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Sales Models and Pricing Strategies for Duty-Free Stores Considering Heterogeneous Consumers: A Case Study in Beijing

Abstract. *Tax free industry refers to the tourism service industry that allows specific retailers to sell duty-free goods to inbound and outbound tourists in order to achieve certain political and economic policies and promote the development of tourism consumption, so it is of great theoretical and practical significance to study the sales model and pricing strategy of duty-free stores. This paper advances its basic hypotheses, explores three sales modes of duty-free stores and heterogeneous consumer decision-making behaviour, constructs equilibrium price and revenue level models under different sales modes, establishes the equilibrium decision-making model of pricing strategies under different sales modes of duty-free stores, and conducts numerical simulation analysis. This analysis reveals that (1) the heterogeneous characteristics of high-value and low-value consumers influence the sales patterns of duty-free stores and have an important impact on their pricing strategies; (2) heterogeneous consumers differ substantially in the perceived value of goods in the market, which influences their purchasing patterns, which also has an important impact on the revenue and market share of duty-free stores; and (3) the market shares of high-value consumers and the difference in initial perceived value determine the sales patterns and pricing strategies of duty-free stores and ultimately affect their revenue levels.*

Keywords: *duty-free stores, sales model, pricing strategy, heterogeneous preferences, numerical simulation.*

JEL Classification: D11, D12.

1. Introduction

The consumer heterogeneity means that consumers have different consumption concepts and consumption styles depending on their individual characteristics, such as income, age, gender, family, and location, and that consumers from different groups may have different consumption behaviours for the same product. The unique policy and price advantages of the products sold in duty-free stores attract many consumers, and this substantial customer base generates considerable profits; however, the Chinese government has implemented clear policies to restrict the target, amount, and quantity of duty-free products. Duty-free stores have unique features not shared with the general retail industry, such as special consumer groups, special shopping locations, and price and brand advantages, which are offered for

the convenience of inbound tourists and to meet their shopping needs, and the corresponding consumer groups also differ from those of the general retail industry, which leads to obvious heterogeneity in consumer consumption preferences in duty-free stores. Therefore, in view of the heterogeneous behaviour of their customers, duty-free stores need to adopt different sales models and pricing strategies, analyse consumer behaviour under two different contexts of consumers' perceived certainty and perceived uncertainty in the value of goods, devise their sales models accordingly, and formulate scientific pricing strategies to provide a decision basis for marketing strategy management.

Duty-free stores often apply dynamic pricing as a marketing strategy in various business activities to cope with the variability of consumer behaviour and the uncertainty of market demand for goods. Besanko et al. (1990) first applied the concept of strategic consumers to an intertemporal pricing model and found that the optimal pricing strategy for short-sighted consumers, when applied to the pricing strategy for rational consumers, would be more profitable than following a rational consumer equilibrium pricing policy of a monopolist with lower profits. Based on the rational expectations equilibrium approach and the newsvendor model, Ye et al. (2016) found that additive and multiplicative profit expectations of a strategic consumer supply chain positively affect the retailer's optimal expected profit under the two customer demand functions. There is extensive research on dynamic pricing aspects of goods in the fresh food and electronics goods industries. To solve the problem of the declining value of duty-free goods, some scholars have considered the behaviour of strategic consumers in their research on goods pricing and constructed an inventory decision model, an out-order stage model, and a two-stage pricing model (Goran et al., 2020; Alyouzbaky et al., 2021; Gao et al., 2022). Based on a setting with strategic consumers, Stoica et al. (2023) conducted an in-depth study on the channel selection of merchandise returns for resale in the apparel industry.

In general, most existing studies on consumer behaviour have focused on exploring the internal and external factors of individual consumers to analyse their influence on a certain phenomenon or mechanism. In addition, the development of behavioral decision theory has gradually included the hesitancy and uncertainty of decision makers, but it has mostly been applied in the field of multiattribute decision making, few studies have applied it to the field of consumer behaviour decision making, and the issue of the heterogeneity of consumer behaviour and the connection between merchants' sales patterns and pricing strategies has not yet been examined. Based on this, taking the consumption behaviour of heterogeneous consumers in a duty-free shop in Beijing as an example, the basic hypothesis is put forward of the study, three sales models of duty-free shops and the consumption decision-making behaviour of heterogeneous consumers is studied, so as to provide decision-making basis and method guidance for duty-free stores to select appropriate sales mode and pricing strategy in this paper.

2. Basic assumptions and consumer shopping decisions

2.1 Basic assumptions and parameter settings

To study the sales model and pricing strategy of duty-free stores with heterogeneous consumers, it is necessary to set and interpret the relevant variables. Based on the research results of the literature (Wang et al., 2023; Zivlak et al., 2023), combined with the research object and research needs, the variables are involved in this study are listed in Table 1. The mixed sales model is denoted by M, and this model can be divided into two purchase scenarios - online purchase and brick-and-mortar purchase, which are denoted by MF and MN, respectively; OF denotes the general offline (brick-and-mortar) sales model, while the online (Internet) sales model is denoted by ON.

Table 1. Description of basic variables

Variables.	Definition	Variables	Definition
p_{OF}	The price of goods in the offline general sales model	m	Potential basic consumers
p_{ON}	Price of goods in the online/Internet sales mode	q	The proportion of high-value consumers among potential consumers
p_{MF}	The price of offline goods under the hybrid sales model	β	Consumer preference rate
p_{MN}	The price of online goods under the hybrid sales model	α	Factors influencing the online sales of duty-free stores
v	Perceived value of goods at the time of consumer purchase decision	c	Advertising costs for online sales of duty-free stores
v_{H}	Initial perceived value of goods by high-value consumers	s	Attractiveness of online advertising for duty-free stores
v_{L}	Initial perceived value of goods by low-value consumers	u_{s}	Utility for online consumers
Δv	The amount of change in the perceived value of goods by potential online shoppers	u_{R}	The utility of online potential consumers

Source: Authors' own creation.

Hypothesis 1: Consumers' perceived value of goods, as proposed by Yu et al. and Zivlak et al., has mainly been characterised physical goods, but with the rapid development of e-commerce, the goods market is changing rapidly (Pishbahar et al., 2020). Consumers' perceived value of goods varies widely, and it varies with factors such as brand strength of goods, service value, marketing efforts, and the life cycle stage that the goods are in. According to the magnitude of consumers' perceived value of goods, Liu et al. classified them into two specific categories, high and low value, denoted by v_{H} and v_{L}, where the subscripts H and L are abbreviations for high and low, respectively, thus dividing consumers into two categories, i.e., high- and low-value consumers(Xie et al., 2023). In this paper, we refer to the assumptions in the literature (Xie et al., 2023) and assume that in the current market

situation, the proportions of high- and low-value consumers are q and $1-q$, respectively, which obey the Bernoulli distribution. In addition, the probability distributions of the two types of consumers are public information.

Hypothesis 2: Based on the marketing methods and intensity in the early stage, there are consumers who are aware of a product on the market but have not yet generated actual consumption behaviour, and we set the number of such consumers as m. In addition, when a duty-free store adopts a mixed strategy of offering both physical and online sales, these consumers can be divided into two categories: online and offline consumers. When the market is large enough, the intersection of these two categories of consumers is an empty set. Moreover, based on Assumption 1, we know that high- and low-value consumers obey a Bernoulli distribution, so in this scenario, the numbers of the two are qm and $(1-q)m$, respectively.

Hypothesis 3: In the online sales model, when there are consumers who are aware of a good in the market and choose to generate purchase behaviour on the Internet, then the recipients of online advertisements will be affected, causing the perceived value of the goods v_H or v_L to rise from $v = v_H(v_L) + \Delta v$, thus increasing the likelihood that viewers of online advertisements will purchase the good. However, placing online advertisements also increases the cost of duty-free stores, which is calculated as $c = \beta \Delta v$. Here, the cost coefficient of online advertising is denoted by β, and its value affects the degree of promotion efficiency, which is a reflection of social influence.

Hypothesis 4: In the online sales model, when consumers choose to purchase goods on the Internet and pay for them successfully, they can enjoy online discount prices and realise benefits, and they can also have a demonstration effect on other potential consumers, stimulating the latter to have the desire to purchase or strengthen that desire. We believe that the strength of the online discount and the personal preferences of online consumers will affect the strength of the demonstration effect, and we have $s = \alpha(p_{MF} - p_{MN})$. P denotes the price, which is used to characterise the price of a product; $P_{MF} - P_{MN}$ is the difference in the price of a given product in online and brick-and-mortar stores in a mixed sales model; and α is the coefficient of the demonstration effect, which takes values in the range [0,1].

2.2 Sales model of duty-free stores and consumers' decision-making behaviour

This section focuses on the pricing strategies of duty-free stores and consumer spending (buying) behaviour based on three different sales models.

2.2.1 Offline general sales model

Based on the special characteristics of duty-free stores, in this model, consumers can only make purchases in the physical store, i.e., the duty-free shop we are discussing. First, the duty-free store sets the price of the product, and the consumer, who is already aware of the product, decides whether to make a purchase based on this price. Thus, it is clear that the decision makers are the duty-free store and the consumer.

We know that the high- and low-value consumers follow the Bernoulli distribution, so when the number of consumers who are aware of the product on the market but have not yet actually consumed is m, the numbers of high- and low-value consumers ar e qm and b$(1-q)m$, respectively. Therefore, the duty-free store will select its pricing strategy and set the price parameter at p_{OF}. Note that the price $p_{OF} \leq v_H$ must be less than or equal to the perceived value of the product by the high-value consumers if the duty-free store wishes to increase revenue. Based on the price set by the duty-free store, consumers who are aware of this product on the market but have not yet actually purchased it decide whether to purchase the product. When $u_i = v_i - P_{OF} \geq 0$, the consumer will make a purchase; otherwise, no purchase will occur, where u_i is used to denote the perceived net utility generated by the purchase of the product, and $i = H, L$.

2.2.2 Online/Web Sales Model

Based on the special characteristics of duty-free stores, in this model, duty-free stores first set the prices of products and place online advertisements. Generally, to purchase products at duty-free stores, customers need to register as members. Therefore, the duty-free store can post online advertisements for member consumers based on their consumption preferences, age, gender, and other heterogeneous factors, and the consumers who receive the information will make the decision of whether to buy. Thus, the subjects who need to make decisions are the duty-free store, the consumer, and the recipient of the online advertisement.

Similar to the normal offline sales model, the duty-free store industry in this model sets pricing strategies based on the distribution of high- and low-value consumers and sets the price parameter at p_{ON}. The price parameter of $p_{ON} \leq v_H$ must be set at a level less than the perceived value of the product by the high-value consumers if the duty-free store wishes to increase revenues.

2.2.3 Hybrid sales model

As a particular type of shop, duty-free stores have unique characteristics. The first is their sales method; unlike other physical stores, duty-free stores are generally membership-based, and customers need to join before they can purchase products. The second concerns their geographical location; while traditional stores are

generally located in regional centres or areas with large numbers of people, duty-free stores are usually located in land, sea and air ports, i.e., airports, terminals, and other areas. The last are the characteristics of their sales model. The products of duty-free stores can be purchased offline, but customers can also purchase certain products conveniently on the Internet.

Under this sales model, duty-free stores need to set separate prices for brick-and-mortar and online purchases by setting the prices p_{MF} and p_{MN}, where $p_{MF} > p_{MN}$ and $p_{MN} \leq v_H$, respectively. According to the previous analysis, the difference in price between physical store purchases and online purchases under this sales model will induce consumers to make online purchases and generate additional utility, which will be set as s, and $s = \alpha(p_{MF} - p_{MN})$. The expected utility of consumers who are already aware of this good in the market but have not yet actually consumed when buying online is set such that $E(u_{SF})$ $E(u_{SF}) = v_i - p_{MN} - \beta E(\Delta v) + s$, $E(\Delta v) = (1-q)(p_{MN} - v_L)$. Only under the conditions of $E(u_{SF}) \geq 0$ $E(u_{SF}) \geq v_i - p_{MN}$ will the consumer purchase online, and the net utility from a physical store purchase is $v_i - p_{MN}$.

3. Model construction

3.1 Equilibrium price and revenue level under different sales models

By comparing and discussing the optimal price models of duty-free stores under the offline general sales model, only online sales model, and mixed sales model, we obtain the equilibrium prices and the embodied revenue levels of duty-free stores under the above three sales models.

3.1.1 Equilibrium price and revenue level under the offline ordinary sales model

The first is to offer a low price to as many groups of consumers as possible who are aware of the item on the market m.

$$\pi^1_{OF} = \max mp^1_{OF} \ s.t. \ p^1_{OF} \leq v_H \tag{1}$$

The second is to charge a high price and only target consumer groups in the current market who are aware of the item and assign it a high value qm.

$$\pi^2_{OF} = \max mp^2_{OF} \ s.t. \ v_L \leq p^2_{OF} \leq v_H \tag{2}$$

3.1.2 Balanced price and revenue levels in the online/web sales model

Pricing strategy 1: Use the perception effect to ensure that all consumers who are able to experience it are likely to buy the product at its online sales price. Here,

$p_{ON}^1 \le v_L$. According to the analysis, the expected utility level of all consumers in the market when buying online/Internet goods at their online price satisfies $E(u_{SN}^1) \ge 0$, and the minimum utility level under this purchase mode satisfies $\underline{u}_{SN}^1 \ge 0$, and purchases of goods in this mode are achieved; that is, each consumer can generate two units of goods sales by purchasing goods through this mode, and the duty-free store's revenue function is

$$\pi_{ON}^1 = \max 2mp_{ON}^1 \ s.t. \ p_{ON}^1 \le v_L \tag{3}$$

Proposition 1: When a solely online sales model is adopted, the group of consumers who experience the perception effect of the goods chooses the online/Internet method to purchase the goods, and the equilibrium price level of the duty-free store is $p_{ON}^{1*} = v_L$, the sales volume of the goods is $d_{ON}^1 = 2m$, and the revenue level is $\pi_{ON}^1 = 2mv_L$.

Pricing strategy 2: Use the perception effect to ensure that high-value consumers will buy the goods at their online price. Here, $v_L < p_{ON}^2 \le v_H$. The high-value consumers ($E(u_{SN}^2) \ge 0$) in the marketplace use the online method to successfully purchase the goods, i.e., $\underline{u}_{SN}^2 \ge 0$. That is, each high-value consumer can generate two units of merchandise sales by purchasing merchandise through this mode, and the duty-free store's revenue function is

$$\pi_{ON}^2 = \max 2mp_{ON}^2$$

$$s.t. \begin{cases} v_L < p_{ON}^2 \le v_H \\ v_H - p_{ON}^2 - \beta(1-q)(p_{ON}^2 - v_L) \ge 0 \\ v_H - p_{ON}^2 - \beta(p_{ON}^2 - v_L) \ge 0 \end{cases} \tag{4}$$

Proposition 2: When an online/Internet sale only model is adopted, the equilibrium price, merchandise sales, and revenue levels of duty-free stores are shown in the following equation when the high-value consumers who experience the perception effect of the merchandise choose the online/Internet method to purchase.

$$\begin{cases} p_{ON}^{2*} = \dfrac{v_H + \beta v_L}{1 + \beta} \\ d_{ON}^2 = 2qm \\ \pi_{ON}^2 = 2qm \dfrac{v_H + \beta v_L}{1 + \beta} \end{cases} \tag{5}$$

Pricing strategy 3: Use the perception effect to ensure that only high-value consumers who experience it are likely to purchase goods at their online price; however, only high-value consumers who view advertisements for online goods purchase online, so that online consumers satisfy $E(u_{SN}^3) \geq 0$, with $\underline{u_{SN}^3} < 0$. When purchasing with probability q, each online/Internet consumer produces two units of merchandise sales with probability q. Thus, the revenue function of the duty-free store is

$$\pi_{ON}^3 = \max 2q^2 m p_{ON}^3$$

$$s.t. \begin{cases} v_L < p_{ON}^3 \leq v_H \\ v_H - p_{ON}^3 - \beta(1-q)(p_{ON}^3 - v_L) \geq 0 \\ v_H - p_{ON}^3 - \beta(p_{ON}^3 - v_L) < 0 \end{cases} \tag{6}$$

3.1.3 Equilibrium price and revenue level under the mixed sales model

Pricing strategy 1: makes the group of consumers in the perception stage intensify their willingness to purchase and consider purchasing the goods when they are faced with a certain price of online goods, i.e., $p_{MN}^1 \leq v_L$. The analysis shows that when the price of goods is p_{MN}^1, the consumers in the perception stage will ignore the price change of offline goods and choose to purchase goods mixed online, i.e., in the case of pricing strategy one, each consumer will purchase two units of goods with the equilibrium price level, the equilibrium price goods sales volume, and the revenue of duty-free stores at this price.

$$\begin{cases} p_{MF}^{1*} = v_H \\ p_{MN}^{1*} = v_L \\ d_M^1 = 2m \\ \pi_M^1 = 2mv_L \end{cases} \tag{7}$$

Pricing Strategy 2: In the perception stage, target only the consumers with high consumption frequency and brand loyalty who will then purchase the goods, i.e. $v_L < p_{MN}^2 \leq v_H$. In this case, it is also necessary to encourage mixed online purchases by consumers $E(u_{SN}^2) \geq 0$ and $E(u_{SN}^2) \geq v_H - p_{MF}^2$, and assume that the transaction can be successfully carried out; at this point, $\underline{u_{SN}^2} \geq 0$ and $\underline{u_{SN}^2} \geq v_H - p_{MF}^2$. Each consumer will purchase two units of merchandise; therefore, the revenue model for the duty-free store is as follows.

$$\pi_M^2 = \max 2qmp_{MN}^2$$

$$s.t. \begin{cases} v_L < p_{MN}^2 \leq v_H, p_{MN}^2 \leq p_{MF}^2 \\ v_H - p_{MN}^2 - \beta(1-q)\left(p_{MN}^2 - v_L\right) + \alpha\left(p_{MF}^2 - p_{MN}^2\right) \geq 0 \\ v_H - p_{MN}^2 - \beta(1-q)(p_{MN}^2 - v_L) + \alpha(p_{MF}^2 - p_{MN}^2) \geq v_H \\ v_H - p_{MN}^2 - \beta(p_{MN}^2 - v_L) + \alpha(p_{MF}^2 - p_{MN}^2) \geq 0 \\ v_H - p_{MN}^2 - \beta(p_{MN}^2 - v_L) + \alpha(p_{MF}^2 - p_{MN}^2) \geq v_H - p_{MF}^2 \end{cases} \quad (8)$$

Pricing Strategy 3: In the perception stage; target consumers who consume frequently and have high brand loyalty who will then consider buying the goods at a certain price level and transact in the hybrid online channel; i.e., $v_L < p_{MN}^3$ „ v_H. It is necessary to ensure that consumers with a high frequency of consumption and high brand loyalty are successful in purchasing the goods during the hybrid online shopping process. If the purchase fails; this type of consumer will choose to spend the price p_{MF}^3 to purchase the goods in the hybrid offline channel; here, $\underline{u_{SM}^3} < v_H - p_{MF}^3$ and $v_H - p_{MF}^3 ..0$. Each consumer who purchases a good through the hybrid online channel has a probability of purchasing two units of the good of q and a probability of purchasing one unit of the good of $1-q$. The revenue function of the duty-free store in this case is

$$\pi_M^3 = \max qm(2qp_{MN}^3 + (1-q)p_{MF}^3)$$

$$\begin{cases} v_L < p_{MN}^3 \text{ „ } v_H \\ p_{MN}^3 \text{ „ } p_{MF}^3 \\ v_H - p_{MN}^3 - \beta(1-q)(p_{MN}^3 - v_L) + \alpha(p_{MF}^3 - p_{MN}^3) ..0 \\ v_H - p_{MN}^3 - \beta(1-q)(p_{MN}^3 - v_L) + \alpha(p_{MF}^3 - p_{MN}^3) .. v_H - p_{MF}^3 \\ v_H - p_{MN}^3 - \beta(p_{MN}^3 - v_L) + \alpha(p_{MF}^3 - p_{MN}^3) < v_H - p_{MF}^3 \\ v_H - p_{MF}^3 ..0 \end{cases} \quad (9)$$

When $q \leq \hat{q}_1$, pricing strategy I is selected, i.e.,

$$\begin{cases} p_{MF}^* = v_H \\ p_{MN}^* = p_{MN}^{1*} = v_L \end{cases} \quad (10)$$

When $\hat{q}_1 < q$, $\hat{q}_2$, pricing strategy II is selected, i.e.,

$$
\begin{cases}
p^*_{MF} = v_H \\
p^*_{MN} = p^{2*}_{MN} = \dfrac{(1+\alpha)v_H + \beta v_L}{1 + \alpha + \beta}
\end{cases}
\tag{11}
$$

When $q > \hat{q}_2$, pricing strategy III, is selected i.e.,

$$
\begin{cases}
p^*_{MF} = v_H \\
p^*_{MN} = p^{3*}_{MN} = \dfrac{(1+\alpha)v_H + \beta(1-q)v_L}{1 + \alpha + \beta(1-q)}
\end{cases}
\tag{12}
$$

where $p^{1*}_{MN} < p^{2*}_{MN} < p^{3*}_{MN}$; $\hat{q}_1 < q_1$; $q_0 < \hat{q}_1$; $q_1 < \hat{q}_2 < q_2$; and $\hat{q}_1$.

$$
\hat{q}_1 = \frac{(1+\alpha+\beta)v_L}{(1+\alpha)v_H + \beta v_L}
\tag{13}
$$

Here, we assume that the share of high-value consumers with high consumption frequency and high brand loyalty is low.

When q, q_0, pricing strategy I is selected, i.e.,

$$
\begin{cases}
p^*_{MF} = v_H \\
p^*_{MN} = p^{1*}_{MN} = v_L
\end{cases}
\tag{14}
$$

When $q > q_0$, pricing strategy III is selected, i.e.,

$$
\begin{cases}
p^*_{MF} = v_H \\
p^*_{MN} = p^{3*}_{MN} = \dfrac{(1+\alpha)v_H + \beta(1-q)v_L}{1 + \alpha + \beta(1-q)}
\end{cases}
\tag{15}
$$

3.2 Balanced decision on pricing strategy under different sales models

Under the condition of q, $\hat{q}_1$, $\pi^*_{OF} < \pi^*_{ON} = \pi^*_M = \pi^1_{on} = \pi^1_M$, the optimal approach is to implement a low online price strategy, regardless of whether an online only sales model or a mixed sales model is used, corresponding to the following expressions.

$$\begin{cases} p_{ON}^* = p_{ON}^{1*} = v_L \\ p_{MF}^* = v_H \\ p_{MN}^* = p_{MN}^{1*} = v_L \end{cases} \tag{16}$$

Under the condition of $\hat{q_1} < q_n$, $\hat{q_2}$, $\pi_{OF}^* < \pi_{ON}^* < \pi_M^* = \pi_M^2$, a higher online price under the mixed sales model is the optimal choice, corresponding to the expression

$$\begin{cases} p_{MF}^* = v_H \\ p_{MN}^* = p_{MN}^{2*} = \dfrac{(1+\alpha)v_H + \beta v_L}{1+\alpha+\beta} \end{cases} \tag{17}$$

Under the condition of $\hat{q_2} < q_n$, 1, $\pi_{OF}^* < \pi_{ON}^* < \pi_M^* = \pi_M^3$, setting a high online price under the mixed sales model is the optimal choice, and the corresponding formula can be expressed as

$$\begin{cases} p_{MF}^* = v_H \\ p_{MN}^* = p_{MN}^{3*} = \dfrac{(1+\alpha)v_H + \beta(1-q)v_L}{1+\alpha+\beta(1-q)} \end{cases} \tag{18}$$

4. Numerical simulation

4.1 Data sources

To make the theoretical results obtained in this paper more intuitive and effective, the important theorems are analysed using data and simulation tests(Gao et al., 2022; Suchanek et al., 2023) In this paper, a duty-free store (supporting online shopping) in Beijing Capital Airport is used as an example to simulate and analyse the personalisation of consumer behaviour patterns and the salesperson's sales effect through MATLAB simulation software. The relevant consumer data in the simulation model, such as demographics, the situation they are in, their preference status, and the acceptance rate of sales, are set based on the results of field research. The number of consumers received by the duty-free store in a certain period is set at 200, 2156 sets of consumption records are generated in the process, and the number of potential consumers is set at $m = 3428$, low-value consumers $v_L = 50$, high-value consumers $v_H = 150$, $\alpha = 0.5$ and $q \in (0,1)$. Based on the order in which consumers choose to purchase different product categories, when the number of product categories sold in a duty-free store changes, the changes in the total profit, market share, and profitability per unit of product are analysed and compared. Based on this, we examine how the duty-free store determines the optimal number of

product categories when the costs of product development and design and marketing are considered in the optimal product category selection order.

4.2 Changes in revenue under different sales models

Assuming that the number of product categories to be selected by the retailer is N ($1 \leq N \leq M$), the pricing strategy of duty-free stores under different sales modes can be derived when N is 1, 2..., 100 categories. In addition, by selecting and comparing three sales modes, namely, the offline general sales mode (S_{OF}), online sales mode (S_{ON}) and mixed sales mode (S_{Mi}), the different sales revenues of duty-free stores are analysed and compared. When duty-free stores adopt different merchandising models of S_{OF}, S_{ON} and S_{Mi}, their total profit and total market share vary with the number of merchandising models M, as shown in Figure 1.

(A) Change in total profit

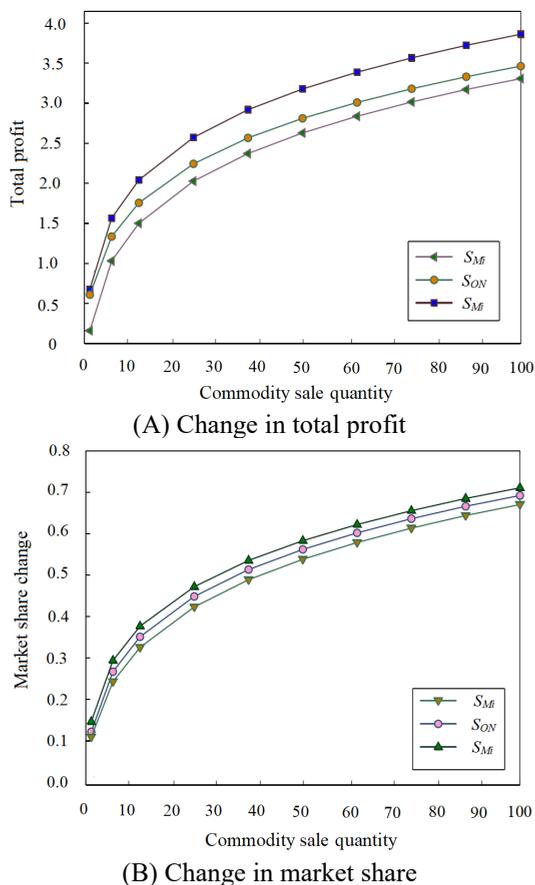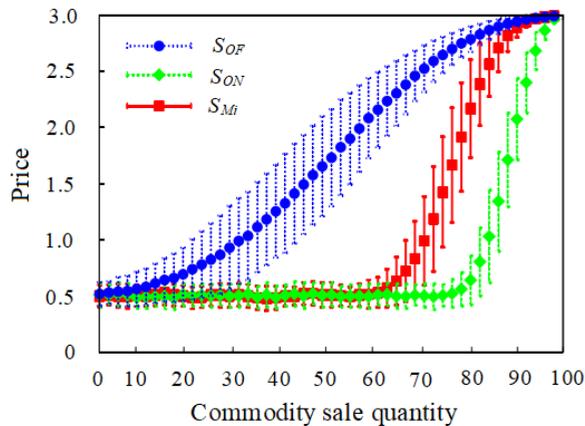(B) Change in market share

Figure 1. Changes in profit and market share under different sales models
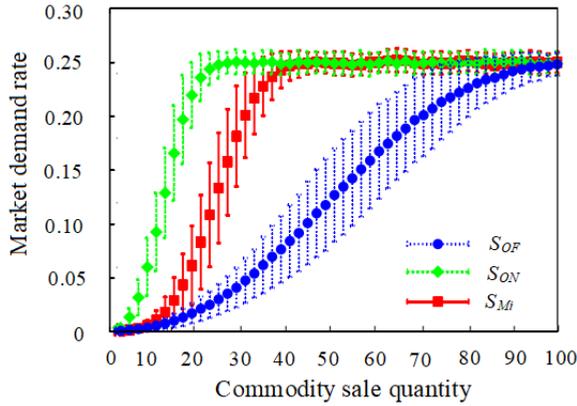*Source*: Authors' own creation.

As shown in Figure 1, the total profit and market share obtained by duty-free stores based on three different sales models are affected by the number of goods sold and increase in the same direction. Among the three sales models, the total profit and market share of duty-free stores are the highest when adopting the hybrid sales model, the lowest total profit and market share obtained when adopting the offline general consumption model, and the online only sales model is always in between. In addition, the total profit and total market share of duty-free stores decrease with the increase in the number of goods sold when the offline general sales model and the online only sales model are adopted. When the hybrid sales model is adopted, the marginal revenue of duty-free stores in general shows an increasing trend, which further indicates that the greater the number of goods sold by duty-free stores, the greater their total sales revenue.

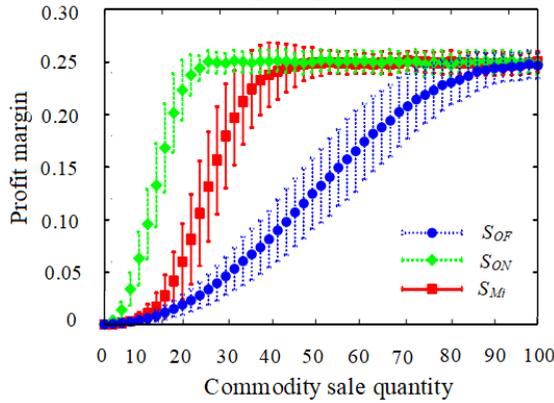### 4.3 Changes in pricing strategies under different sales models

To further analyse the impact of the changes in the sales model of the duty-free store on the pricing strategy of goods, the changes in the price, demand and profit of the goods of the duty-free store under different sales models are examined, and its pricing strategy is explored based on the changes in these three indicators. Based on the marketing flow data of this duty-free store, the changes in merchandise pricing strategies under different sales patterns are shown in Figure 2. Figure 2(A) shows the trend of price under different sales patterns; Figure 2(B) shows the trend of demand for product categories under different sales patterns; and Figure 2(C) shows the trend of profits under different sales patterns.

(A) Trends in commodity price changes corresponding to different pricing strategies

(B) Trends in the market demand rate of goods corresponding to different pricing strategies

(C) Trends in profitability corresponding to different pricing strategies
Figure 2. Changes in pricing strategies under different sales models
Source: Authors' own creation.

As Figure 2 (A) shows, with a change in the number of product categories sold by duty-free stores, the mixed sales model yields the highest price, followed by that of the online only sales mode, and that of the ordinary offline sales mode. This indicates that the adoption of the mixed sales model can make duty-free stores more profitable, and even if the prices are higher, consumers facing higher prices are willing to buy goods from duty-free stores in the mixed mode. Moreover, to further examine the pricing strategies adopted under different sales models, the relationship between the change in the number of goods categories sold in duty-free stores and the change in market share should be examined. As seen in Figure 2(B), the market share of high-value consumers is higher in the mixed sales model, the market share of low-value consumers is higher in the offline general sales model, and the market share of both high-value and low-value consumers are in between in the online only sales model. In addition, as shown in Figure 2(C), the profits from the sales of goods also show that different sales modes affect the pricing strategies of duty-free stores. Under the mixed sales mode, the market share of high-value consumers is higher,

and the preference rate of consumers is larger, which results in the largest profits obtained by duty-free stores. Under the offline general sales mode, the market share of low-value consumers is larger, resulting in the smallest profits. Under the offline general sales model, the market share of low-value consumers is larger, resulting in the smallest profit. Under the online only sales model, the market shares of high-value and low-value consumers are between the those of the other two models, and thus the profit for duty-free stores is between that of the offline general sales model and the mixed sales model.

5. Conclusions

Taking a duty-free shop in Beijing Capital Airport as an example, this paper specifically studies the three sales methods used by the duty-free shop in the actual marketing process: offline general sales, online/online sales, and hybrid sales. On this basis, the basic assumptions of the study are presented, the three sales modes of duty-free stores and the consumption decision-making behaviour of heterogeneous consumers are explored, the equilibrium price and income level models under different sales modes of duty-free stores are constructed, and then the pricing equilibrium decision-making models under different sales modes of duty-free stores are established, and the numerical simulation analysis is carried out. The results show that the optimal decision of duty-free stores on their sales models is affected by consumer preferences and the proportion of high-value consumers, and the optimal price strategy of duty-free stores under various sales models is also directly affected by the two factors; the consumer preference rate is reflected by the difference between the two types of consumers in their initial perception of commodity value, while the high-value consumer preference is reflected by the distribution proportion of the high-value market; No matter what kind of sales mode is selected, based on the preference rate of high-value consumers and the degree of heterogeneity, duty-free stores will benefit more when adopting the high-price strategy. For low value consumers, duty-free stores should choose the low-price strategy of mixed sales mode or offline sales mode.

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