

E-commerce Price War Based on Game Theory

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ABSTRACT

In the increasingly complex competition among firms, price war often takes place between E-commerce firms. The reasons for a price war in the E-commerce industry are various. This paper uses the game theory method to discuss the formation of competition mode and further study the possibility of price coordination behavior in the industry. These analyses to the enlightenment are that firms must pay more attention to technological innovation and product innovation to get rid of the price war trap and improve the industry competition level. At the same time, e-commerce should adopt a rational marketing strategy to avoid the destruction of the market competition environment and the loss of consumer confidence caused by an excessive price war.

Keywords: price war; game theory; prisoner's dilemma; e-commerce

1. INTRODUCTION

In 2012, a lot of price wars broke out in China's e-commerce market. JD.com CEO Liu Qiangdong said JD.com would maintain zero profit for the next three years, and all its appliances' prices are guaranteed to be at least 10 per cent cheaper than those of Gome and Suning. For it, JD.com carried on price control to the Gome and Suning. Suning then responded that the prices of all products, including appliances, would be lower than JD.com. Dangdang, Gome also joined the scuffle, e-commerce price war into the white-hot phase. In this price war, all firms have suffered great losses.

Of course, there are also some firms in the price war to gain profits. For example, the price war took place in the colour TV industry. From 1988 to 1989, Changhong launched the first price war. After the success of the price war, on March 26, 1996, Changhong launched a second price war, and other major brands have also lowered their products' prices. Changhong stood out in the price war and became a giant in the industry. However, excessive price wars eventually led to the decline of Changhong.

Not hard to find, the price war is a kind of commercial competition behaviour that e-commerce firms that reduce the product price to suppress the competitors and enlarge the market share [1]. The definition of the price war, because of its subjectivity and arbitrariness, has always been a problem. Heil and Helsen describe a set of qualitative conditions that can be used to determine a price war, which includes: first that actions and responses

are primarily concerned with competitors rather than consumers; second, pricing interactions are undesirable for competitors; and third, no competitor intentionally triggers a price war; fourth, pricing behaviour violates industry norms; fifth, pricing interactions occur at a faster rate than previous interactions; and finally, the direction of the pricing is downward but such pricing behaviour is unsustainable [2]. Most of these situations are easy to observe, and in fact, most media coverage of price wars is based on these observations.

In the short term, the butterfly effect cannot be ignored behind the price war: price war can help firms to digest inventory, relieve financial pressure, increase social purchasing power, and force firms to improve production efficiency. However, in terms of the goods themselves, excessive price competition could lead enterprises to have no time to research and develop core technology. Then homogeneity competition may make lower industry profits and even deficit [3]. Meanwhile, If the commitment to customers is hard to fulfil, firms will lose the customer's trust and loyalty, and the brand image will be damaged.

In conclusion, competitive firms have to pay a heavy price once they get into a price war, whether win or lose. However, price wars can easily break out. Hence, how to avoid a price war, beat the opponent in the price war, and minimize their losses, should the paper be actively concerned about. It's also useful for firms to perceive the reasons for the occurrence of price wars and to take an objective look at the impact of price wars. Based on that,

firms are supposed to design reasonable and effective competitive strategies and gain successive improvements on corporate competitiveness.

To be specific, this article attempts to use the game theory and information economics analysis method to explore the form of the e-commerce price war, how to make the industry get rid of the plight of the price war trap, and further study the possibility of price coordination behaviour in the industry. The analysis of our enlightenment is that firms must pay more attention to technology and product innovation to get out of the price war trap and improve the industry competition level.

The remainder of this paper is organized as follows. Section 2 presents the literature review on price war. The set-up of the model and the analysis of the "price war" game is described in Section 3. And Section 4 describes the Nash Equilibrium of the "price war" game. Further, Section 5 makes a discussion, and Section 6 provides a conclusion of this research.

2. LITERATURE REVIEW

Pricing is a key decision that all profit-seeking firms must make in their day-to-day operations. The outbreak of price war has its inevitability, which can be analysed from the perspective of industry and firms.

2.1. Product Homogenization

If the product homogeneity is serious, that is, product substitution between firms is high. Further, the price elasticity of the demand curve that the firm faces is big. Therefore, once a firm in the industry begins to cut prices, the firms, which produce similar products, must make corresponding price reduction behaviour to maintain their market share [4]. From the consumer's point of view, firms' products are identical. In essence, low-priced firms are more likely to attract consumers.

2.2. Increased Market Share

Market share is the proportion of sales a company occupies in the industry, indicating its competitive position [5]. The increase of market share means the increase of sales volume so that firms can make more profits. There are many ways to expand market share, such as establishing brand image, enhancing product quality, but these need a longer settling time. Because the price war is simple, the effect is quick. Firms often take it as the main method to promote their market share.

2.3. Scale Effect

According to the economics theory, before the production scale reaches a certain level, the production cost per unit product decreases gradually with the increase of production. Meanwhile, the price war is

essentially a low-cost strategy. As a result, the price war is easy to break out in the industry, which has a scale effect [6]. Only those industries that have more room to cut prices will pursue low-cost expansion strategies. And in the process of the price war, according to the principle of survival of the fittest, those firms with poor performance and poor management will be gradually eliminated. In this way, the industry scale effect is more significant, and the cost will be further reduced, triggering a new round of price war.

2.4. Small Profit But Quick Turnover.

Firms adopt the low price competition strategy because they hope to obtain more profit through the "small profit but quick turnover". "Small profits but high turnover" refers to the phenomenon that firms increase product sales by reducing unit product prices, which can stimulate the consumer to purchase [7]. However, products that can achieve "small profits but high turnover" must have a higher elasticity of demand. When the price of the product falls, sales can increase more than the price, and hence, the total revenue increases.

In Green and Porter, the price war results from a collusive break-up of the equilibrium during periods of (unobservable) low demand [8]. And Elzinga and Mills showed that in the case of high switching costs, to attract new consumers or steal consumers from existing firms, a new entrant will initiate a price war by offering a lower price to temporarily compensate for the consumers' switching costs [9]. The price discount would entice the consumers to choose another brand and give up their current choice. Cabral noted that emphasising leadership in market share would make firms become more aggressive in pricing [10].

In addition to the causes of the price war, a large number of literature explores the impact of price war and the response measures to a price war. Lambertini and Rossini use the Prisoners' Dilemma game method to analyze the issue of investment under Bertrand competition and Cournot competition [11]. They show that product innovation may give rise to the choice of no heterogeneity due to a Prisoners' Dilemma, regardless of whether Bertrand or Cournot competition is assumed. Axelrod found that cooperation can exist in the Prisoners' Dilemma game by setting a player's type as tit-for-tat (TFT). This cooperative strategy has been proven to be successful in a repeated Prisoners' Dilemma game against other strategies [12]. Therefore, the paper could say that the best explanation of cooperation in a Prisoners' Dilemma game is "reciprocity". Mueller explains the situation where cooperation takes place in a Prisoners' Dilemma game from the viewpoint of psychology [13].

The evolutionary model is often used to analyze a Prisoners' Dilemma game and to investigate how mechanical and rational strategies interact under various

environments. For enhancing the cooperation levels in a large population of players, Almanasra S present an evolutionary model, which focuses on optimizing the communication topology of players and building a knowledge base to support players' future decisions [14]. In the model of Li and Kendall, the iterated prisoner's dilemma proved to be an ideal model for the evolution of cooperation among payoff-maximizing individuals [15].

3. METHOD

3.1. Prisoner's Dilemma in Game theory

Game theory is a powerful tool for representing the interactions of selfish actors [16] and has been introduced into the field of e-commerce.

The classic "prisoner's dilemma" game in game theory shows why a price war breaks out. The "prisoner's dilemma" game is as follows: two suspects were caught by the police, but there wasn't enough evidence to convict. So the police separated the two suspects (A and B) and interrogated them separately. The police told them that if they were both silent, both were sentenced to five years; if they both confessed, they would be sentenced for one year, which is less than the circumstances of silence, and if one person confessed and the other didn't, the one who told the truth would be released and the one who silent would be sentenced for 10 years. The payoff matrix is as follows (see Table 1):

Table 1. Prisoner's dilemma payoff matrix

	Prisoner B stays silent	Prisoner B confesses
Prisoner A stays silent	(-5,-5)	(0,-8)
Prisoner A confesses	(-8,0)	(-1,-1)

In this case, no matter what the other person chooses, the individual's best choice is to confess, which is a classic Nash Equilibrium. From the payoff matrix, then the paper can concluded that they could get a better payoff if they all keep quiet. However, because of human selfishness and fear of the other side of betrayal, no matter what the other person decides, every prisoner gets a higher reward by betraying another prisoner. Both sides aim to maximize their own profits when they make decisions. However, the result is that they cannot realize their own best profit and the overall best profit [17].

3.2. Price War

Now, this paper applies the "prisoner's dilemma" model to market competition. In the price war, this paper assumed that there are only two oligopolistic firms on the market, such as JD.com and Suning. They sell homogeneous products to consumers and wants to gain more market share and further earn greater profits. Meanwhile, the game process has the following two

characteristics: 1) Complete Information. Usually, firms' pricing behaviour is public to others and also for consumers, so it can be considered there is complete information in the market; 2) Repeated Game. Both firms' prices are constantly changing, and the competitors change their prices according to others' prices. For example, in the price war between JD.com and Suning, JD.com moves first, chooses to reduce the price. Suning observes JD.com's strategic choice and then reduces the price. Then, JD.com reduced the price again, and this process repeated. Therefore, the price war is a repeated game. In conclusion, the complete information repeated game model is suitable to describe the price war between JD.com and Suning.

Both sides can adopt four price strategies: (high-priced, high-priced), (high-priced, low-priced), low-priced, high-priced) and (low-priced, low-priced). This paper assumed that, if JD.com and Suning both choose to take high-priced policy, each of them can get 100 units income. If they both choose to take low-priced policy, each of them can get 70 units income, and if one firm takes high-priced policy, and the other firm takes low-priced policy, the firm who reduce price can get 150 units income, and the firm who doesn't reduce price can only get 20 units income. The detailed payoff matrix is as follows (see Table 2).

Table 2. The price war's payoff matrix

	JD.com (high-priced)	JD.com (low-priced)
Suning (high-priced)	(100,100)	(20,150)
Suning (low-priced)	(150,20)	(70,70)

Because this game is a non-cooperative game and both sides are sure that the other side will make decisions based on the principle of profit maximization, so the equilibrium is that both sides adopt a low-price strategy to protect themselves. However, it is not an ideal result for both players. From the market point of view, consumers welcome price competition. It is no exaggeration to say that most consumers like low-priced policies. Because of the huge impact of market share, the price-fixing cartel is not enough to bind. If one of them starts to reduce the price, the price agreement will be broken. In pursuit of profit maximization, each firm has no power to maintain the agreement. This is a rational choice between individuals and groups, which is reflected in the price war.

The idea of Game Theory is that oligopolistic firms engaged in price wars often find themselves in a kind of prisoner's dilemma: If others don't reduce prices, I reduce prices can capture market share. If others reduce prices, I have to reduce prices. Otherwise, I will be eliminated. Like prisoners, firms know that collusion is attractive, but

they worry that their partners will default, taking a big chunk of the market [18].

Just like the price war between e-commerce, JD.com came up with a "zero-margin" stunt to increase sales and market share. Hence, its competitors, Suning and Gome, had to reduce prices to meet the challenge, which breaks the balance of the original price system. That's why price war is so easy, and this led everyone in the war to fall into the price trap.

3.3. Nash Equilibrium OF the Price War GAME

In the traditional prisoner's dilemma, it is known that (confess, confess) is the only Nash equilibrium, and prisoners will choose to be honest. The e-commerce price war game also has a unique Nash equilibrium, that is, (low-priced, low-priced).

It is sure that the "Nash equilibrium" of e-commerce price war is stable, which benefits consumers but hurts online retailers' profits seriously. Therefore, the price war means the suicide of online retailers, and the e-commerce price war may lead to an inefficient zero profit result. Each firm will consider adopting the high-priced strategy or adopt the low-price strategy to form the monopoly price and try to obtain the monopoly profit. If a monopoly can be formed, both sides of the game have the greatest common profit. This is what monopolies usually do, that is, increasing prices. The other extreme case is that both parties adopt the high-priced policy. From this, this paper derives a basic rule: "Base your own strategy on the assumption that your opponent will act in his or her best interest". In fact, the equilibrium of perfect competition is "Nash Equilibrium" or "non-cooperative game equilibrium". In this state, each retailer or consumer is in accordance with the prices set by others to make decisions. In this equilibrium, each firm has to make profit maximization, and the consumer has to make a utility maximization problem, resulting in zero profit. That is, the price equals marginal cost [19]. In the case of perfect competition, non-cooperative behaviour leads to the desired economic efficiency. If firms take cooperative action and decide to shift to monopolistic prices, the economic efficiency of society will be undermined. That is why the WTO and national governments should strengthen the significance of anti-monopoly.

Until now, this paper is talking about a game in which there is only one "Nash Equilibrium", but there are games in which there are multiple Nash Equilibria. If the paper modified the benefits of duopoly price-cutting competition, that is, when one of the duopolies chooses to reduce its price, it does not expand its market share and obtain higher profits, on the contrary. Because the consumer expects retailers to further reduce the price and hence holds money to wait and see, which causes a lower profit of retailer. The corresponding payoff matrix is as follows (see Table 3).

Table 3. The price war's payoff matrix (multiple Nash equilibrium)

	JD.com (high-priced)	JD.com (low-priced)
Suning (high-priced)	(100,100)	(50,80)
Suning (low-priced)	(80,50)	(70,70)

In the above model, this paper can find two Nash Equilibrium, namely (high-priced, high-priced) and (low-priced, low-priced). Obviously, (high-priced, high-priced) is better in terms of Pareto efficiency, so (high-priced, high-priced) is Vilfredo Pareto's dominant equilibrium in this game. In other words, if the decision-makers are both rational, then there should not be a price war between the two firms. In other words, (high-priced, high-priced) should be the reasonable outcome of this game.

Based on the Nash Equilibrium, a conclusion can be a draw. Cooperation is the best self-interest strategy. It must follow the principle that if everyone can make the best decision they can, then a group of participants is in the Nash Equilibrium, taking into account the decisions of others in the game main emphasis of collective reason. At the same time, Nash Equilibrium is a non-cooperative game equilibrium, which emphasizes individual rationality.

4. DISCUSSION

Does an oligopoly have to be a prisoner's dilemma? Does it have to be competitive and low-margin? Not necessarily. The industry where three or four long-established players exists can explain this question. For years, the operators of these firms have grown tired of losing money in price wars and have come to an understanding that all firms keep their prices high and no one is trying to take market share from their competitors. Although each firm is tempted to cut prices on its competitors, operators know that the benefits will not last. They know their competitors will retaliate due to renewed price wars and lower profits in the long run. To avoid such a negative result for both parties, each firm may take a cooperative policy behaviour of minimum price or production limit and price insurance. The so-called cooperative strategy behaviour is the consistent actions taken by firms to restrict competition, whose nature is collusion, and price alliance is the most common kind of collusion.

5. CONCLUSION

The price competition is an effective way to make the price at a reasonable level and force firms to reduce the operating cost. It is beneficial to the firm and consumers and, in the long run, to the efficiency of economic development. However, excessive competition will

reduce the interests of firms. Therefore, competitors in one certain industry should adopt an active strategy to avoid falling into a downward spiral of price war under certain conditions. The strategy that should be followed depends on competitors and market conditions. To begin with, firms should consider the resources they own and their operating capacity. If possible, it can be combined in a lot of ways. No matter what strategy is taken to avoid or against the price war, all firms must ultimately maintain their core competitiveness and maintain a lasting advantage. Price competition is only the primary stage of market competition. In contrast, quality, service and innovation play a greater role in today's industry.

Adopting a competitive price strategy is one of the key factors to conquer consumers, show the competitive charm of brands, and seize more room for survival and development. It is also an important means to achieve the goal of "win-win" for producers, consumers and competitors. The idea running through this pricing strategy is to show the company's strategy to competitors: Don't cut the price so easily, once the competitors cut the price, they break the original written or unwritten agreement, then you should follow the strategy and quickly send a market signal to your competitors that do not engaged in a massive market share battle, but just a trial price reduction, after several rounds of pricing, the two sides make a commitment to some degree, and achieve a "win-win" situation.

Although in some industries, some backward firms need to be eliminated by means of the price war. However, when the competition among firms develops to a certain degree, firms must take some form of cooperative action to stop the irresponsible malignant competition behaviour and avoid the industry overall suffering the heavy loss.

The price war, especially the vicious price war, reduces the sales revenue of firms and causes a large number of workers to lose their jobs and increases the heavy burden of society. Therefore, the igniting of the price war is conducive to peer firms and harmful to society. In the end, it also harms them. The rational firms will not let themselves into a price war.

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