Perspective of Game Theory on E-commerce Platforms During the Online Shopping Festivals

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Abstract. Online shopping is becoming more and more popular. E-commerce platforms hold online shopping festivals in order to obtain more profits and reduce the inventory. Because the limited sum of the market demand, e-commerce platforms spare no pains to seize more market share and obtain more orders. There is a game among e-commerce platforms during the online shopping festivals. In this paper, based on the game theory, the price wars among platforms during double 11 online shopping festival and 618 online shopping festival are reviewed. And the influence of price wars and coping strategies based on the game theory are reviewed.

Keywords: Game theory; E-commerce platform; Online shopping festival; Price war.

1. Introduction

With the development of the economy, more and more people enjoy shopping in order to improve their life. With the fast development of technology, the internet becomes much more popular and the express delivery industry is growing spectacularly in many countries, which makes it possible for people to sell and purchase online. For some sellers, there is no need to pay extra to buy or rent physical shops if they choose to sell goods online. For consumers, on the internet, there are much more types of goods than any particular physical shop. With online shopping, consumers do not need to spend time and money on commuting to and from physical shops. It is really convenient for sellers and consumers to trade on the internet. As a result, online transaction is chosen by more and more sellers and consumers.

Since 1952, the day after thanksgiving has been regarded as the beginning of the Christmas shopping season in the United States. Later, that day was named "Black Friday", which is the first shopping festival in the world. On that day, many stores offer highly promoted sales at discounted prices in order to sell more goods and reduce stocks. The consumers also like to purchase at such low prices so that they can save money. Later, the shopping festival was introduced around the world. After the rise of online shopping, many online stores began to participate in shopping festivals. In many countries, there are some popular shopping festivals in which both online and offline stores participate. For example, the annual "boxing day" on December 26th is the biggest shopping festival in Britain [1]. In China, the "double 11 shopping festival" and the "618 shopping festival" are the two biggest shopping festivals in China.

By participating in online shopping festivals, sellers can not only reduce stocks and gain profit, but they can also generate publicity, which is beneficial to their later business. During online shopping festivals, consumers may not only buy goods they really need but also buy things they think they might need in the future because of the low prices. As a result, the volume of transactions during the online shopping festival is always a big number. The "Cyber Monday" on November 30th, 2020, was the biggest online shopping festival in the history of the United States with a total of $10.7 billion in online spending. Total transactions during China's 618 online shopping festival in 2020 reached US$2.38 trillion. In addition, during the double 11 online shopping festival in 2021, the gross merchandise value was more than $150.5 billion.

Game theory is the study of mathematical models of strategic interactions among rational agents [2]. The "game" in this sense is a bit different from what ordinary people play in daily life. It is defined as a formal description of a strategic situation, with two or more rational "players" and each with two or more strategies. However, there is a possible lack of knowledge, and a payoff function

over a set of players' interactions [3]. During online shopping festivals, there are some games taking place, such as the game between the sellers and consumers, the game among e-commerce platforms, and the game among different online stores on the same platform. In this paper, the game among e-commerce platforms will be discussed. Because the market demand is limited, the increase in orders on one platform is always accompanied by a decrease in orders on another platform. Consequently, all the e-commerce platforms try their best to attract consumers and increase the number of orders so that they can earn more profit.

2. The double 11 Online Shopping Festival

2.1 Origin

The Single's Day, also called Bachelors' Day, takes place each year on November 11th, which is an unofficial holiday in China. The Arabic numeral 1 looks like a bare stick, which means bachelor in Chinese slang. As a result, a group of single college students in China chose November 11th, the date with most Arabic numerals 1, to celebrate themselves and protest traditional couple-centric festivals [4]. In 2009, Taobao Mall, which was renamed Tmall, the online retail giant in China made an attempt in order to increase sales. This platform tried to create a shopping festival of its own. Taobao Mall held the double 11 online shopping festival on November 11th, 2009. At that time, only twenty-seven stores took part in this online shopping festival and conducted price promotions, but the gross merchandise value of goods ordered during the double 11 sales period reached up to $7.5 million [5]. From then on, Taobao Mall holds the double 11 online shopping festival and conducts price promotions in November every year. Later, other e-commerce platforms also began to conduct price promotions during the double 11 online shopping festival.

2.2 Analysis of the Game Among different Platforms

Tmall and Jingdong Mall (internationally known as Joybuy, also known as JD.com and formerly called 360buy) are the two biggest e-commerce platforms in China. These two platforms together accounted for 74.6% of business-to-consumer (B2C) online transactions in 2019. Because of the limited market demand, the promotion strategies they adopt may seriously affect the trade and market share of each other. During the double 11 online shopping festival, it seems that the prices of goods at Jingdong Mall are lower than that at Tmall.

Lin thinks that the game between Tmall and Jingdong Mall during the online shopping festival is a sequential game [6]. The strategies that Tmall adopted are giving allowances to consumers, preselling (encouraging consumers to pay the deposit in advance and to pay the balance on November 11th), flash sales for hot products, and so on. By giving allowances and adopting the model of preselling, Tmall can attract and catch users in advance and create an atmosphere of consumption. And the purpose of setting up flash sales for hot products is to maintain the exposure of the above strategies. In addition, to defeat Jingdong Mall, Tmall encouraged the brands to only sell on Tmall. In this case, Jingdong Mall must take action to fight back. Jingdong Mall urgently contacted brands and asked them to sell their goods on Jingdong Mall, including the brands which were required to only sell on Tmall. The exposure of the brands which succeeded in the preselling model of Tmall would be limited. Besides, advantage categories of Jingdong Mall were sold at lower prices with free gifts.

To simply the game between Tmall and Jingdong Mall, the strategies adopted by Jingdong Mall will be regarded as fighting back in the following discussion. The game tree is as Fig.1 (the indicators are artificially assigned to facilitate understanding):

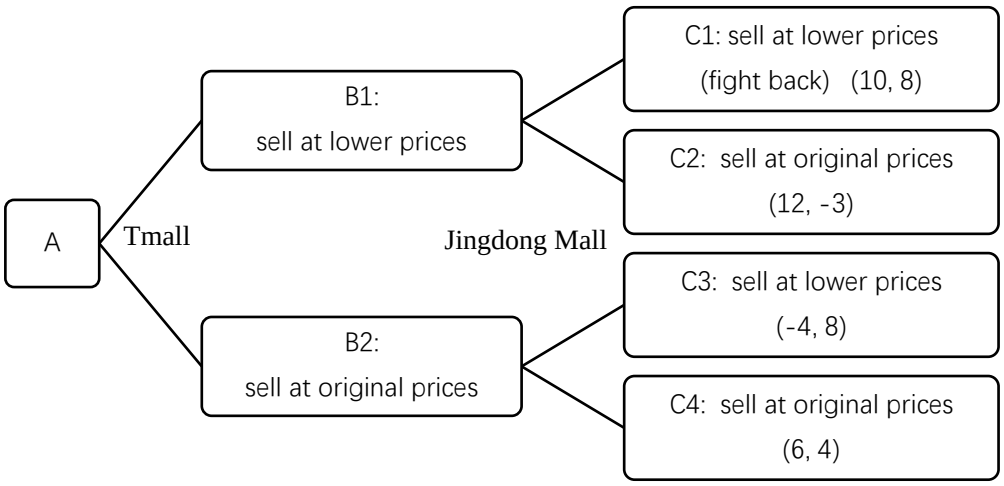


Fig. 1 The game tree of the game between Tmall and Jingdong Mall during the double 11 online shopping festival.

If both platforms choose to sell at original prices during the double 11 online shopping festival, the daily market share will be maintained at (6, 4) and both of them cannot take this opportunity to gain additional revenue. If one platform chooses to sell at original prices while the other chooses to sell at lower prices, the platform which does not choose to sell at lower prices will lose orders and even face losses. If both platforms choose to sell at lower prices, the potential volume of orders will increase and finally both of them will benefit from higher total consumption [7].

Under the condition that the online market demand remains unchanged, the Bertrand model can be used to analyze the game between two platforms. The normal form representation of this game is $\langle N, S, U \rangle$, where: $N = \{1,2\}$ is a set of players, $S = \{S_1, S_2\}$ is a 2-tuple of pure strategy sets, one for each player, and $U = \{U_1, U_2\}$ is a 2-tuple of payoff functions. c denotes the cost of goods, p_i denotes the price on platform i $(p_i > c, i = 1,2)$, and $X(p_i)$ denotes the total market demand, namely the total sales of two platforms [8]. Therefore, when the price on platform i I s p_i, the sales of platform i is:

$$X_i(p_i) = \begin{cases} X(p_i), & p_i < p_j \\ \frac{X(p_i)}{2}, & p_i = p_j, (i,j) \in \{(1,2),(2,1)\} \\ 0, & p_i > p_j \end{cases} \quad (1)$$

The profit that platform i gains is $\pi_i = X_i(p_i)(p_i - c)(i = 1,2)$. If the platform i chooses to sell goods at price $p_i(p_i > c)$, the platform $j(j \neq i)$ will choose to sell goods at a lower price to obtain all the orders and profit, and then the platform i will choose to sell goods at a price lower than the platform j, and the cycle repeats. Eventually, both platforms will choose to sell goods at a price that equal to c.

Let π_m denote the total profit. It is defined as $\pi_m = \pi_1 + \pi_2 = X_1(p_i)(p_i - c) + X_2(p_i)(p_i - c) = X(p_i)(p_i - c)f(x)$. In addition,

$$U_i = \begin{cases} \pi_m, & p_i < p_j \\ \frac{\pi_m}{2}, & p_i = p_j, (i,j) \in \{(1,2),(2,1)\} \\ 0, & p_i > p_j \end{cases} \quad (2)$$

If two platforms choose to cooperate, they will gain π_m each other. If one of them choose to sell at a price lower than the other, the final price will be c and both of them will gain no profit. The payoff matrix is as Table 1.

Table 1. The standard Bertrand model.

		Jingdong	
		sell at original prices	sell at lower prices
Tmall	sell at original prices	$\left(\frac{\pi_m}{2}, \frac{\pi_m}{2}\right)$	$(0, \pi_m)$
	sell at lower prices	$(\pi_m, 0)$	$(\varepsilon, \varepsilon)$

Here, ε is a non-negative number tending to 0. There is a Nash equilibrium when both platforms choose to sell at lower price. But this kind of strategy is not sustainable because of the meager profit. They will choose to cooperate and sell goods at the optimal monopoly price $p_m^* = p_1 = p_2$. Afterwards, both of them will obtain $\pi_m^*/2$. In daily sales, the random price promotions of two platforms can be regarded as an infinite game and they reach an agreement in disguise to share profits.

But how can platforms obtain extra profit by participating in the online shopping festival? In fact, the online market demand is not constant. When consumers find that the price on e-commerce platforms is much lower than in the physical shops, they will naturally choose online shopping. So in this case, the original Bertrand model is not applicable. The new payoff function should be:

$$U_i' = \begin{cases} \xi\pi_m, & p_i < p_j \\ \frac{\eta\pi_m}{2}, & p_i = p_j < p_m^* \\ \frac{\pi_m^*}{2}, & p_i = p_j = p_m^* \\ 0, & p_i > p_j \end{cases}, (i,j) \in \{(1,2),(2,1)\}, 1 < \xi < \eta \quad (3)$$

In addition, the new payoff matrix is as Table 2.

Table 2. The Bertrand model with expanded demand.

		Jingdong	
		sell at original prices	sell at lower prices
Tmall	sell at original prices	$\left(\frac{\pi_m}{2}, \frac{\pi_m}{2}\right)$	$(0, \xi\pi_m)$
	sell at lower prices	$(\xi\pi_m, 0)$	$\left(\frac{\eta\pi_m}{2}, \frac{\eta\pi_m}{2}\right)$

In brief, when e-commerce platforms hold price reduction promotions, business stealing takes place and the e-commerce platforms obtain more profits. This is one of important reasons why e-commerce platforms hold online shopping festivals.

3. The 618 Online Shopping Festival

3.1 Origin

Jingdong, one of the biggest e-commerce companies in China, was founded by Liu Qiangdong on June 18th, 1998. And in 2004, its retail platform went online, which is known as Jingdong Mall now [9]. From then on, Jingdong Mall began to launch marketing promotions around its anniversary every year. The 618 online shopping festival was first officially launched in June 2010, as a competitor to double 11 online shopping festival, which was held by Tmall, the arch rival of Jingdong Mall. Later, the 618 online shopping festival became the shopping festival for all platforms. Many e-commerce platforms launch promotions during the 618 online shopping festival, including Tmall, Pinduoduo, and even some short video platforms like TikTok.

3.2 Analysis of the Game Among Different Platforms

The price war is a kind of commercial competition between companies by reducing the price of goods they sell. In this way, companies can beat rivals, seize market share and reduce inventory. In 2012, the comment of Liu Qiangdong, the CEO of Jingdong, became the signal of the price war. At that time, at least three big e-commerce platforms participated in the price war. From then on, during every big online shopping festival, many e-commerce platforms spare no pains to seize more market share and obtain more profits. Nearly all of them take price war as an important or even dominant strategy.

Tmall and Jingdong Mall are regarded as two oligarchs of the online shopping industry in China. Luo thinks that the game between these two e-commerce platforms in the price war during the 618 online shopping festival has following features [10]:

(1) Both platforms have special staffs to follow up the price of good on other platforms, so both sides of the game know all the relative information of their rival well, that is, it a game of perfect information.

(2) Both sides of the game should make decision as soon as possible, because in the process of promotions, a slow step may result in losing users and even a loss of losing large profits. Therefore, both platforms will not let themselves take action later than their rival. So this game is simultaneous, in other words, it is a static game.

(3) Similar products of different brands or different packaging cannot completely replace each other. Two platforms do not contain exactly the same kind of goods and nearly all the consumers have the platforms they prefer. As a result, there is no complete substitution in this game.

According to the above features, the "prisoner's dilemma" model can be used to analyze the game between Tmall and Jingdong Mall in the price war during the 618 online shopping festival. It is assumed that players of this game are rational. The payoff matrix is as Table 3 (the indicators are artificially assigned to facilitate understanding).

Table 3. The prisoner's dilemma model

		Jingdong	
		sell at original prices	sell at lower prices
Tmall	sell at original prices	(10,8)	(6,10)
	sell at lower prices	(12,4)	(8,6)

("sell at lower prices","sell at lower prices") is a Nash equilibrium and it seems that price war is the best strategy for two platforms. So both platforms choose to sell goods at lower prices. This result is in line with the conclusion of the prisoner's dilemma. Price war does not maximize the total profits of the two platforms, nor does it make any platform obtain the maximum of the profits, but it maximizes the interest of consumers. In fact, brands, retailers and platforms can liquidate inventory and raise publicity by launching price promotion. For this reason, online stores would participate in online shopping festivals and sell goods at lower prices though thy could not obtain huge profits. In addition, business stealing happens during online shopping festivals. According to the Bertrand model modified with expanded demand in section 2.2, it can be proved that platforms can obtain extra profits by launching price war.

4. The Influence of Price War and the Coping Strategies

4.1 Advantages and Disadvantages

The price war also refers to all kinds of market competition behaviors that take price as a competitive strategy. It brings benefit as well as harm to companies, industries, consumers and even the whole society.

According to Luo, the price wars can be divided into two categories, namely rational price wars and extreme price wars [5]. Rational price wars bring e-commerce platforms more profits and higher visibility, while the offline retail sector may suffer some losses. At the same time, consumers can buy what they want at lower prices. Besides, rational price wars can stimulate demand of people and increase consumption, and they benefit express logistics and other surrounding industries. However, extreme price wars result in low profit of manufacturers and distributors. and quality of products and services will decline because of the extremely low prices, which will suffer the interest of consumers and damage the reputation of corresponding companies and even the whole industries.

According to Guo, price war does harm to the long-term production, research and development of manufacturers, and it reduces the expected price of consumers, which finally damages the interest of all the corresponding industries [10].

4.2 Method to Avoid the Price War

Since there are many disadvantages of the price war, especially the extreme kind, measures should be taken to avoid the price war.

Supposed there are two e-commerce platforms in the game of online shopping. The payoff matrix is as Table 4.

Table 4. The payoff matrix of two platforms

		platform 2	
		sell at original prices	sell at lower prices
platform 1	sell at original prices	(A, B)	$(A - X_1, B + X_1)$
	sell at lower prices	$(A + X_1, B - X_1)$	$(A - X_2, B - X_2)$

Guo thinks that a public regulator can be set up to monitor the commodity prices and punish the initiators of price war [10]. Supposed that the regulator gains when the market develops healthily and suffers loss when the market develops maliciously. Then the payoff matrix of the game between the distributors and the regulator is as Table 5.

Table 5. The payoff matrix of distributors and the regulator

		regulator	
		supervise	not to intervene
distributors	sell at original prices	(0,0)	$(0, X_5)$
	launch prices	$(-X_3, 0)$	$(X_1, -X_4)$

Then there are three players in the game, namely platform 1, platform 2 and the regulator. The payoff matrix of three players in the game with supervision is as Table 6. and the payoff matrix of three players in the game without intervention is as Table 7.

Table 6. The payoff matrix of the game with supervision

		platform 2	
		sell at original prices	sell at lower prices
platform 1	sell at original prices	$(A, B, 0)$	$(A - X_1, B + X_1 - X_3, 0)$
	sell at lower prices	$(A + X_1 - X_3, B - X_1, 0)$	$(A - X_2 - X_3, B - X_2 - X_3, 0)$

Table 7. The payoff matrix of the game without intervention

		platform 2	
		sell at original prices	sell at lower prices
platform 1	sell at original prices	(A, B, X_5)	$(A - X_1, B + X_1, -X_4)$
	sell at lower prices	$(A + X_1, B - X_1, -X_4)$	$(A - X_2, B - X_2, -2X_4)$

When there is no regulator to supervise the companies, ("sell at lower prices", "sell at lower prices") is the only Nash equilibrium and the price war will bring undesirable consequences. When there are regulators to supervise the companies, the price war may be avoided.

When $X_1 - X_2 < X_3 < X_1$, there is no Nash equilibrium in this game, so the price war will not happen. When $X_1 \leq X_3$, ("sell at original prices", "sell at original prices") is a Nash equilibrium in this game, so the price war will not happen. When $X_3 < X_1 - X_2$, ("sell at lower prices", "sell at lower prices") is the only Nash equilibrium and the price war will happen. In conclusion, when $X_3 > X_1 - X_2$, the price war can be eliminated. That is, when the punishment of the price war is severe enough, the e-commerce platforms have no motivation to launch price wars.

5. Conclusion

Holding online shopping festivals is an important strategy of e-commerce platforms to attract consumers, gain profits and raise publicity. During the online shopping festivals distributors spare no pains to stimulate consumption, liquidate inventory and thereby gain benefits. The price war, namely selling goods at lower prices, is the main strategy that e-commerce platforms adopt during the online shopping festivals. Based on the game theory, the platforms worry that the rivals will launch the price war while they choose to sell goods at original prices and thereby, they will suffer losses. As a result, the platforms choose to sell goods at lower prices. The price war brings a lot of short-term benefits to companies, and it promotes the economics as well.

However, launching price war cannot be a long-term strategy. The price war, especially the extreme kind, does harm to manufacturers, e-commerce platforms and other corresponding industries, and finally damage the interest of consumers. In order to avoid the bad influences, in addition to e-commerce platforms taking the initiative to make changes, corresponding laws and regulations are also important. Public regulators should be set up to supervise the companies and the commodity prices. And the punishment of price war should be set reasonably.

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