

Game analysis of price war among merchants in the coffee market

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Abstract. In recent years, with the improvement of the national economy, the improvement of living standards and the deepening of people's understanding of coffee culture, China's coffee market has entered a period of rapid development. The number of coffee brands and chain stores has increased rapidly, and coffee culture has gradually integrated into people's daily lives. In order to better and faster occupy the domestic coffee market, the two major coffee giants Luckin Coffee and Kudi have chosen price war as their main strategy. This study uses the prisoner's dilemma, the Bertrand model and repeated games to analyze the price game competition behavior between enterprises, and explores how enterprises can more effectively deal with the risks of price wars and reduce the negative impact of price wars. The results show that enterprises can enhance their market competitiveness through non-price competition (such as product differentiation, brand building, customer loyalty, etc.), and at the same time stabilize market prices through cooperation and tacit understanding to ensure the long-term sustainable development of enterprises. The effectiveness of these methods has been tested, and relevant strategic recommendations have been put forward.

1 Introduction

With the continuous development of social economy, China's coffee market continues to expand. Among the many coffee brands, Luckin Coffee and Kudi Coffee rank at the top. In order to expand their market share, the two companies often compete fiercely through price wars. They attract consumers and enhance their competitiveness by issuing low-price coupons. Price wars will directly affect consumers' purchasing decisions, especially in a price-sensitive market environment [1]. In February 2023, Kudi Coffee launched the "Hundred Cities and Thousands of Stores Coffee Carnival" event, with more than 70 products starting at 9.9 yuan. In April of the same year, Luckin Coffee followed suit and announced that it would launch 9.9-yuan coupons in Luckin stores near the newly opened Kudi stores [2]. By June 2023, Luckin Coffee further expanded the scale of the event and launched the "Ten Thousand Stores Celebration" event, promoting the 9.9-yuan coupon to all stores nationwide, and in August officially announced that the 9.9 yuan discount would be a long-term promotion strategy. Price wars within a reasonable price range will help companies

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expand and further improve their competitiveness. However, vicious price wars will cause companies to suffer continuous losses and are not conducive to their long-term development. Many companies have experienced financial pressure in price wars, especially in the initial stages of cost pressure and profit squeeze [3].

Studies have shown that low-price discounts can effectively attract consumers, but long-term reliance on price discounts may weaken the brand's perceived value. The performance of Luckin Coffee and Kudi Coffee in price wars reflects this, especially the financial fluctuations in the early stages of the promotion. Luckin Coffee and Kudi Coffee's price war strategies fully utilize consumers' price sensitivity, but they also face challenges in consumers' brand loyalty [4-6]. This paper takes Luckin Coffee and Kudi Coffee as research objects, conducts in-depth analysis and exploration of the price competition strategies of both parties, summarizes the success points, optimizes sales strategies based on this, proposes strategies to deal with price war risks, analyzes the effectiveness of the strategies, explores the feasibility of non-price competition strategies, and puts forward improvement suggestions [7].

Research had shown that enterprises should have constantly explored their own potential to introduce product differentiation, developed their own distinctive products, avoided price wars caused by enterprise pricing, which led to disorderly competition and vicious competition in the market, and promoted the healthy and sustainable development of the country's market-oriented reforms [8].

Some studies had used repeated games to analyze the cooperation path between enterprises and had proposed that establishing a long-term cooperative relationship was likely to solve the prisoner's dilemma. Regardless of whether the game parties had adopted a trigger strategy or a tit-for-tat strategy, they would have spontaneously punished the non-cooperative party in the next round, which would have helped to establish a long-term and stable cooperative relationship between each other. If enterprises wanted to develop steadily and make profits, they should have cooperated for mutual benefit [9, 10].

Some scholars' research on price wars had mainly revolved around the low-price bidding behavior as a strategic behavior in the game between enterprises. Dong had used the Bertrand model to conduct data analysis and had proved through analysis that the low-price bidding behavior was the result of the Bertrand price game between the parties in the market and was a strategic behavior in the game between enterprises [3]. Wu had believed that any form of competition was initially based on "price" or "output," but ultimately it came down to quality competition. Only by maintaining continuous innovation and progress could one maintain an absolute advantage and survive [11].

In recent years, with the continuous expansion of the Chinese coffee market, although some researchers had analyzed Chinese coffee companies and had pointed out the problems with their marketing strategies, such as the single product variety, lack of innovation, and gradually reduced profits, there had still been deficiencies in the research on price wars between companies in the coffee market. Based on the above, this paper aimed to further study the price war in the Chinese coffee market, use the Bertrand price competition model of product differentiation and repeated games, analyze the process of price wars, and explore the effectiveness of corporate differentiation and cooperation in dealing with price wars.

2 Equations and mathematics

2.1 Problem setting

This paper establishes a prisoner's dilemma game to further analyze the competitive behavior of the two oligopolistic enterprises, Luckin Coffee and Kudi. The four strategy combinations

of the two parties in the game are: (price reduction, price reduction) (no price reduction, no price reduction) (price reduction, no price reduction) and (no price reduction, price reduction). For analysis, this paper established a game matrix, marked Luckin Coffee as A and Kudi as B, and assumed that the daily income of both parties is (3,3).

When both parties choose not to reduce prices, the income of A and B is 3; if both parties choose to reduce prices, the income of both parties will drop to 2. If A chooses to reduce prices and B does not, A's income will rise to 4, while B's income will drop to 1; conversely, if A does not reduce prices and B chooses to reduce prices, A's income will be 1, while B's income will increase to 4. In this case, if A and B both choose not to reduce prices, their respective incomes are 3. However, in order to obtain higher income, A will choose to reduce prices because this will increase A's income from 3 to 4. Similarly, when B faces a choice, if A does not lower the price, B can increase his profit from 1 to 4 by choosing to lower the price. Therefore, in order to maximize his personal interests, B will also choose to lower the price. In the end, both parties choose to pursue their own maximum interests, thus forming a Nash equilibrium state, that is, (lower price, lower price) (Table 1).

Table 1. Prisoner's Dilemma Analysis

	B: Price reduction	B: No price reduction
A: Price reduction	(2,2)	(4,1)
A: No price reduction	(1,4)	(3,3)

2.2 Bertrand price model

Some scholars' research on price wars mainly revolves around the low-price bidding behavior as a strategic behavior in the game between enterprises. Dong used the Bertrand model to conduct data analysis, and proved through analysis that the low-price bidding behavior is the result of the Bertrand price game between the parties in the market, and is a strategic behavior in the game between enterprises [3]. Based on this, this paper further studies the Bertrand price competition model of product differentiation and explores the effectiveness of enterprise differentiation in dealing with price wars.

Bertrand, a famous French economist, proved that under the assumption that the products of enterprises are homogeneous, when enterprises adopt price as their own competitive strategy, the profit of enterprises is zero under equilibrium conditions when the price is equal to the marginal cost, which is the so-called "Bertrand paradox" (Table 2).

The way to solve this paradox is to introduce product differentiation. Under the assumption that the products of the game parties are different in quality, brand, etc., the Bertrand game model is constructed for analysis. Assume that the prices of the above-mentioned companies A and B are p_1 and p_2 respectively. Therefore, construct their respective market demand:

$$q_1 = a - bp_1 + cp_2 \quad (1)$$

$$q_2 = a - bp_2 + cp_1 \quad (2)$$

Table 2. Variable Description Table

Symbol	Meaning
p_1	Luckin Coffee Price
p_2	Price of Kudi Coffee
q_1	Market demand for Luckin Coffee
q_2	Market demand for Kudi coffee
a	The largest potential demand in the market
b	The sensitivity of demand to its own price (self-price elasticity coefficient, $b > 0$)
c	The sensitivity of demand to competitors' prices (cross-price elasticity coefficient, $0 < c < b$)

3 Results and discussion

3.1 Preliminary work

Assuming that the marginal cost of the two enterprises is zero (i.e. $MC_1=MC_2=0$), their profit function can be expressed as:

$$\pi_1 = p_1 q_1 = p_1(a - bp_1 + cp_2) \quad (3)$$

$$\pi_2 = p_2 q_2 = p_2(a - bp_2 + cp_1) \quad (4)$$

Derivative of π_1 with respect to p_1 :

$$\frac{\partial \pi_1}{\partial p_1} = a - 2b \cdot p_1 + c \cdot p_2 = 0 \quad (5)$$

$$p_1 = \frac{a+cp_2}{2b} \quad (6)$$

Derivative of π_2 with respect to p_2 :

$$\frac{\partial \pi_2}{\partial p_2} = a - 2b \cdot p_2 + c \cdot p_1 = 0 \quad (7)$$

$$p_2 = \frac{a+cp_1}{2b} \quad (8)$$

Substituting the function of enterprise a into the function of enterprise b, the paper gets:

$$p_2 = \frac{a+c \cdot \frac{(a+cp_2)}{2b}}{2b} \quad (9)$$

Expand and simplify:

$$p_2 = \frac{a}{2b} + \frac{c}{2b} \cdot \frac{a+cp_2}{2b} \quad (10)$$

$$p_2 = \frac{a}{2b} + \frac{c \cdot a}{4b^2} + \frac{c^2 \cdot p_2}{4b^2} \quad (11)$$

Solve for p_2 :

$$p_2 = \frac{a(2b+c)}{4b^2-c^2} \quad (12)$$

Similarly, substituting the function of firm b into the function of firm a, the paper obtains the equilibrium solution of p_1 :

$$p_1 = \frac{a(2b+c)}{4b^2-c^2} \quad (13)$$

The price Nash equilibrium of the two enterprises in the market is:

$$p_1 = p_2 = \frac{a(2b+c)}{4b^2-c^2} \quad (14)$$

In summary, since the products of the two companies are differentiated, the equilibrium price will not drop to the marginal cost as in the Bertrand model of homogeneous products (i.e., the "Bertrand paradox"). Since the products are differentiated (consumers have different preferences for the two coffee brands), the demand of the two companies does not rely entirely on price competition, but also on the brand effect brought about by product differentiation. This allows companies to increase their market share through differentiated advantages (such as improving product quality, improving consumer experience, etc.) in competition, rather than just relying on price wars. In a market with differentiated products, companies can achieve an equilibrium state by adjusting their pricing strategies. The higher the degree of product differentiation, the greater the space for companies to compete through non-price factors (such as brand, quality, and service), the intensity of price competition will be relatively reduced, and the market will present a healthier and more orderly competition situation. Companies should continue to strengthen the differentiation of products and services, increase the advantages of non-price competition through brand building, customer experience improvement, and reduce dependence on price wars.

Although Luckin Coffee and Kudi's coffee products are both coffee, they differ in brand, product variety, and consumer experience. According to the Bertrand model, assuming that both companies offer products with certain differentiation (such as unique coffee recipes,

high-quality customer service, etc.), their pricing strategies will not completely drop to marginal cost.

In practice, the price war between Luckin and Kudi did not reduce prices to marginal cost. This shows that product differentiation allows the two companies to maintain a certain price level in the market. For example, although both companies adopted a promotional price of 9.9 yuan, due to the differences in products (such as coffee types, store atmosphere, etc.), consumers' price sensitivity has decreased. Therefore, in addition to price competition, the two companies can use brand effects and product differentiation to maintain a higher price level and achieve profitability.

3.2 Repeated game analysis

Assume that two companies (Luckin and Kudi) play an infinitely repeated game in the differentiated product market. In each period, the companies have two choices: maintain high prices or reduce prices. The ruthless strategy means that once a company chooses to reduce prices in any round, the other company will permanently choose low prices in all subsequent rounds to punish the other party (Table 3).

Table 3. Variable Description Table

symbol	
p_H	High price when both parties cooperate (collusive price)
p_L	Low price under price reduction strategy (price war price)
π_H	The profit per period of enterprises when colluding on high prices
π_L	The profit per period of a company in low-price competition (price war)
δ	is the discount factor, which represents the present value weight of future income ($0 < \delta < 1$)
v_H	Maintain the discounted value of a high-price strategy
v_D	Discounted value of price reduction strategy

For an infinitely repeated game, the benefit of the firm choosing to maintain a high price can be expressed as the sum of discounted benefit streams:

$$v_H = \frac{\pi_H}{1-\delta} \quad (15)$$

If the company chooses the price reduction strategy, its short-term benefits in the first round are:

$$\pi_D = p_L q_D = p_L(a - bp_L + cp_H) \quad (16)$$

After the price reduction, the price in the remaining periods drops to p_L because the other party adopts a ruthless strategy, and its profit per period is π_L . Therefore, the discounted profit of the price reduction strategy is:

$$v_D = \pi_D + \frac{\delta \cdot \pi_L}{1-\delta} \quad (17)$$

In order to form a subgame-refined equilibrium, the enterprise's discounted benefit v_H must be greater than or equal to the price reduction benefit v_D , that is:

$$\frac{\pi_H}{1-\delta} \geq \pi_D + \frac{\delta \cdot \pi_L}{1-\delta} \quad (18)$$

$$\pi_H \geq (1-\delta) \cdot \pi_D + \delta \cdot \pi_L \quad (19)$$

This inequality is the condition for the collusive high-price strategy to become a refined equilibrium.

In infinitely repeated games, companies use ruthless strategies to help maintain high-price collusion to avoid profit losses caused by price wars. The specific analysis is as follows:

High discount factor promotes cooperation: When δ is larger, that is, companies attach more importance to future profits, the attractiveness of collusion increases. At this time, companies are more inclined to maintain high prices to obtain long-term stable profits.

The trade-off between the short-term attractiveness of price reduction and long-term punishment: Once a company reduces its price, it may gain higher market share and profits in the short term (π_p), but as another company retaliates with a ruthless strategy, all future period earnings will fall to a low level (π_l). Therefore, when δ is high, companies are more likely to choose to maintain high prices to avoid long-term losses.

The impact of product differentiation: In the differentiated product market, consumers are less sensitive to prices, and companies have greater opportunities to make profits through non-price competition (such as brand differentiation, product quality improvement). Therefore, the higher the degree of product differentiation, the greater the possibility of collusion to maintain high prices.

From the above analysis, it can be concluded that in infinitely repeated games, the use of ruthless strategies can effectively maintain high-price collusion among companies. When companies value future earnings (high discount factor), collusion on high prices is more likely to become a subgame refined equilibrium. Price reduction behavior between companies may lead to a decline in long-term profits and weaken the overall competitiveness of the market. Using ruthless strategies to maintain high-price cooperation helps reduce losses caused by price wars and promote the stability and healthy development of the market. Companies can improve their market pricing capabilities by enhancing product differentiation (such as branding, product improvement, etc.) and reduce their dependence on price wars, making it easier to reach high-price collusion and avoid vicious competition. Companies should adopt a cooperative strategy in market competition to maintain high prices and avoid long-term losses caused by price wars. This strategy is of great significance to long-term cooperation between companies and stable market development.

It can be seen that in the price war between Luckin and Kudi, this paper can observe that the game between the two companies has an indefinite repetitive feature. The price war in early 2023 (Kudi's 9.9 yuan event) triggered Luckin's quick response (launching a 9.9 yuan coupon). If the two companies continue to choose a price reduction strategy (price war), they will face lower profit levels in the long run.

In order to avoid the loss of long-term profits, the two companies may choose to maintain high prices, especially under the threat of ruthless strategies. For example, if Luckin Coffee decides to stop price cuts and raises prices at a certain stage, and Kudi adopts a ruthless strategy (maintaining low prices for a long time), Luckin Coffee may readjust its pricing strategy in subsequent rounds to avoid continued low profits. Therefore, companies should attach importance to future earnings (higher discount factor δ) and choose cooperation rather than price wars to achieve long-term stable profits.

4 Conclusion

Kudi and Luckin should give priority to avoiding price wars and maintain higher market prices through cooperation or tacit understanding to avoid short-term profit declines and long-term brand damage. The two companies should enhance product differentiation, develop new flavors, expand product lines, and enhance brand stories to reduce the impact of price competition. Promote win-win cooperation, such as co-branded marketing, expand market coverage, resist other competitors, and promote the healthy development of the industry. At the same time, strengthen brand building and customer loyalty, and reduce price-sensitive consumers. Companies should also reduce operating costs and achieve long-term profitability through innovation and optimized management. Establish an internal price

monitoring and rapid response mechanism, track price changes in real time, negotiate to set a minimum price line, ensure price stability, and avoid vicious price wars.

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