufacturer, respectively. The retailer's (Π_R), manufacturer's (Π_M), and supply chain's (Π_{SC}) profit functions are expressed as follows.

$$\Pi_R = \sum_{i=1}^{2} \lambda_i(p_i - w_i - G_i)k_i\, p_i^{\alpha_i}\, \theta_i^{\beta_i} - \lambda_i H_i \tag{1}$$

$$\Pi_M = \sum_{i=1}^{2}(w_i - c_i - V_i)k_i\, p_i^{\alpha_i}\, \theta_i^{\beta_i} - I_i\theta_i^2 - (1-\lambda_i)\,(p_i - w_i - G_i)k_i\, p_i^{\alpha_i}\, \theta_i^{\beta_i} - (1-\lambda_i)H_i - F_i \tag{2}$$

$$\Pi_{SC} = \sum_{i=1}^{2}(p_i - c_i - G_i - V_i)k_i\, p_i^{\alpha_i}\, \theta_i^{\beta_i} - I_i\theta_i^2 - H_i - F_i \tag{3}$$

Method: A classical optimization technique is used to solve the model theoretically. Equation (4) is obtained by differentiating equation (1) with respect to p_i and equal to zero.

$$p_i(w_i) = \alpha_i\,(w_i + G_i)/(\alpha_i - 1) \tag{4}$$

Putting the value of $p_i(w_i)$ in Equation (2) and differentiating concerning w_i and θ_i the Equation (5) and Equation (6) are obtained.

$$w_i^* = \frac{\alpha_i c_i + G_i\,\lambda_i + V_i\alpha_i}{\alpha_i - \lambda_i} \tag{5}$$

$$\theta_i(w_i) = e^{\frac{\ln(2)+\ln\frac{I_i(\alpha_i-1)}{5\,\beta_i k_i\left(c_i+G_i+V_i-\alpha_i(c_i+G_i-w_i)-\lambda_i(G_i-w_i)\right)}+\alpha_i \ln\frac{\alpha_i\,(w_i+G_i)}{(\alpha_i-1)}}{\beta_i-2}} \tag{6}$$

The optimal value θ_i^* and p_i^* is obtained by putting the value of w_i^* in the Equation (4) and Equation (5), which are as follows

$$\theta_i^* = e^{\frac{\ln(2)+\ln\frac{I_i(\alpha_i-1)}{\beta_i k_i(c_i+G_i+V_i)}+\alpha_i \ln\frac{\alpha_i^2(c_i+G_i+V_i)}{(\alpha_i-\lambda_i)(\alpha_i-1)}}{\beta_i-2}},\quad p_i^* = \frac{\alpha_i^2(c_i+G_i+V_i)}{(\alpha_i-\lambda_i)(\alpha_i-1)}. \tag{7}$$

Therefore, the optimal profits are as follows

$$\Pi_R^* = \sum_{i=1}^{2} \lambda_i(p_i^* - w_i^* - G_i)k_i\,(p_i^*)^{\alpha_i}\,(\theta_i^*)^{\beta_i} - \lambda_i H_i \tag{8}$$

$$\Pi_M^* = \sum_{i=1}^{2}(w_i^* - c_i - V_i)k_i\,(p_i^*)^{\alpha_i}(\theta_i^*)^{\beta_i} - I_i(\theta_i^*)^2 - (1-\lambda_i)\,(p_i^* - w_i - G_i)k_i\,(p_i^*)^{\alpha_i}\,(\theta_i^*)^{\beta_i} - (1-\lambda_i)H_i - F_i \tag{9}$$

$$\Pi_{SC}^* = \sum_{i=1}^{2}(p_i^* - c_i - G_i - V_i)k_i\,(p_i^*)^{\alpha_i}\,(\theta_i^*)^{\beta_i} - I_i(\theta_i^*)^2 - H_i - F_i. \tag{10}$$

RESULTS

For finding the optimal result, MATLAB R2023b is used in this model. The optimal value of λ_i^* is obtained by using a simple goal-seeking technique because the demand function is complex and nonlinear. To find the optimal values of λ_i^* and result, the input parameters are listed from Davoudi et al., (2023) and set according to necessity, which as I_1=35, $k_1 = 9600$, b_1= 9.09, c_1 =1.1, $\beta_1 = 0.5, \alpha_1 = 2.5, V_1 = 3.5$, $H_1 = 5.3, G_1 = 0.8$, $F_1 = 0.8$, I_2=34, $k_2 = 9500$, b_2= 9.08, c_2 =1, $\beta_2 = 0.49, \alpha_2 = 2.4, V_2 = 3.4$, $H_2 = 4.3, G_2 = 0.9$, $F_2 = 2.4$. The optimal values of λ1 and λ2 are 0.71 and

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0.73, are obtained by using the equation $\frac{\partial}{\partial \lambda_i} \Pi_R^* = 0$. The result of the model is shown in the **Table 2**. The Concavity of the profit of the result connecting DC retailing price is represented in the **Fig 2**.

Table 2: The optimum profit and decision variables of the result

θ_1^*	θ_2^*	p_1^*	p_2^*	w_1^*	w_2^*	Π_M^*		Π_R^*	Π_{SC}^*
0.56	0.67	12.78	13.06	6.74	6.72	74.78		104.78	179.41

Some special cases

Some special cases are discussed here.

Without consideration of the offline channel: In this case, the optimal values (OVs) of profit functions and different decision variables (DVs) are $\theta_2^* = 0.67, p_2^* = 13.06, w_2^* = 6.72, \Pi_R^* = 59.99, \Pi_M^* = 47.04,$ and Π_{SC}^*=105.04. However, without an online channel, the profit of the retailer, manufacturer, and SCM is decreased by 40.89 %, 42.22 %, and 41.45 %, respectively. Thus, the application of an online channel is too beneficial for the whole SCM and members.

Without consideration of the online bargaining: In this case, the OVs of profit functions and different DVs are $\theta_1^* = 0.43, p_1^* = 15, w_1^* = 8.2,\ \theta_2^* = 0.6, p_2^* = 13.06, w_2^* = 6.72, \Pi_R^* = 99.96, \Pi_M^* = 60.64, and\ \Pi_{SC}^* = 160.6$. However, without online bargaining, the profit of the retailer, manufacturer, and SCM is decreased by 3.99 %, 18.91 %, and 13.62 %, respectively. Thus, the application of an online bargaining channel is too beneficial for members and the SCM.

Without consideration of the offline bargaining: In this case, the OVs of profit functions and different DVs are $\theta_1^* = 0.58, p_1^* = 12.57, w_1^* = 6.74,\quad \theta_2^* = 0.5, p_2^* = 15.58, w_2^* = 8.18, \Pi_R^* = 99.11, \Pi_M^* = 55.57, and\ \Pi_{SC}^* = 154.98$. However, without online bargaining, the profit of the retailer, manufacturer, and SCM is decreased by 5.41 %, 25.69 %, and 10.48 %, respectively. Thus, the application of an online bargaining channel is too beneficial for members and the SCM. The **Fig 3** shows the concavity of this system's profit function.

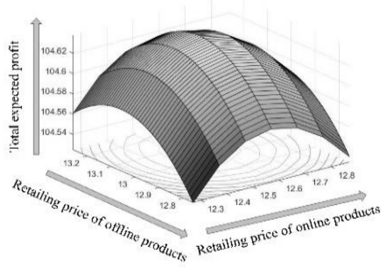

Fig 2 Concavity of the original system's profit function

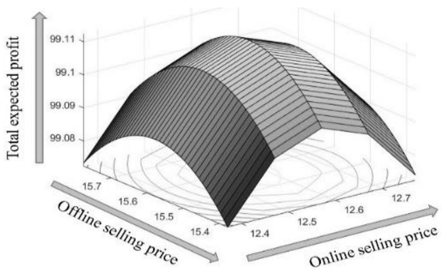

Fig 3 Concavity of last special case's profit function

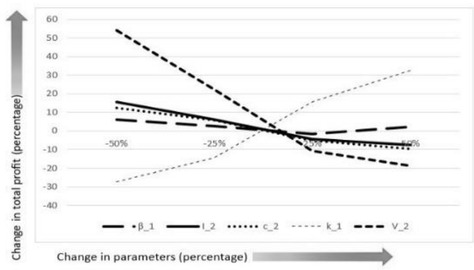

Fig 4 Graphical representation of sensitive analysis

Sensitive analysis

Sensitive analyses are explained for 6 important parameters α_2, $\beta_2, c_2, k_1, I_2,$ and V_1. The effect of the supply chain's profit is observed for ± 50 %and ± 25 % change of those parameters in the sensitivity analysis (**Table 3**). The table shows that α_2 is a too huge sensitive parameter, where k_1 and V_1 are major sensitive parameters, and all other parameters are less sensitive. The graphical representation of sensitivity analysis is shown in the **fig 4**.

Table 3 Sensitivity analysis of principal parameters

Parameter	Changes (in%)	Π_{SC}^*	Parameter	Changes (in%)	Π_{SC}^*	Parameter	Changes (in%)	Π_{SC}^*
β_1	-50%	6.14	k_1	-50%	-27.49	c_2	-50%	12.56

	-25%	2.47		-25%	-14.52		-25%	5.84
	+25%	-1.54		+25%	15.79		+25%	-5.1
	+50%	-2.21		+50%	32.68		+50%	-9.59
α_2	-50%	3807.3	I_2	-50%	15.71	V_1	-50%	54.17
	-25%	335.38		-25%	6.09		-25%	22.29
	+25%	-50.89		+25%	-4.35		+25%	-10.72
	+50%	-60.02		+50%	-7.68		+50%	-18.84

MANAGERIAL INSIGHTS

1. In an DC GSCM, profit increases as the selling prices decrease, since demand in both channels is inversely related to price. Therefore, the selling prices for both channels should be strategically set to stimulate demand and maximize the total profit.
2. The demand for products is influenced by the implementation of green innovation across both online and offline channels. Studies indicate that supply chain profits improve as DC green innovation efforts increase. Therefore, managers should focus on enhancing green innovation strategies across all sales platforms.
3. Two-channel bargaining is a key consideration for the successful selling of any item. Customers will typically negotiate price, whether they buy online or in stores. Thus, managers need to establish an optimal bargaining ratio between both channels to optimize total supply chain profit.

CONCLUSION AND FUTURE EXTENSION

This model introduces a novel approach for DC bargaining in the GSCM. The research shows that strategic coordination via efficient bargaining mechanisms can have a dramatic impact on minimizing channel conflict and maximizing overall profit. This study also concludes that RSC acts as an incentive for both the retailer and manufacturer, and a fair revenue-sharing contract is essential for maintaining long-term collaborations between the retailer and manufacturer. To meet customer demands and to gain maximum market reach, companies use DC systems. However, customers' bargaining power affects profit and decision-making. This results in mutual gains due to cooperative strategies that include agreements for revenue sharing. Our study focuses on the requirement for flexible and adaptable strategies to manage the dynamic demands of customers. Basically, bargaining in an DC increases competitiveness and flexibility in supply chain management. When the retailer does not allow bargaining in offline/online channel, the profit of retailer decreases to 5.41% / 3.99%, whereas, the profit of the manufacturer, and whole supply chain decreases by 25.69 %/18.91% and 10.48 %/13.62%, respectively. If this business continues only in the offline channel, the profit decreases by 40.89 %, 42.22 %, and 41.45 %, respectively. The production system, inspection, and remanufacturing of faulty products can be added in this study as an extnsion (Sarkar et al., 2025). One can add promotional efforts (Datta et al. 2025) and treaceability through RFID to this study.

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