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COORDINATING OMNICHANNEL PRICING UNDER BOPS: THE ROLE OF MONEY-BACK GUARANTEES IN CHANNEL PRICING DECISIONS

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Abstract*: This paper develops a three-stage Stackelberg dynamic game model to investigate pricing coordination in a decentralised Buy-Online-Pick-up-in-Store (BOPS) retail system under money-back guarantee (MBG) policies. The model incorporates two behavioural parameters, product matching rate and offline inconvenience cost, and derives closed-form equilibrium pricing solutions under both MBG and non-MBG scenarios. Comparative statics and numerical simulations are conducted to examine how these behavioural factors and a platform-provided per-order subsidy influence online retail price, offline retail price, and wholesale price. The results show that a higher product matching rate generally strengthens pricing power across channels, while the pricing effect of MBG depends on the interaction between product-fit uncertainty and offline inconvenience cost. MBG can stabilise the online retailer's pricing response under different offline inconvenience conditions, but it may also create asymmetric pricing incentives between online and offline channels. These findings contribute to the literature on dynamic games and omnichannel retail operations by linking refund policy design with strategic pricing coordination in BOPS systems.*

Keywords*: BOPS; game theory; money-back guarantee; product matching rate; pricing optimization.*

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Introduction

In recent years, the integration of online and offline channels has become a major trend in retailing, driven by technological advancement and changing consumer expectations. The Buy-Online-Pick-up-in-Store (BOPS) model allows consumers to purchase products online and collect them from physical stores, thereby combining the convenience of e-commerce with the immediacy and trust of offline fulfilment. Global retailers such as Walmart, Best Buy, and JD.com have adopted BOPS to improve service efficiency, reduce last-mile delivery pressure, and strengthen cross-channel integration (Agatha, 2024). However, the decentralised nature of BOPS also creates pricing coordination challenges, as online and offline retailers often operate with different cost structures, service responsibilities, and pricing incentives.

A key challenge in BOPS operations is product-matching uncertainty, which arises when consumers cannot fully assess whether a product will meet their expectations before purchase (Liu et al., 2023). To reduce perceived risk and enhance consumer confidence, retailers often adopt money-back guarantee (MBG) policies that allow dissatisfied consumers to receive refunds (Li et al., 2025). Although MBG can stimulate demand and strengthen consumer trust, it may also increase return-related burdens and alter consumers' channel preferences across online, BOPS, and offline options. This creates a strategic tension in pricing decisions: the online retailer may gain greater pricing flexibility from enhanced consumer confidence, whereas the offline retailer may face weaker pricing power if consumer demand shifts toward online ordering and BOPS fulfilment.

Existing studies have examined omnichannel pricing, return policies, and channel coordination from different perspectives. Some research shows that return policies can influence consumer purchase intentions and repeat buying behaviour (Ahmed et al., 2024), while other studies demonstrate that MBG can improve consumer confidence under specific product-matching conditions (Tang et al., 2023). Stackelberg game models have also been applied to analyse pricing power and channel leadership in omnichannel environments (Yu et al., 2024; Jiang & Wu, 2024). Nevertheless, limited attention has been given to how MBG interacts with consumer behavioural parameters and platform-mediated coordination mechanisms in a decentralised BOPS pricing system.

Consumer choice in BOPS settings is strongly affected by product fit and channel-related effort. The product matching rate reflects the likelihood that a product satisfies consumer expectations, whereas offline inconvenience cost captures the time and effort associated with store pickup, queuing, and in-store processing (Ge & Zhu, 2023; Liu et al., 2025). These behavioural factors not only influence channel choice but also determine how MBG affects equilibrium pricing decisions. Moreover, many BOPS systems are supported by platform-based incentives, such as per-order subsidies paid to offline retailers for fulfilment services. Although such subsidies are common in practice, their role in coordinating pricing decisions under MBG remains insufficiently explored.

This paper examines how MBG policies affect pricing coordination in a decentralised BOPS system. We develop a Stackelberg game model in which the online retailer acts as the leader and the offline retailer acts as the follower. The model incorporates two behavioural parameters, namely product matching rate and offline inconvenience cost, and introduces a platform-mediated subsidy paid to the offline retailer for each BOPS transaction. By comparing scenarios with and without MBG, the study derives equilibrium pricing strategies and analyses how

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refund guarantees and platform subsidies jointly shape channel pricing decisions and coordination outcomes.

This study addresses three research questions: (1) How does the implementation of MBG affect equilibrium pricing strategies across BOPS channels? (2) Under what conditions does MBG enhance or undermine the profits of online and offline retailers? (3) How can platform-mediated subsidies help rebalance profit allocation and support channel coordination under MBG?

This study makes several contributions to the literature on omnichannel retailing and refund policy design. First, it develops a behaviourally enriched Stackelberg game framework that integrates MBG policies with product matching rate and offline inconvenience cost, thereby extending prior models that often assume risk-neutral consumers or centralised pricing control. Second, it introduces a platform-mediated subsidy mechanism to examine how refund and subsidy policies jointly influence pricing coordination in decentralised retail networks. Third, the findings provide practical insights into when MBG should be implemented and how retailers can coordinate pricing and incentive mechanisms under varying levels of product uncertainty and offline inconvenience.

The remainder of the paper is organised as follows. Section 2 reviews the relevant literature on BOPS, MBG, and behaviour-driven pricing. Section 3 presents the model setup and assumptions. Section 4 analyses the equilibrium pricing outcomes under MBG and non-MBG regimes. Section 5 reports the numerical experiments on pricing coordination and platform subsidy effects. Section 6 discusses the theoretical and managerial implications. Section 7 concludes the paper.

Literature review

This section reviews prior studies on omnichannel retailing, BOPS pricing, money-back guarantee (MBG) policies, and behaviour-driven pricing. These streams provide the theoretical basis for developing a behaviourally informed Stackelberg game model that examines pricing decisions, profit allocation, and channel coordination in a decentralised BOPS system.

Omnichannel retailing and BOPS pricing strategies

The rapid development of digital retailing has encouraged firms to integrate online and offline channels. Among various omnichannel strategies, the Buy-Online-Pick-up-in-Store (BOPS) model has gained increasing attention because it combines online shopping convenience with offline fulfilment reliability (Li & Liang, 2024). BOPS can reduce delivery time, lower logistics costs, and enhance cross-channel synergy (Tan et al., 2023). However, it also introduces pricing coordination challenges, as online and offline channels often operate with different cost structures, service responsibilities, and pricing incentives.

From a pricing perspective, decentralised BOPS systems may suffer from price misalignment and channel cannibalisation. Liu et al. (2025) show that the absence of coordinated pricing can reduce overall channel performance, while Li et al. (2023) emphasise that consumer preference heterogeneity significantly affects demand allocation across channels. Existing studies also suggest that behavioural frictions, such as offline inconvenience costs and refund-related perceptions, influence consumers' channel choices (Wolf & Steul-Fischer, 2023). Nevertheless, most BOPS pricing models still pay limited attention to platform-mediated coordination mechanisms, such as per-order subsidies paid to offline stores for fulfilment support. This study

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therefore extends prior research by modelling decentralised BOPS pricing decisions with behavioural factors and platform-based coordination.

Money-back guarantees policy

Money-back guarantees are widely used to reduce perceived purchase risk and stimulate demand (Lin et al., 2024). By offering refunds for unsatisfactory products, MBGs strengthen consumer trust under uncertainty (Li et al., 2023). Although MBG policies have been widely examined in online retailing contexts (Tang et al., 2023; Guo et al., 2024), their strategic role in BOPS pricing systems remains insufficiently explored.

Prior studies show that MBG policies affect demand allocation, pricing decisions, and return-related strategic behaviour (Li et al., 2025; Zhang et al., 2024). When perceived product fit is high, MBG may function mainly as a trust signal with limited operational burden (Lin et al., 2024). Conversely, when product uncertainty is high, MBG may increase return frequency and impose additional return-related pressure on retailers (Sujuan et al., 2023). Fan et al. (2023) further show that optimal refund decisions depend on cost structure and consumer risk aversion, while Liu (2024) suggests that refund policies may generate asymmetric responses between online and offline channels because of differences in return-handling processes. However, most existing studies analyse MBG in single-channel or centrally coordinated systems (Lin et al., 2023), leaving its role in decentralised BOPS pricing coordination underexplored.

Behavior-driven pricing in omnichannel models

Recent omnichannel pricing research has moved beyond purely cost- or demand-based models toward behaviourally grounded frameworks. Pricing decisions are increasingly shaped by consumers' perceived risk, convenience, and trust (Ahmed et al., 2024; Sutisna et al., 2023), especially in BOPS contexts where consumers interact with both online interfaces and offline fulfilment processes (Xu et al., 2023).

Two behavioural parameters are particularly relevant to this study: product matching uncertainty and offline inconvenience cost. Product matching uncertainty reflects the subjective probability that a product meets consumer expectations without prior physical inspection (Dimoka et al., 2012). It directly affects expected utility and the likelihood of refund invocation under MBG policies (Aouad & Saban, 2023; Gao et al., 2023). Offline inconvenience cost captures the time and effort associated with store pickup, such as travel and queuing (Kim et al., 2023), and can be incorporated into pricing models to reflect experiential frictions in omnichannel shopping (Cabral et al., 2023). By explicitly modelling these two parameters, this study links consumer behavioural responses with strategic pricing coordination in BOPS systems.

Summary and research gaps

The literature on omnichannel retailing has evolved from conventional cost-based pricing models toward behaviourally enriched and decentralised analytical frameworks (Rodríguez-García et al., 2024). Prior studies have examined BOPS pricing, refund policies, and consumer behavioural responses (Liu et al., 2023; Bieniek, 2023; Chen & Jian, 2023). However, three gaps remain. First, MBG policies and behavioural parameters are often examined separately rather than within a unified analytical framework. Second, platform-mediated coordination mechanisms, such as subsidies for BOPS fulfilment, are rarely incorporated into behavioural pricing models. Third, limited research examines how refund guarantees interact with product matching uncertainty and offline inconvenience cost under decentralised BOPS structures.

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Addressing these gaps, this study develops a Stackelberg game framework that integrates MBG policies, product matching rate, offline inconvenience cost, and platform subsidies to analyse pricing coordination in BOPS systems.

Model setup

Problem description and modeling framework

Consider a two-stage supply chain composed of online retailer (O) and offline retailer (S). The online retailer sells products through online channels and BOPS channels, and po indicates the selling price of the product. In addition, online retailer also wholesale products to offline retailer at wholesale prices w. At the same time, the offline retailer sells products to consumers at a retail price p_s. Therefore, consumers can purchase goods through three channels: online channel, BOPS channel, and physical channel. Under this model, consumers place orders online but may choose between two fulfillment modes: home delivery or in-store pickup (Tang et al., 2024).

The decentralised structure creates pricing and profit-allocation challenges because the online and offline retailers have different decision rights and cost responsibilities. The online retailer determines the online retail price and wholesale price, whereas the offline retailer determines the offline retail price. To support BOPS fulfilment, the platform provides a per-order subsidy λ to the offline retailer. This subsidy captures the compensation provided for store-based fulfilment and reflects coordination practices in omnichannel platforms. Consumer channel choice is affected not only by price but also by two behavioural parameters: product matching rate and offline inconvenience cost.

The product matching rate represents the probability that the purchased product meets consumer expectations. If the product does not match expectations, consumers may return it under the MBG policy and receive a refund. Offline inconvenience cost captures the physical and temporal effort associated with store visits, such as travel, waiting, and in-store processing. Following Gallino and Moreno (2014), the online inconvenience cost is normalised to zero because it is relatively lower than the effort required for store-based fulfilment. Following Gao and Su (2016), offline inconvenience cost is assumed to follow a uniform distribution over $(0,1)$.

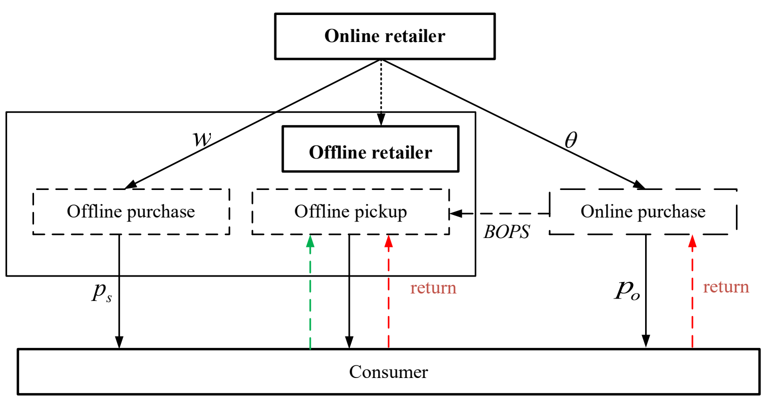

Figure 1. BOPS supply chain structure

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The game proceeds in three stages. First, the online retailer acts as the Stackelberg leader and sets the online retail price and wholesale price. Second, the offline retailer observes these decisions and sets the offline retail price. Third, consumers observe all prices and policy conditions and choose among online, BOPS, and offline channels according to utility maximisation. The model notations are summarised in Table 2.

Table 1: Model notations

Symbol	Definition
p_o	Online retail price
p_s	Offline retail price
h_s	Cost of inconvenient shopping in offline retail channel
r	Additional revenue for offline retailer
λ	Per-order subsidy paid by the platform to the offline retailer for BOPS fulfillment
w	Product wholesale price
θ	Product match rate
v	Consumers' willingness to pay for products
ϕ	Return cost as a percentage of retail price
$U_i, i = o,s,b$	Consumer utility when shopping through i channel
$Q_i, i = o,s,b$	The market demand of i channel
π_o	Profit of online retailer
π_s	Profit of offline retailer
π_t	Total profit (online retailer and offline retailer)

Consumer utility and channel demand

Consumers are heterogeneous in their valuation of products and choose the channel that maximises their utility. In offline stores, consumers can inspect products before purchase, which reduces mismatch risk. In contrast, consumers using online or BOPS channels cannot fully evaluate product fit before purchase. Let o, b, and s denote the online, BOPS, and offline channels, respectively.

Following the modeling approach of Balakrishnan, we introduce a parameter $\theta \in (0,1)$, referred to as the matching rate, which denotes the probability that a purchased product satisfies the consumer's expectations. Consequently, the mismatch rate is $1-\theta$, corresponding to the probability of a product return. Each consumer is characterised by a willingness to pay for a match and, if it is a mismatch, by a willingness to pay for a mismatch. For simplicity, we assume that the return rate, return cost, and refund policy are identical across both online and BOPS channels. In addition, returned products have zero salvage value, and the unit production and operating costs for both online and offline retailers are normalised to zero.

Based on these assumptions, we now proceed to analyse consumer utility across different shopping channels.

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(1) Online channel utility: If the retailer does not provide a money-back guarantee (MBG), mismatched products cannot be returned, and the consumer's utility from purchasing a matched product online is given by:

$$U_o^{no-MBG} = \theta(v - p_o)$$

If a money-back guarantee is offered, unmatched products can be returned, but the return cost is proportional to the product price. Let $\phi \in [0,1]$ denote the return cost rate. Then, the utility from mismatched products is $(1-\theta)(-\phi p_o)$. The total expected utility for online purchase under MBG becomes:

$$U_o = \theta(v - p_o) - (1-\theta)\phi p_o$$

(2) Offline store channel utility: When consumers purchase products directly from a physical store, they experience in-store inconvenience cost h_s, which includes product searching, in-store evaluation, and checkout time. This cost also varies and follows a uniform distribution $h_s \sim U[0,1]$. Because consumers can evaluate the product physically before purchasing, we assume that mismatches are negligible. Thus, utility from store purchases is:

$$U_s = \theta(v - p_s) - h_s$$

(3) BOPS channel utility: Under the BOPS channel, consumers place an order online and pick up the product at a physical store. This avoids both the delay in home delivery and the checkout effort in physical shopping. The inconvenience cost for BOPS is modelled as a weighted combination, where captures the reduced inconvenience of hybrid fulfilment. If MBG is not available, the expected utility is:

$$U_{bops}^{no-MBG} = \theta(v - p_o) - kh_s$$

With MBG, the consumer also faces potential return costs for unmatched products, so expected utility becomes:

$$U_{bops} = \theta(v - p_o) - (1-\theta)\phi p_o - kh_s$$

To compare consumer utilities across different shopping channels under varying policy settings, we summarize the expected utility expressions for each option in
Table **2**.

Table 2: Utility expressions for consumer choices with and without MBG

Channels	No money-back guarantee	Provide money-back guarantee
U_o	$\theta(v-p_o)$	$\theta(v-p_o)-(1-\theta)\phi p_o$
U_s	$\theta(v-p_s)-h_s$	$\theta(v-p_s)-h_s$
U_{bops}	$\theta(v-p_o)-kh_s$	$\theta(v-p_o)-(1-\theta)\phi p_o-kh_s$

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Based on the preceding analysis, we derive the product demand functions for the online channel, BOPS channel, and offline physical store channel under two scenarios: with and without a MBG. The demand expressions without MBG are given by equations (1) – (3), and those under MBG are expressed in equations (4) – (6).

$$\bar{Q}_o(p_o)=\frac{h_s k\left(h_s k+2\theta(1-k)p_o\right)}{2(1-k)^2} \tag{1}$$

$$\bar{Q}_b(p_o,p_s)=\frac{h_s k^2-\theta(1-k)(p_o-2+p_s)+\left(1-k^2\right)h_s}{2(1-k)^2 k} \tag{2}$$

$$\bar{Q}_s(p_o,p_s)=\frac{(\theta p_s-h_s)\left(\theta p_s+\theta p_o+(1-k)h_s\right)}{k} \tag{3}$$

$$\hat{Q}_o(p_o)=\frac{kh_s\left(kh_s-2(1-k)\left(\theta h_s+\left(\theta(-1+\phi)-\phi\right)p_o\right)\right)}{2(1-k)^2} \tag{4}$$

$$\hat{Q}_b(p_o,p_s)=\frac{\left(\theta p_s+\left(\theta+(1-\theta)\phi\right)p_o+h_s-kh_s\right)(1-k)-k^2 h_s}{k(1-k)^2} \tag{5}$$

$$\hat{Q}_s(p_o,p_s)=\frac{\left(\theta+(1-\theta)\phi\right)p_o-\theta p_s+k(1+h_s)-h_s}{k} \tag{6}$$

In the BOPS model, the offline retailer is responsible for inventory storage and providing in-store pickup services. To compensate for this role, the platform pays a fixed subsidy, denoted by λ, for each BOPS transaction. In addition, we assume that BOPS customers may generate incidental in-store purchases when visiting the physical store (Ge & Zhu, 2023). Let r represent the additional revenue obtained by the offline retailer from such consumer behaviors.

Based on the above model assumptions, the profit functions of the online and offline retailers can be formulated as follows:

$$\pi_o(w,p_o)=wQ_s+p_o(Q_o+Q_b)-\lambda Q_b \tag{7}$$

$$\pi_s(w,p_s)=(p_s-w)Q_s+(r+\lambda)Q_b \tag{8}$$

Result

Model analysis

This section presents the core analytical results of the proposed Stackelberg game model in the omnichannel retailing context. Building on the foundational assumptions and structural framework introduced earlier, we focus on how the presence or absence of a MBG policy affects the optimal pricing strategies of both online and offline retailers.

Model without a money-back guarantee

Proposition 1 *In the absence of a money-back guarantee, the unique Stackelberg equilibrium solution provides the optimal decision-making strategy.*

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The best wholesale price, retail price, and profit of online retailer (9)-(11):

$$\overline{w}^* = \frac{2h_s\theta - 2\lambda h_s - (1-k)\theta + h_s r}{2\theta^2} \tag{9}$$

$$\overline{p}_o^* = \frac{2h_s\theta(1-k) - 2kr\lambda - kh_s\theta\lambda}{2\theta^2} \tag{10}$$

$$\overline{\pi}_o^* = \frac{1}{4\theta^2(k-1)k}\begin{pmatrix} -3\lambda^2(k-1) + \lambda\left(-11k^2 + h_s\theta\left(17k - 11k^2 - 6\right) - 6kh_s + 3r + k\theta\left(11 + 2kh_s - 3r\right)\right) + \\ (1-k)\theta\begin{pmatrix} 6k^2 + 2h_s^2 k\theta(3k-5) - 2kh_s r - 3r + k\theta(5r - 4kh_s) + \\ h_s\theta\left(12k^2 + 4kh_s + k\theta(5r - 10 - 4kh_s)\right) \end{pmatrix} \end{pmatrix} \tag{11}$$

The optimal retail price and optimal profit of offline retailer (12)-(13):

$$\overline{p}_s^* = \frac{2h_s\theta(3-k) - \theta\left((r+\lambda)h_s + \lambda\right) - k(1+h_s)\theta}{4\theta^2} \tag{12}$$

$$\overline{\pi}_s^* = \frac{1}{16\theta^2 k(1-k)}\begin{pmatrix} 4\theta(\lambda + r)\left(\left(3\lambda + 6h_s\theta^2(-1+k) + 6k - 4kh_s + 3r\right)(1-k) - 4k^2h_s\theta\right) - \\ (1-k)\theta\left(3\lambda + 2h_s\theta(-3+k) + 2k + 3r\right)\left(5\lambda + 6k + 2h_s\theta(-7+3k) + 9r\right) \end{pmatrix} \tag{13}$$

Proposition 1 provides the equilibrium decisions of the online and offline retailers in the absence of a money-back guarantee. Analyzing the influence of the product matching rate between online retailers and offline retailers on the optimal decision, we can get the following inference.

Lemma 1. *Without a money-back guarantee, the optimal online retail price $\overline{p}_o^*$ and the offline retail price $\overline{p}_s^*$ both increase with the product matching rate θ. Moreover, the optimal wholesale price $\overline{w}^*$ set by the online retailer responds to the level of incremental offline spillover revenue r as follows:*

- *If $r \geq 2\lambda$, $\overline{w}^*$ increases with θ.*
- *If $r < 2\lambda$, $\overline{w}^*$ decreases with θ.*

Lemma 1 reveals that the product matching rate θ significantly influences both retail and wholesale pricing strategies in the absence of a money-back guarantee. As consumers become more confident that the product matches their expectations, both the online and offline retailers tend to adopt higher retail prices. This pricing response is more pronounced for the online retailer, who benefits from reduced return risks, thereby gaining more pricing power relative to the offline counterpart.

Furthermore, the wholesale price $\overline{w}^*$ set by the online retailer is closely tied to the additional in-store revenue r earned by the offline retailer. Since a portion of r stems from BOPS consumers making unplanned in-store purchases, a higher r implies that the offline retailer is more willing to purchase inventory through the BOPS channel. In such cases, the online retailer raises the wholesale price in tandem with increasing product matching rate θ. Conversely, when r is low, the online retailer strategically lowers the wholesale price, even if θ continues to rise, to incentivize offline participation.

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Model with a money-back guarantee

In the same way, using the reverse recursion method to solve the equilibrium of the above optimization problem, the solution first finds the retail price of the offline retailer, and then solves the wholesale price and retail price of the online retailer. The following conclusions can be obtained.

Proposition 2 *In the presence of a money-back guarantee, the unique Stackelberg equilibrium solution yields the following optimal decisions:*

The best wholesale price, retail price, and profit of online retailer (16)-(18):

$$\hat{w}^* = \frac{(1-\theta)\phi(h_s-(1-\theta)(\lambda+r)\phi)-k((1-\theta)\phi(3+h_s)-4\theta)}{(1-\theta)^2\phi^2} \tag{16}$$

$$\hat{p}_o^* = \frac{(1+h_s)k\phi-h_s(1-\theta)\phi-\theta(\lambda+r)-k\theta(\phi+h_s\phi-4)}{(1-\theta)^2\phi^2} \tag{17}$$

$$\hat{\pi}_o^*(w,p_o) = \frac{1}{(1-k)(1-\theta)^2\phi^2}\left(\begin{array}{l} (h_s-(1-\theta)\lambda\phi)(\theta-1)\phi+k^2r((\phi+h_s\phi-2r)\theta-(1+h_s)\phi)- \\ k\left(\begin{array}{l} (1+h_s)\theta^2\phi^2\lambda+(2h_s\phi+\phi-2(1+h_s)\phi^2\lambda-2r)\theta+ \\ ((1+h_s)\phi\lambda-2h_s-1)\phi \end{array}\right) \end{array}\right) \tag{18}$$

The optimal retail price and optimal profit of offline retailer (19)-(20):

$$\hat{p}_s^* = \frac{(4+h_s)k\phi-h_s(1-\theta)\phi\lambda-k\theta((4+h_s)\phi-4r)}{(1-\theta)^2\phi^2} \tag{19}$$

$$\hat{\pi}_s^*(p_s) = \frac{1}{(k-1)(1-\theta)^2\phi^2}\left(\begin{array}{l} k^2\theta-(1-\theta)^2(r+\lambda)\phi^2+ \\ k\left(\begin{array}{l} (1+h_s)(r+\lambda)\phi^2+(1+h_s)(r+\lambda)\theta^2\phi^2- \\ \theta(1+2\phi^2(1+h_s)(r+\lambda)) \end{array}\right) \end{array}\right) \tag{20}$$

Building upon the equilibrium decisions presented in
Proposition **2**, we further examine how variations in the product matching rate influence the strategic responses of online and offline retailers. This analysis yields the following lemma.

Lemma 2. *Under the money-back guarantee scenario, the optimal wholesale price* $\hat{w}^*$ *and online retail price* $\hat{p}_o^*$ *both increase with the product matching rate* θ*. Similarly, the optimal offline retail price* $\hat{p}_s^*$ *also increases as* θ *rises.*

Lemma 2 highlights the pricing response of both online and offline retailers under a MBG policy when the product matching rate improves. As consumers are more likely to receive products that meet their expectations (i.e., higher matching rate θ implies lower return rate), online retailers can strategically increase both the wholesale $\hat{w}^*$ and retail prices $\hat{p}_o^*$. This pricing adjustment allows them to capture additional margin while reducing the potential costs associated with returns, thereby improving overall profitability. Similarly, for offline retailers, an increase in the product matching rate θ enhances consumers' confidence in in-store purchases, leading to higher conversion rates and increased demand. Consequently, offline retailers are incentivized to raise retail prices and expand their order quantities, ultimately boosting sales and profits. These findings suggest that improving product-consumer fit, especially under an MBG setting, can serve as a powerful lever to strengthen pricing power and supply chain coordination.

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Comparative pricing analysis under MBG vs. Non-MBG

The following mainly compares the best wholesale price and retail price of online retailers with or without refund guarantee, and the best retail price of offline retailers to analyze the impact of product matching rate on the optimal pricing strategy of both parties in the supply chain.

Lemma 3. *The influence of the money-back guarantee on online retailers' pricing strategy is jointly determined by the product matching rate (θ) and the offline shopping inconvenience cost (h_s). The comparative results are as follows:*

- *if* $\theta \le \tilde{\theta}_1$ *and* $h_s \le \breve{h}_s$, $\overline{w}^* \ge \hat{w}^*$*; otherwise* $\overline{w}^* < \hat{w}^*$
- *if* $\theta \le \tilde{\theta}_2$, $\overline{p}_o^* \le \hat{p}_o^*$*; otherwise* $\overline{p}_o^* > \hat{p}_o^*$

$$\theta_1 = \frac{2\lambda + \sqrt{4\lambda^2 - 4(4\lambda + 4r)(-1 + 2\lambda h_s + k + h_s r)}}{8(\lambda + r)}, \quad \breve{h}_s = \frac{1-k}{2\lambda + r}$$

$$\theta_2 = \frac{\phi^2 \lambda k A}{3A} - \frac{2^{1/3}\left(6\phi^2\lambda k - \phi^4\lambda^2 k^2\right)}{3A} + \frac{A}{32^{1/3}},$$

$$A = \left(27\phi^2\lambda k - 18\phi^4\lambda^2 k^2 + 2\phi^6\lambda^3 k^3 + 3\sqrt{3}\sqrt{27\phi^4\lambda^2 k^2 - 4\phi^6\lambda^3 k^3}\right)^{1/3}$$

Lemma 3 reveals that the optimal wholesale price set by the online retailer is jointly influenced by the product matching rate and the offline channel's trouble cost, whereas the optimal retail price is solely determined by the product matching rate. Specifically, when the product-matching rate is low, and the trouble cost in the offline channel is also low, consumers tend to favour offline purchases. This shifts market power toward the offline retailer, placing the online retailer at a disadvantage. To counter this, under a MBG policy, the online retailer may raise the wholesale price to curb the offline retailer's market-share expansion. At the same time, a low product-matching rate under MBG implies a higher return risk for the online retailer. In response, the retailer strategically lowers the wholesale price to encourage more consumers to purchase through the BOPS channel, thereby transferring potential return risks to offline fulfilment and mitigating refund losses. As for retail pricing decisions, when product matching is poor, the online retailer adopts a low-price strategy under non-MBG conditions to attract demand. However, under MBG, the retailer must contend with potential return losses. To compensate, a high-price strategy is adopted, allowing the online retailer to absorb the cost of returns while maintaining profitability.

Lemma 4. *The impact of money-back guarantee on the optimal pricing strategy of offline retailer is as follows: if* $\theta \le \overleftrightarrow{\theta}$ *and,* $h_s \le h_s$; $\overline{p}_s^* \ge \hat{p}_s^*$ *otherwise* $\overline{p}_s^* < \hat{p}_s^*$.

$$\overleftrightarrow{\theta} = \frac{B - 4\phi\sqrt{(1-h_s)(\lambda kr + k^2 r) - 6h_s kr - h_s kr^2}}{B}, \quad h_s = \frac{\lambda + k}{6 + \lambda + k + r}$$

$$B = \phi^2\lambda + 6\phi^2 h_s + \phi^2\lambda h_s + \phi^2 k + 3\phi^2 h_s k + \phi^2 h_s r$$

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Lemma 4 indicates that when both the product matching rate and the offline trouble cost are low, offline retailers are more likely to adopt high-pricing strategies in the absence of a money-back guarantee. Under such circumstances, online retailers also tend to set high wholesale prices to protect their margins. In response, offline retailers raise prices to offset rising procurement costs and mitigate potential losses. This high-pricing strategy by offline retailers is not only driven by the wholesale price set by the online retailer, but also influenced by channel demand transfer. Specifically, some consumers who originally intended to shop online switch to the BOPS channel. This shift intensifies offline retailers' pricing power, reinforcing their preference for a premium pricing approach in low-uncertainty, low-in-store-convenience environments.

A comprehensive analysis of Lemmas 3 and 4 reveals that online retailers tend to adopt high-price strategies when implementing a MBG, whereas offline retailers are more inclined to lower retail prices. This pattern arises because the presence of MBG effectively alleviates consumers' concerns about product quality, thereby increasing their confidence in purchasing through both online and BOPS channels. As a result, the demand flowing through these channels expands, enabling online retailers to raise retail prices to capture greater profits. Conversely, the adoption of an MBG policy by online retailers can divert demand away from the offline channel, negatively impacting offline retailers. In response, offline retailers are compelled to reduce retail prices to retain customers and remain competitive. This finding suggests that implementing a money-back guarantee under the omnichannel BOPS model does not necessarily mitigate channel conflict; in fact, it may exacerbate tensions between online and offline channels due to asymmetric pricing incentives and demand redistribution.

Numerical experiments

To gain further managerial insights and validate the theoretical findings, this section conducts numerical experiments based on the proposed Stackelberg game model. The analysis examines how product matching rate, offline inconvenience cost, MBG implementation, and platform subsidy affect pricing strategies, profit outcomes, and channel profit coordination. Unless otherwise specified, the parameter settings are as follows: $\theta \in (0,\ 1)$, $r = 0.4$, $\phi = 0.2$, $\lambda = 0.2$, $k = 0.3$ (Tang et al., 2024). The low inconvenience cost level is set as $h_s = 0.3$, and the high level as $h_s = 0.7$ (Gao & Su, 2016). Through comparative analysis across different scenarios, we aim to reveal the dynamic effects of MBG on dual-channel coordination under the BOPS system.

Impact of product matching rate on pricing strategies

This section numerically examines how the product-matching rate θ, representing the probability that a product meets consumer expectations, affects pricing strategies across different channels. Specifically, we validate the theoretical conclusions from
Lemma 1 and
Lemma 2 by separately analysing retail and wholesale pricing under both non-MBG and MBG conditions.

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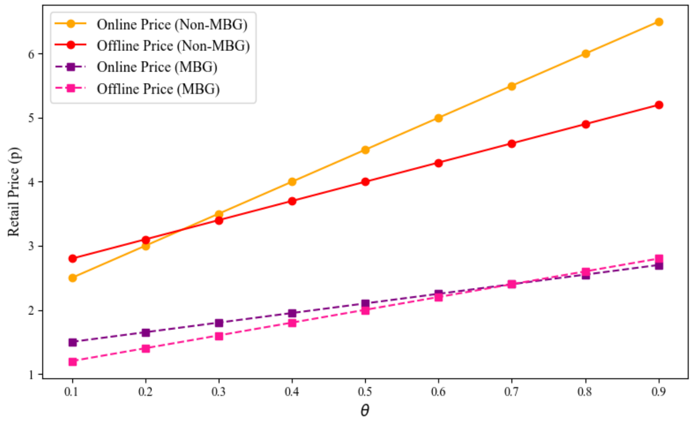

Figure 2. Impact of product matching rate on retail prices
Source: Authors' own

Figure shows that both online and offline retail prices increase with the product matching rate. The results clearly show that both prices increase monotonically with θ. In the non-MBG condition, online retailers significantly increase p_o as θ rises, reflecting reduced product return risk and improved pricing power. Offline prices p_s also rise, though less sharply, as the improved product fit increases consumer satisfaction and reduces purchasing hesitation. In the MBG setting, despite potential return obligations, both retailers still raise prices as θ increases due to reduced refund losses.

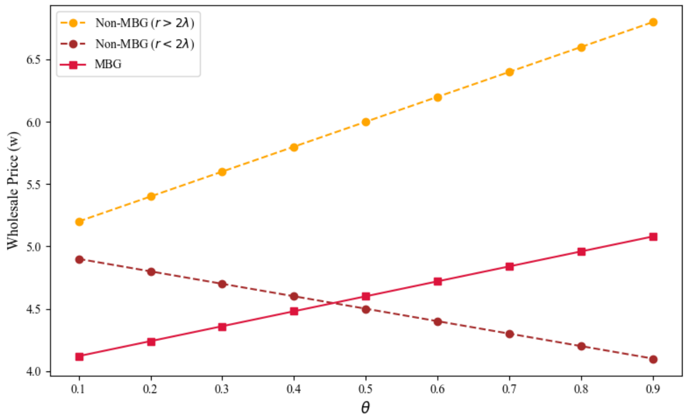

Figure 3. Impact of matching rate (θ) on wholesale price (w)
Source: Authors' own

Figure presents the impact of θ on the wholesale price w set by the online retailer. The wholesale price also responds to changes in the product matching rate. Without MBG, its movement depends on the additional in-store revenue obtained by the offline retailer. When such revenue is high, the online retailer has stronger incentives to raise the wholesale price. When it is low, the online retailer may reduce the wholesale price to encourage offline participation. Under MBG, the wholesale price increases more consistently because improved product matching reduces return-related losses and enhances pricing confidence.

These findings validate the pricing behavior predicted by
Lemma 1 and

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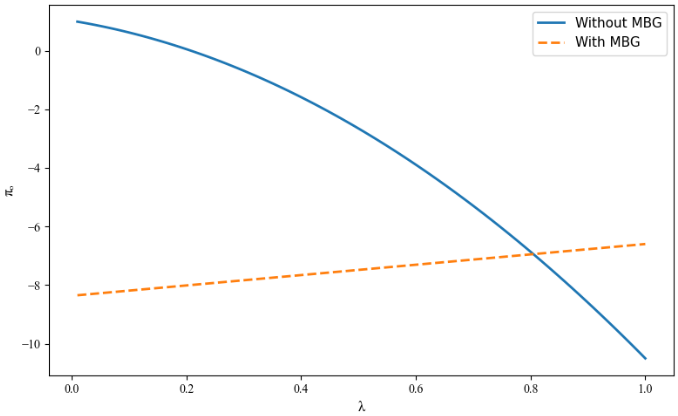
Lemma 2, respectively. Improvements in product fit not only reduce consumer uncertainty but also provide retailers with pricing leverage across channels. Furthermore, comparing MBG and non-MBG settings reveals that refund policies moderate channel pricing dynamics and influence coordination strategies in omnichannel environments.

Comparative analysis of platform subsidy under MBG and Non-MBG policies

To evaluate the coordinating role of platform subsidies in decentralized BOPS systems, this section investigates how variations in the per-order subsidy affect the profit outcomes of online and offline retailers under different refund policy regimes. In particular, we compare profit trajectories with and without a MBG, focusing on how λ redistributes channel earnings and mitigates profit asymmetry caused by MBG-induced demand shifts. The total system profit is also analyzed to assess whether subsidy adjustments improve efficiency or merely redistribute value across channels.

To isolate the impact of the platform subsidy on channel profitability, we maintain consistency with the benchmark parameter settings used in previous sections. The product matching rate is fixed at a relatively high level, $\theta = 0.75$. The subsidy level varies from 0 to 1 in increments of 0.1. Two policy regimes are considered: one with an active MBG, and one without. Under each regime, we compute and compare the online retailer's profit, the offline retailer's profit, and the total system profit across different levels of λ.

Figure illustrates the impact of platform subsidy λ on online profit, offline profit, and total system profit, under two contrasting policy regimes: with and without a MBG. As seen in panel (a), the online retailer's profit gradually decreases as λ increases, particularly under the no-MBG scenario where the subsidy primarily represents a loss of margin. In contrast, under MBG, the profit level is lower overall due to return-related risks, but the marginal decline is milder, suggesting that subsidy redistribution or demand balancing mechanisms may buffer the impact. Panel (b) reveals that without MBG, the offline retailer's profit remains flat and low, indicating weak responsiveness to subsidies alone. However, when MBG is in place, π_s increases steadily with λ, underscoring the critical role of subsidies in sustaining offline channel engagement under heightened return expectations. Finally, panel (c) shows that total system profit deteriorates with increasing λ in the absence of MBG, reflecting inefficient redistribution without incentive alignment. By contrast, MBG transforms subsidy into a coordination lever that enhances both channel profitability and system efficiency. Together, the three panels highlight that MBG and platform subsidies function best as complementary tools, rather than substitutes, in achieving omnichannel profit alignment.



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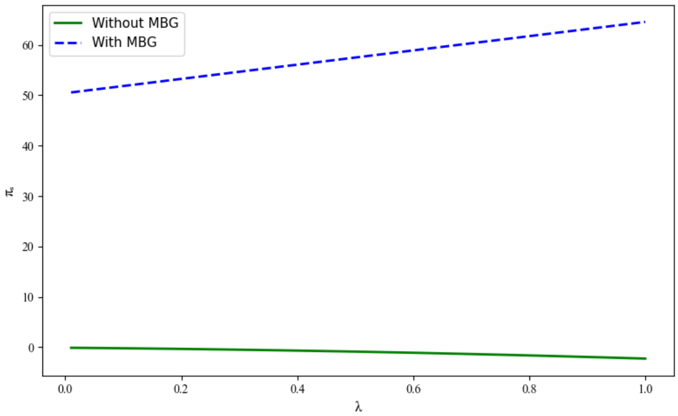
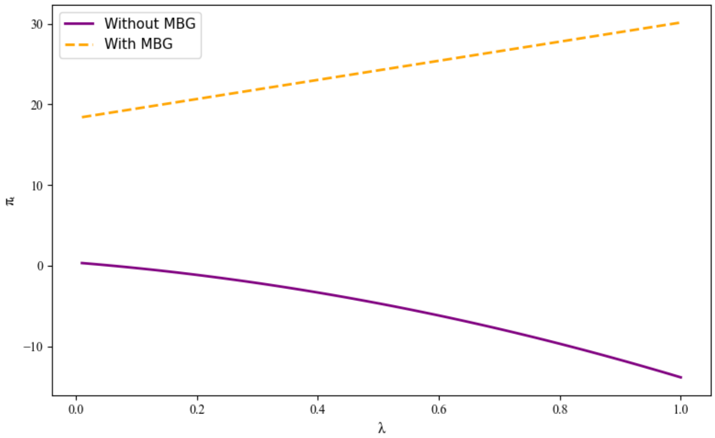
(a) Impact of λ on online retailer profit



(b) Impact of λ on offline retailer profit



(c) Impact of λ on total profit

Figure 4: Impact of λ on profit

Source: Authors' own

These findings suggest that platform subsidies alone are insufficient to drive channel coordination or profitability; it is the combination with refund guarantees that unlocks their full strategic value. To maximise omnichannel performance, platforms should treat subsidies and return policies as jointly designed instruments rather than isolated levers.

Discussion

Theoretical Contributions

This study contributes to the literature on omnichannel operations and behavioural game theory by integrating MBG policies and behavioural parameters into a unified Stackelberg framework. Unlike prior studies that often examine refund guarantees or behavioural factors separately, this study jointly models product matching rate and offline inconvenience cost to capture consumers' cognitive and experiential responses in BOPS environments. This behaviourally enriched model extends existing game-theoretic research by linking consumer uncertainty, channel-related effort, and strategic pricing coordination under decentralised decision-making. In addition, by incorporating a platform-mediated subsidy mechanism, the study connects

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refund policy design with channel coordination and profit allocation in dual-channel retail systems.

Managerial Illustration and Practical Relevance

The findings provide practical implications for omnichannel retailers such as JD.com, Walmart, and Best Buy, where MBG and platform subsidies are often used to balance channel incentives. The numerical experiments suggest that MBG policies are most effective when consumers face moderate product uncertainty. Under this condition, MBG acts as a credibility signal that increases consumer confidence and enhances online profitability without creating excessive return-related costs. However, when consumers already have high confidence in product fit or when offline inconvenience costs are high, the marginal value of MBG declines.

For example, in a JD.com BOPS context, applying MBG to standardised, high-certainty products such as electronics may mainly shift demand from offline to online channels without generating substantial new demand, thereby compressing the offline retailer's margin. In contrast, for categories with moderate fit uncertainty, such as apparel or home goods, MBG can more effectively stimulate demand and improve channel performance. Therefore, MBG should not be applied uniformly across all product categories; instead, retailers should target product types and consumer segments where its trust-enhancing value exceeds its return-related cost.
From a coordination perspective, refund guarantees and platform subsidies should be treated as complementary mechanisms. Platform subsidies alone may be insufficient to rebalance channel profits, but when combined with MBG, they can help compensate offline retailers for BOPS fulfilment and reduce profit asymmetry. Retailers and platforms may therefore consider adaptive subsidy schemes based on return rates, fulfilment volume, and channel performance. Meanwhile, offline retailers can reposition themselves as service- or experience-oriented nodes by offering fitting services, instant exchange, or post-purchase support, thereby mitigating the profit compression caused by MBG-induced demand shifts.

Consumer Heterogeneity

Although the model assumes a representative consumer for analytical tractability, real consumers differ in risk tolerance, trust, and sensitivity to offline inconvenience. These differences may influence how consumers respond to MBG policies and BOPS fulfilment options. Consumers with higher risk aversion are more likely to value MBG and shift toward online or BOPS channels, whereas consumers with lower risk aversion may rely more on direct offline inspection and remain less sensitive to refund guarantees.

This implies that retailers should consider differentiated MBG strategies rather than adopting a single refund policy for all consumers. For example, personalised MBG arrangements, loyalty-based guarantees, partial refunds, or AI-driven product recommendations could be used to match refund policies with consumer preferences and product characteristics. Incorporating such heterogeneity into future modelling or empirical validation would further improve the practical applicability of refund-based coordination strategies.

Limitations and Future Research

Several limitations should be acknowledged. First, the model adopts static assumptions regarding consumer parameters and pricing decisions. Future studies could extend the framework to dynamic settings in which refund expectations, consumer trust, and risk perceptions evolve over time. Second, empirical validation is needed to confirm the behavioural

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mechanisms proposed in this study. Case-based evidence or survey data from actual BOPS implementations, such as JD.com or Walmart, could provide additional support for the theoretical findings.

Future research could also examine AI-driven personalisation or dynamic refund mechanisms that adjust refund levels according to consumer profiles, purchase histories, or product categories. In addition, extending the model to cross-border BOPS systems, competitive platforms, contract-based coordination, or multi-product settings would broaden the applicability of the framework and provide deeper insights into refund-driven omnichannel management.

Conclusion

This study investigates pricing strategies and profit allocation in a decentralised BOPS system by developing a Stackelberg game model involving an online retailer and an offline retailer. The model incorporates two behavioural parameters, product matching rate and offline inconvenience cost, to capture consumers' product-fit uncertainty and channel-related effort. It further examines how MBG policies affect equilibrium pricing decisions and how platform subsidies can support profit coordination between online and offline channels.

The results show that a higher product matching rate generally strengthens the pricing power of both online and offline retailers. Under MBG, the online retailer can benefit from increased consumer confidence, particularly when product matching uncertainty is moderate. In this situation, MBG serves as a trust-enhancing mechanism that stimulates online and BOPS demand. However, as consumers become more confident in product fit, the marginal value of MBG declines, suggesting that a universal MBG policy may not always be cost-efficient.

The findings also reveal that MBG can create asymmetric effects across channels. While the online retailer may gain from increased demand and stronger pricing power, the offline retailer may experience profit compression as demand shifts toward online and BOPS channels. This indicates that MBG does not automatically reduce channel conflict; rather, it may intensify profit imbalance if not supported by appropriate coordination mechanisms. The platform subsidy plays an important role in this regard. Although subsidies alone have limited coordination effects, their combination with MBG can help rebalance profit allocation and sustain offline retailer participation in BOPS fulfilment.

Overall, this study enriches the theoretical understanding of how refund policies interact with pricing decisions in decentralised omnichannel retailing. From a managerial perspective, MBG should be implemented selectively according to product uncertainty, consumer characteristics, and offline inconvenience costs. Retailers should also design flexible incentive mechanisms, such as fulfilment subsidies, profit-sharing arrangements, or differentiated commission structures, to reduce profit imbalance across channels. Offline stores can further strengthen their strategic role by shifting from purely transactional spaces to service- and experience-oriented fulfilment nodes.

Despite its theoretical contribution, this study adopts simplified assumptions regarding consumer behaviour and channel relationships. Future research may introduce dynamic consumer preferences, adaptive refund behaviour, empirical data, or competitive platform

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settings to improve model realism and broaden the strategic implications of refund-based BOPS coordination.

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