Advance Selling and Service Cancellation when Consumers are Overconfident

Abstract Purpose – This paper aims to study the joint decision making of advance selling and service cancellation for service provides with limited capacity when consumers are overconfident.

Design/methodology/approach – For the case in which consumers encounter uncertainties about product valuation and consumption states in the advance period and are overconfident about the probability of a good state, we study how the service provider chooses the optimal sales strategy among the non-advance selling strategy, the advance selling and disallowing cancellation strategy, and the advance selling and allowing cancellation strategy. We also discuss how overconfidence influences the service provider's decision making.

Findings – The results show that when service capacity is sufficient, the service provider should adopt advance selling and disallow cancellation; when service capacity is insufficient, the service provider should still implement advance selling, but allow cancellation; and when service capacity is extremely insufficient, the service provider should offer spot sales. Moreover, overconfidence weakens the necessity to allow cancellation under sufficient service capacity and enhances it under insufficient service capacity, but is always advantageous to advance selling.

Practical implications – The obtained results provide managerial insights for service providers to make advance selling decisions.

Originality/value – This paper is among the first to explore the effect of consumers' overconfidence on the joint decision of advance selling and service cancellation under capacity constraints.

Keywords Overconfidence; Advance selling; Cancellation; Uncertainty; Capacity constraint

Paper type Research paper

1. Introduction

Advance selling occurs when an enterprise provides consumers with an opportunity to purchase before spot selling (Shugan and Xie, 2000). With the development of mobile Internet and social media, advance selling has become increasingly common (Ancillaia et al., 2019; Dwivedi et al., 2023). Based on a survey by Syntun, a leading big data company in China, online sales during the "Single Day" shopping festival in 2020 reached 67 billion EUR, of which advance sales accounted for roughly 36% during the first three days of November. Not only has advance selling of physical products reached a considerable scale, but that of various services has also found its way into almost every aspect of daily consumption. Advance booking of train, air, hotel, scenic spot, tournament, and performance tickets anytime and anywhere through apps, such as 12306, Ctrip, Qunar, and Damai, has become a habit for most Chinese consumers. Consumer demand tends to be more personalized and fragmented, which requires enterprises to pay more attention to consumer behavioral preferences when implementing advance selling, such as loss aversion (Zhao and Stecke, 2010), regret (Nasiry and Popescu, 2012), strategic behavior (Lim and Tang, 2013), and social learning (Peng et al., 2020). Additionally, overconfidence is considered (Li et al., 2016).

In the era of e-commerce, although consumers may learn about some product information through comments from other consumers on social media or e-commerce platforms (Anastasiei et. al., 2023), they are exposed to numerous uncertainties because the physical experience is impossible for them when they make online purchase decisions (Ghosal and Chatterjee, 2014; Xu and Duan, 2020; Luo et al., 2021). This circumstance is particularly true for consumers that arrive in the advance selling period, who face marked isolation between purchasing and consumption. Therefore, enterprises must consider the influences of such uncertainties when implementing advance selling. Consumers' uncertainties mainly include uncertainties about product quality (Yu et al., 2015a), product valuation (Zhang et al., 2022), and consumers' consumption state (Cirillo et al., 2018). In our paper, we are concerned about the last two uncertainties. Extensive studies have been conducted on enterprises' advance selling strategy, which are based on consumers' uncertainty about product valuation. For example, Zhang and Yang (2021) discussed the deferred payment strategy. Wu et al. (2021) studied the advance selling strategy considering advertising based on the newsvendor model. Gao and Chen (2015) considered consumers' uncertainties about product valuation and consumption states, which consumers must confront when ordering service-oriented products in advance.

As an example, consider Damai, a professional ticket-selling company. This example is also one of motivations of our paper. Consumers must order tickets on this website long before a sports event or performance starts. For instance, tickets for the 2019 FIBA Basketball World Cup held in China were sold two months before the event. In the case of service-oriented products, consumers must usually go to the location on a certain date. However, scheduling several days or even several months ahead of time is inherently variable. As the consumption date nears, consumers typically give up their tickets if they encounter bad weather, illness, or an emergency. If consumers postpone buying tickets until the consumption day, they are likely to pay a higher price or tickets are sold out. Therefore, consumers are uncertain about whether the planned trip will become impossible because of their personal consumption state in addition to uncertainty about whether the service will match their preferences. Furthermore, consumers tend to ignore such information or factors that may cause poor consumption states and pay more attention to information favorable to good consumption states, showing overconfidence in the probability of embarking on trips eventually. On the eve of the World Cup, many consumers sold tickets at low prices on the second-hand platform Xianyu due to unplanned family emergencies. This behavior is highly similar to consumer behavior studied by Vigna and Malmendier (2006), who indicated that consumers often buy gym cards confidently, but end up failing to use them when it is time to exercise.

Van den Steen (2011) indicated that overconfident consumers have perfect Bayesian rationality and update their expectations based on the Bayesian law. He then proposed two mechanisms to measure consumers' overconfidence. One mechanism is about the differences in the expected valuation of different agents. The greater the differences in the expected valuation between different agents, the greater the degree of overconfidence. The other mechanism is in the differences of variances. The smaller the estimated variance, the greater the degree of overconfidence. Li et al. (2016) examined the influences of consumers' overconfidence on advance selling of physical goods without considering consumers' uncertainty about consumption states. However, service-oriented products must involve consumers' direct experience at the point of consumption, which renders consumers' consumption states highly significant. Moreover, consumers' overconfidence may increase the uncertain risks they face in the advance selling period and further influence service providers' advance selling strategy.

To reduce the potential loss consumers may suffer because of uncertainties in the advance selling period and encourage them to purchase ahead of time, service providers often allow consumers to cancel orders if they find that their product valuation does not live up to their expectations or the consumption state is not ideal. Although the protection of consumer rights and interests has received more and more attention from countries, platforms and enterprises (Cauffman, 2019), service providers typically set a time limit for consumers to cancel orders and only part of the advance payment will be returned. For instance, Shanghai Hyatt Hotel does not offer order cancellation for consumers who plan to celebrate Christmas in the metropolitan area and book hotels several weeks in advance through Ctrip, whereas the nearby JI Hotel allows consumers to cancel their preorders. As another example, consumers are only allowed to cancel orders more than 20 days before the performance day if they preorder performance tickets through Damai. However, only 20%–70% of the advance payment is refunded for other cancellation reasons (https://help.damai.cn/helpPage.htm?pageId=101), and the complicated refund policy often incurs extra hassle cost for consumers. Guo (2009) considered consumers' personal factors, such as health and schedule changes, which lead to their uncertainty about consumption states. He analyzed whether competitive service providers should allow consumers to cancel orders and return part of the money. Zhang et al. (2021b) considered consumers' uncertainties about consumption states in the advance selling period and product valuation in the spot selling period, and discussed the feasibility of allowing cancellation and a partial refund as a price commitment tool in the case of service-oriented products. Previous research on advance selling considering order cancellation did not take into account consumers' overconfidence, which may significantly impact consumers' decisions to cancel orders. For example, consumers' overconfidence in consumption states may increase sales in the advance selling period, but it greatly results in order cancellation after consumers know their consumption states in the spot selling period. Therefore, service providers should be prudent to the cancellation decision.

Also, capacity limitation is the natural constraint for service-oriented products. For both physical goods and service-oriented products, an enterprise under capacity constraints must reasonably allocate its capacity in the advance selling and spot selling periods to maximize profits (Mesak et al., 2010; Liu and Ryzin, 2011; Yu et al., 2015b). This is particularly the case for service providers because they rarely expand their service capacity within a short period of time, and the value of unsalable or unused service often amounts to zero. Whether to sell in advance and allow order cancellation, along with the prices set, affect the intertemporal allocation of capacity. This is because advance selling can contribute to increasing sales in the advance selling period by taking advantage of consumers' uncertainties (Prasad et al., 2011), allowing order cancellation impacts the scale of products available for sale in the spot selling period, and under different prices sets, consumers make different choices about when to purchase. Xie and Gerstner (2007) discussed the possibility of service providers' gaining additional revenue by allowing consumers in the advance selling period to cancel their orders, given that the canceled service may be sold a second time. Oh and Su (2018) studied service providers' optimal advance selling and capacity allocation strategies for hotel-type products, with order cancellation arising from the consumers' schedule changes that are taken into consideration, and even in the case of consumers not coming for consumption on the spot. Although service providers' advance selling strategy under capacity constraints was considered in previous studies, it remains unclear how consumers' overconfidence influences service providers at different levels of capacity to make decisions on advance selling and order cancellation.

Motivation by the practice of advance selling of service providers and customers' overconfident behavior in the process of purchasing decisions, we hypothesize that overconfidence not only affects consumers' purchasing behavior, but also has a significant impact on whether service providers should implement advance selling and allow consumers to cancel orders. Hence, we analytically explore the service providers' decisions of advance selling and service cancellation when consumers are overconfident in this work. Specially, we study the following questions:

(1) How service providers can implement the optimal selling strategy when consumers are showing overconfidence in the uncertainty about future consumption states, that is, they are excessively optimistic about a comfortable consumption state. Will service providers adopt advance selling or choose spot selling near the consumption day?

(2) When implementing advance selling, should service providers allow overconfident consumers to cancel orders after their uncertainty about consumption states is eliminated?

(3) How capacity constraints and overconfidence will influence optimal decisions of service providers? How they determine the optimal advance selling price, spot selling price, and refund on canceled orders based on their capacity?

The main contribution of this work is that we established a joint decision model of advance selling and service cancellation combined with consumers' overconfidence and took into account the capacity constraints of service providers. We investigated the influence of overconfidence on advance selling and cancellation decisions under different levels of service capacity. Overconfidence is always beneficial to an advance selling strategy because consumers are overoptimistic in the face of uncertainty, but it has a two-sided impact on the cancellation strategy, which depends on the capability levels of service providers. Our research enriches the literature, such as the work of Li et al. (2016), who only studied advance selling strategies for physical products, and deepens the understanding of the effects of overconfidence. We also provided a complete theoretical decision-making path for service providers under capacity constraints to better use and guide the purchasing decisions of overconfident consumers and implement advance selling efficiently.

The remainder of this paper is organized as follows: In Section 2, we review relevant literature. In Section 3, We establish a model under relatively sufficient service capacity and discuss the optimal prices set and revenue making under the non-advance selling strategy, advance selling and disallowing cancellation strategy, and advance selling and allowing cancellation strategy. In Section 4, we examine service providers' optimal selling strategy and the influences of consumers' overconfidence through a comparative analysis of the prices and revenue under the three strategies. In Section 5, we discuss the model under insufficient service capacity. Finally, in Section 6, we draw conclusions.

2. Literature Review

Our paper is closely related to the literature on advance selling and overconfidence.

(1) Advance selling

Many scholars have studied the driving effects of uncertainty when exploring the motivations of an enterprise to sell in advance. Weng and Parmar (1999) believed that advance price discounts attract price-sensitive consumers to buy in advance, whereas they may not buy at all at a normal selling price; hence, advance selling increases demand and decreases the variance of the spot demand. Tang et al. (2004) considered that advance price discounts enable some consumers who originally buy other brands to turn into buyers of a new brand. They also compared the matching degree of supply and demand using the advance sales volume to forecast the spot demand. All the literature discussed demands uncertainty from the enterprise perspective. The enterprise can lock in part of demand through advance selling and improve the accuracy of forecasting future demand using information in the advance selling season (Kuthambalayan et al., 2015). Based on utility theory, in more recent literature, scholars have considered consumers' uncertainties during the advance period and studied how an enterprise should implement advance selling.

Xie and Shugan (2001) considered consumers' uncertainty about product valuation and discussed the impacts of capacity constraints, limiting advance sales volume, and consumers' risk aversion preferences on an enterprise's advance selling decision making. Chennamaneni et al. (2017) studied whether service providers make decisions by advance selling directly or with intermediaries involved, given that intermediaries can provide consumers with faster services to improve the consumers' valuation of the product. Chu and Zhang (2011) held that a lack of product information learned by consumers leads to their uncertainty about the product valuation. They supposed merchants can control the degree of releasing product information endogenously and that the level of the released information directly influences consumers' uncertainty. The result demonstrated that merchants should not release information completely in any case. Cachon and Feldman (2017) discussed the effectiveness of advance selling in a competitive environment. The homogeneity of consumer groups caused by product valuation uncertainty in the advance period intensifies price competition, which reduces profits. Similarly, Huang et al. (2017) assumed that product valuation is uncertain to consumers in the advance period and that merchants are willing to offer free gifts to all those who buy in advance to encourage consumers to pre-purchase, and then explore the decisions of the optimal product price and the best quality of free gifts.

Relatively, few studies have been conducted on advance selling strategies that take consumers' uncertainty about consumption states into consideration. Uncertainty may result from public and private factors. The former may be bad weather and the latter may be illness or a family emergency. Gao et al. (2012) studied the advance selling strategy when future weather conditions represented by temperature determine consumers' consumption states. To stimulate consumers' participation in advance selling, merchants promise consumers that they can acquire some compensation if the weather is bad. The result indicates that the combination of a weather-related compensation mechanism and advance selling strategies contributes to a rise in sales volume and profits. Gao and Chen (2015) investigated the influence of advance selling discounts on profits considering product valuation uncertainty and consumption state uncertainty. Their result shows that the no-show behavior of advance consumers under a poor consumption state is not necessarily favorable to retailers.

The existence of uncertainty puts consumers who order in the advance period at risk. To encourage advance sales, an enterprise often takes some measures to reduce the risks of uncertainty, such as allowing orders to be canceled and offering refunds if consumers change their minds. Zhang et al. (2021a) studied the optimal advance selling strategy when retailers can adopt an omni-channel preordering strategy by configuring physical showrooms in which consumers can examine the forthcoming to-be-released products thoroughly. Pang et al. (2021) and Zhan et al. (2021) explored the value of a price guarantee in encouraging consumers, under the risks of uncertainties, to preorder. Mao et al. (2016) explored the joint decision-making problem of advance selling and buyback agreements. Li et al. (2014) discussed the optimal advance selling strategy of retailers with consumers' opportunistic returns. Li et al. (2021) considered freight insurance, which can further reduce the risks of uncertainties. For service-oriented products, common practice is that service providers allow consumers who preorder to cancel their orders in the spot selling period and refund part of the advance payment (Guo, 2009; Zhang et al., 2021b; Xie and Gerstner, 2007).

To Sum up, we study service providers' decisions under customers' both product valuation uncertainty and consumption state uncertainty based on utility theory, so the existing relevant literature is of important reference value to establish the model. The literature also helps us to understand the value of allowing cancellations and important factors influencing cancellation decisions, so we can better describe the mechanism of service providers' cancellation decisions for advance selling orders.

(2) Overconfidence

As a decision-making bias, overconfidence is widespread in practice, and has been considered in extensive literature. Most of the literature is about decision-makers' overconfidence in the financial field. For example, they are inclined to buy and hold high-risk portfolios when investing in stocks (Odean, 1998) and overestimate the return rate when investing in projects (Malmendier and Tate, 2008).

Research on overconfidence in supply chain management has been increasing in recent years. Song et al. (2021) and Wang et al. (2021) considered the overconfident manufacturer, and analyzed the impact of overconfidence on inventory strategies and coordination strategies of supply chains. Ren and Croson (2013) and Ren et al. (2017) studied overconfidence based on the newsvendor model. Their experiment and modeling analysis demonstrated that overconfidence can well explain the phenomenon that decision makers always choose the suboptimal strategy in supply chain and inventory management. Li et al. (2017) studied overconfident newsvendors under competition and found that overconfidence in a competitive environment can offset part of the adverse effect caused by competition compared with the decrease in expected profits caused by overconfidence in a monopolistic environment. Li (2019) explored the effects of overconfidence on distribution channels comprising manufacturers, retailers, and consumers. His results demonstrated that overconfidence can reduce double marginalization and is likely to increase the profits of distribution channels.

Relatively little literature exists on consumers' overconfidence. Vigna and Malmendier (2006) found that overconfidence well accounts for consumers' irrational behavior when they buy fitness club packages. Surprisingly, they opt to purchase the club's monthly cards, with which the average fitness cost per visit is higher than the charge paid by times. Regarding the pricing structure of mobile phone service plans, Bar Gill and Stone (2012) adopted an empirical method and analyzed how consumers' overconfidence influences the service plans provided by telecom service providers. Lu et al. (2013) studied the relevance of time pressure to the causes of consumers' overconfidence in false promotion and how overconfidence impacts their willingness to pay. For consumers that are overconfident and risk averse, Li et al. (2016) provided the conditions for pure advance selling, pure spot selling, and selling in both periods based on the mean-variance method to model consumers' utilities. Thus, they further proposed that retailers tend to sell in both periods when the degree of overconfidence increases. These research results are of reference value for embedding consumers overconfident behavior into the advance selling model.

(3) Utility theory

In addition to the literature on advance selling and overconfidence, we would like to briefly describe the utility theory on which this model is based. Utility theory is often used to analyze how consumers allocate their income among various goods or services to achieve utility optimization, and it is an important method to study consumer behavior. Consumer utility refers to the degree to which buyers can get satisfaction from a product or service. Also, consumer utility is an important indicator to measure product quality and service level of enterprises, and an important means to maintain and improve consumer satisfaction and loyalty. Therefore, enterprises are committed to improving consumer utility.

Consumer utility is usually described by utility function. Product attributes, consumer preferences and even market environment factors can be incorporated into the function model, so that enterprises can formulate relevant operational strategies according to consumers' choices. For example, Xiao and Shi (2016) characterizes the consumer utility purchasing online using product price and that purchasing offline using both price and traffic distance, and they study the priority supply problem of both channels by constructing the consumer utility function. As mentioned above, consumer utility theory is also suitable for the study of enterprise advance selling decision-making. In the literature we mentioned, many scholars explore advance selling strategy through utility theory, and embed many factors into the consumer utility function, including opportunistic return behavior (Li et al., 2014), price guarantee (Pang et al., 2021), free gift giving (Huang et al., 2017), competitive environment (Cachon and Feldman, 2017), regret preference (Nasiry and Popescu, 2012) and so on. The factors closely related to our paper have appeared in the literature based on utility theory, such as overconfidence behavior (Li et al., 2016), consumption state uncertainty (Gao and Chen, 2015), order cancellation (Guo, 2009) and capacity constraint (Oh and Su, 2018). Although there is no literature that incorporates those factors above at the same time, it is appropriate to choose the utility theory to carry out the research.

To summarize, previous research has rarely touched upon consumers' overconfidence and an enterprise's decision making about advance selling. It is not clear how services providers make decisions for advance selling and service cancellation when consumers are overconfident. Our paper tries to fill in this gap. To the best of our knowledge, we are the first to explore the effect of consumers' overconfidence on the joint decision of advance selling and service cancellation under capacity constraints. Li et al. (2016) may be the only paper to research advance selling with consumers' overconfidence, but it is significantly different from our paper. Table 1 displays the position of this research, thereby indicating our contributions to the literature.

Table 1. The distinction of our paper with related literature

Streams	Advance	Overconf	Cancell	Capacity	Consumption

	selling	-idence	-ation	constraint	state uncertainty
Our paper	✓	✓	✓	✓	✓
Li et al. (2016)	✓	✓			
Zhang et al. (2021)	✓		✓		✓
Oh and Su (2018)	✓			✓	✓
Yu et al. (2015b)	✓			✓	
Xie and Gerstner (2007)	✓		✓	✓	
Lu et al. (2013)		✓			

Table by authors.

3. Model

3.1 Problem Description

Consider a service provider that sells service-oriented products with a fixed consumption date, such as tickets for performances and sports events. The service provider can sell products in advance and decide whether the orders in the advance period are allowed to be canceled.

Consumers arrive in two periods. We assume that the number of consumers arriving in each period is equal: both are *N*. Consumers' product valuation denoted by v follows the uniform distribution on [0,1], and the probability density function and cumulative distribution function are represented by $f(\cdot)$and $F(\cdot)$, respectively. Given that the first period is relatively distant from the consumption date, consumers lack the information required to assess their exact valuation of the products; that is, valuation uncertainty exists in the advance period, and it is not until the second period that consumers can be strongly certain whether the products match their preference. Moreover, advance purchasers are not certain about their consumption state near the fixed consumption date in the future. If they encounter illness, bad weather, or any other unexpected accidents, they fail to go to the spot as scheduled. Suppose that the probability that consumers are in a good state is β. Then they arrive for spot consumption as planned. Accordingly, the probability that they are in a bad state is $1-\beta$. Then they give up consumption. Suppose $\beta \in [\frac{1}{2},1]$, that is, the probability of a good state cannot be overly small, which is more in line with reality; otherwise, consumers may have a lower intention to purchase in advance. However, whether consumers are in a good state can only be certain in the second period when the consumption day approaches. Therefore, the advance period in our study refers to the period of time that is slightly distant from the consumption date and the spot period is the period of time near the consumption date when consumers are already certain about their consumption states. The division of the two periods is similar to the setting of Lim and Tang (2013).

With reference to the expression of Gao and Chen (2015), consumers' expected utility under two uncertainties in the advance period is denoted by βEv, that is, in a good state, consumers obtain the expected utility Ev; otherwise, they give up consumption and obtain zero utility. Ev is the expected valuation of the product. Suppose that consumers that arrive in the advance period are overconfident. Their overconfidence, as Van den Steen (2011) stated, is shown in their overoptimistic forecasting of the future, which is often expressed as overestimating the means or underestimating the variances. Overconfident consumers think the probability of a good state is $\beta + \delta \in (\frac{1}{2}, 1]$, that is, $\delta \in (0, 1 - \beta]$, to ensure that the probability is not greater than 1. When consumers are risk neutral, overestimating the probability of a good state is essentially equal to overestimating the expected valuation of the product. Thus, overconfident consumers expect that utility purchasing in the advance period is $(\beta + \delta)Ev$ rather than βEv when they are completely rational. The expression has a likeness to that in the extended model proposed by Li et al. (2016), in which overconfidence is represented as overestimating the means. Additionally, consumers in the advance period are highly strategic and choose a best purchasing time by evaluating the utilities of buying in advance and waiting.

Suppose the service provider's capacity is exogenous and limited, the cost is zero, and the salvage value of unsold units is zero (Wang and Zeng, 2016). Considering the similarity in the methods used to discuss $T > N$ and $T \leq N$ and the complexity of the expression of the latter, we first study the scenario of $T > N$ and then discuss the consistency of the conclusions when $T \leq N$.

The service provider has three strategies available. The first is non-advance selling, that is, spot selling directly when the consumption date is near. The second is advance selling, but disallowing canceling orders in the advance period. The third is advance selling and allowing cancellation, with part of the ticket fee returned. These three strategies are denoted by N, A, and C, respectively. We assume the product price is p_N when advance selling is not available, and the advance price and spot price are p_{1i} and $p_{2i} (i = A, C)$, respectively. The consumers' hassle cost of cancellation is $h > 0$, and they acquire the refund $R \geq h$. The profits corresponding to these three strategies are π_j $(j = N, A, C)$. We focus on which strategy is optimal to the service provider when consumers are overconfident, and how overconfidence affects the feasible regions of those strategies. Table 2 lists the notation used in this paper.

Table 2. Notation.

Notation	Interpretation

N	The number of consumers arriving in each period
v	Consumers' product valuation
β	Good consumption state probability of customers
δ	The level of customers' overconfidence
T	Capacity of the service provider
h	Hassle cost of cancellation
R	Refund customers can get when they choose to cancel orders
p_N	Product price when advance selling is not available
p_{1i}	Advance price when advance selling is available, $i = A, C$
p_{2i}	Spot price when advance selling is available, $i = A, C$
U_a	Expected utility of purchasing in advance selling period
U_w	Expected utility of purchasing in spot period
π_j	Profit under different strategies, $j = N, A, C$

Table by authors.

3.2 Strategy *N*: Non-advance Selling

When the service provider adopts the non-advance selling strategy, all consumers' valuations of the product and their consumption states are certain near the consumption date. Only the $2\beta N$ consumers in a good state consider making a purchase, whereas the remaining $2(1-\beta)N$ consumers in a bad state choose to leave. Consumers who are in a good state choose to buy the product if the valuation is not less than the price; otherwise, they choose to leave. The service provider sets appropriate prices to maximize revenue according to the relationship between the service provider's service capacity and consumers' demand. When service capacity exceeds demand, a surplus of service capacity transpires, and the service provider sells the products at the optimal price under unconstrained capacity. Conversely, when service capacity is smaller than demand, the service provider raises the price to sell all the products at the market-clearing price. Therefore, we have Theorem 1.

Theorem 1. When the service provider chooses not to sell in advance, if $T \geq \beta N$, then $p_{N1} = \frac{1}{2}$ and $\pi_{N1} = \frac{\beta N}{2}$; and if $T < \beta N$, then $p_{N2} = 1 - \frac{T}{2\beta N}$, $\pi_{N2} = \left(1 - \frac{T}{2\beta N}\right)T$.

All proofs for our paper are in the appendix.

Theorem 1 provides the prices and profits of the non-advance selling strategy. As a basic model, we compare it with the advance selling strategies to obtain the feasible conditions. We only consider $T > N$ now; hence, $p_{N1} = \frac{1}{2}$, $\pi_{N1} = \frac{\beta N}{2}$.

3.3 Strategy A: Advance Selling and Disallowing Cancellation

Consumers that arrive in the advance period have three choices: buying in advance, waiting, and leaving. They must evaluate the risks of uncertainties about product valuation and consumption states if they choose to buy in advance, and the possibility of paying a higher price if they choose to wait.

The expected utilities of consumers from purchasing in advance and waiting are $U_a = (\beta + \delta)Ev - p_{1A}$ and $U_w = (\beta + \delta)\int_{p_{2A}}^{1}(v - p_{2A})f(v)dv$, respectively. Consumers who postpone their purchasing decisions to the spot period choose to buy only if they are in a good state and the product valuation is not lower than the spot price. The pricing strategy in the spot period is the same as that under the non-advance selling strategy; that is, the optimal spot price without capacity constraints is adopted when service capacity is sufficient, whereas the market-clearing price is applied if service capacity is insufficient. Consequently, there exists no risk of stockouts if consumers who arrive in the advance period choose to postpone buying, but they might have to pay a higher price. Not only do overconfident consumers overestimate the expected utility of advance purchasing, but they also overestimate the expected utility of waiting.

Consumers purchase in advance when $U_a \geq U_w(\geq 0)$; that is, $p_{1A} \leq (\beta + \delta)Ev - (\beta + \delta)\int_{p_{2A}}^{1}(v - p_{2A})f(v)dv = \frac{\beta+\delta}{2}[1 - (1 - p_{2A})^2]$. If the condition is met, then all consumers who arrive in the advance period choose to buy. The service provider chooses the highest price to maximize revenue; hence, the optimal advance price follows:

$$p_{1A} = \frac{\beta+\delta}{2}[1 - (1 - p_{2A})^2]. \quad (1)$$

The purchasing behavior of consumers that arrive in the spot period is the same as that under the non-advance selling scheme; that is, only consumers in a good state whose valuation of the product is not less than the spot selling price choose to buy. The profit function is

$$\pi_A = p_{1A}N + p_{2A}\beta N\bar{F}(p_{2A}), \quad (2)$$

$$\text{s.t. } \beta N\bar{F}(p_{2A}) \leq T - N. \quad (3)$$

The two terms in the profit function (2) represent the revenue in the advance period and spot period, respectively. Constraint (3) means that the remaining service capacity available in the spot period is not less than the spot demand. This is determined by the pricing mechanism in the spot period. When service capacity is relatively tight, the service provider reduces demand by raising the price to clear all products. Theorem 2 characterizes the optimal prices under Strategy A.

Theorem 2 When the service provider chooses advance selling, if $T \geq \widehat{T_A}$, then

$p_{1A1} = \frac{\beta+\delta}{2}[1-\frac{\beta^2}{(3\beta+\delta)^2}]$, $p_{2A1} = \frac{2\beta+\delta}{3\beta+\delta}$, $\pi_{A1} = \frac{(2\beta+\delta)^2}{2(3\beta+\delta)}N$; and if $\mathrm{N} < T < \widehat{T_A}$, then $p_{1A2} = \frac{\beta+\delta}{2}[1-\frac{(T-N)^2}{(\beta N)^2}]$, $p_{2A2} = \frac{(1+\beta)N-T}{\beta N}$, $\pi_{A2} = \frac{[(1+\beta)N-T][(3\beta+\delta)T-(1-\beta)\delta N-(3-\beta)\beta N]}{2\beta^2 N}$. Additionally, $\widehat{T_A} = N + \frac{\beta^2}{3\beta+\delta}N$, p_{1Ak}, p_{1Ak}, π_{Ak} $(k = 1,2)$ denote two different settings of prices and profits.

Theorem 2 provides the pricing path when the service provider adopts the advance selling strategy according to the service provider's service capacity. Comparing Theorem 2 with Theorem 1, we find that $\widehat{T_A} > \beta N$; that is, the equilibrium point of supply and demand moves backward compared with the point under the non-advance selling strategy, and supply tends to be tense against demand. This is because advance selling lengthens the distance between purchasing and consumption, and creates consumers' uncertainties about product valuation and consumption states in the advance period. By offering price discounts, the service provider attracts consumers to purchase in advance. Among the consumers, those who are in a bad state and have a low valuation of the product choose to leave in the case of non-advance selling. Therefore, advance selling boosts market demand, which is consistent with the conclusions in relevant literature, such as those by Xie and Shugan (2001). Ultimately, uncertainty in the advance period is useful for merchants to increase demand.

Corollary 1 $\frac{\partial p_{1Ak}}{\partial \beta} > 0$, $\frac{\partial p_{2A1}}{\partial \beta} < 0$, $\frac{\partial p_{2A2}}{\partial \beta} > 0$, $\frac{\partial \pi_{Ak}}{\partial \beta} > 0$; $\frac{\partial p_{1Ak}}{\partial \delta} > 0$, $\frac{\partial p_{2A1}}{\partial \delta} > 0$, $\frac{\partial p_{2A2}}{\partial \delta} = 0$, $\frac{\partial \pi_{Ak}}{\partial \delta} > 0$; $\frac{\partial \widehat{T_A}}{\partial \beta} > 0$, $\frac{\partial \widehat{T_A}}{\partial \delta} < 0$, where $k = 1,2$.

Corollary 1 shows that the advance price positively relates to the probability of consumers' being in a good state and the degree of overconfidence. This is because an increase in consumers' overconfidence and the probability of a good state can enhance the expected utility of purchasing in the advance period, which makes consumers willing to pay a higher advance price. The spot price under sufficient supply is negatively correlated with the probability of a good state, but the spot price under tight supply positively correlates with the probability of a good state. This is because an increase in the probability of a good state means an increase in demand. When supply is sufficient, it is more economical for the service provider to sell more products to reduce the residual loss at a lower price. When supply is insufficient, demand stimulated by an increase in the probability of a good state can be satisfied using a higher market-clearing price, and a surplus of products does not transpire. Moreover, increasing demand creates a tenser supply–demand relation, and thus a higher spot price is allowed.

The spot price is positively associated with the degree of overconfidence under sufficient supply, whereas it is independent of overconfidence under tight supply. This is because an increase in the advance price expands the space for raising the spot price, but the market-clearing price is only related to supply and demand in the spot period under tight supply. The profit function positively correlates with the probability of a good state and the degree of overconfidence. Consumers' overconfidence is beneficial to the service provider, which increases the advance price and spot price. Although the spot demand may decrease, the price increase still enables the service provider to gain more profits.

3.4 Strategy *C*: Advance Selling and Allowing Cancellation

With the implementation of the advance selling strategy, consumers face the risks of uncertainty when deciding to buy in advance. In practice, the service provider often allows consumers to back out when they are certain about the product valuation and consumption states in the spot period to encourage advance sales. Consumers can return goods and acquire a refund in terms of physical products. If the product is service oriented, such as tickets, consumers can obtain a refund of a certain amount when they cancel the order.

Under Strategy *C*, which offers advance selling and allows cancellation, the expected utility when consumers order in advance is $U_a = (\beta+\delta)[\int_0^{R-h}(R-h)f(v)dv + \int_{R-h}^{1} vf(v)] + (1-\beta-\delta)(R-h) - p_{1C}$. The first term denotes the utility in a good consumption state. If consumers cancel orders in the second period, they obtain the utility $R-h$; that is, they receive a partial refund and pay the hassle costs, such as communication cost and time cost. If they do not cancel, they obtain the utility v. Thus, consumers choose to cancel orders if $R-h \geq v$. The second term means that consumers give up consumption if they are in a bad state. Thus, the utility they obtain when choosing to cancel is $R-h$. The third term is the advance price consumers must pay.

The expected utility in the case of waiting is the same as that in the case of advance selling and disallowing cancellation, that is, $U_w = (\beta+\delta)\int_{p_{2C}}^{1}(v-p_{2C})f(v)dv$. Given that consumers eliminate all uncertainties near the consumption date, the service provider usually does not allow them to cancel orders.

If consumers choose to buy in advance, they should meet the condition $U_a \geq U_w (\geq 0)$, that is, $p_{1C} \leq (\beta+\delta)[\int_0^{R-h}(R-h)f(v)dv + \int_{R-h}^{1} vf(v)] + (1-\beta-\delta)(R-h) - (\beta+\delta)\int_{p_{2C}}^{1}(v-p_{2C})f(v)dv = \frac{\beta+\delta}{2}[1+(R-h)^2-(1-p_{2C})^2] + (1-\beta-\delta)(R-h)$. At this point, all consumers that arrive in the advance period choose to buy. The service provider should sell at the highest price, that is,

$$p_{1C} = \frac{\beta+\delta}{2}[1 + (R-h)^2 - (1-p_{2C})^2] + (1-\beta-\delta)(R-h). \quad (4)$$

Moreover, consumers that arrive in the spot period choose to buy when they are in a good consumption state and the product valuation is not less than the spot price. Therefore, the profit function is

$$\pi_C = p_{1C}N - R[(1-\beta) + \beta F(R-h)]N + p_{2C}\beta N\bar{F}(p_{2C}), \quad (5)$$

$$\text{s.t.}\ \ R \geq h, \quad (6)$$

$$\beta N\bar{F}(p_{2C}) \leq T - N + (1-\beta)N + \beta N F(R-h) = T - \beta N\bar{F}(R-h). \quad (7)$$

The three terms in the profit function (5) are the revenue in the advance period, the refund that results from consumers' cancellation, and revenue in the spot period. Constraint (6) shows that the refund should at least cover the consumer's hassle costs so that consumers that buy in advance choose to cancel orders if they find themselves in a bad state in the spot period. This is to ensure that consumers who are unable to come because of a poor consumption state report the fact to the service provider through the order cancellation and refund mechanism so that the service provider can resell the canceled service capacity after the refund (Xie and Gerstner, 2007). Constraint (7) is similar to Strategy A and means that the remaining service capacity available in the spot period is not less than the spot demand. The difference is that service capacity available at this point includes not only the remaining sales capacity after advance selling but also service capacity that is canceled by advance buyers who are in a bad state and who have a lower valuation of the product. Additionally, overconfident consumers expect that the probability of cancellation in the spot period because of a bad state is $1-\beta-\delta$, but the actual probability is $1-\beta$. We consider the difference of these two probabilities when modeling consumers' expected utility and the service provider's profit function.

Now we solve the equation to obtain Theorem 3.

Theorem 3. The service provider has three pricing portfolios according to service capacity under the advance selling and allowing cancellation strategy, as indicated in Table 3, where $\widehat{T_C} = \frac{(4\beta+\delta)\beta N}{3\beta+\delta}$, $\widetilde{T_C} = \frac{(4-h)\beta^2 N}{3\beta+\delta}$.

Theorem 3 provides the optimal prices when the service provider implements the advance selling and allowing cancellation strategy. Thus, when service capacity is relatively sufficient, consumers can only obtain compensation equal to the hassle costs if canceling orders, but under insufficient service capacity, the service provider is willing to offer a refund relatively larger than the hassle costs ($R_{C3} \geq h$ when $T \leq \widetilde{T_C}$). This is because the canceled products can be resold and higher refund compensation results in an increase in the number of canceled orders. This means more unsalable products or a lower spot price when service capacity is sufficient. By contrast, under insufficient service capacity, the service provider should pay higher refund compensation to improve the supply ability in the spot period. Additionally, the advance price and spot price decrease as service capacity increases.

Corollary 2. The relationship between the three pricing strategies given in Theorem 3 with the probability of a good state, the degree of overconfidence, and the hassle costs are shown in Table 4. Additionally, $\frac{\partial \widehat{T_C}}{\partial \beta} > 0$, $\frac{\partial \widehat{T_C}}{\partial \delta} < 0$, $\frac{\partial \widehat{T_C}}{\partial h} = 0$, $\frac{\partial \widetilde{T_C}}{\partial \beta} > 0$, $\frac{\partial \widetilde{T_C}}{\partial \delta} < 0$, $\frac{\partial \widetilde{T_C}}{\partial h} > 0$. In Table 4, "↗," "↘," and "−" represent monotonic increasing, monotonic decreasing, and independence, respectively.

Table 3. Pricing Strategy for Advance Selling and Allowing Cancellation

Pricing strategy	Advance price, spot price, refund, profit
$C1$: $\mathrm{T} \geq \widehat{T_C}$	$p_{1C1} = \frac{\beta+\delta}{2}\left[1 - \frac{\beta^2}{(3\beta+\delta)^2}\right]$
	$p_{2C1} = \frac{2\beta+\delta}{3\beta+\delta}$
	$R_{C1} = h$
	$\pi_{C1} = \frac{(2\beta+\delta)^2 - 2h(1-\beta)(3\beta+\delta)}{2(3\beta+\delta)} N$
$C2$: $\widetilde{T_C} < \mathrm{T} < \widehat{T_C}$	$p_{1C2} = \frac{\beta+\delta}{2}[1 - \frac{(T-\beta N)^2}{(\beta N)^2}]$
	$p_{2C2} = 1 - \frac{T-\beta N}{\beta N}$
	$R_{C2} = h$
	$\pi_{C2} = \frac{8\beta^2 N + (2\delta N - 3T)\beta - \delta T}{2\beta^2 N} T - [2\beta + (1-\beta)h]N$
$C3$: $T \leq \widetilde{T_C}$	$p_{1C3} = \frac{(\beta+\delta)^2 T^2 + [(\beta+\delta)\beta h - (3\beta+\delta)]\beta N T + (4-h)\beta^3 N^2}{4\beta^3 N^2}$
	$p_{2C3} = \frac{(4+h)\beta^2 N - (\beta-\delta)T}{4\beta^2 N}$
	$R_{C3} = \frac{(4+3h)\beta^2 N - (3\beta+\delta)T}{4\beta^2 N}$
	$\pi_{C3} = \frac{2[(4+3h)\beta + \delta h]\beta^2 N T - (3\beta+\delta)(\beta-\delta)T^2 - (8-\beta h)\beta^3 h N^2}{8\beta^3 N}$

Table by authors.

According to Corollary 2, the refund consumers receive when they cancel orders is independent of the probability of a good state and the degree of overconfidence under sufficient service capacity, and a bad consumption state is the only reason for canceling now. However, under insufficient service capacity, the refund increases with

β but decreases with δ. This is because an increase in the probability of a good state not only means greater demand in the second period but also a decrease in the number

Table 4. Parameter Analysis of the Prices and Profits under Strategy *C*

Price strategy		β	δ	h
$C1$: $T \geq \widehat{T_C}$	p_{1C1}	↗	↗	–
	p_{2C1}	↘	↗	–
	R_{C1}	–	–	↗
	π_{C1}	↗	↗	↘
$C2$: $\widetilde{T_C} < T < \widehat{T_C}$	p_{1C2}	↗	↗	–
	p_{2C2}	↗	–	–
	R_{C2}	–	–	↗
	π_{C2}	↗	↗	↘
$C3$: $T \leq \widetilde{T_C}$	p_{1C3}	↗	↗	↗
	p_{2C3}	↗	↗	↗
	R_{C3}	↗	↘	↗
	π_{C3}	↗	↗	↘

Table by authors.

of consumers who cancel orders because of a bad state. Then the service provider must raise the refund to force consumers with a lower product valuation to cancel orders so that more saleable products become available. The spot price rises with increased overconfidence, which leads to a decrease in the spot demand. This means that replenishing supply by canceling orders is not that urgent, hence the service provider can lower the refund. Furthermore, the service provider must increase the refund to offset the increase in consumers' hassle costs. The advance price and spot price change with β and δ under Strategy *C*, and similarly under Strategy *A*. The prices are independent of the hassle costs under sufficient service capacity, whereas they are positively correlated under insufficient service capacity. The key is whether the service provider must encourage consumers with a lower valuation of the product to cancel orders through higher refunding. In terms of profits, consumers' overconfidence is still beneficial to the service provider under Strategy *C*, but the hassle costs compel the service provider to offer a higher refund, which causes a drop in revenue.

Additionally, similar to Strategy *A*, the threshold $\widehat{T_C}$ increases with the probability of a good state, but decreases with the degree of overconfidence. This is because the spot demand rises and the quantity of orders canceled because of a bad state falls when the probability of a good state increases. Moreover, the spot demand falls because of a higher spot price, and the quantity of orders canceled because of a lower product valuation rises when the degree of overconfidence decreases.

Theorem 3 and Corollary 2 provide three pricing schemes under the advance selling and allowing cancellation strategy, and their relationship with relevant parameters. Given that the profit function (5) and constraint (7) are based on $T > N$, not all three pricing strategies are feasible under all conditions. We obtain the sets of feasible strategies under corresponding δ and β by comparing the service capacity thresholds $\widehat{T_C}$, $\widetilde{T_C}$, and N, as indicated in Corollary 3.

Corollary 3. The feasible conditions for the three pricing strategies in Theorem 3 are shown in Table 5, where $\delta_1 = \frac{(4\beta-3)\beta}{1-\beta}$, $\delta_2 = [(4-h)\beta - 3]\beta$.

Table 5. Feasible Conditions of the Three Pricing Strategies under Strategy *C*

β	δ	Sets of feasible pricing strategies
$\beta \le \frac{3}{4}$	$\delta < 1-\beta$	$\{C1\}$
$\frac{3}{4} < \beta \le \frac{3}{4-h}$	$\delta < \min\{\delta_1, 1-\beta\}$	$\{C1, C2\}$
	$\delta_1 \le \delta < 1-\beta$	$\{C1\}$
$\beta > \frac{3}{4-h}$	$\delta < \min\{\delta_2, 1-\beta\}$	$\{C1, C2, C3\}$
	$\delta_2 \le \delta < \min\{\delta_1, 1-\beta\}$	$\{C1, C2\}$
	$\delta_1 \le \delta < 1-\beta$	$\{C1\}$

Table by authors.

Corollary 3 shows that when the probability of a good state is small, demand in the second period decreases and the number of orders canceled because of a bad state is large so that supply is always greater than demand. Then, the only feasible strategy is *C1*. As the probability of a good state increases, demand gradually approaches supply, and even exceeds it. *C2* and *C3*, which offer the market-clearing price, are only likely to be dominant strategies when the degree of overconfidence is sufficiently low. This is because when δ is low, the optimal spot price is relatively low and demand in the second period becomes high, which may lead to the market-clearing price. If δ is extremely high, the number of consumers whose product valuation is higher than the spot price is small because of the higher spot price; thus, demand is lower than supply and the service provider must adopt strategy $C1$.

4. Strategy Comparison and Analysis

Comparing the optimal pricing under Strategy N, A, and C given in Theorems

1, 2, and 3, we obtain Corollaries 4 and 5.

Corollary 4. $\widehat{T_A} > \widehat{T_C} > \beta N$.

Corollary 5. When $T > N$, the price under the non-advance selling strategy is lower than the spot price when advance selling is implemented; the advance price and spot price in Strategy *C* are not higher than those prices in Strategy *A*.

Corollary 4 shows that because Strategy *A* takes advantage of consumers' uncertainties about product valuation and consumption states, the actual sales volume greatly improves, and the threshold of tightness between supply and demand is the largest. Strategy *C* only uses the product valuation uncertainty and there exists no uncertainty with Strategy *N*, therefore, the corresponding thresholds decrease in turn. The differences of tightness between supply and demand are also the reason for the differences in the prices given in Corollary 5. The selling price under the non-advance selling strategy is the lowest because of the highest supply but least demand, and the selling price under Strategy *C* comes second. Supply in the spot period is the tightest under Strategy *A*, hence the highest price. The conclusion in Corollary 5 differs from that of Mao et al. (2016). They indicated that compared with the advance selling and disallowing cancellation strategy, allowing consumers to cancel orders and obtain a partial refund is good for retailers to set a higher advance price. The reason is that Mao et al. (2016) assumed that the spot price is determined exogenously by the market and did not consider capacity constraints. Corollary 5 is drawn in consideration of the service provider's limited service capacity and endogenous pricing in the spot period. We believe that Corollary 5 is a beneficial extension of and complement to the conclusion in the literature.

Because of the complexity of profit functions, we use numerical examples to analyze the influences of relevant parameters on the profit functions in the three strategies. The main parameter values are set as follows: Case 1: $N = 1$, $\beta = 0.85$, $\delta = 0.1$, $h = 0.05$; Case 2: $N = 1$, $\beta = 0.81$, $\delta = 0.1$, $h = 0.05$; and Case 3: $N = 1$, $\beta = 0.85$, $\delta = 0.02$, $h = 0.05$. We use the first two datasets for comparing and analyzing the influences of the probability of a good state, and the first and third datasets for comparing and analyzing the influences of overconfidence. The results are shown in Figures 1 and 2, respectively. We use different line types and markers to distinguish the profit function curve of each pricing strategy, and the critical points T_{AC} of Strategies *A* and *C* are represented by square points. From the two figures, we obtain the following findings.

Finding 1: When $T > N$, the non-advance selling strategy is always dominated because surplus products always exist. After the implementation of the advance selling strategy, consumers in the advance period choose to buy because of uncertainties about product valuation and consumption states, which significantly increases sales and causes service capacity to be sold out.

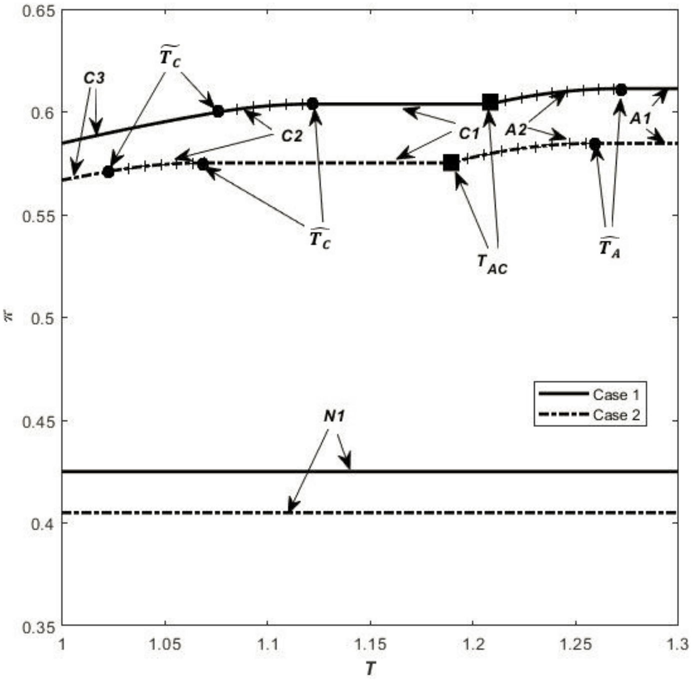

Figure 1. Comparison of the Profits of Each Strategy for Different β

Figure by authors.

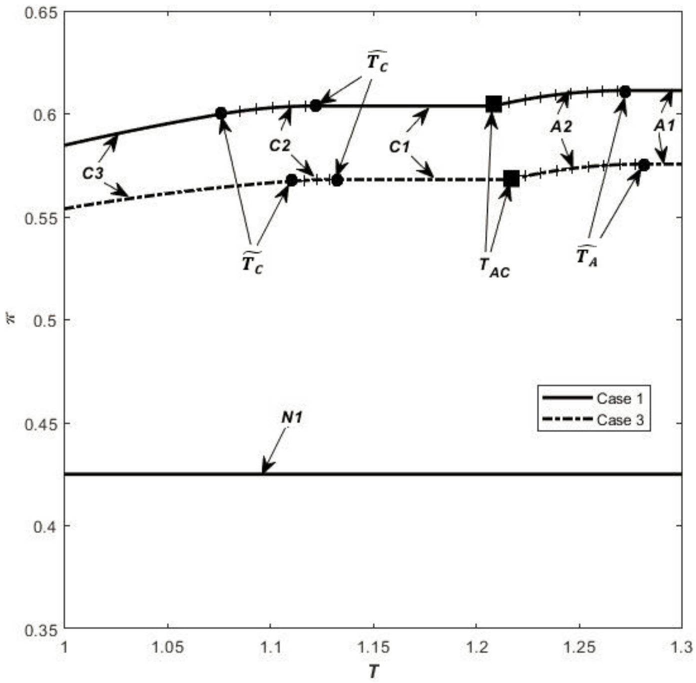

Figure 2. Comparison of the Profits of Each Strategy for Different δ

Figure by authors.

Finding 2: When service capacity is relatively large, the advance selling and disallowing cancellation strategy is dominant. Contrarily, selling in advance and allowing cancellation are better. There exists a critical value of service capacity T_{AC}, which serves as a point for the service provider to determine whether allowing cancellation is economical. Despite that, allowing order cancellation enables the service provider to replenish salable service capacity in the spot period, which means that once canceled products cannot be resold, the service provider loses the refund paid to consumers who cancel orders. Therefore, for the service provider to allow cancellation under relatively sufficient service capacity would be unwise.

Finding 3: The greater the probability of a good state, the more profitable allowing cancellation is to the service provider. Figure 1 shows that T_{AC} moves to the right with an increase in β and the feasible interval of Strategy *C* increases. This is because as the spot demand increases and the number of consumers canceling orders decreases because of a bad consumption state, higher service capacity is needed to alleviate the tightness between supply and demand.

Finding 4: Compared with the non-advance selling strategy, overconfidence expands the feasible space of the two advance selling strategies. Compared with the advance selling and disallowing cancellation strategy, overconfidence compresses the feasible space of the advance selling and allowing cancellation strategy. Figures 1 and 2 show that, with increased overconfidence, the profits under Strategies A and C are more obvious than the profits under Strategy *N*. This is because, whether in the advance period or spot period, the service provider can set higher prices. Moreover, increased overconfidence leads to an increase in the spot price when orders can be canceled (Strategy $C1$, Corollary 2) and demand immediately decreases. The spot price remains unchanged when cancellation is not allowed (Strategy $A2$, Corollary 1), then demand remains stable. Therefore, T_{AC} moves to the left.

Finding 5: The service provider may develop a wrong sales strategy if it ignores or is unable to assess consumers' overconfidence accurately. As shown in Figure 2, if the service provider underestimates the intensity of consumers' overconfidence, it may improperly allow consumers to cancel orders when it should have adopted Strategy A, and vice versa.

5. Results Under $T \leq N$

In Sections 3 and 4, our study is based on the premise of $T > N$. We find solutions in a similar manner when $T \leq N$.

In terms of Strategy *N*, the conclusion is the same as that in Theorem 1.

For Strategy A, salable service capacity is not greater than the number of consumers in the advance period, which causes no products to be available for sales in the spot period. Therefore, the entire sales process includes the advance period alone and consumers choose to buy if the expected utility in the advance period is not less than zero, that is, $U_a = (\beta + \delta)Ev - p_{1A} \geq 0$. Thus, the optimal advance price is $p_{1A} = \frac{\beta+\delta}{2}$. Therefore, the profit function is

$$\pi_A = p_{1A}T. \tag{8}$$

For Strategy C, even if all the products can be sold in the advance period, some consumers cancel orders because of their bad state or lower valuation of the product, and the canceled products can be resold. Therefore, Strategy C splits into the advance period and spot period. We assume that the service provider adopts the first-come-first-served rationing strategy in the advance period according to the actual scenarios. Consumers who cannot buy in the advance period because of insufficient service capacity choose to wait and purchase until the spot period. At this point, the expression for the expected utility in the two periods is the same as that when $T > N$, and the formation for the advance price is shown in Eq. (4). The profit function is

$$\pi_C = p_{1C}T - R[(1-\beta) + \beta F(R-h)]T + p_{2C}\beta(2N-T)\bar{F}(p_{2C}), \tag{9}$$

$$\text{s.t. } R \geq h, \tag{10}$$

$$\beta(2N-T)\bar{F}(p_{2C}) \leq (1-\beta)T + \beta TF(R-h) = T - \beta T\bar{F}(R-h). \tag{11}$$

The solving process is similar to that when $T > N$; hence, we do not repeat it here. Table 6 presents the spot price and refund for the three feasible pricing schemes under Strategy C. The corresponding advance prices, profits, and the thresholds $\widehat{T_C}$ and $\widetilde{T_C}$ can also be obtained. Because of the complexity in the expression, we do not list them in the table.

Table 6. Pricing Strategy for Advance Selling and Allowing Cancellation ($T \leq N$)

Pricing strategy	Spot price and refund
$C1$: $T \geq \widehat{T_C}$	$p_{2C1} = \frac{2\beta N + \delta T}{4\beta N - (\beta-\delta)T}$ $R_{C1} = h$
$C2$: $\widetilde{T_C} < T < \widehat{T_C}$	$p_{2C2} = 1 - \frac{(1-\beta)T}{\beta(2N-T)}$ $R_{C2} = h$
$C3$: $T \leq \widetilde{T_C}$	$p_{2C3} = \frac{(4N^2+4hNT-hT^2)\beta^2-(4N-T)\beta T-\delta T^2-4(N-T)(1+h)\beta\delta N}{4\beta N[(\beta-\delta)N+\delta T]}$ $R_{C3} = \frac{(4N^2+2hNT-hT^2)\beta^2-(2N-T)(\beta-\delta)T-4(N-T)\beta\delta N}{4\beta N[(\beta-\delta)N+\delta T]}$

Table by authors.

Similarly, we use numerical examples to analyze the impacts of relevant parameters on the profit function of each strategy. The number of consumers and the hassle costs are denoted by $N = 1$ and $h = 0.05$, respectively, and the probability of a good state and the degree of overconfidence are set as follows: Case 1: $\beta = 0.6$,

$\delta = 0.2$; Case 2: $\beta = 0.5$, $\delta = 0.2$; and Case 3: $\beta = 0.6$, $\delta = 0.1$. We use the first two datasets to analyze the influence of β, and the first and third datasets to analyze the influence of δ. The results are shown in Figures 3 and 4, respectively. The marking pattern is the same as that in Figures 1 and 2, and the square points represent T_{NC}; that is, the threshold of Strategies *N* and *C*. From Figures 3 and 4, we obtain the following findings.

Finding 1: The revenue of the service provider is positively related with overconfidence and the probability of a good state. $\widehat{T_C}$ and $\widetilde{T_C}$ are positively related with β and negatively related with δ. Corollaries 1 and 2 still hold.

Finding 2: The advance selling and disallowing cancellation strategy under $T \leq N$ is always dominated. In nature, the strategy abandons spot sales. Despite the fact that the service provider can sell all the products in the advance period, the existence of uncertainty makes it difficult to set a higher price. Strategy *A* may be superior to the non-advance selling strategy when service capacity is relatively large, but the convenience of resales by allowing cancellation makes Strategy *C* superior to Strategy *A*.

Finding 3: The non-advance selling strategy is dominant under relatively low service capacity. This is because the service provider can set a price that is sufficiently high under small service capacity. In addition, under extremely low service capacity, even if the service provider allows cancellation to make profits from resales, the number of products available in the spot period is highly limited and the service provider must also pay the refund.

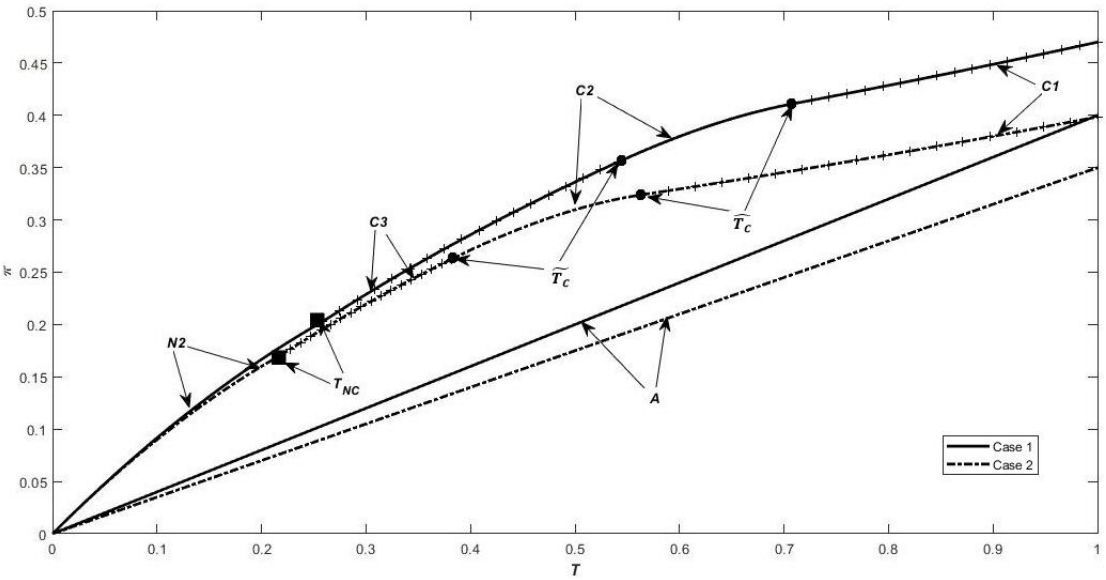

Figure 3. Comparison of the Profits of Each Strategy for Different β ($T \leq N$)
Figure by authors.

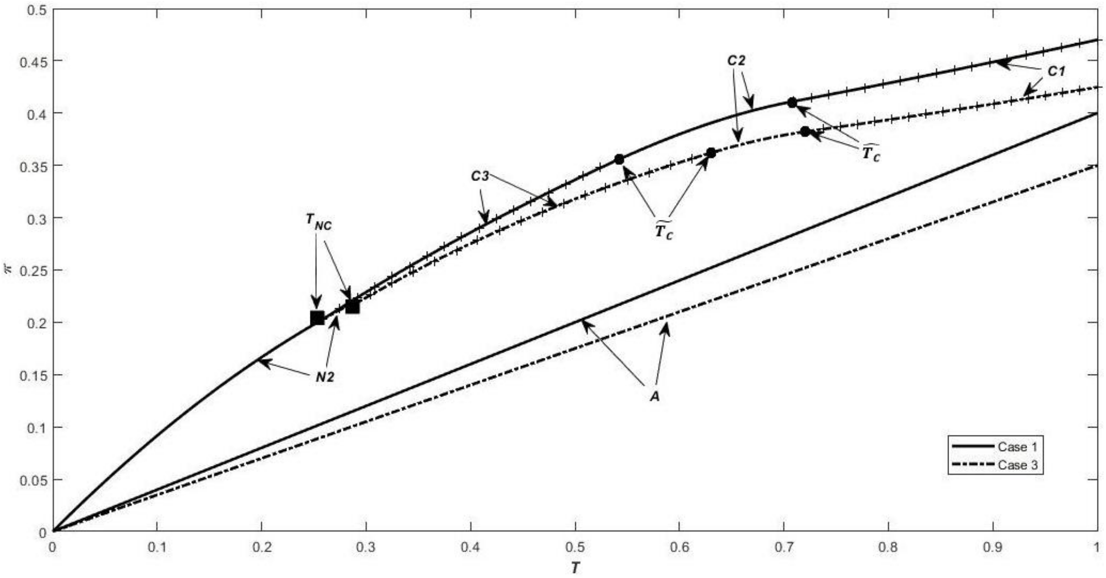

Figure 4. Comparison of the Profits of Each Strategy for Different δ ($T \leq N$)
Figure by authors.

Finding 4: The greater the probability of a good state, the greater the favorable interval of the non-advance selling strategy. As shown in Figure 3, T_{NC} moves to the right as β increases and the feasible interval of Strategy *N* increases. This is because the selling price under the non-advance selling strategy escalates and the number of consumers that cancel orders decreases because of a bad consumption state, which means that the implementation of Strategy *C* requires higher service capacity.

Finding 5: Compared with the non-advance selling strategy, overconfidence expands the feasible space of Strategy *C*, as shown in Figure 4. An increase in overconfidence allows the service provider to raise the advance price and spot price without affecting the revenue of the non-advance selling strategy. Therefore, T_{NC} moves to the left. Moreover, T_{AC} and T_{NC} move to the left with δ. However, the former means that the necessity of allowing cancellation falls, and the latter means that the necessity of allowing cancellation rises. This is because the former is under sufficient supply and canceled service capacity may not be sold, whereas the latter is under tight supply and replenishment from canceled service capacity is highly urgent.

Ultimately, the conclusions and internal reasons when $T \leq N$ are consistent with those when $T > N$. The service provider should deal with consumers' overconfidence rationally or it may develop wrong sales strategies.

6. Conclusions

Our study was based on consumers' overconfidence, which is highly common in uncertain environments. We focused on a service provider with limited service capacity, who faced consumers that were overconfident about the probability of a good consumption state and confronted with the uncertainties of product valuation and consumption states in the advance period. We studied how the service provider chooses the optimal sales strategy among the non-advance selling strategy, the advance selling and disallowing cancellation strategy, and the advance selling and allowing cancellation strategy. We discussed how overconfidence influences the service provider's decision making. Below, we summarize the most interesting findings, which are the answers for the three questions in Section 1.

First, in most cases, service providers should adopt advance selling in the face of overconfident customers. And only when the service capacity is very low, the non-advance selling strategy dominates. Consumers' overconfidence positively influences the price and feasible interval of advance selling.

Second, service providers should not allow customers who bought in advance to cancel orders when the service capacity is very low and very large. In other words, the advance selling and disallowing cancellations strategy only dominates under middle service capacity. When service capacity is relatively sufficient, consumers' overconfidence makes it less necessary to allow them to cancel orders; and when service capacity is relatively insufficient, service providers should allow order cancellation if they choose to sell in advance and consumers' overconfidence expands the feasible space for allowing order cancellation. And overconfidence may negatively influence the refund price for canceled orders under relatively insufficient service capacity.

Third, customers' overconfidence is always beneficial to adopting advance selling regardless of service providers' service capacity, but it has a two-sided impact on the cancellation strategy, which depends on the capability levels of service providers. Therefore, service providers should fully consider the levels of customers' overconfidence and service providers' capacity for optimal decisions.

To highlight the contribution of results, we compare them with others from the relevant literature. On the one hand, our paper is the first to the joint decision of advance selling and service cancellation under capacity constraints considering consumers' overconfidence. Even though Li et al. (2016) studies advance selling decisions combining overconfident behavior, it is significantly different from ours. Our paper differs from the extant literature in three aspects as follows: First, in our paper, we consider consumers' overconfidence in their consumption state uncertainty, which is manifested in the overestimated probability of a good state in the future, but Li et al. (2016) studied consumers' overconfidence in uncertainty about product valuation. Second, in our paper, we investigate whether to allow consumers to cancel orders when the service provider offers advance selling and expound the influences of overconfidence on decision making regarding cancellation, whereas this was not discussed in previous papers. Third, in our paper, we study the impacts of limited service capability on advance selling in terms of service-oriented products when consumers are overconfident, which was not mentioned in extant literature. On the other hand, our results deepen the understanding of overconfident behavior for decision-making of enterprises, e.g., the one-sided influence on advance selling of overconfidence and the two-sided influence on cancellation of overconfidence. We also present decision-making paths of enterprises base on different levels of overconfidence. Actually, there's not a lot of research on overconfident behavior in individuals especially customers, so our results could enrich the extant results on consumer overconfidence. In addition, our utility function construction for overconfident consumers based on the utility theory may have certain reference value for modeling when consumers have multiple uncertainties, and also have certain reference significance for modeling with other irrational behaviors similar to overconfidence, such as panic buying (Chua et. al., 2021), impulse purchasing and so on.

Practically, our model has some theoretical implications for similar research and our findings have some managerial implications for service providers' advance selling decisions. For the former, although we build the model for service-oriented products, it has some reference value for the model construction when we try to study physical product manufacturers with capacity constraints. Besides, our assumptions about consumers' overconfident behavior and how they are embedded in the model based on the consumer utility theory should also have some enlightening value for the study of similar topics. For the latter, that is, managerial implications, we elaborate in the following three paragraphs.

First, for ticket-type service-oriented products, such as tickets for concerts and sports events, particularly hot tickets, consumers are so tremendously enthusiastic that they often overestimate the probability of being in a comfortable consumption state when making purchasing decisions. When developing sales strategies, service providers should pay attention to and identify consumers' overconfident behavioral preferences through market research and sales data analysis, and weigh whether to sell in advance or allow cancellation based on limited capacity. For example, service providers could investigate consumers' attitudes and evaluations of service-oriented products through social media, and evaluate consumers' willingness to pay through flexible operation of advance selling and service cancellation, which include differential pricing based on the time of purchasing and cancelling and option pricing mechanism of advance selling. In addition, they should evaluate consumers' overconfidence through order cancellation rates of similar sports events and concerts in the past. Then service providers with limited capacity may optimize the decisions, including whether and when to advance sell, whether to allow cancellation and the beast proportion of refund, and so on.

Second, regarding seasonal service-oriented products, such as hotels, consumers are less willing to book hotels during the off season and hotels are in excessive supply. However, they have stronger willingness and show a greater degree of overconfidence during the high season, particularly before the eve of important holidays, and hotels' supply often falls short of demand. Our findings suggest that hotel service providers should start advance selling earlier in the off season and prolong the advance selling period to include as many consumers as possible. Moreover, order cancellation should be allowed to encourage consumers to preorder. In the case of extreme oversupply, consumers should not be allowed to cancel their orders. In high season, service providers should implement advance selling and allow order cancellation. If demand exceeds supply extremely, service providers should give up advance selling, but choose spot selling instead near the consumption day when consumers are certain about consumption states. In conclusion, service providers should make dynamic adjustments to their advance selling and order cancellation strategies according to the changes of off and peak seasons and consumers' behavioral preferences to maximize profit.

Although we study the strategies for service-oriented products, the conclusions have some reference value for physical products. For example, if the physical product is an experiential product and the manufacture's capacity is limited, such as red wine, customers may be overconfident about the valuation of wine and consumption state of tasting. Then the manufacture may refer to the results in our paper to optimize decisions of advance selling and order cancellation. Regardless of product types, enterprises need to follow reasonable steps to make decisions. Firstly, the internal and external environment analysis is carried out to clarify product characteristics, service capabilities and target customers. Then, enterprises should implement the market research and estimate the utility of target customers based on the utility theory, and analyze their possible behavior choices. Finally, they could make joint decisions of advance selling and orders cancellation, set appropriate prices, and constantly adjust and optimize the strategies according to the implementation of decisions.

Our research has some limitations, which open future research scope correspondingly. First, we only discussed service providers' optimal refund when overconfident consumers cancel their orders. In further research, we can discuss the time limit for allowing order cancellation and different levels of refund corresponding to the cancellation time. Second, for simplicity, we assumed that all consumers in the advance selling period had the same degree of overconfidence. Different types of people, such as people of different countries, ages, and experiences, may have different overconfident behavior. In the future, we will consider the heterogeneity of overconfidence and try to make comparative studies. Finally, we must explore the influence of consumers' overconfidence on service providers' advance selling and order cancellation strategies in a competitive environment.

Data Availability

The model verification data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

Appendix

Proof of Theorem 1: When supply exceeds demand, the service provider sells products at the unconstrained optimal price. The profit function $\pi_N = 2\beta N(1-p_N)p_N$ is concave. From the first order condition, we have $p_N = \frac{1}{2}$. The number of consumers buying at this point is $2\beta N(1-p_N) = \beta N$. Therefore, $T \geq \beta N$ shall be satisfied under oversupply. When supply falls short of demand, the service provider sells at the market-clearing price. Then $T = 2\beta N(1-p_N)$, we have $p_N = 1 - \frac{T}{2\beta N}$. The market-clearing price is higher than the unconstrained optimal price, i.e., $1 - \frac{T}{2\beta N} > \frac{1}{2}$, thus we have $T < \beta N$.

Proof of Theorem 2: Given that $\frac{\partial^2 \pi_A}{\partial {p_{2A}}^2} = -(3\beta+\delta)N < 0$, the profit function with respect to p_{2A} is concave.

From Formulas (1)–(3), we construct Lagrange equation: $L = \frac{\beta+\delta}{2}[1-(1-p_{2A})^2]N + p_{2A}\beta N(1-p_{2A}) + \lambda[T - N - \beta N(1-p_{2A})]$. From Kuhn-Tucker conditions, we have:

$$\begin{cases} \frac{\partial L}{\partial p_{2A}} = [(2-3p_{2A})\beta + (1-p_{2A})\delta]N + \lambda\beta N = 0 \\ \lambda[T - N - \beta N(1-p_{2A})] \end{cases}.$$

When $\lambda = 0$, from $\frac{\partial L}{\partial p_{2A}} = 0$ we have $p_{2A} = \frac{2\beta+\delta}{3\beta+\delta}$. Substituting it into Formula (3) we have $T \geq \widehat{T_A}$. When $\lambda \neq 0$, $T - N - \beta N(1-p_{2A}) = 0$, we have $p_{2A} = \frac{(1+\beta)N-T}{\beta N}$. Substituting it into $\frac{\partial L}{\partial p_{2A}} = 0$ we obtain $\lambda = 1 - \frac{(3\beta+\delta)(T-N)}{\beta^2 N}$, and from $\lambda > 0$ we obtain $T < \widehat{T_A}$. Substituting p_{2A} into Formulas (1) and (2), respectively, we get corresponding advance prices and profits.

Proof of Corollary 1: It can be proved by calculating the first derivative of δ and β for advance prices, spot prices, profit functions and service capacity thresholds in Theorem 2.

Proof of Theorem 3: Given that $\frac{\partial^2 \pi_C}{\partial p_{2C}^2} = -(3\beta + \delta)N < 0$, $\frac{\partial^2 \pi_C}{\partial R^2} = -(\beta - \delta)N < 0$, $\frac{\partial^2 \pi_C}{\partial p_{2C}\partial R} = \frac{\partial^2 \pi_C}{\partial R \partial p_{2C}} = 0$, and the Hessian matrix is greater than 0, the profit function with respect to p_{2C} and R is a joint concave function.

From Formulas (4)–(7), we construct Lagrange equation: $L = p_{1C}N - R[(1-\beta) + \beta F(R-h)]N + p_{2C}\beta N\bar{F}(p_{2C}) + \lambda_1(R-h) + \lambda_2[T - \beta N\bar{F}(R-h) - \beta N\bar{F}(p_{2C})]$. From Kuhn-Tucker conditions, we have:

$$\begin{cases} \frac{\partial L}{\partial p_{2C}} = [(2-3p_{2C})\beta + (1-p_{2C})\delta]N + \lambda_2\beta N = 0 \\ \frac{\partial L}{\partial R} = -[(1+h-R)\delta + \beta R]N + \lambda_1 + \lambda_2\beta N = 0 \\ \lambda_1(R-h) = 0 \\ \lambda_2[T - \beta N\bar{F}(R-h) - \beta N\bar{F}(p_{2C})] = 0 \end{cases}.$$

1) When $\lambda_1 = 0$, $\lambda_2 = 0$, from $\frac{\partial L}{\partial p_{2C}} = 0$ we have $p_{2C} = \frac{2\beta+\delta}{3\beta+\delta}$; from $\frac{\partial L}{\partial R} = 0$ we have $R = -\frac{(1+h)\delta}{\beta-\delta} < 0$. The results do not meet the Formula (6), hence no solution.

2) When $\lambda_1 = 0$, $\lambda_2 \neq 0$, $p_{2C} = 1 - \frac{T-(1-R+h)\beta N}{\beta N}$. Substituting it into the equation set, we obtain $R = \frac{(4+3h)\beta^2 N - (3\beta+\delta)T}{4\beta^2 N}$, $p_{2C} = \frac{(4+h)\beta^2 N - (\beta-\delta)T}{4\beta^2 N}$. From $R \geq h$, we have $T \leq \widetilde{T_C}$; from $\lambda_2 = \frac{(4+3h)\beta^3 N + (\delta h N - 3T)\beta^2 + (2\delta\beta + \delta^2)T}{4\beta^3 N} > 0$, we have $\mathrm{T} < \frac{[(4+3h)\beta + \delta h]\beta^2 N}{(\beta-\delta)(3\beta+\delta)}$. Given that $\frac{[(4+3h)\beta+\delta h]\beta^2 N}{(\beta-\delta)(3\beta+\delta)} - \widetilde{T_C} = \frac{4(\delta+\beta h)N}{(\beta-\delta)(3\beta+\delta)} > 0$, it only needs to satisfy $T \leq \widetilde{T_C}$.

3) When $\lambda_1 \neq 0$, $\lambda_2 = 0$, $R = h$. From $\frac{\partial L}{\partial R} = 0$, we have $\lambda_1 = (\delta + \beta h)N > 0$; from $\frac{\partial L}{\partial p_{2C}} = 0$, we get $p_{2C} = \frac{2\beta+\delta}{3\beta+\delta}$; substituting it into Formula (7), we have $\mathrm{T} \geq \widehat{T_C}$.

4) When $\lambda_1 \neq 0$, $\lambda_2 \neq 0$, $R = h$, $p_{2C} = 1 - \frac{T-(1-R+h)\beta N}{\beta N} = 1 - \frac{T-\beta N}{\beta N}$. From $\frac{\partial L}{\partial p_{2C}} = 0$, we have $\lambda_2 = \frac{(4\beta+\delta)\beta N - (3\beta+\delta)T}{\beta^2 N} > 0$, i.e., $\mathrm{T} < \widehat{T_C}$. From $\frac{\partial L}{\partial R} = 0$, we have $\lambda_1 = 3T + \frac{\delta}{\beta}T - (4-h)\beta N > 0$, i.e., $T > \widetilde{T_C}$. Thus, $\widehat{T_C} > \widetilde{T_C}$.

Substituting p_{2C} and R into Formulas (4) and (5), we can obtain corresponding advance prices and profits.

Proof of Corollary 2: It can be proved by calculating the first derivative of δ, β, and h for advance prices, spot prices, profit functions and service capacity thresholds in Theorem 3.

Proof of Corollary 3: From $\widehat{T_C} > N$ we have $\delta < \delta_1$; from $\widetilde{T_C} > N$ we have $\delta < \delta_2$. When $\beta \leq \frac{3}{4}$, $\delta_1 \leq 0$, $\delta > \delta_1$. Therefore, $\widehat{T_C} < N$ and only Strategy $C1$ is feasible when $T > N$. When $\frac{3}{4} < \beta \leq \frac{3}{4-h}$, $\delta_1 > 0$, $\delta_2 \leq 0$; when $\beta > \frac{3}{4-h}$, $\delta_1 > 0$, $\delta_2 > 0$. Combining Theorem 3, we have Corollary 3.

Proof of Corollary 4: $\widehat{T_A} - \widehat{T_C} = 1 - \beta > 0$, $\widehat{T_C} - \beta N = \frac{\beta^2 N}{3\beta+\delta} > 0$.

Proof of Corollary 5: When $T \geq \widehat{T_A}$, $p_{2A1} = p_{2C1} > p_N$. p_{2A1} and p_{2C1} are the lowest prices for Strategy *A* and Strategy *C*, respectively, $p_{1A1} = p_{1C1}$. When $\widehat{T_C} \leq T < \widehat{T_A}$, $p_{1A2} > p_{1C1}$, $p_{2A2} > p_{2C1}$. When $\widetilde{T_C} < T < \widehat{T_C}$ and $T \leq \widetilde{T_C}$, we only need to make similar comparisons.

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