Analysis of AI Customer Service Application Strategy of E-commerce Platform based on Hotelling Model

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Abstract

This study employs the Hotelling model and backward induction to analyze the decision-making processes of providers and e-commerce platforms. The findings reveal that AI customer service exerts distinct influences on product pricing, market demand, and profits for both high-quality and low-quality e-commerce platforms. Pricing is subject to various constraints. In terms of market demand, the demand for low-quality e-commerce platforms consistently lags behind that of high-quality platforms. Regarding charging standards, both platforms are inclined to accept the service when the charge is low; only high-quality e-commerce platforms accept it at a medium charge; neither accepts it when the charge is high. The provider's service is shaped by cost differences and application levels: when the cost difference is significant and the application level of high-quality e-commerce is elevated, the provider demonstrates greater willingness to enhance service quality. When the gap in application levels between the two types of platforms widens, the provider tends to invest more resources; however, an increase in the application level of low-quality e-commerce platforms may inhibit the provider's investment.

Keywords

AI Customer Service, Hotelling Model, High-Quality E-Commerce, Low-Quality E-Commerce, Tariffs.

1. Introduction

The application of AI customer service in e-commerce platforms has become a key tool for improving customer service efficiency, and scholars have discussed this aspect in depth. AI customer service effectively improves customer satisfaction and loyalty by understanding customer needs and providing real-time feedback[1]. In addition, AI customer service systems, with their emotion recognition capabilities, were able to adjust their responses in real time according to customer emotions, thus improving the user experience[2]. Bertsimas et al.'s application of machine learning and data-driven optimization in supply chain demand forecasting analysis indicates that AI can significantly enhance the efficiency of logistics and inventory management[3].

In recent years, the rapid advancement of AI has had a profound impact on e-commerce operational strategies, driving interaction and efficiency between businesses and consumers. Kian et al. proposes an e-commerce system model that explores the application of AI in enhancing customer satisfaction and system efficiency. The research, through quantitative analysis methods, combined with case studies, shows that AI significantly optimizes shopping experience and operational performance[4]. In addition, analysis of online shopping behaviour reveals the far-reaching impact of the digital economy and AI on market change[5]. Cui et al. found that a deep convolutional neural network-based cross-border e-commerce marketing strategy guides how to optimize data-based marketing strategies by validating the model to

improve the economic efficiency of cross-border e-commerce platforms[6]. ChatGPT's application mechanism in the e-commerce industry and its impact on future development, revealing its potential to enhance operational efficiency through personalized services and intelligent customer support, and predicting that it will change the competitive landscape of the market and improve consumer satisfaction[7]. Vapiwala et al. have attempted to identify various factors affecting AI for customer engagement in the Indian e-commerce space[8]. The combination of AI and online marketing to drive innovation in China's e-commerce, using a multi-case analysis method, results show that AI has changed traditional marketing methods and improved market responsiveness[9]. How AI and digital marketing affect consumer purchase intent, the study found that while AI did not have a significant impact on perceived value, the impact of digital marketing on purchase intent was positive and significant, a result that emphasises the key role of digital marketing in boosting consumer purchase intent[10].

2. Problem Description and Underlying Assumptions

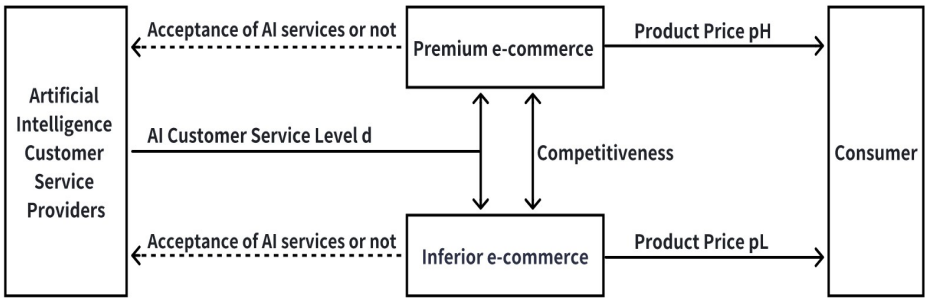

Figure 1. Research framework

The two competing e-commerce platforms each offer alternative products, considering the need to purchase the AI customer service service from the AI provider. In order to analyse the differences in the choice of AI customer service by competitive e-commerce platforms with different market positions, H and L denote e-commerce platforms in a relatively advantageous and disadvantageous position, respectively. The AI customer service provider implements an AI service strategy to the e-commerce platforms by making strategic investments in the field of AI customer service, so that the AI customer service has a certain level of service capability, and thus provides paid AI customer service to the e-commerce platforms. It is assumed that the provider's AI customer service level reaches *d*, the cost to be invested is $kd^2/2(k>0)$, and k denotes the coefficient of influence of the AI customer service level on the cost of inputs. the AI customer service level *d* largely responds to the strength of the provider's investment in AI customer service. The research framework is shown in Figure 1.

This article assumes that, in the absence of AI customer service, consumers derive initial utility from purchasing products on two e-commerce platforms. The products offered by these platforms exhibit a high degree of homogeneity in terms of material performance. However, the key distinctions between high-quality e-commerce platform H and low-quality e-commerce platform L are evident in two aspects: First, there is a disparity in the application levels of AI customer service across the platforms. Platform H demonstrates a higher application level of AI customer service compared to platform L, which enhances consumer utility and better satisfies their personalized needs. Let $\alpha_i d$ denote the increase in utility, where α_i represents the application level of AI customer service, $\alpha_H > \alpha_L$. Second, the unit customer service fees differ between the platforms, with platform H offering a cost advantage, specifically $c_H < c_L$.

Let p_i denote the retail price of the product on the e-commerce platform, and x_i represent the distance from the consumer to e-commerce platforms H and L, with H located at 0 and L at 1. Let $x_H = x$ and $x_L = 1 - x$ denote the distances between the consumer and e-commerce platforms H and L, respectively, where the values lie within the range [0, 1]. Based on the classic Hotelling model, consumers pay travel costs when visiting e-commerce platforms. In the context of AI customer service provision, this paper conceptualizes travel costs as preference costs for e-commerce platforms, denoted by t as the unit preference cost. When e-commerce platforms opt to adopt AI customer service, consumer utility is represented by $U_i = v + \alpha_i d - p_i - tx_i$ (if the platform does not adopt AI customer service, the consumer's utility is $U_i = v - p_i - tx_i$). Suppose v is large enough to ensure $U_i > 0$. Here, p_i represents the retail price of the product on e-commerce platform i, q_i represents the market demand for the product on e-commerce platform i, π_i represents the profit of e-commerce platform i, and π_p represents the profit of the AI customer service provider.

Let D_i denote the fee charged by the AI provider to the e-commerce platform for AI customer service. Let $D_i = D$ indicate the scenario in which the AI provider charges an identical fee for AI customer service to both e-commerce platforms (equivalent to $D_i = 0$ when the e-commerce platform does not adopt AI customer service).

3. Model Construction and Analysis Derivation

According to the Hotelling model, the demand for each of the two products is obtained:

$$q_H = x = \frac{d(\alpha_H - \alpha_L) - p_H + p_L + t}{2t} \tag{1}$$

$$q_L = 1 - x = \frac{d(\alpha_L - \alpha_H) + p_H - p_L + t}{2t} \tag{2}$$

As the leader in the supply chain, the AI customer service provider first determines the level of AI customer service, denoted as *d*. Subsequently, the e-commerce platform, acting as the follower, decides on the retail price of the products p_i. The optimization problem for the e-commerce platform is addressed using the backward induction method.

$$\max_{p_i} \pi_i = (p_i - c_i) q_i - D_i \tag{3}$$

The retail prices of the products of e-commerce H and e-commerce L are obtained from the first order conditions:

$$p_H^* = \frac{d(\alpha_H - \alpha_L) + 3t + 2c_H + c_L}{3} \tag{4}$$

$$p_L^* = \frac{d(\alpha_L - \alpha_H) + 3t + c_H + 2c_L}{3} \tag{5}$$

Then solve the problem of optimising the AI provider:

$$\max_{d} \pi_p = \sum_{i=H,L} D_i - \frac{kd^2}{2} \tag{6}$$

Substitute(1)、(2)and(4)、(5)to(6), the optimal AI customer service level d of the e-commerce platform can be obtained from the first order condition as:

$$d^* = \frac{(\alpha_L - \alpha_H)(c_H - c_L)}{18kt - (2\alpha_H - 2\alpha_L)^2} \tag{7}$$

Substitute d^* to p_i, q_i, π_i and π_p, the optimal product price, market demand, profit and optimal profit of the AI customer service provider of the two e-commerce platforms are obtained as:

$$p_H^* = \frac{-\Delta\alpha^2\Delta c}{54kt - 3(2\alpha_H - 2\alpha_L)^2} + t + \frac{2}{3}c_H + \frac{c_L}{3} \tag{8}$$

$$p_L^* = \frac{\Delta\alpha^2\Delta c}{54kt - 3(2\alpha_H - 2\alpha_L)^2} + t + \frac{c_H}{3} + \frac{2c_L}{3} \tag{9}$$

$$q_H^* = \frac{1}{8}\left(4 - \frac{\Delta c}{t} + \frac{3k\Delta c}{B}\right) \tag{10}$$

$$q_L^* = \frac{\Delta c}{6t} + \frac{1}{2} - \frac{\Delta\alpha^2\Delta c}{12tB} \tag{11}$$

$$\pi_H^* = -D + \frac{\left[\Delta\alpha^2(\Delta c - 4t) + 6kt(3t - \Delta c)\right]^2}{8t\left[\left(\sqrt{2}\Delta\alpha\right)^2 - 9kt\right]^2} \tag{12}$$

$$\pi_L^* = -D + \frac{[\Delta\alpha^2(\Delta c + 4t) - 6kt(\Delta c + 3t)]^2}{8t\left[\left(\sqrt{2}\Delta\alpha\right)^2 - 9kt\right]^2} \tag{13}$$

$$\pi_p^* = 2D - \frac{kd^2}{2} + \frac{1}{6}\left(3 + \frac{\Delta c}{t} - \frac{\Delta\alpha^2\Delta c}{2tB}\right)\left(\frac{c_H + 2c_L}{3} + t - \frac{\Delta\alpha^2\Delta c}{6B}\right) + \frac{1}{8}\left(4 - \frac{\Delta c}{t} + \frac{3k\Delta c}{B}\right)\left(\frac{2c_H + c_L}{3} + t + \frac{\Delta\alpha^2\Delta c}{6B}\right) \tag{14}$$

4. Analysis of Equilibrium Results

In order to facilitate the discussion on the implementation of AI customer service service strategies by AI customer service providers and the selection of AI customer service strategies by e-commerce platforms, this section divides the model into four scenarios. E-commerce does not adopt AI customer service scenario (NA), only high-quality e-commerce adopts AI customer service scenario (AH), only poor-quality e-commerce adopts AI customer service scenario (AL), and both high-quality and poor-quality e-commerce adopts AI customer service scenario (AA).

4.1. Analysis of the Balanced Results of the Two E-commerce Platforms

Proposition 1: When both e-commerce platforms offer AI customer service, the retail prices of products from high-quality e-commerce platforms will always be lower than those from low-quality ones.

Proposition 2: $p_H^{AA}<p_H^{NA}<p_H^{AL}<p_H^{AH}$, $p_L^{AH}<p_L^{AL}<p_L^{NA}<p_L^{AA}$

Proposition 2 shows that AI customer service has an opposite effect on the retail price of the products of the two e-commerce platforms, with the high-quality e-commerce platforms having the lowest retail price of their products when both e-commerce platforms are receiving AI service, and the highest retail price of their products when only the high-quality e-commerce are being served by AI service. In contrast, the retail price of the products of the poor-quality e-commerce is highest when both e-commerce receive AI customer service.

Proposition 3:

When AI customer service is applied to high-quality e-commerce, under condition $\frac{1}{6}[3-\frac{\Delta c}{t}+\frac{\Delta c+3t}{2t(2\Delta\alpha^2-9kt)}]>D$, high-quality e-commerce achieves a profit advantage; under condition $\frac{1}{6}[3-\frac{\Delta c}{t}+\frac{\Delta c+3t}{2t(2\Delta\alpha^2-9kt)}]<D$, low-quality e-commerce achieves a profit advantage; under condition $\frac{1}{6}[3-\frac{\Delta c}{t}+\frac{\Delta c+3t}{2t(2\Delta\alpha^2-9kt)}]=D$, the profits of both types of e-commerce are equal.

4.2. Analysis of AI Customer Service Vendor Equilibrium Results

Corollary 1: Under the AH scenario, d^{AH*} is positively correlated with both Δc and α_H.

$$d=\frac{(\alpha_L-\alpha_H)(c_H-c_L)}{18kt-(2\alpha_H-2\alpha_L)^2},\ \frac{\partial d^{AH*}}{\partial\Delta c}=\frac{\Delta\alpha}{2B}>0,\ \frac{\partial d^{AH*}}{\partial\alpha_H}=-\frac{2\Delta\alpha^2\Delta c}{B^2}+\frac{\Delta c}{2B}>0$$

From **Corollary 1**, it can be known that when only high-quality e-commerce platform choose to accept AI customer service, the greater the degree of difference in production costs Δc between the two e-commerce platforms, and the higher the data utilization level of the high-quality e-commerce platform that accepts AI customer service, the more actively the AI provider will invest in the research and development of AI customer service and be more willing to provide high-level AI customer service.

Corollary 2: Under the AA scenario, d is positively correlated with Δc and α_H; and negatively correlated with $\Delta\alpha$ and α_L.

$$\frac{\partial d^{AA*}}{\partial\Delta c}=\frac{\Delta\alpha}{2B}>0,\ \frac{\partial d^{AA*}}{\partial\Delta\alpha}=\frac{\Delta c}{2B}<0,\ \frac{\partial d^{AA*}}{\partial\alpha_H}=-\frac{2\Delta\alpha^2\Delta c}{B^2}+\frac{\Delta c}{2B}>0,\ \frac{\partial d^{AA*}}{\partial\alpha_L}=\frac{2\Delta\alpha^2\Delta c}{B^2}-\frac{\Delta c}{2B}<0$$

As can be seen from **Corollary 2**, for the use of AI customer service level, the greater the gap between the two e-commerce platforms, the greater the provider's investment in AI customer service, the higher the level of AI customer service on the provider. At the same time, the higher the level of AI customer service application of high-quality e-commerce platforms, the positive incentive for providers to improve the level of AI customer service; low-quality e-commerce platforms are gradually improving the application of AI customer service, which will have an inhibiting effect on the implementation of the provider's AI customer service strategy, that is, with the gradual improvement of low-quality e-commerce platforms in the application of AI customer service, the provider's investment in AI customer service will gradually decrease.

Proposition 4:

$$d^{AH}-d^{AA}=-\frac{\alpha_H\Delta c}{2A}-\frac{\Delta\alpha\Delta c}{2B}>0$$

Proposition 4 suggests that the AI customer service provider will invest more money in AI customer service in the case where only high-quality e-commerce platforms accept AI customer

service, so that the AI customer service provider will have a higher level of AI customer service in this case. If both platforms choose to accept AI customer service, but instead have a certain inhibiting effect on the enthusiasm of the provider AI customer service investment.

5. Selection and Implementation Analysis of Artificial Intelligence Customer Service Strategy

5.1. Analysis of E-commerce AI Customer Service Strategy Options

Proposition 5 The optimal profit of a quality e-commerce company with different standards of AI customer service fees has the following relationship**:**

(1) When $D - D_C > 0$ and $D - D_F > 0$ holds, high-quality e-commerce profits are highest when no e-commerce adopting AI , next highest in the AI-only serving low-quality e-commerce scenario, next highest in the AI-only serving high-quality e-commerce scenario, and lowest in the AI-serving both e-commerce scenario.

(2) When $D - D_C > 0$ and $D - D_F < 0$ holds, divided into two cases:

1) When $D - D_A > 0$, high-quality e-commerce profits are highest in the no e-commerce adopting AI scenario, next highest in the AI serving both e-commerce scenario, next highest in the AI serving only poor quality e-commerce scenario, and lowest in the AI serving only high-quality e-commerce scenario.

2) When $D - D_A < 0$, high-quality e-commerce profits are highest when AI serves both e-commerce businesses, next highest when no e-commerce businesses adopt AI, next highest when only AI serves low-quality e-commerce businesses, and lowest when only AI serves high-quality e-commerce businesses.

(3) When $D - D_C < 0$ and $D - D_F < 0$ holds, divided into three cases:

1) When $D - D_A > 0$ and $D - D_B > 0$ holds, high-quality e-commerce profits are highest in the no e-commerce adopting AI scenario, next highest in the AI serving only high-quality e-commerce scenario, next highest in the AI serving both e-commerce scenario, and lowest in the AI serving low-quality e-commerce scenario only.

2) When $D - D_A > 0$ and $D - D_B < 0$ holds, high-quality e-commerce profits are highest in the high-quality-only e-commerce with AI, second highest in the no e-commerce with AI services, next highest in the AI serving both e-commerce, and lowest in the poor-quality-only e-commerce with AI services.

3) When $D - D_A < 0$ holds, high-quality e-commerce profits are highest when only high-quality e-commerce adopts AI, next highest when AI serves both e-commerce, next highest when no e-commerce adopts AI services, and lowest when only poor quality e-commerce adopts AI services.

Proposition 6 The optimal profit of low-quality e-commerce platforms under different standards of AI customer service fee.

Proposition 6 shows that once the AI customer service strategy is implemented in the e-commerce platform, regardless of the fee standard, as long as there are e-commerce platforms that accept the service, it is bound to damage the profit of the low-quality e-commerce platforms, and the low-quality e-commerce platforms prefer no AI customer service, which confirms that the low-quality e-commerce platforms in the absence of acceptance of the AI customer service service, the choice of the choice of not accepting the results of low-quality e-commerce platforms, the conclusion and the citation is consistent with the reasoning, which also is that the quality e-commerce in the absence of accepting AI customer service service does not accept AI customer service In addition, the low-quality e-commerce in the choice of

accepting the quality e-commerce, depending on the standard of charges of AI customer service, if the standard is lower than the D_C, the low-quality e-commerce preference to accept the AI customer service; if the standard is higher than the D_C, the non-acceptance is the dominant strategy of the low-quality e-commerce.

Corollary 3 When the charge is low, both parties tend to accept AI customer service($0 < D \le D_C$), which is because the revenue brought by the service is greater than the cost at this time; when the charge is in the middle range($D_C < D \le D_B$), high-quality e-commerce platforms will accept the service in order to obtain higher profits, while low-quality e-commerce platforms choose not to accept the service due to cost-benefit considerations; when the charge is higher($D_B < D$), both parties believe that the acceptance of the service will reduce the profit, so they both choose not to accept it.

5.2. Analysis of AI Customer Service Strategy Implementation

Corollary 4 Implementation options for the provider's AI customer service strategy: the implementation of the AI customer service provider's strategy under different conditions. When the market conditions make it most profitable not to implement the strategy, the provider will choose not to invest resources to carry out the service and not to charge fees. And when implementing the strategy can bring higher profits, the provider will choose to implement the service for high-quality e-commerce (AH scenario) or for two e-commerce platforms (AA scenario) according to the specific conditions, and set the charges and determine the level of service input accordingly.

6. Conclusion

Focusing on AI customer service in e-commerce, this study constructs a Hotelling model to analyse the strategic interactions between AI customer service providers and competing e-commerce platforms. It is found that AI customer service has different impacts on quality and low-quality e-commerce platforms in terms of product pricing, market demand and profit. No AI customer service and AI customer service service two e-commerce scenarios, high-quality e-commerce products retail price is lower; AI customer service makes high-quality e-commerce prices first rise and then fall, and low-quality e-commerce prices first fall and then rise. Demand, low-quality e-commerce is always lower than high-quality e-commerce, and the level of profit varies in different situations. Tariffs have a significant impact on e-commerce decisions. At low prices, both parties tend to accept the service; at medium prices, the high-quality e-platforms accept but the low-quality e-platforms do not; at high prices, neither party accepts. The service level decision of the provider is affected by the e-commerce factors, the production cost difference between the two e-commerce platforms, high-quality e-commerce use level is positively related to the service level, the difference between the two e-commerce platforms 'use level is positively related to the service level, and the low-quality e-commerce platforms' use level is negatively related to the service level. For business management, e-commerce platforms should choose AI customer service strategy according to their own situation and cost-benefit assessment. High-quality e-commerce platforms can take advantage of the technology and actively adopt it to enhance their competitiveness; low-quality e-commerce platforms need to carefully weigh the costs and benefits. providers should provide customised services and reasonable pricing based on e-commerce differences and variations.

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