

The E-Commerce Price Wars (Oligopoly & Prisoner's Dilemma)

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ABSTRACT

Oligopoly stands as a major driver controlled by only a few large firms having a huge market share in an industry, adding significant impact on market dynamics. This study provides complete insights on oligopoly and prisoner's dilemma in e-commerce price wars. It analyzes different features of oligopoly, strategic interactions, interdependence across firms, and entry barriers. This paper also examines several examples to explain Prisoner's dilemma by comparing two firms and their decisions in an example. It elucidates oligopoly behavior of firms as part of game theory.

There are different reasons behind price war in ecommerce industry. This study attempts to use behavioral analysis and game theory to explore various forms of competition and possibility of further study behind price coordination behavior. The study suggests the need to improve competition level in the industry for organizations to get rid of price war trap. Organizations should focus more on their product and technological innovation. Meanwhile, ecommerce enterprises should be rational to make strategies to avoid destruction from market competition and loss of confidence among consumers caused by excessive price war in extreme situations.

Keywords – oligopoly, ecommerce price wars, Prisoner's dilemma, ecommerce industry, game theory, behavioral analysis

1. Introduction

Rapid growth of IT sector is fundamentally the major cause of e-commerce war. Over the years, e-commerce has been developed rapidly and price war usually occurs among different commodities. The price war involves all the products that are widely used and spread to the major ways of sales. Even though the price war in e-commerce sector may become the war of words eventually due to several reasons, it still made it challenging to get rid of "price war trap". All the manufacturers were involved in one way or the other for a long time due to repetitive war (Hu and Tang, 2014).

Butterfly effect is something one cannot ignore behind the price war. When it comes to commodity, excessive competition for the price could result in lack of time for organizations to build core technology with research and industry profits may be reduced by the homogeneity competition. Even though home appliance sector keeps on growing in the country, there are low profit margins in the industry instead of core competitiveness for over 10 years, i.e., usually in less than 5%. Hence, price wars result in extreme effects. Overall, there are several competitive behaviors in the industry, including merger, advertising, and pricing behavior.

Pricing characterizes the comprehensiveness of the enterprise. Behind the price benefit, strengths are the benefits of economies of scale, technology, production costs, marketing channels, value chain, and service brand. On the current situation of e-commerce sales, price could vary widely in the origin of price war, which can be achieved efficiently (Ouyang and Tao, 2005). Hence, pricing is very vital in price war. There are concerns about eliminating the harmful effect of price war and pricing the product. As per the above arguments, this study will discuss the forms of price war and making e-commerce industry to get rid of the trap of price war, using oligopoly and prisoner's dilemma to discuss the pattern of competition and explore the odds of coordination behavior. To get rid of the trap of price war, it is analyzed that competition level would be improved and there is a need to focus more on innovation in technology and products (Zhang, 1996).

Due to complex nature of oligopoly, which is due to organizations depending on each other mutually, there is no universal, individual theory on oligopoly behavior like the way there are theories on other market structures. Rather, game theory is used by many economists, i.e., a branch of mathematics for analyzing situations where enterprises have to decide and get payoffs as per other players' decisions. Game theory is applied on a large scale in the domain of social sciences, law, business, and military strategy. Nash Equilibrium is the key concept of game theory. Developed by 1994 Nobel Prize-winning mathematician, John Nash, the concept of Nash Equilibrium is applied in economies of scale. It is applied when no player can change their decision, considering the decisions of other players and assuming that their decision would remain unchanged. Hence, all players make optimal decisions as per other players' decisions (Kreps, 2018).

2. Literature Review

Lambertini (1997) modeled the decision between price and quantity to soothe collusion. It is observed that it relocates the dilemma of prisoners backward, i.e., from the market to a stage where variable of the market is selected to withstand collusion, and where rates of discount looked as payoffs. Also, when behavior type and market variable are chosen, a prisoners' dilemma takes place, whether cooperative or non-cooperation.

Milovanska-Farrington (2025) introduced game theory and oligopoly introduced in the real world. The readers would be able to identify real-world oligopoly, analyze the games in similar move of complete data to evaluate the strategy of each player, identify applications of Prisoner's dilemma in real-world, the Nash equilibrium of the game, and other problems related to game theory to determine backward induction and complete information to know the subgame.

Alqahtani and Makki (2023) analyzed oligopoly market in F&B sector on the basis of game theory. They collected data from two top competitors in food and beverage industry. They focused on 5 social interaction decisions – price war, campaigns, R&D investment, new policy, and arrival of new product. The games designed were based on Deadlock, Extensive-Form models, and the Prisoner's Dilemma. This study also addresses the players, games, actions, representations, payoffs, and findings in different stages for each of those decisions. In this study, some of the implications support decision-makers in F&B industry to develop proactive and reactive strategies for actions made by competitors and retaining competitive edge.

In the wider game theory framework, the Prisoner's Dilemma was studied to elucidate not just decision making and interaction with theoretical constructs, but also improves knowledge of its applications in different areas significantly. While the dilemma introduces a paradox among combined welfare and rationality of an individual, Dao (2024) proposed a robust model to resolve and track stress arising in political negotiation, financial competition, cybersecurity, and managing communal resources. This analysis majorly reiterates the major role played by interdisciplinary methods to address challenges posed by the dilemma of the prisoner. Findings in this study highlights that constant innovation in policy and research is needed for making the most of game theory to promote more balanced and combined interactions in both global and domestic areas.

Hu and Tang (2014) focused on home appliance sector as it is among the most competitive arenas in terms of price war. There are different reasons to choose price war in home appliance in ecommerce industry. They applied economics analysis and game theory to explore the form of pattern of competition to explore the odds of coordination in the sector. It is found that there is a need to focus more on innovation and technology to get rid of trap of price war and improve competition level in the industry. There should be rationality in the e-commerce market to avoid destruction of competition and loss of confidence among consumers due to heavy price war.

3. The Prisoner Dilemma

The classic "prisoner's dilemma" is the sign of breakout of price war in game theory. There are two suspects in this dilemma – A and B without any evidence for conviction. After separating both suspects, the same choice is offered by the police – If one betrays and other stays silent, the

one who betrays will be released immediately and the one who remains silent would be imprisoned for 8 years. If both confess at the same time, they would be jailed for 5 years. If two people stay silent, they would be imprisoned for one year. Table 1 illustrates the matrix of payoff.

Table 1 – The Payoff Matrix in Prisoner's Dilemma

	Prisoner B cooperates (silence)	Prisoner B betrays (defects)
Prisoner A cooperates (silence)	(-5, -5)	(0, -8)
Prisoner A betrays (defects)	(-8, 0)	(-1, -1)

Source - Hu and Tang (2014)

Basically, there are two cases – cooperative and non-cooperative. In the case of cooperation, there is collective rationality. In non-cooperative, it is assumed that participants are pursuing rewards and they are rational individuals. It is seen that individuals would get better reward with cooperation. However, because of fear of other individual betraying and selfishness of humans, irrespective of what the other person chooses, the payoff is higher for betrayal for both prisoners. With static games of scribing, it is concluded that both of them could be rewarded equally with “cooperative, cooperative” strategy (Xie, 2008).

Back to ecommerce price war, it is assumed that there are only two firms in oligopoly in the market. They both want to cover the market share for higher profits. At the same time, there are two characteristics for meeting the game process – (1) The pricing behavior is public for two companies and competitors can easily get other price details for consumers; (2) Both prices are changing constantly in the repeated game. In this game, rival changes the price seeing the price of other. Here, price competition is the competitive strategy that is being used by both sides.

The basic conditions of repeated game model are met, i.e., having complete information in the repeated game model. If both companies are increasing the price, there are paybacks of 100 units for each of them. Both companies can have 70 units each if both reduce price. If a company cuts prices and other doesn't, the one who doesn't gets 20 units while the other who reduces price gets 150 units. Table 2 shows the pay-off matrix between two companies.

Table 2 – The payoff matrix in price war

	Company X (high priced)	Company X (low-priced)
Company Y (high-priced)	(100, 100)	(20,150)
Company Y (low-priced)	(150,20)	(70,70)

Source – Hu and Tang (2014)

There are two choices for two companies – lower price or keep it and repeat, to expand market share. The consumers accept the competition from the market point of view. It goes without saying that consumers want better deal. Due to huge influence of market share of organization, the cartel of fixing the price is not binding well. The price agreement bankruptcy is created when one of them started to slash price. To maximize the interest, there is no power for each company to retain the agreement. The choice between the group and individual is rational, which is observed in the price war.

The oligopoly firms engaged in price competition are usually ended up in prisoner's dilemma. If one firm doesn't slash prices, other captures the market using low price. If other reduces prices, one has to reduce it too. Even though all companies know the outcome is better in collusion like a prisoner, they are worried that partners will default (Zhang, 2012). If one organization reduces prices to increase sales and capture market share, other has to reduce prices to break up the balance. In this war, everyone falls in the price trap.

3.1 The Nash Equilibrium

The Nash Equilibrium is the concept of game theory which identifies outcomes where no player can change their decisions. It is something like the situation of "Confess, Confess" in Prisoner's dilemma. It means neither player can switch to do better when other confesses. For example, in airline, "Low Fare, Low Fare" is the Nash equilibrium. For the society or the players, Nash equilibrium is not necessarily the ultimate outcome. It may minimize overall surplus relative to competitive pressure. It is simply the point of stability. Once reached, no player would like to diverge at a stable point. There are various Nash equilibria in some games and there is no Nash equilibrium in pure strategies where mixed strategies are needed to be analyzed (Fudenberg and Tirole, 1991).

3.2 Identifying Nash Equilibrium in Payoff Matrix

In a 2x2 payoff matrix, it is easy to find the Nash equilibria after knowing the method. The best response to the strategies of each player should be identified for each player –

- Fix the strategy of one player by looking at one row or column at a time
- Find the best response of other player, i.e., strategy giving best payoff in that row or column
- Circle or underline the best response in each row or column
- Identify the cell where both players are giving their best response

In Nash Equilibrium, cartel includes a group of firms which agrees to organize their pricing decisions or output explicitly. A collusive agreement is an informal or formal agreement where firms accept the condition to limit competition. As per game theory, all players are completely rational to calculate the right strategies accurately. In reality, emotions, incomplete data, and cognitive biases may influence decision-makers. Systematic departures have been covered by behavioral economics from the assumption of rational enterprise. It is important to understand the payoffs and strategies of all players to find a Nash equilibrium. Real firms are highly uncertain about the costs, intentions, and capacity of their rivals. In the payoff metrics, the accurate numbers are pedagogical tools. They can only estimate real-world payoffs. A single decision point is analyzed by a typical game theory model. As firms learn, innovate and adapt over time, actual competition is ongoing (Zhang, 2012).

3.3 Game Theory and Oligopoly – Common Mistakes to Avoid

- Oligopoly is often confused with monopoly. Oligopoly consists of various interdependent firms who have to consider reactions of each other. In monopoly, there is no strategic interaction in a single firm. The analytical tools are completely different for maximizing profit and for game theory.
- The outcome of prisoner's dilemma, i.e., failure in cooperation, is applied to one-shot games. With repeated interactions, firms can maintain cooperation with tit-for-tat strategies. It is always a one-shot to analyze an oligopoly when firms compete for longer period and when firms make wrong predictions.
- Nash equilibrium is not always different. There are various Nash equilibria in games and some don't have any equilibrium at all. It is not guaranteed that there is a unique equilibrium in prisoner's dilemma.
- Explicit collusion is also confused with unspoken mutuality. Antitrust law bans explicit agreements for dividing markets or fixing prices. Firms arrive individually at similar prices in parallel pricing behavior with rational strategies. It is a natural form of oligopoly.
- Cartels are constantly pressured from the cheating incentive. Price increases dramatically after price collapse and quota violations. Price increases dramatically due to violations. The discipline of cartel erodes over time as members consider their own interests.

4. The Oligopoly Structure

Markets come in different forms with own implications and features in this age of economics. Oligopoly is one of those market structures holding a vast swap in redefining economies and industries across the world. Oligopoly refers to small number of large organizations having a huge market share. It adds a different scenario where pricing strategies, market changes, and competition meet (Caves & Porter, 1978). In oligopoly, only a few dominant firms wield huge impact on market outcomes and pricing, often adding soft balance between competition and cooperation. Several small firms operate individually in oligopoly, unlike ideal competition. In monopoly, one firm rules the market. In oligopoly, middle ground is created with a few firms competing for control.

Usually, only a few firms dominate the oligopoly markets, i.e., around 2-10. They hold a huge amount of market share with huge influence and pricing power (Bain, 1950). In oligopoly market, the actions of one firm impact the competitors' decisions and strategies. Firms have to consider the responses of their rivals when it comes to make decisions related to marketing, pricing and production. In oligopoly, while competition for price is one factor, firms also have to engage with product innovation, advertising, and customer service in non-price competition. This way, firms can stand out and build brand loyalty without having to wage price wars (Ciobanu, 2011).

Without collusion, firms may adopt price leadership, where price is set by a dominant firm and others follow it. It can ensure stability in the market price, while other firms can avoid direct face-off (Mazzeo, 2002). Oligopoly markets are defined by smart interaction where firms react to actions of one another and anticipate the same. It can cause complex processes related to decision-making as firms consider the possible outcomes of several plans (Modigliani, 1958). Firms in oligopoly hold a lot of market power, enabling them to affect market outcomes and prices to their benefits. It can result in market inequality and inefficiencies as smaller rivals find it hard to compete (Zhou, 2024).

Because of concerns over competition and market power, oligopoly markets prevent fixing of prices, collusion, and other behaviors as they are subject to antitrust control. Government tracks such competition and puts regulations to secure consumers and encourage fair competition. Oligopoly markets may result in economic stability by minimizing volatility and holding price levels. However, excessive collusion or market power can affect overall financial efficiency and distortions in the market (Brander & Lewis, 1986). Oligopoly adds complex and captivating structure of the market which affects economies across the world. With few of the leading firms, market outcomes, competition, and strategies, oligopoly provides both opportunities and challenges for consumers, policymakers, and businesses. It is important to understand the

dynamics of oligopoly to explore modern markets and promote financial welfare in a highly globalized world.

4.1 The Entry Barriers

The setting of oligopoly is created with a combination of entry barriers and differentiation of product to create monopolies redefining competition in the monopoly. For instance, when a patent is granted by the government for innovation, it may generate monopoly. When patents are granted by the government, for example, three pharma companies have their own blood pressure medications. Then those firms can be oligopoly. In the same way, when the quantity demanded, a natural oligopoly will take place and it is big enough for limited firms to work at long-run curve of average cost. The market may grow with only 2-3 firms in oligopoly as no smaller firm can work at low average cost and there is no single large organization that could sell what it manufactured (Marinho, 2024).

At the average cost curve, the market demand for quantity may be 2-3 times more than the market demand to produce. So, market may have more room for 2-3 oligopoly firms. Again, the average costs would be higher in smaller firms and may not compete, while other large firms produce high amount which couldn't sell at reasonable price. This combination of market demand and economies of scale generate entry barrier, which resulted in duopoly, for example, in large passenger aircrafts between Airbus and Boeing (Marinho, 2024).

At the core of monopoly, the product difference at the competition can also generate oligopoly. For instance, firms may have to reach some minimum size before spending enough on marketing to form a reasonable brand identity. When it comes to competition between Pepsi and Coca-Cola, the problem is not technological challenge in producing fizzy beverages, but creating marketing effort and brand name. This is where it is important to understand the characteristics of oligopoly (Marinho, 2024).

In oligopoly, only a few individual firms compete and each firm focuses on what other firm does and it can be done because of competition between only a few firms. Entry barriers reduce competition by avoiding new firms to enter into the market. Oligopoly depends inherently among firms. Its model is complex. Instead of using traditional models, different kind of model is needed to know behavior of oligopoly firms, i.e., Game Theory models.

4.2 Prisoner's Dilemma in Oligopoly

Oligopoly members may also face prisoner's dilemma. The oligopoly members may face prisoner's dilemma. If each of the member cooperates and holds output down, they may enjoy high monopoly profits. However, each member must be worried that though they are holding the

output, others may take the benefit and raise output for higher profits. Duopoly is a 2-firm oligopoly which can be explained with an example. Suppose there are Firms A and B. Both accept the condition to hold the output, they act as monopoly together and earn profits of \$1000. However, their main strategy is to improve output. In the Nash Equilibrium, each firm makes profit of \$400 (Phlips, 1995).

There is a reason why firms don't trust one another and refrain from cooperating. It could be explained with Firm A's situation. If firm A perceives that B will increase output and don't respect the agreement, then A will also increase the output. When both firms expand the output, profit will be \$400 for A. If B increases the output and A holds, the profit for A would have been only \$200. If A feels that B will hold the output down and cooperate, A may not accept the chance by increasing output and higher profits. If B holds down, A can increase profit to \$1500 by increasing output. Hence, it makes sense for firm A to increase output if B holds the output down and it is sensible to expand output if B does the same. Although both firms could make highest profits combined by producing lower output and behaving as monopolist, the output of prisoner's dilemma is that both may end up in a circumstance where each earn only \$400 each by increasing output (Phlips, 1995)

5. Discussion and Conclusion

Price cartels are factually the collusion across firms and regulating price actions. Party involved in collusion is also the part of the business. Price coordination is very important as one of the governance functions of trade associations but it has not been focused in the law consistently. As there is scarcity of legitimacy in price collusion, the price coordination doesn't have clear contract or agreement most of the time in enterprises. Usually, oligopolistic markets have major challenges to make entry barriers against new firms in the industry or creating troubles for current firms to leave the competition. These barriers are economies of scale, high capital investments, regulatory pressures, and patents.

Oligopolies are defined by small set of large firms controlling the market. They are known for high concentration ratio measuring the market share managed by large firms and this ratio is usually high in oligopolistic markets. Oligopolistic firms understand the decisions and actions of their competitors. They also need to consider how their choices affect the reactions and behavior of rival firms like marketing strategies and pricing. Firms engaged in oligopoly often become the part of differentiation of the product to stand out with different quality, brand value, and advertising.

Oligopoly enables firms to collude and set prices to reduce competition and improve their profits. Collusion can add stability in the market to minimize uncertainty for consumers and

firms. Destructive price wars can also be avoided by collusion. Firms may compete to achieve market share aggressively to increase profits separately. Collusion is prohibited by antitrust laws to encourage free competition among firms. Incentives and goals may be different across firms to make collusion challenging. Overt collusion is another challenge which occurs when firms set prices and cooperate openly. It can form cartels, which are known to be explicit agreements to coordinate among firms. In addition, tacit collusion refers to behavior of firms to resemble collusion without agreement. Firms may go with common price patterns set in competition or achieve price leadership where one top firm sets the price for others to follow.

The prisoner's dilemma is a traditional scenario of game theory where two firms make choices which may cause suboptimal results. In terms of oligopoly, if both firms decide to go all in, they may both suffer with lower margins and wage price war. If both firms set prices higher and collude, they could maximize profits for their own good. The dilemma takes place as each firm can beat the collusion to achieve larger profit share but they both end up worse if both firms achieve the same.

There are also different types of competition in price. Price war is the most common type where tough competition reduces prices to achieve market share. It also affects profitability of firms. Predatory pricing also occurs when very low prices are set by the firm to drive competition and it can also increase prices. Controlling prices is the strategy where prices are set low enough by the large firm to prevent new market entry. Firms focus on unique features and qualities of products with quality, branding, advertising, or design. Firms often engage in large marketing and promotion efforts to build brand awareness and loyalty. They need to compete by developing new technologies, processes, or products. They offer complete customer support and service as competitive edge. Efficient networks should be developed for distribution.

In reality, price competition is not repetitive. If there is a chance to skip price wars for organizations, it is important to reach win-win situations under certain competition. If only the rivalry is enough, the answer is yes. After tough price wars and long time, there are odds that those giants who survived could coordinate the price. In majority of cases, they choose to act as "don't know" or "no refutation". This way, oligopoly can stop the fire of price and enjoy high profits altogether, unless there is a need to cooperate.

In private, price collusion could take place much likely. Such price strategies are adopted by many countries, such as, price alliance for win-win situations. There are definitely some limitations among countries. Hence, it could last longer. In case of ecommerce enterprises, this kind of alliance would definitely collapse due to lack of stability and legality. Hence, it is concluded that competition is still the mainstream while cooperation is at the background, given

the existing situation of development of enterprises. In pursuit of profitability, several collusions will still take place from oligopoly as the odd of coordination in some industries.

Price war is effective to keep the price reasonable and pressurize organizations to reduce costs of running businesses, which will be win-win for both consumers and brands in the long run. However, over-competition could reduce the benefits for enterprises. Hence, in terms of competition, they must take proactive measures to avoid being trapped in a spiral of price war in some situations. This strategy relies on market condition and competitors. It should take both resources owned by enterprises and its ability of management. It can combine different ways.

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