frontiers | Frontiers in Sustainable Food Systems

TYPE Original Research
PUBLISHED 25 September 2024
DOI 10.3389/fsufs.2024.1439105

OPEN ACCESS

EDITED BY
Wenbo Li,
Jiangsu Normal University, China

REVIEWED BY
Wenbin Wang,
China University of Mining and Technology, China
Christian Bux,
University of Foggia, Italy

*CORRESPONDENCE
Shiqi Xu
✉ shiqixubiz@163.com

RECEIVED 27 May 2024
ACCEPTED 09 September 2024
PUBLISHED 25 September 2024

CITATION
Xu G, Tang Y and Xu S (2024) Promotion strategies of food delivery O2O supply chain with anti-food waste regulation.
Front. Sustain. Food Syst. 8:1439105.
doi: 10.3389/fsufs.2024.1439105

Promotion strategies of food delivery O2O supply chain with anti-food waste regulation

Guangye Xu[1], Yan Tang[1] and Shiqi Xu[2]*

[1]School of Management, Nanjing University of Posts and Telecommunications, Nanjing, China, [2]College of Modern Logistics, Guangzhou Panyu Polytechnic, Guangzhou, China

This paper connects food waste with food delivery service and aims to explore the impacts of the anti-food waste regulation on food waste generation and the selection of promotion strategy in an Online-to-Offline (O2O) supply chain. Using a game-theoretical approach, we focus on three prominent promotion strategies—a no-promotion strategy (*N* strategy), a price discount strategy (*D* strategy), or a volume-based price discount strategy (*S* strategy). Our research results indicate that the restaurant's choice of promotion strategy is almost independent of the intensity of anti-food waste penalties. However, the optimal strategy of the platform and the amount of waste are influenced by it. Under certain conditions, restaurants and platforms were able to achieve a win-win situation through promotion strategies. In the case of the relaxation of anti-food waste regulations, both restaurants and platforms tend to adopt the *D* strategy. In contrast, when penalties are stronger, platforms may be forced to accept *D* or *S* strategy because of the proactive behaviors of restaurants, even if they would prefer not to adopt promotion strategies. Overall, the government should consider bringing restaurants under regulation to protect platform revenue and effectively reduce food waste.

KEYWORDS

food waste, O2O supply chain, food delivery, promotion strategies, anti-food waste regulation

1 Introduction

In recent years, the global online food delivery market has expanded swiftly as consumer demand for dining convenience has surged, spawning a multitude of online food delivery services (Habib et al., 2022). Online-to-Offline (O2O) food delivery services represent a novel approach to ordering food online and receiving it offline within the restaurant. This model marks a significant shift in the era of "Internet Plus" and constitutes a key area within e-commerce (Cheong and Law, 2022; Du et al., 2021; Roh and Park, 2019). The ubiquity of smartphone applications and online payment systems has facilitated convenient food ordering and payment for users across various locations and at any time (Hultman et al., 2011; Kaur et al., 2021). The adoption of advanced technology has broadened the user base and operations of food delivery services (Gajdzik et al., 2023; Ali-Alsaadi et al., 2023; Dörnyei et al., 2023). Nonetheless, this burgeoning growth has been accompanied by a distressing increase in food waste (Trivedi et al., 2023). According to the Food and Agriculture Organization of the United Nations (FAO), approximately one-third of the world's food produced for human consumption is lost or wasted, amounting to around 1.3 billion tons of food (Akkaş and Gaur, 2022).

The global situation of food loss and waste is currently a complex issue (Na et al., 2022). This problem directly impacts global hunger and sustainability in the 21st century (FAO, 2020). In 2017, the United Nations set a sustainability goal to halve global *per capita* food waste at the retail and consumer levels by 2030. However, food waste and loss are not limited to developing countries; it has become a global concern. In addition to the food itself, this issue results in the wastage of resources such as water, land, energy, labor, and capital, which severely undermines economic and environmental sustainability (FAO, 2020). The abundance of material goods in society contributes to the significant amount of waste. Supermarkets, for example, incur costs to dispose of and destroy unsold food nearing expiration. In some cases, surplus produce is discarded, and even milk and butter have been dumped into the sea by the European Union. This highlights the extent of the problem and the need for effective measures to reduce food loss and waste. In the European Union (EU), it is estimated that more than 84 million tons (Mt) of food waste was generated in 2018 from agricultural production to final consumption, which represents approx.—13% of the food produced in the European boundaries. Specifically, 56–80% of the entire amount is generated at the household and food service levels, which means 47 to 67 Mt (Bux et al., 2023). The first survey in Southern Italy to evaluate attitudes on food waste in the hospitality sector, responsible for a third of the region's waste, revealed an average sustainability score of 84 for hotel managers' awareness of sustainable practices and recycling in Apulia. However, their score on attitudes towards food waste management strategies was only 65. The study found a positive correlation between hotel star rating and sustainability awareness, but a negative one with the number of rooms and attitudes towards waste management. It identified the foods most frequently wasted and emphasized the need for improved circularity and sustainability in the hotel industry (Lagioia et al., 2024). As a result, regulators are increasingly focusing on reducing food waste and many countries are implementing regulations against food waste (Szulecka and Strøm-Andersen, 2022).

According to data released by the China Internet Network Information Center (CNNIC), as of December 2022, the number of online food delivery users in China had reached 521 million. Food delivery platforms, such as "Ele. me" and "Mei tuan," continue to see a steady influx of new outlets every day, as well as a certain number of outlets shutting down, which intensifies competition in the restaurant market (Han et al.). Many restaurants turn to promotion strategies, such as price discounts and quantity discounts, to thrive in this competitive environment (Duan and Li, 2021; Zhang et al., 2022; Igarová et al., 2023). Therefore, restaurants must carefully select promotion strategies that are more tailored to their specific circumstances (Xie and Bing, 2022; Lee and Charles, 2021). Simultaneously, there has been growing interest in the factors influencing the choice of promotion strategies and how different promotion strategies impact the optimal decision-making of distribution supply chain members (Kumawat and Barker, 2023; Xu et al., 2021).

In terms of anti-food waste, the existing literature mainly examines the impact of anti-food waste regulations on the restaurant as a whole (Feng et al., 2022). Nevertheless, the lack of focus on the rapidly emerging online food delivery market is a gap, which does not take into account the link between online food delivery and food waste. The absence of relevant studies in the academic sector has led to difficulties in government regulation, resulting in a growing problem of wastage in the industry. The problem of waste in this industry is increasing day by day. Some scholars have also begun to pay attention to the food waste phenomenon in the process of online food delivery services and explore the reasons behind it, the factors considered mainly include food quality, delivery time, the amount of ordered meals, etc. Meanwhile, the O2O model studied in this paper requires us to develop a dual-channel environment for online food delivery that considers anti-food waste regulation and addresses the following key issues:

1 What is the impact of anti-food waste regulation on food waste in the O2O food delivery supply chain?
2 How will anti-food waste regulation affect the decision-making of members of the O2O food delivery supply chain?
3 How will the anti-food waste regulation change the choice of promotion strategies of restaurants and online food delivery platforms?

In this paper, we consider three strategies: no promotion strategy (*N* strategy), price-discount promotion strategy (*D* strategy), and volume-based price discount strategy (*S* strategy). Meanwhile, how anti-food waste regulations affect restaurants' and platforms' choices of promotion strategies is examined, as well as their impact on food waste. We offer new insights into the contextual factors influencing promotion strategies, including the strength of anti-food waste penalties, the commission percentage, and offline dining costs. Additionally, we explore the mechanisms of how anti-food waste regulations interact with promotion strategies within the O2O food delivery supply chain, thereby filling a gap in this research. It also provides recommendations for government regulators to formulate regulatory strategies to help companies collaborate with regulators to reduce food waste and ensure economic sustainability and operational efficiency.

The rest of the paper is structured as follows. In Section 2, a literature review of the Anti-food waste regulation, O2O supply chain and promotion strategies. Section 3 gives the problem description and hypotheses of the paper, as well as solves the optimal solution under various strategies. Section 4 uses numerical examples to further investigate related issues that cannot be analyzed comparatively due to the complexity of the model and Section 6 is the concludes. The proofs of the paper are in the Supplementary material.

2 Literature review

This paper considers three core research topics, such as anti-food waste regulation, O2O (online-to-offline) supply chain management and promotion strategies. This section will delve into the relevant research literature to better understand the interdependencies and differences between this paper and the existing literature.

2.1 Anti-food waste regulation

Food waste is becoming a growing concern for governments and societies, not only in terms of the food crisis for people globally, but also in relation to economic development, environmental

sustainability and social equity (De Steur et al., 2016; Mithun Ali et al., 2019; Dumitru et al., 2021; Krishnan et al., 2022). The existing literature provides a systematic account of food waste avoidance and the adoption of appropriate regulatory mechanisms by the regulators (Mesiranta et al., 2022; Teng et al., 2021; Steenmans and Malcolm, 2023).

Corrado and Sala (2018) argue that food waste is also an inefficiency within the food supply chain. In a study by Govindan (2018), it was noted that food waste could be reduced by 23% through more effective food supply chain management methods. Kourmentza et al. (2018) reveal that reducing food waste is increasingly seen as central to food supply chain management. As explored by Göbel et al. (2015), government regulations are a key method of reducing food waste along the supply chain. Enforcing penalties for food waste through the enforcement of regulations can help reduce the incidence of food waste. The French government has been effective in improving waste control by enforcing penalties on supermarkets for discarding edible food (Cane and Parra, 2020). Government regulations have a significant impact on firms in the supply chain. Parfitt et al. (2010) criticized such regulations, arguing that they create invisible economic pressures while encouraging firms to comply, with small firms being the most strongly affected. In addition, the imposition of regulatory compliance is often combined with incentives and penalties to constrain firms to take measures to avoid waste, while providing motivation for firms to focus on waste management (Thi et al., 2015; Chalak et al., 2016). Walia and Sanders (2019) illustrate how companies, in response to government regulations, have primarily focused on increased research funding aimed at waste reduction. They also report greater incentives for the research and development of technologies and strategies that minimize waste, including the practice of donating food that would otherwise be discarded, which can be used to offset corporate taxes.

Contrast to the aforementioned anti-food waste studies, which typically focus on the impact of regulatory compliance on both consumers and producers, this paper explores how these regulatory policies affect restaurants' choices of promotion strategies in the online food delivery industry. We focus on the impact of the strength of anti-food waste penalties on different promotion strategies in the O2O food supply chain, revealing how these regulations affect restaurants' and platforms' choice of promotion strategies and optimization decisions. In addition, while existing studies typically examine anti-food waste regulations in multiple domains, this study targets specific areas of the food delivery O2O supply chain. This targeted research approach provides more direct and applicable insights into food waste issues in this emerging industry.

2.2 O2O supply chain management

With the development of the Internet era, domestic and foreign scholars have focused on the research of the O2O supply chain. Gu et al. (2023) aimed to develop a theoretical model to explore how the anticipated regret affects pricing and advertising decisions and profits of retailers in the online-to-offline (O2O) supply chain. Narang and Shankar (2019) primarily concentrate on the parallels and distinctions among retailers utilizing mobile app platforms for both online and offline sales and returns. He et al. (2019) addressed the issue concerning the sale of fresh agricultural products in both online and offline markets while examining the optimal decisions made by agricultural supply chain members. Gao and Su (2018) and Gao and Su (2017) conducted an analysis of the effective dissemination of product information by retailers in both online and offline channels. Additionally, they explored how consumers make choices regarding purchasing channels based on this information. Lin et al. (2022) emphasized the significance of establishing distribution centers as fundamental elements in food delivery systems. They aimed to investigate factors influencing the perception and acceptance of retail delivery systems among urban Chinese consumers. Gharehgozli et al. (2017) identified pivotal characteristics of the food supply chain and deliberated on emerging trends that will shape the future of food transportation. In contrast to these investigations, primarily centered around e-commerce platforms, this paper specifically concentrates on food delivery platforms and restaurants.

2.3 Promotion strategies

Promotion strategies have been incorporated into the food delivery supply chain to address intense market competition and mitigate the impact of queue congestion on the profits of supply chain members. Rosin et al. (2023) determine the healthiness of promoted versus non-promoted products, and quantify the effects of promotions on sales to examine the frequency of promotions on breakfast cereals and drinks. Cheng et al. (2023) explored three promotion scenarios: seller-led, platform-led, and leaderless-led, elucidating optimal strategies and decision-making patterns in these contexts through programmatic models and experiments. Chaudhary et al. (2022) addressed the challenge of determining the optimal promotion strategy for diffusion models within specific segmented markets. Feng et al. (2021) examined the exchange costs incurred by consumers during the search and utilization of coupons, gift cards, and other processes when the same product is offered by third-party sellers. They also investigated the impact of different financing models on the effectiveness of promotion strategies.

The preceding research investigates the selection of promotion strategies in diverse scenarios and examines their effects on ordering and pricing, without explicitly addressing food delivery platforms. In contrast, this study is centered on the choice of promotion strategies within the O2O food delivery supply chain, specifically focusing on the restaurants.

3 Materials and methods

3.1 Problem description and hypotheses

Consider an O2O food delivery supply chain system consisting of a food delivery platform providing online services and a restaurant providing online delivery and offline dining. In this O2O food delivery supply chain system, there will be three promotion strategies for online orders: no-promotion strategy (*N* strategy), a price discount strategy (*D* strategy), or a volume-based price discount strategy (*S* strategy). Under the *D* strategy, the restaurant will decide food prices for offline channels and the ratio of price discounts for online channels, and the platform does not make decisions and only charges a certain percentage of the service fee for the use of the online channel

by the restaurant. Under the *S* strategy, the platform first decides the food price for online orders, and then the restaurant decides the food price for offline channels (Table 1).

When delving into the degree of utility and price improvement β under an *S* strategy, several pivotal considerations must be taken into account. These encompass consumer behavior, market structure, the attributes of products and services, and the competitive landscape. β may fall short in encapsulating the full extent of utility and price improvement, as these parameters require tailoring to the specific market milieu and consumer behavior. Nevertheless, β can serve as a proxy for the intricate interplay of decision-making variables and market conditions. In practice, businesses typically rely on market research, consumer polling, and data analytics to ascertain the optimal settings for these parameters, ensuring the effectiveness of their strategies in bolstering utility and competitive standing. For the sake of analysis and without loss of generality, the following assumptions are further stated:

> *Hypothesis 1*: Since it is easy to dispose of excess food offline and the "clean plate campaign" has a significant impact on consumers' waste behavior, we only consider that food waste occurs in online ordering, and consider that the delivery platform should bear the responsibility of anti-food waste (Han et al., 2019; Zheng et al., 2023).

Hypothesis 2: The service cost of the delivery platform and the unit production cost of the restaurant are assumed to be 0, and the offline service crowding effect is considered, that is, the waiting cost of customers for offline is T (Eser et al., 2014; Luan and Corman, 2022).

Hypothesis 3: In order to ensure that the number of online and offline channel sales under no promotion strategy is positive, $\rho < \rho_1$ and $\eta_1 < \eta < 1$, where $\rho_1 = \frac{(1-\theta)V+T}{k}$, $\eta_1 = 2\frac{(1-\theta)k\rho + 2(1-\theta)^2 V - 2(1-\theta)T}{\theta\left(T-3(1-\theta)V-k\rho\right)}$.

Hypothesis 4: In order to ensure that the number of online and offline channel sales under D strategy is positive, $\delta < \theta$ and $\eta_2 < \eta < 1$, where $\eta_2 = \frac{\delta^2 - 2\delta\theta + \theta}{\delta(\delta-\theta)}$.

Hypothesis 5: In order to ensure that the number of online and offline channel sales under volume-based discount strategy is positive, $\Delta < \frac{3(1-\beta\theta)V - k\rho}{1-\beta}$, $T < 3V(1-\beta\theta) - (1-\beta)\Delta + k\rho$, $\eta_3 < \eta < 1$, where $\eta_3 = \frac{2k\rho(1-\beta\theta)}{\beta\theta\left(T+V(1-\beta\theta)+\Delta(1-\beta)-k\rho\right)}$.

Hypothesis 6: In order to ensure that the parameter settings under the volume-based price discount strategy are realistic, $1 < \beta < \frac{1}{\theta}$, $\mu < 1$, and $\beta\mu < 1$.

Hypothesis 7: Both restaurateurs and delivery platforms are rational in their decision-making, with their own profit maximization as the decision-making goal, and the choice of promotion strategies is determined by the restaurants.

TABLE 1 Summary of notations.

Parameters	
V	Total demand of market
η	Platform's commission rate
θ	delivery network adaptability
T	Cost of offline dining
δ	Price discount rate under the *D* strategy
μ	Degree of price concessions under the *S* strategy
β	Degree of utility and price improvement under the *S* strategy
Δ	Increased cost per unit of product under the *S* strategy
k	Unit penalty cost of food waste by government
ρ	Waste ratio of online meal units
Decision variables	
p_r	Food price of offline channel
p_o	Food price of online channel
Dependent variables	
d_r	Food sales quantity of offline channel
d_o	Food sales quantity of online channel
w^j	Amount of food waste under the *j* strategy, $j \in \{N,D,S\}$
π_r^j	Profit of the restaurant under the *j* strategy, $j \in \{N,D,S\}$
π_o^j	Profit of the platform under the *j* strategy, $j \in \{N,D,S\}$

According to the above, the sales quantity function of offline and online channels under the *N* strategy, *D* strategy and *S* strategy can be assumed as Equations 1–3:

$$d_o^N = \frac{T+p_r-p_o}{1-\theta} - \frac{p_o}{\theta},\ d_r^N = V - \frac{T+p_r-p_o}{1-\theta} \tag{1}$$

$$d_o^D = \frac{T+(1-\delta)p_r}{1-\theta} - \frac{\delta p_r}{\theta},\ d_r^D = V - \frac{T+(1-\delta)p_r}{1-\theta} \tag{2}$$

$$d_o^S = \frac{T+p_r-\beta\mu p_o}{1-\beta\theta} - \frac{\mu p_o}{\theta},\ d_r^S = V - \frac{T+p_r-\beta\mu p_o}{1-\beta\theta} \tag{3}$$

Thus, the amount of food waste in the online channels of the three strategies $j \in (N,D,S)$ can be obtained as Equation 4:

$$W^j = \rho d_o^j \tag{4}$$

Further, the profit function of restaurant and platform under the three strategies can be obtained as follows:

$$\pi_r^N = (1-\eta) p_o d_o^N + p_r d_r^N \tag{5}$$

$$\pi_o^N = \eta p_o d_o^N - k\rho d_o^N \tag{6}$$

$$\pi_r^D = (1-\eta)\delta p_r d_o^D + p_r d_r^D \tag{7}$$

$$\pi_o^D = \eta\delta p_r d_o^D - k\rho d_o^D \tag{8}$$

$$\pi_r^S = (1-\eta)\beta\mu p_o d_o^S + p_r d_r - (\beta-1)\Delta d_r^S \tag{9}$$

$$\pi_o^S = \beta\eta\mu d_o^S p_o - k\rho d_o^S \tag{10}$$

In Equations 5, 7, 9, the item is the profit of offline dining under the three strategies. In Equations 6, 8, 10, the item is the profit of the online delivery services under the three strategies. Using backward induction, we summarize the optimal decision results under the three strategies in Supplementary Table S1.

3.2 Model analysis

In this section, we first analyze the effects of anti-food waste regulation, cost of offline dining on optimization decisions under the three strategies. Then we compare and analyze the optimal decision results of the *N* strategy, *D* strategy, and *S* strategy.

3.2.1 The impact of anti-food waste regulation

Proposition 1. (i) $\frac{dp_r^{N*}}{dk} > 0$, $\frac{dp_o^{N*}}{dk} > 0$, and $\frac{dp_r^{N*}}{dk} < \frac{dp_o^{N*}}{dk}$. (ii) $\frac{\partial d_r^{N*}}{\partial k} > 0$, $\frac{\partial d_o^{N*}}{\partial k} < 0$, and $\frac{\partial d_r^{N*}}{\partial k} < \left|\frac{\partial d_o^{N*}}{\partial k}\right|$. (iii) $\frac{dW^{N*}}{dk} < 0$.

Proposition 1 suggests that the adoption of the *N* strategy results in increased food prices and sales volume in the offline channel, while concurrently reducing sales volume and food waste in the online channel. Furthermore, anti-food waste regulations exert a more pronounced impact on prices and sales volume in the online channel compared to the offline channel. Under the *N* strategy, these regulations necessitate platforms to proactively manage and curtail ordering volumes, which leads to a decrease in online sales volume and subsequent reduction in food waste within the online channel. With strict implementation of anti-food waste regulations, restaurants and platforms may elevate prices as a means to safeguard their profits, albeit with effective control over the amount of waste generated in the online channel.

Proposition 2. Under the *D* strategy, food prices and sales quantity of online and offline channels, online food waste and the restaurant's profits are not affected by the anti-food waste regulation, but the platform's profits will change with the strength of the anti-food waste regulation.

Proposition 2 indicates that under the *D* strategy, restaurants have the autonomy to set prices in the offline channel, with food delivery prices being adjusted accordingly. The optimization decisions made by restaurants are independent of the platform's obligations to enforce food waste regulations. With the *D* strategy, restaurants will not suffer from food wastage and will thus be able to adjust their business strategies flexibly according to their situation and changes in the environment to maximize profits. However, under the *D* strategy, the platform assumes the responsibility for food waste penalties, which directly impacts the platform's profitability. As the government's anti-food waste policy is further implemented, the fines faced by delivery platforms may escalate significantly. In response, platforms might opt to increase the commission rate for online services to offset the costs associated with anti-food waste measures. Nevertheless, under the *D* strategy, the government's directive for platforms to assume responsibility for waste prevention does not effectively reduce food waste in the online channel, rendering the anti-waste requirement essentially toothless. Consequently, for the price discount strategy, it is imperative for the government to not solely burden platforms with the responsibility for anti-food waste efforts but to include restaurants within the regulatory scope as well.

Proposition 3. (i) $\frac{dp_r^{S*}}{dk} > 0$, $\frac{dp_o^{S*}}{dk} > 0$, and $\frac{dp_r^{S*}}{dk} < \frac{dp_o^{S*}}{dk}$ (ii) $\frac{\partial d_r^{S*}}{\partial k} > 0$, $\frac{\partial d_o^{S*}}{\partial k} < 0$, and $\frac{\partial d_r^{S*}}{\partial k} < \left|\frac{\partial d_o^{S*}}{\partial k}\right|$. (iii) $\frac{dW^{S*}}{dk} < 0$.

Proposition 3 suggests that adoption of the *S* strategy leads to an increase in food prices and sales volume in the offline channel, while concurrently reducing sales volume and food waste in the online channel. The impact of anti-food waste regulations on prices and sales volume in the online channel is greater than that in the offline channel. Under the *S* strategy, these regulations necessitate platforms to moderate the intensity of price discount offers, which results in a decrease in online sales volume and a subsequent reduction in food waste within the online channel. With rigorous enforcement of anti-food waste regulations, restaurants and platforms may elevate prices to compensate for the costs associated with anti-food waste penalties.

3.2.2 The impact of cost of offline dinning

Proposition 4. (i) $\frac{dp_r^{N*}}{dT} < 0$, $\frac{dp_o^{N*}}{dT} > 0$, $\left|\frac{dp_r^{N*}}{dT}\right| < \frac{dp_o^{N*}}{dT}$. (ii) $\frac{\partial d_r^{N*}}{\partial T} < 0$, $\frac{\partial d_o^{N*}}{\partial T} > 0$, and $\left|\frac{\partial d_r^{N*}}{\partial T}\right| > \frac{\partial d_o^{N*}}{\partial T}$. (iii) $\frac{dW^{N*}}{dT} > 0$.

Proposition 5. (i) $\frac{dp_r^{D*}}{dT} < 0$. (ii) $\frac{\partial d_r^{D*}}{\partial T} > 0$, $\frac{\partial d_o^{D*}}{\partial T} > 0$, and $\frac{\partial d_r^{D*}}{\partial T} > \frac{\partial d_o^{D*}}{\partial T}$. (iii) $\frac{dW^{D*}}{dT} > 0$.

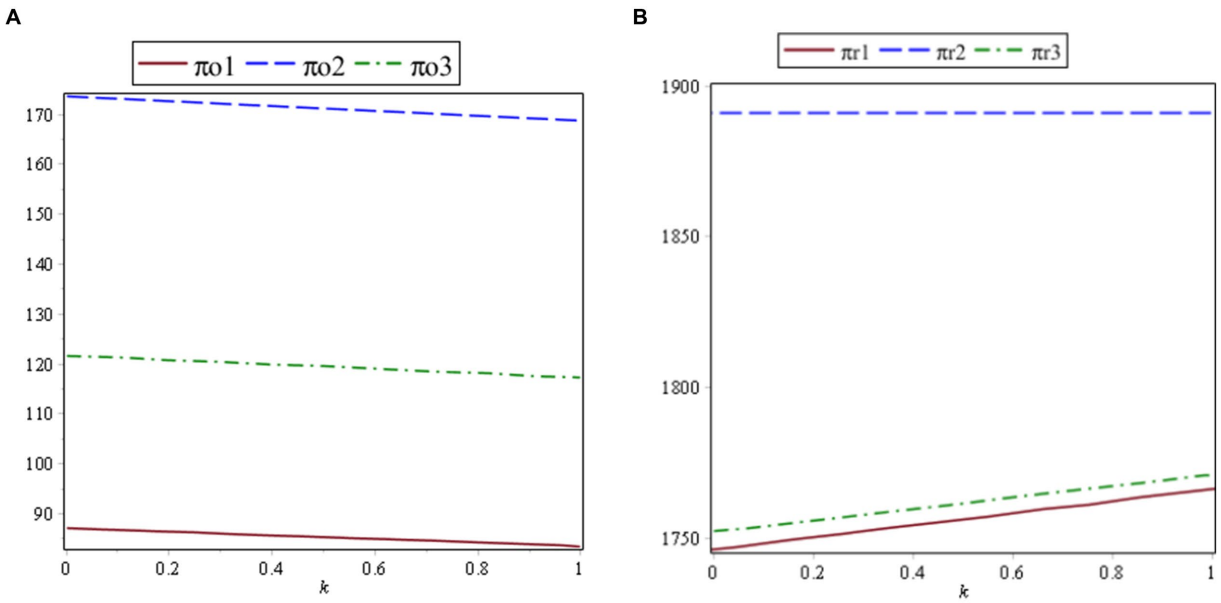

FIGURE 1
The impact of k on the profit for the platform and restaurant. **(A)** Profit of the platform. **(B)** Profit of the restaurant.

Proposition 6. (i) $\frac{dp_r^{S*}}{dT} < 0$, $\frac{dp_o^{S*}}{dT} > 0$, $\left|\frac{dp_r^{S*}}{dT}\right| < \frac{dp_o^{S*}}{dT}$. (ii) $\frac{\partial d_r^{S*}}{\partial \mathrm{T}} < 0$, $\frac{\partial d_o^{S*}}{\partial \mathrm{T}} > 0$, and $\left|\frac{\partial d_r^{S*}}{\partial T}\right| > \frac{\partial d_o^{S*}}{\partial T}$. (iii) $\frac{dW^{S*}}{dT} > 0$.

Propositions 4–6 indicate that under all three strategies, the cost of offline dining decreases offline prices and demand, while concurrently increasing online prices and demand, as well as the amount of food wasted (with the *D* strategy having no impact on online prices). The cost of offline dining has a more significant impact on prices and demand in the online channel than in the offline channel. This suggests that when the cost of offline dining is changed, the online channel reacts more substantially, and the platform attracts more consumer choices, potentially increasing online prices to improve profitability.

Under these three strategies, the cost of dining increases for consumers, which tends to drive them towards choosing the online channel, resulting in a decrease in sales in the offline channel. In response, restaurants may reduce offline prices to retain customers. However, the increased demand for online channels can lead to an increase in food waste. To mitigate this issue, the government should implement anti-food waste regulatory measures.

4 Results

Considering the complexity of the model, the previous section did not examine the effect of the unit penalty cost of food waste by government k and the cost of offline dining T on the online and offline profits, the specific results are shown in Figures 1, 2. In view of this, in this section, the choice of promotion strategies for restaurants and platforms will be analyzed by numerical simulation. Key parameters selected in this section include the unit penalty cost of food waste by government k, the commission percentage η and the cost of offline dining T. The specific results are shown in Figures 3, 4. Other parameters are assigned as: $V = 100$, $\eta = 0.1$, $\delta = 0.8$, $\theta = 0.82$, $\mu = 0.8$, $\beta = 1.1$, $\rho = 0.1$, $\mathrm{T} = 8$, $k = 0.8$, and $\Delta = 4$.

Through market research, historical data analysis, and numerical simulation, one can establish key parameters and conduct multiple runs to compare profit outcomes under varying strategies in more reflective real-world scenarios. Analyzing and comparing these simulations can yield the most effective combination of promotion strategies, aiding restaurants and platforms in maximizing profits while minimizing food waste. In practice, optimal promotion strategies are chosen based on market conditions, customer behaviors, and cost structures, with numerical simulation aiding in understanding the influence of different factors on profits and guiding decision-making.

As can be seen in Figure 1, as the anti-food waste penalty increases, the platform's profit decreases under all three strategies, while the restaurant's profit increases under all three strategies. However, the degree of change in both online and offline prices is most significant when restaurants choose the *S* strategy as the penalty changes. For both restaurants and platforms, the *D* strategy will result in higher profits, while the *S* strategy will also provide a degree of boost to profits, but this may change with the increasing severity of anti-food waste penalties.

Figure 1 indicates that heightened government regulation aimed at reducing food waste can enhance the profitability of restaurants. This is particularly true as consumers increasingly prefer offline dining experiences, granting restaurants greater leverage to increase their prices. Delivery platforms, in response, will also elevate prices to safeguard their revenue streams, yet this is counteracted by a reduction in sales volume, which overall leads to lower profitability. This strategy can provide restaurants with objective profit gains, while strategy offers incremental profit increases over the status quo. For delivery

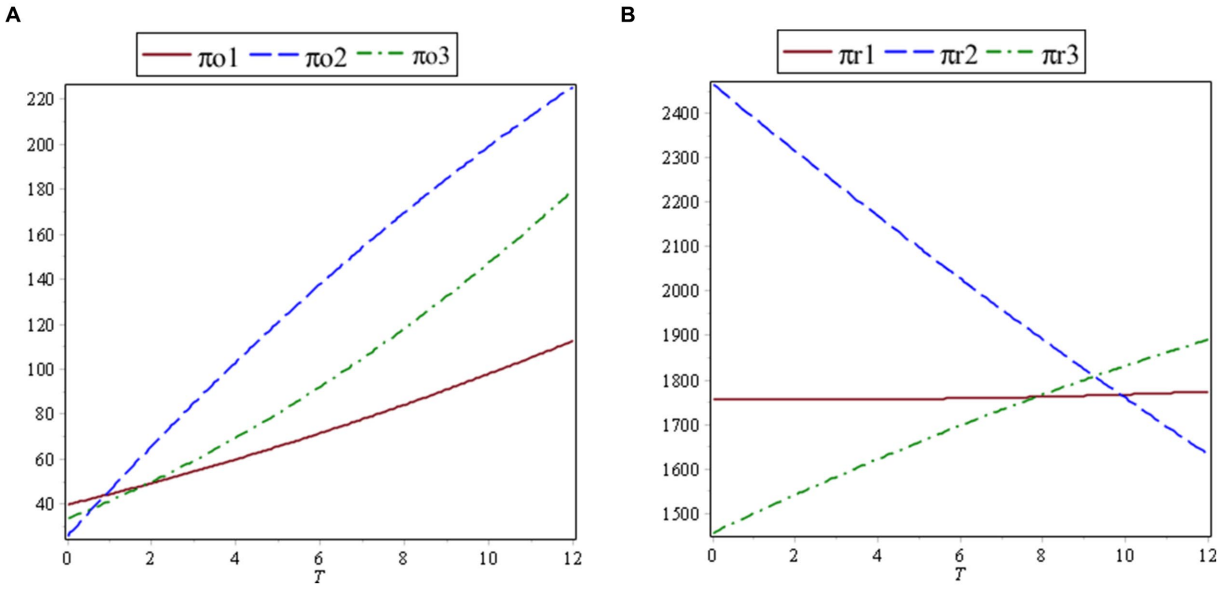

FIGURE 2
The impact of T on the profit for the platform and restaurant. **(A)** Profit of the platform. **(B)** Profit of the restaurant.

platforms, the implementation of promotion strategies can effectively elevate their profits, with the *D* strategy being particularly promising as it has the potential to drive exponential profit growth. Considering the strength of the anti-food waste penalty alone, the *D* strategy emerges as the preferred option, given its direct impact on profit margins.

Figure 2 reveals that as the cost of offline dining increases, the platform's profit rises under all three strategies, with the largest increase observed under the *D* strategy. For restaurants, as the cost of offline dining continues to rise, profits under the *N* strategy initially decrease before increasing. However, under the other two strategies, there is only a minimal change in profit. Profits under the *D* strategy is highest when the cost of offline dining is very low but gradually decline to a minimum and exhibit the most significant changes as the cost of offline dining increases. In contrast, restaurant profits under the *S* strategy increase as the cost of offline dining rises, reaching their peak when the cost of offline dining is very high. Therefore, when the cost of offline dining varies, restaurants should select different strategies to maximize their profits.

Figure 2 offers insights into the promotion decisions made by restaurants and platforms in response to the costs associated with offline dining. It illustrates the varying impacts of three promotion strategies on profitability as these costs change. The data suggest that as the cost of dining-in increases, delivery platforms consistently benefit from this rise, as consumers are inclined to opt for delivery services due to the inconvenience and higher expenses associated with dining-in. This preference is fundamentally driven by utility considerations.

Among the three strategies, the *D* strategy yields the most substantial increase in platform revenue, while the *S* strategy generates intermediate profits. For restaurants, profits under the *N* strategy exhibit a pattern of initial decrease followed by an increase, although this impact is relatively minor compared to the other two strategies. Under the *D* strategy, profits initially peak but can decline significantly as offline dining costs rise. This suggests that when consumers face high in-store dining costs, a price discount strategy is the most attractive option.

Restaurant's profits under the *S* strategy increase, which benefits both the restaurant and the platform, though the impact is moderate. This strategy allows consumers to mitigate the negative effects of higher offline dining costs through increased volume and improved pricing. Consequently, restaurants are likely to employ different promotion strategies to safeguard their profits in response to varying costs associated with offline dining.

Figure 3 demonstrates the impact of commission rates and offline dining costs on platform profits under varying levels of anti-food waste penalties. With a low penalty, the platform achieves the highest profit under the *D* strategy irrespective of the commission percentage. However, when the offline dining cost is low and the commission percentage is minimal, the *S* strategy is more favorable, and it is optimal to forgo promotion strategies entirely when the commission percentage is high. In the scenario of a high penalty, provided that the commission percentage and offline dining costs are within reasonable limits, the *N* strategy becomes the restaurant's preferable choice, yielding higher profits than the other two strategies.

Figure 3 shows that when the anti-food waste penalties are small, the platform does not need to worry about the high cost of penalties affecting profits due to increased demand. Thus, the *D* strategy is able to attract consumers to choose the platform for ordering food, and at the same time, consumers will prefer ordering food online due to the increased cost of visiting the restaurant. However, when the commission percentage is lower and the cost of dining in the store is also lower, the utility of the *S* strategy to the consumer is significantly higher, so the consumer will bring more revenue to the platform in this case. If the platform charges a higher commission to the restaurant and the cost of offline dine-in is not too high, then it can generate as much profit as possible for the restaurant without using promotion strategies, and in this case the platform relies mainly on commissions

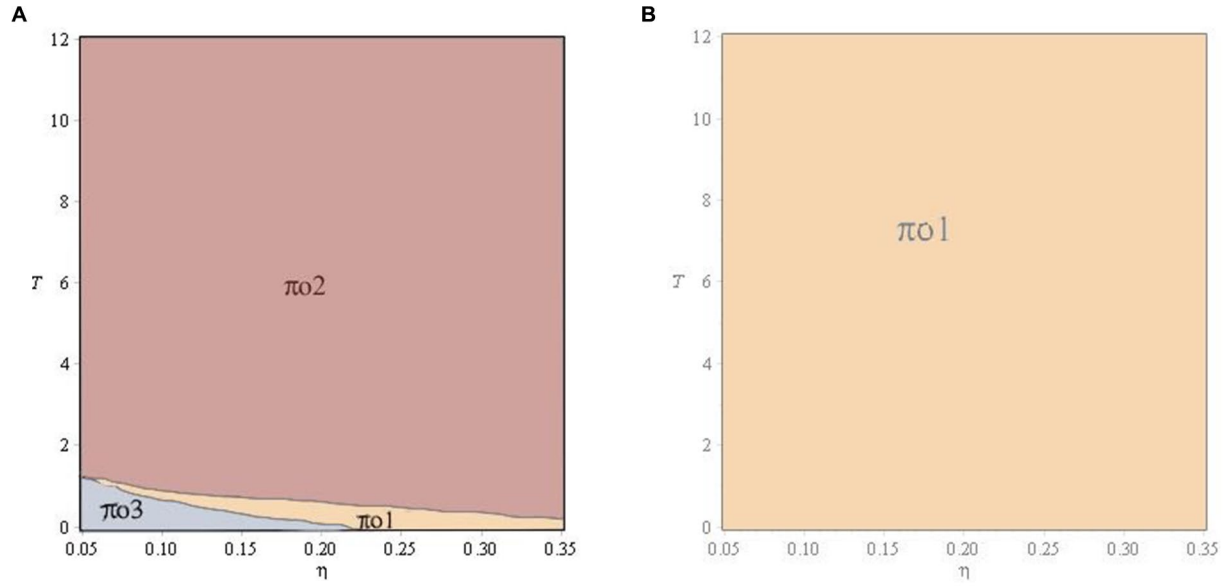

FIGURE 3
The impact of η and T on the profit for the platform. **(A)** k = 0.2. **(B)** k = 0.8.

from online orders. When the penalties for food waste are high, promotions will not be as effective and the platform will not be able to get more out of it. If the government strengthens the regulation of food waste, the platform will increase its sales volume under the influence of the promotion strategy, which will also bring higher penalty costs. Meanwhile, the profits it gains cannot offset the penalty costs, so the platform will consider not adopting the promotion strategy.

Figure 3 indicates that in the presence of low anti-food waste penalties, the platform does not face a significant risk of profit erosion due to increased demand-driven penalty costs. Consequently, the *D* strategy proves effective in attracting consumers to choose the platform for food ordering. Concurrently, the higher cost of dining in-store prompts consumers to prefer online food orders. Nevertheless, when both the commission rate and the in-store dining costs are low, the *S* strategy offers a higher utility to consumers, thereby generating greater revenue for the platform. In instances where the platform imposes a higher commission on restaurants while keeping the cost of offline dining reasonable, it can maximize restaurant profits without employing promotion strategies. In such cases, the platform primarily relies on commissions from online orders. When anti-food waste penalties are high, promotion strategies become less effective, and the platform may not derive substantial benefits from them. If the government enforces stringent regulations on food waste, the platform's sales volume may increase due to the promotion strategy, but this could also lead to higher penalty costs. In scenarios where the profits gained do not outweigh the penalty costs, the platform may opt not to adopt promotion strategies.

In conclusion, Figure 3 reveals the complex interplay between anti-food waste regulations, promotion strategies, and platform profits. Strict penalties can lead platforms to reconsider their use of promotions, prioritizing the protection of their financial margins. This analysis offers a understanding of how platforms navigate promotion strategies in the online-to-offline (O2O) marketplace, underscoring the importance of considering both regulatory constraints and business objectives when making decisions in this space.

Figure 4 depicts the influence of commission rates and offline dining costs on restaurant profits in the context of varying anti-food waste penalties. In scenarios where penalties are low, restaurants opt for the *D* strategy when the cost of offline dining is low, as this strategy maximizes profits. Conversely, when the cost of dining-in is high and the commission rate is low, the *S* strategy is more profitable. In cases where the commission rate is high, restaurants tend not to employ any promotion strategies. Under high penalty conditions, the intervals where restaurant profits are similar across strategies remain relatively unchanged from low penalty scenarios. However, the decision-making intervals for the *D* strategy decrease, while those for the remaining two strategies, *N* and *S*, increase notably. This suggests that as penalties intensify, the choice between *N* and *S* strategies becomes more critical, and restaurants may be more inclined to adopt the *D* strategy, possibly due to its comparatively stable profit potential in the face of higher penalty costs.

As can be seen from Figure 4, the strength of the anti-food waste penalty will not have a significant impact on the strategy choice of restaurants, but there will be some slight changes locally, mainly because the anti-food waste penalty is more about regulating the platform orders, while dine-in is considered to be supervised by the merchants to a certain extent. Within a reasonable commission ratio, when the cost of offline dining is small, restaurants will prioritize the *D* strategy, and the *D* strategy can maximize restaurant profits, the reason may be that the platform price is tied to the restaurant price, and the restaurant has a higher decision power. With the rise in the cost of offline dining, when the commission ratio is low, a greater number of consumers are drawn to the delivery platform. At this juncture, the *S* strategy emerges as the restaurant's preferred choice, as it complements the platform's full-reduced discounts and offline dining, thereby enhancing consumer utility. Conversely, when the commission ratio is high, restaurants may opt to forgo promotional

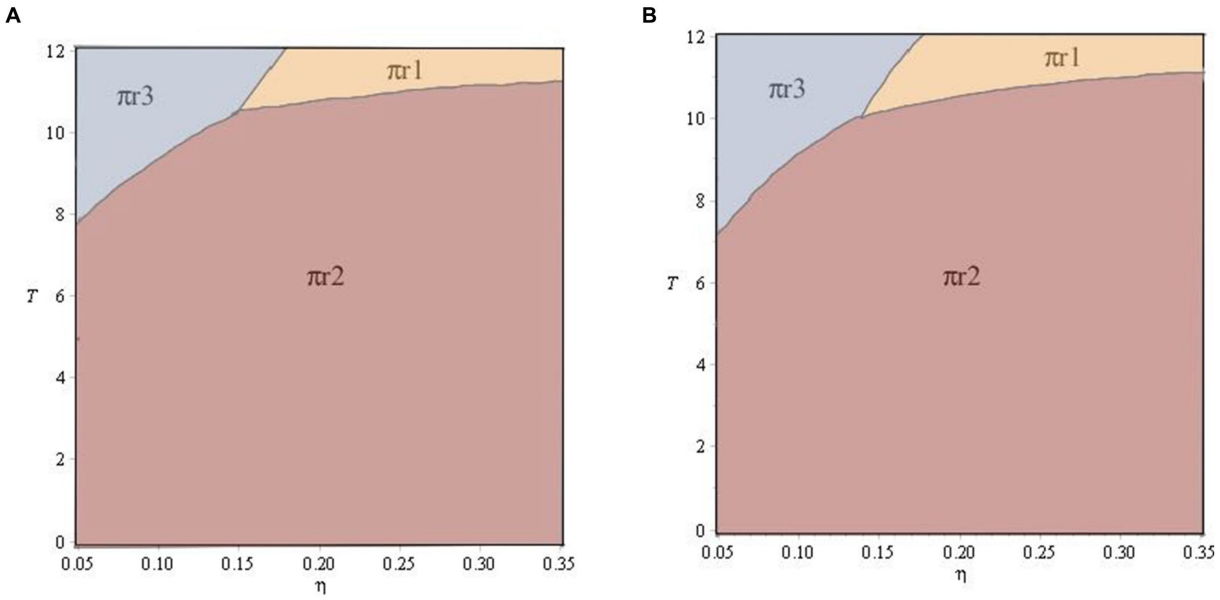

FIGURE 4
The impact of η and T on the profit for the restaurant. **(A)** $k = 0.2$. **(B)** $k = 0.8$.

strategies, with the platform's high commissions helping to offset the costs associated with offline dining.

When the penalty for food waste is higher, the effect of the *D* strategy will be weakened, while the *S* strategy will help the restaurant to be profitable in more cases, and the restaurant only needs to adjust its strategy for some special cases. This also implies that increased government regulation of food waste will affect restaurants to a lesser extent, but it will also change the choice of promotion strategies of restaurants to a certain extent, which will affect the profitability and wastage of the platform, and therefore restaurants should be the source of government control of the promotion situation in the market.

In summary, Figures 3, 4 effectively illustrate the strategic decisions made by restaurants and platforms in response to varying levels of regulation, commission rates, and offline dining costs. Restaurants must consider not only their interests but also the profits and waste management of the platform when choosing promotion strategies. When penalties are low, the choice of the *D* strategy by restaurants is more dependent on the cost of offline dining. This suggests that the *D* strategy can often lead to a win-win scenario for both restaurants and platforms. However, when the offline dining costs are very low or very high, the preferred strategies for the platform and the restaurant will change, and at these times, the commission percentage becomes a primary consideration for selecting *N* and *S* strategies.

Generally, when the commission percentage is low, the *S* strategy is adopted to enhance consumer utility and thereby safeguard revenue. Conversely, when the commission percentage is high, both the restaurant and the platform may choose not to employ promotion strategies to increase their profits. It is evident that under low penalty conditions, the selection of promotion strategies can be used to achieve a mutually beneficial outcome for both the restaurant and the platform. This comprehensive analysis provides valuable insights into the complex dynamics of promotion strategy decisions in the O2O food delivery ecosystem.

Under high penalty conditions, the platform consistently achieves the highest profits by adopting the *N* strategy. Consequently, restaurants must select their promotion strategies based on their circumstances. The platform's preference for the *N* strategy is driven by its role as the primary entity subject to government anti-food waste regulations. Therefore, the platform must effectively manage the waste penalties associated with promotion strategies in the face of high penalties. Interestingly, the profit of the restaurant under high penalties does not differ significantly from that under low penalties. This suggests that restaurants are not significantly influenced by the anti-food waste regulatory mechanism. The *D* strategy remains optimal for a substantial range of scenarios, ensuring a win-win situation with the platform when both the commission percentage and the cost of offline dining are high. This finding highlights the importance of balancing regulatory compliance with strategic business decisions to maximize profits in the O2O food delivery context.

Under the umbrella of strict anti-food waste regulations, especially when these are enforced with considerable intensity, promotion strategies may not be significantly affected. The main reason for this phenomenon is that restaurants, as the main decision-makers of promotion strategies, are not strictly enforced in the regulatory mechanisms, but platforms pay for it, thus effectively controlling the waste generated by the platforms. From an economic and managerial point of view, this suggests that both restaurants and platforms need to strengthen their cooperative dynamics and agree on cooperative contracts to effectively address the challenge of profitable and sustainable co-promotion in the face of strict regulations and changing market conditions. The findings emphasize the changing dynamics between dominant and dominated stakeholders under different levels of government regulation and highlight the urgent need to strengthen strategic alliances, cost management, and operational harmony.

5 Discussion and conclusion

In this paper, we explore and analyze the complex dynamics of the relationship between food delivery platforms and restaurants under various regulatory, economic, and operational conditions. More specifically, we delve into three different promotion strategies that influence the interaction between platforms and restaurants: the no promotion strategy (*N* strategy), the price discount promotion strategy (*D* strategy), and the volume-based price discount promotion strategy (*S* strategy).

Our findings firstly show that in the case of regulating food delivery platforms only, anti-food waste regulation will not work on the choice of promotion strategies, owing to restaurants as decision-making agents will not be significantly affected, but it plays a role in the improvement of wastefulness. Accordingly, the government needs to consider giving restaurants some responsibility for anti-food waste. We then find that regardless of whether the penalty is high or low, there is no significant change in the choice of promotion strategies by restaurants for different scenarios and only a slight influence. The situation is quite different for platforms, which do not want to use promotion strategies when the penalty is high, which may be a limitation of the anti-food waste penalty for platforms, but under certain conditions, win-win situations are also formed for both restaurants and platforms. Thus, under certain conditions, utilizing promotion strategies can benefit both parties in the supply chain.

However, this win-win situation requires high conditions, especially in the case of severe anti-food waste penalties, as platforms always tend not to adopt promotion strategies. When the cost of offline dining is moderate, both restaurants and platforms will adopt price discount strategy. In addition, stricter anti-food waste regulations will exacerbate the tendency not to adopt promotion strategies. This trend implies that as regulatory penalties increase, platforms may incur more penalties, and restaurants may have something to lose as a result. Finally, we find that both restaurants and platforms tend to adopt the *D* strategy when the government weakens penalties, mainly because restaurants can better control prices and platforms do not have to worry about excessive penalty costs. However, when penalties are strong, platforms may be forced to accept either the *D* strategy or the *S* strategy due to the restaurant's proactive actions, even if they wish to refrain from adopting a promotion strategy.

In an economic and managerial sense, the increasing government regulation and shifting market conditions necessitate closer collaboration between restaurants and platforms. This approach underscores the significance of fostering strategic alliances and coordinating cost management and operational strategies in a highly regulated business environment. From a broader societal perspective, the promotion strategies discussed in this paper should encourage rational thinking among the stakeholders in the O2O food delivery supply chain, particularly restaurants, and platforms. The critical importance of strategic choices in maintaining competitive advantage, increasing revenue, and driving sustainability emphasizes the necessity for a holistic cost–benefit assessment of the supply chain, flexibility in responding to regulatory changes, and responsiveness to green policies. Collaboration between restaurants and platforms can foster strategies that not only adhere to regulatory requirements but also enhance their market positions optimally. This collaboration can lead to more efficient operations, reduced waste, and improved customer satisfaction, which are essential for long-term success in the O2O food delivery services.

The academic and practical implications of this study could serve as a valuable resource for policymakers and stakeholders in the restaurant industry who are involved in dual-channel operations. It offers insights that may inform the development of more rational policies and strategies aimed at ensuring economic sustainability and environmental responsibility. In conclusion, this paper underscores the adaptability of promotion strategies within the context of anti-food waste regulations. The findings lay a crucial foundation for future research into the development of promotion strategies specifically tailored for dual-channel operations in the restaurant industry. Additionally, the study highlights the profound impact of government regulations on the operational decisions of both restaurants and platforms, emphasizing the need for ongoing research and adaptation in response to changing regulatory landscapes.

In the context of promotion strategy selection for restaurants, our study offers a more nuanced framework that factors in market dynamics and consumer behavior trends. Through numerical simulations, we provide clear insights that assist regulators and managers in making informed decisions regarding promotion strategies. Our research underscores the critical role of understanding consumer price sensitivity in crafting effective promotions. Furthermore, we highlight the necessity for restaurants to maintain flexibility and adaptability in their management approaches. In a market that is constantly evolving, the ability to swiftly adjust promotion strategies in response to shifts in competition and demand is essential for maximizing profits and enhancing competitiveness. The key contributions of our study can be summarized as follows:

(1) The impact of promotion strategies on profitability varies depending on market conditions.
(2) Consumer sensitivity to price changes is a pivotal consideration in strategy selection.
(3) Restaurants must be accommodating in modifying their promotion strategies to optimize profitability and bolster market position.

For restaurants and platforms, grasping the real-world performance of various marketing strategies is essential for crafting effective promotion programs and boosting profitability. Moreover, the insights provided by our research are valuable for public policymakers. They can utilize our findings to gain a deeper understanding of the market dynamics, enabling them to design more targeted policies that foster industry growth. For instance, policymakers might explore offering incentives to food and beverage companies that adopt promotion strategies shown to enhance efficiency and profitability.

Although the modeling work in this paper effectively captures the core elements of promotion strategies within the O2O supply chain of the restaurant at an abstract level, it is acknowledge that there may be additional factors that influence the choice of promotion strategies. These factors could include online and offline crowding effects, as well as the regulatory environment specific to restaurants. Future research could build upon the findings of this study by investigating the impact of these additional factors on promotion strategy decisions. Understanding the interplay between these factors and promotion strategies could provide a more comprehensive framework for

policymakers and stakeholders to develop and implement effective strategies that balance economic sustainability with environmental responsibility. This could involve exploring the dynamics of crowding effects on consumer behavior, the implications of different regulatory frameworks, and the potential for strategic partnerships between restaurants and platforms to mitigate the negative impacts of waste.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

GX: Writing – original draft, Writing – review & editing, Investigation. YT: Data curation, Formal analysis, Investigation, Methodology, Writing – review & editing. SX: Conceptualization, Investigation, Supervision, Visualization, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. This work is supported by the National Natural Science Foundation of China (No. 72171029) and by the Postgraduate Research and Innovation Project Foundation of Jiangsu (No. KYCX23_0935).

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs.2024.1439105/full#supplementary-material

References

Akkaş, A., and Gaur, V. (2022). OM forum—reducing food waste: an operations management research agenda. *Manuf. Serv. Oper. Manag.* 24, 1261–1275. doi: 10.1287/msom.2021.1044

Mithun Ali, S., Moktadir, M. A., Kabir, G., Chakma, J., Rumi, M. J. U., and Islam, M. T. (2019). Framework for evaluating risks in food supply chain: implications in food wastage reduction. *J. Clean. Prod.* 228, 786–800. doi: 10.1016/j.jclepro.2019.04.322

Ali-Alsaadi, A. A., Cabeza-Ramírez, L. J., Sántos-Roldán, L., and Loor-Zambrano, H. Y. (2023). Digital marketing and fast-food intake in the UAE: the role of firm-generated content among adult consumers. *Food Secur.* 12:4089. doi: 10.3390/foods12224089

Bux, C., Zizzo, G., and Amicarelli, V. (2023). A combined evaluation of energy efficiency, customer satisfaction and food waste in the healthcare sector by comparing cook-hold and cook-chill catering. *J. Clean. Prod.* 429:139594. doi: 10.1016/j.jclepro.2023.139594

Cane, M., and Parra, C. (2020). Digital platforms: mapping the territory of new technologies to fight food waste. *Br. Food J.* 122, 1647–1669. doi: 10.1108/BFJ-06-2019-0391

Chalak, A., Abou-Daher, C., Chaaban, J., and Abiad, M. G. (2016). The global economic and regulatory determinants of household food waste generation: a cross-country analysis. *Waste Manag.* 48, 418–422. doi: 10.1016/j.wasman.2015.11.040

Chaudhary, K., Kumar, P., Chauhan, S., and Kumar, V. (2022). Optimal promotional policy of an innovation diffusion model incorporating the brand image in a segment-specific market. *J. Manag. Anal.* 9, 120–136. doi: 10.1080/23270012.2021.1978883

Cheng, X., Deng, S., Jiang, X., and Li, Y. (2023). Optimal promotion strategies of online marketplaces. *Eur. J. Oper. Res.* 306, 1264–1278. doi: 10.1016/j.ejor.2022.08.020

Cheong, F., and Law, R. (2022). Will Macau's restaurants survive or thrive after entering the O2O food delivery platform in the COVID-19 pandemic? *Int. J. Env. Res. Public Health* 19:5100. doi: 10.3390/ijerph19095100

Corrado, S., and Sala, S. (2018). Food waste accounting along global and European food supply chains: state of the art and outlook. *Waste Manag.* 79, 120–131. doi: 10.1016/j.wasman.2018.07.032

de Steur, H., Wesana, J., Dora, M. K., Pearce, D., and Gellynck, X. (2016). Applying value stream mapping to reduce food losses and wastes in supply chains: a systematic review. *Waste Manag.* 58, 359–368. doi: 10.1016/j.wasman.2016.08.025

Dörnyei, K. R., Uysal-Unalan, I., Krauter, V., Weinrich, R., Incarnato, L., Karlovits, I., et al. (2023). Sustainable food packaging: an updated definition following a holistic approach. *Front. Sustain. Food. Syst.* 7:1119052. doi: 10.3389/fsufs.2023.1119052

Du, Z., Fan, Z. P., and Gao, G. X. (2021). Choice of O2O food delivery mode: self-built platform or third-party platform? Self-delivery or third-party delivery? *IEEE. T. Eng. Manag.* 70, 2206–2219. doi: 10.1109/TEM.2021.3069457

Duan, Q., and Li, C. (2021). Research on Dual-Channel supply chain promotion strategy. *Int. J. Inf. Syst. Suppl.* 14, 79–106. doi: 10.4018/IJISSCM.2021070105

Dumitru, O. M., Iorga, C. S., and Mustatea, G. (2021). Food waste along the food chain in Romania: an impact analysis. *Food Secur.* 10:2280. doi: 10.3390/foods10102280

Eser, K., Sigrún, A., and Hayriye, A. (2014). Profit maximization in flexible serial queueing networks. *Queueing Syst.* 4, 427–464. doi: 10.1007/s11134-014-9393-y

FAO. (2020). Tracking progress on food and agriculture-related SDG indicators 2020 - A report on the indicators under FAO custodianship.

Feng, N., Chen, J., Feng, H., and Li, M. (2021). Promotional pricing strategies for platform vendors: competition between first-and third-party products. *Decis. Support. Syst.* 151:113627. doi: 10.1016/j.dss.2021.113627

Feng, Y., Marek, C., and Tosun, J. (2022). Fighting food waste by law: making sense of the Chinese approach. *J. Consum. Policy* 45, 457–479. doi: 10.1007/s10603-022-09519-2

Gajdzik, B., Jaciow, M., Wolniak, R., and Wolny, R. (2023). Gastronomic curiosity and consumer behavior: the impact of television culinary programs on choices of food services. *Food Secur.* 13:115. doi: 10.3390/foods13010115

Gao, F., and Su, X. (2017). Online and offline information for omnichannel retailing. *Manuf. Serv. Oper. Manag.* 19, 84–98. doi: 10.1287/msom.2016.0593

Gao, F., and Su, X. (2018). Omnichannel service operations with online and offline self-order technologies. *Manag. Sci.* 64, 3595–3608. doi: 10.1287/mnsc.2017.2787

Gharehgozli, A., Iakovou, E., Chang, Y., and Swaney, R. (2017). Trends in global E-food supply chain and implications for transport: literature review and research directions. *Res. Transp. Bus. Manag.* 25, 2–14. doi: 10.1016/j.rtbm.2017.10.002

Göbel, C., Langen, N., Blumenthal, A., Teitscheid, P., and Ritter, G. (2015). Cutting food waste through cooperation along the food supply chain. *Sustain. For.* 7, 1429–1445. doi: 10.3390/su7021429

Govindan, K. (2018). Sustainable consumption and production in the food supply chain: a conceptual framework. *Int. J. Prod. Econ.* 195, 419–431. doi: 10.1016/j.ijpe.2017.03.003

Gu, Q., Zhang, R., and Liu, B. (2023). Pricing and advertising decisions in O2O supply chain with the presence of consumers' anticipated regret. *J. Bus. Ind. Mark.* 38, 1135–1149. doi: 10.1108/JBIM-01-2022-0022

Habib, A., Irfan, M., and Shahzad, M. (2022). Modeling the enablers of online consumer engagement and platform preference in online food delivery platforms during COVID-19. *Fut. Bus. J.* 8:6. doi: 10.1186/s43093-022-00119-7

Han, C. W., Ham, S. N., and Moon, H. Y. (2019). Influence of the characteristics of the O2O food delivery platform service on the trust, satisfaction and reuse intention. *J. Hosp. Tour. Res.* 21, 115–128. doi: 10.31667/JHTS.2019.2.78.115

He, B., Gan, X., and Yuan, K. (2019). Entry of online presale of fresh produce: a competitive analysis. *Eur. J. Oper. Res.* 272, 339–351. doi: 10.1016/j.ejor.2018.06.006

Hultman, M., Katsikeas, C. S., and Robson, M. J. (2011). Export promotion strategy and performance: the role of international experience. *J. Int. Mark.* 19, 17–39. doi: 10.1509/jim.11.0022

Igarová, K., Kádeková, Z., Košičiarová, I., Džupina, M., Dvořák, M., and Smutka, L. (2023). Is corporate social responsibility considered a marketing tool? Case study from customers' point of view in the slovak food market. *Food Secur.* 12:2770. doi: 10.3390/foods12142770

Kaur, P., Dhir, A., Talwar, S., and Ghuman, K. (2021). The value proposition of food delivery apps from the perspective of theory of consumption value. *Int. J. Contemp. Hosp. Manag.* 33, 1129–1159. doi: 10.1108/IJCHM-05-2020-0477

Kourmentza, C., Economou, C. N., and Tsafrakidou, P. (2018). Spent coffee grounds make much more than waste: exploring recent advances and future exploitation strategies for the valorization of an emerging food waste stream. *J. Clean. Prod.* 172, 980–992. doi: 10.1016/j.jclepro.2017.10.088

Krishnan, R., Arshinder, K., and Agarwal, R. (2022). Robust optimization of sustainable food supply chain network considering food waste valorization and supply uncertainty. *Comput. Ind. Eng.* 171:108499. doi: 10.1016/j.cie.2022.108499

Kumawat, R. S., and Barker, N. (2023). Study on promotional strategy of Syngenta product Amistar in Hoshiarpur District of Punjab, India. *Asian J. Agric. Ext. Econ. Soc.* 41, 170–174. doi: 10.9734/ajaees/2023/v41i102156

Lagioia, G., Amicarelli, V., Strippoli, R., Bux, C., and Gallucci, T. (2024). Sustainable and circular practices in the hotel industry in southern Italy: opportunities, barriers and trends in food waste management. *Br. Food J.* 126, 428–452. doi: 10.1108/BFJ-12-2022-1144

Lee, L., and Charles, V. (2021). The impact of consumers' perceptions regarding the ethics of online retailers and promotional strategy on their repurchase intention. *Int. J. Inf. Manag.* 57:102264. doi: 10.1016/j.ijinfomgt.2020.102264

Lin, Y., Marjerison, R. K., Choi, J., and Chae, C. (2022). Supply chain sustainability during COVID-19: last mile food delivery in China. *Sustain. For.* 14:1484. doi: 10.3390/su14031484

Luan, X., and Corman, F. (2022). Passenger-oriented traffic control for rail networks: an optimization model considering crowding effects on passenger choices and train operations. *Transp. Res. B Methodol.* 158, 239–272. doi: 10.1016/j.trb.2022.02.008

Mesiranta, N., Närvänen, E., and Mattila, M. (2022). Framings of food waste: how food system stakeholders are responsibilized in public policy debate. *J. Public Policy Mark.* 41, 144–161. doi: 10.1177/07439156211005722

Na, L., Tava, O., Yanping, L., and Abraham, Z. (2022). Reducing food loss and waste in supply chain operations. *Transport Res E-Log* 162:102730. doi: 10.1016/j.tre.2022.102730

Narang, U., and Shankar, V. (2019). Mobile app introduction and online and offline purchases and product returns. *Mark. Sci.* 38, 756–772. doi: 10.1287/mksc.2019.1169

Parfitt, J., Barthel, M., and Macnaughton, S. (2010). Food waste within food supply chains: quantification and potential for change to 2050. *Philos. Trans. R. Soc. B* 365, 3065–3081. doi: 10.1098/rstb.2010.0126

Roh, M., and Park, K. (2019). Adoption of O2O food delivery services in South Korea: the moderating role of moral obligation in meal preparation. *Int. J. Inf. Manag.* 47, 262–273. doi: 10.1016/j.ijinfomgt.2018.09.017

Rosin, M., Young, L., Jiang, Y., Vandevijvere, S., Waterlander, W., Mackay, S., et al. (2023). Product promotional strategies in supermarkets and their effects on sales: a case study of breakfast cereals and drinks in New Zealand. *Nutr. Diet.* 80, 463–471. doi: 10.1111/1747-0080.12800

Steenmans, K., and Malcolm, R. (2023). Editorial: Law, policy and the governance of sustainable food systems. *Front. Sustain. Food. Syst.* 7:1304004. doi: 10.3389/fsufs.2023.1304004

Szulecka, J., and Strøm-Andersen, N. (2022). Norway's food waste reduction governance: from industry self-regulation to governmental regulation? *Scand. Polit. Stud.* 45, 86–109. doi: 10.1111/1467-9477.12219

Teng, C. C., Chih, C., Yang, W. J., and Chien, C. H. (2021). Determinants and prevention strategies for household food waste: an exploratory study in Taiwan. *Food Secur.* 10:2331. doi: 10.3390/foods10102331

Thi, N. B. D., Kumar, G., and Lin, C. Y. (2015). An overview of food waste management in developing countries: current status and future perspective. *J. Environ. Manag.* 157, 220–229. doi: 10.1016/j.jenvman.2015.04.022

Trivedi, V., Trivedi, A., Pandey, K. K., and Chaurasia, S. S. (2023). Ordering the right quantity? Examining the impact of plate size vagueness on food waste in an online food delivery system. *J. Clean. Prod.* 391:136052. doi: 10.1016/j.jclepro.2023.136052

Walia, B., and Sanders, S. (2019). Curbing food waste: a review of recent policy and action in the USA. *Renew. Agric. Food Syst.* 34, 169–177. doi: 10.1017/S1742170517000400

Xie, J., and Bing, C. (2022). Opportunities, Trends and Promotion Strategies of Opportunities, Trends and Promotion Strategies of "Online Fitness" in the Post-COVID-19 Era. *Front. Sport Res.* 4, 56–61. doi: 10.25236/FSR.2022.040610

Xu, X., Mei, Y., Sun, Y., and Zhu, X. (2021). Analysis of the effectiveness of promotion strategies of social platforms for the elderly with different levels of digital literacy. *Appl. Sci.* 11:4312. doi: 10.3390/app11094312

Zhang, C., Wang, X., Zhao, C., Ren, Y., Zhang, T., Peng, Z., et al. (2022). Promotion Lens: inspecting promotion strategies of online E-commerce via visual analytics. *IEEE. T. Vis. Comput. Gr.* 29, 767–777. doi: 10.1109/TVCG.2022.3209440

Zheng, H., Chen, K., and Ma, Z. (2023). Interactive effects of social norms and information framing on consumers' willingness of food waste reduction behavior. *J. Retail. Consum. Serv.* 75:103525. doi: 10.1016/j.jretconser.2023.103525