The International Trade Between Countries in the Cosmetics Industry

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ABSTRACT
Last century, the famous scholar John Nash first introduced his theory about "the Nash equilibrium" and introduced to more people the abstract concept of game theory. With his mathematical abilities, he formulated models that can be better explained and analyzed. His founding was also very interesting and could be applied to different fields during research. Game theory is the study of strategic interactions between rational players, which has been applied in many fields such as sociology, economics, and mathematics. Its importance reveals that using the intricate models to explain different situations. This paper adopts the game theory to analyze the cosmetics industry, which is one very important industry in the world. The model was built, which imitates the collaborations between a retailer and a supplier. The research done has the purpose of illustrating the collaborations between people under the severe condition of Covid-19.

Keywords: *Game theory, Cosmetics, Trade, Economics.*

1. INTRODUCTION

1.1. Background

As it is known to all, game theory is the study of strategic interactions between a set of players whereas every player is rational and will deeply consider how they can maximize their payoffs. Although this kind of study may seem irrelevant to real life, at first sight, there are a lot of circumstances in which people can apply it into the daily lives of people. For instance, when people decide on which concert to attend, which strategy to use while playing chess with friends, or even when people vote during presidential elections. All these examples are things people can apply game theory to.

In this report game theory and its application in international trade between suppliers and retailers from different places in the cosmetics industry will be discussed and analyzed. The game happens under the spread of the coronavirus, also well known as “Covid-19” by most people.

The reason why this setting was chosen is that it not only focuses on our current situation (many people are still suffering from the disease) but also gives people a very realistic model that has a large possibility to occur in real life. While Covid-19 spreads across the world like deadly flu, many of the consumers in different countries need to re-consider how to make consumptions; since the disease is highly infectious, many people would prefer online shopping (using social media or different apps) due to its convenience and safety (buying things using delivery decreases the probability of getting infected by the spreading disease). For most people, doing make-up and staying beautiful is something essential that has made up a large part of our life, so even during the pandemic people would still be using all kinds of cosmetics such as foundation and skin-care lotions.

This inclination changes a lot of things and brings up our game: Due to the pandemic, the supplier of the product is unable to work effectively since some factories may be closed down and workers may be unhappy or inefficient due to the pandemic, which leads to the result that some products are good (of high-quality) and some are bad (of bad-quality). “It’s clear that economic and societal costs will be huge. The pandemic has revealed the vulnerabilities in global supply chains across most, if not all, sectors and industries. Today, organizations are in reaction mode, focused strictly on maintaining supply and meeting customer needs, often through hands-on rigor and hard

work." [2]. Therefore, the supply chain may also change in different ways.

1.2. Related Research

Lambert and Cooper presented a framework about how to successfully integrate the market to support the entire supply-chain management system. They used several case studies about various companies. They proposed a framework about how information flows to both suppliers and consumers and processes through demands and orders. In this process, customer relationships, demand, order, manufacturer, product, and returns are managed separately. At the end of the article, they talked about different ways that the supply chain can improve itself to the different needs of people [3].

Groot and Bruynzeel wished to explore the possible effects of the ingredients in cosmetics. They found out that the ingredients responsible for allergy to cosmetics were determined in patients suffering from the product. They proposed that Kathon CG is the ingredient that is most commonly the cause of all allergies with different experiments done with analyzing different types of cosmetics including lotion and perfume. They concluded that many cheap cosmetics products usually include this kind of ingredient, which is one big disadvantage of low-quality cosmetics products. They also discussed ways in which people can distinguish between low-quality products and high-quality products [4].

Baldwin and di Mauro discussed the overall impact of covid-q9 from a perspective of an economist. They think of the pandemic as both a supply and demand shock that completely affects how to trade and economic activities work (especially in places like China, where the pandemic is deadly and prevailing). They believe that the supply chain would be affected and there would be demand disruptions due to drops in aggregated demand and wait-and-see purchase delays (due to online shopping). The likely nature of economic socks may result in medical shocks (workers produce less GDP), the closing of schools and factories, and the panic of the citizens. These are all variables that may affect the overall well-being of a country[5].

Myerson introduced his understanding of basic game theory and its application in real-life situations. Game theory is the study of strategic interactions among players who always have a rational mind and a preference as well. Roger used mathematical formulas and several real-life scenarios for the readers to explore. He believes that game theory can be applied in any branch of social science and greatly relates to our daily life, even though it may not be so obvious. Basic ideas were introduced in the book, such as Nash equilibrium and Bayesian conditional equilibrium. In brief, the game theory uses mathematical models to study the interactions between intelligent people [6].

Daskin and Church et al. analyzed the disruptions (due to various unexpected events) in the supply chain network using an approach using the game-theory idea. Supply chain disruptions have several causes and once they occur, there is a very little resource regarding supply chain infrastructure because decisions cannot be changed quickly. Therefore, planners must rationally decide the options that are available to them. The authors presented a few models for designing supply-chain related to disruptions that may occur. They also divided each category based on the underlying optimization model and the risk measure (expected cost and actual cost) [7].

Tian and Govindan proposed a dynamic game based on evolutionary game theory for green supply chain management diffusion among Chinese manufacturers. They focused on the relationship between the government and the consumers as the enterprise. The main goal of the paper is to describe the mechanism of GSCM diffusion among the manufacturers in various developing countries, as well as offer advice on establishing appropriate laws and systems that can promote growth for several countries that are still developing. The problem analysis of the game is also given in the essay [8].

Valaskova and Durana explored the impact of Covid-19 on consumer behavior and decision-making. The current COVID-19 pandemic has affected every aspect of consumer behavior—their expenses, investments, and financial reserves, as well as their financial and social well-being. As a consequence of different laws exhibited, consumers and their shopping patterns have changed significantly; thus, the factors that influence new purchase patterns need to be identified to help traders, retailers, and suppliers develop appropriate strategies to respond to important consumer changes in the market. An analysis (Pearson's chi-square test) and correspondence analysis (simple and multivariate) were applied to a sample of 425 Slovak respondents to reveal the most important factors impacting consumers' financial situations, as well as the effects on the maintenance of new shopping habits established during the pandemic period. Their result was that people had to consider deeply before making decisions and many buyers decided to use online shopping methods [9].

Gupta and Kala discussed the impact of the Covid-19 pandemic on purchase and usage patterns of cosmetics among women of India. In India and most countries, cosmetics are starting to become a more and more important part of our life, and most women enjoy using them a lot. However, when the pandemic came upon it impacted the practice of working as well as the behaviors of consumers. Due to variables such as lower-

income, low availability of goods, many women in India decided to purchase cheaper products online, while many people decided to not purchase anything at all due to all kinds of concerns. The revenue of several firms was reduced by over 30 percent[10].

Fudenberg and Tirole offered a formal definition of the Bayesian equilibrium. In a perfect Bayesian equilibrium, the strategies in the equilibrium for the game are given specific beliefs. The beliefs are updated from period to period in accordance. Cohesiveness is restored by recurring that (b) applies to the relative probabilities of types with posterior probability zero. This equilibrium can be applied in many games that are slightly complicated and sometimes require basic mathematical skills[11].

Hu and Stuart Jr. Gave gave an analysis of the Harsanyi Transformation. The economist Harsanyi gave a method for transforming uncertainty over the strategy set of players into uncertainty over their payoffs. The assumptions of this transformation include that all players are rational. The paper shows how, with the belief system model of Aumann, implications can be maintained in the absence of a common belief of rationality. This way of transformation is very useful for games with strategy-set uncertainty [12].

1.3. Objective

This paper will discuss the game theory and its application in international trade between suppliers and retailers from different fields in the cosmetics industry. A typical game was formulated to demonstrate the interactions between players that are similar to those between the supplier and retailer. The cosmetics market is a market in which the demand almost always exceeds the supply, especially during the pandemic. The constructed game happens under the spread of the Covid-19. Observing the situation from an Economists' point of view, a game can be formulated with calculations. This study will be divided into the following four parts: introduction, analysis of the relevant theoretical basis, dynamic game analysis of incomplete information, conclusions, and prospects.

2. BASIC THEORY

2.1. Game theory

Game theory in the form known to economists, social scientists, and biologists, was given its first general mathematical formulation by Neuman and Morgenstern [13]. It was called by most people: The study of the strategic interactions between rational players. In brief, a complete game consists of the following elements: players, set of actions or strategies, sequence of actions, payoffs, and information. Participants are also called decision-making subjects, which can be individuals, organizations, and countries, but people who have nothing to do with the game cannot be called decision-making subjects, such as two people playing chess are decision-making subjects, while the spectators are not decision-making subjects.

Because of the different elements, games can be divided into many types: games can be divided into single-player games and multi-player games according to the number of participants, static games, dynamic games, and repeated games according to the order of actions, complete information games and incomplete information games according to information classification, zero-sum games, and constant-sum games. Due to the behavior, it can be divided into the finite game and infinite game, and according to the collective rationality of individual rationality, it can be divided into the cooperative game and non-cooperative game. The above game classifications are all overlapping, and there is no strict hierarchical relationship. According to the overlapping classification, they can be divided into complete information static game, complete and perfect information dynamic game, complete but imperfect information dynamic game, incomplete information dynamic game, and so on. This paper intends to use an incomplete information dynamic game to analyze the behavior of suppliers and retailers. The following is the explanation of the incomplete information dynamic game. Different concepts, as well as examples, would be used to explicate the idea of a dynamic game with incomplete information. More detailed information will be explained in the other chapters of this paper.

2.2. Dynamic game of incomplete information

The dynamic game of incomplete information is one of the four categories of game theory. A Dynamic game means that the actions are in order. This means, one of the players takes action before the other players and may have some type of advantage. Under the condition of incomplete information, the decision-maker knows which types the opponent has and the probability of each type, that is, he knows the relationship between the different types of participants and the corresponding choices, but he does not know which type the other participants belong to. Because of the sequence of actions, the latter actor can observe the behavior of the former actor and obtain the information of the former actor, to confirm or revise his actions against the former.

At the beginning of a dynamic game with incomplete information, a player establishes his or her preliminary judgment according to the different types of other players and the probability distribution of their types. When the game starts, the player can revise his initial judgment according to the actual actions of the other players he observes, and one chooses their strategy based on this changing judgment.

2.3. Harsanyi Transformation

The Harsanyi Transformation is always something to be discussed when we talk of game theory [14]. In 1967, Harsanyi put forward an idea of transforming the static game of incomplete information into the dynamic game of complete but imperfect information, which is called "Harsanyi transformation". The dynamic game of incomplete information can also be transformed into the dynamic game of imperfect information by Harsanyi transformation. The specific methods are as follows: one is to introduce a virtual "natural" player, also known as "player 0", whose function is to select each actual player in a random way or to extract their respective types, before the selection of the actual players in the game, and these extracted types constitute the type vector t = (t1,……,tn), ti Ti, i= 1,……,n. The second is that this "natural" player lets each actual player know his type, but does not let (all or part of) the players know the types of the other players. The third is to carry out the original dynamic game based on the above, that is, each player chooses the action plan a1,……, and from their own behavior space according to their order.

3. THE MODEL OF THE GAME

3.1. Assumptions

To solve this problem and find the equilibrium in a dynamic game of incomplete information between these two players was designed, which is a type of signaling game as well. One basic view we introduce in the first part should be explained more in our setup of Nature. As we mentioned above, the coronal virus would harm the cosmetics' quality. First and foremost, governments in different regions all published several announcements which forced plenty of factories to close business. "Rayonier Advanced Materials, a leading new Materials company in the industry, would suspend operations during the pandemic. Non-essential production activities, including at seven plants in Canada, will be suspended or reduced as appropriate in response to the impact of the outbreak."[15]).

Nevertheless, citizens' demand for cosmetics never goes down during the period, since cosmetics are still essential in people's daily lives) which results in a significant shortage. Cosmetics are used up quickly and are easily damaged, which means the replacement and demand for cosmetics are always large. During the pandemic, the quotas of raw materials to process decrease seriously. Besides, in the situation that some cities tend to be in lock-down, most exporting companies are not certain of their deliveries, particularly some companies that enjoyed international cooperation before. Thus, there is a Nature N who takes action before the supplier. N can go up or down in the game tree and decide the quality of cosmetics that the suppliers are going to sell to the retailers. In addition, there is a possibility p for N to choose high-quality goods and a possibility of 1-p for N to choose low-quality goods.

Table 1. Assumptions of the game

Assumption	Content
1	Assuming that supplier could always know the type of products but the retailer cannot receive the complete information, which means the retailer could only predict the quality of goods through the supplier's decisions. The supplier could choose between collaborating and not collaborating.
2	The retailers are always willing to collaborate with the supplier and keep their relationship of being business partners. This means, if the supplier chooses to work with them, the retailer would not say no(the game continues)
3	High-quality products bring the retailer higher payoff and low-quality products bring lower payoff.
4	Suppliers always pay the collaboration cost and the extra cost if they provide L since their reputation is destroyed.
5	All players are rational and wish to make the much profit as possible.
6	None of the players can know the exact effect of the pandemic on their products.

3.2. Symbols

Since this is a game of strategic interactions, using symbols allows us to look at the game more clearly and directly. All the symbols can be found in Table 2.

Table 2. Symbols

Item	Symbol
Nature	N
High-quality goods	H
The payoff of high-quality goods	K(H)
The payoff of low-quality goods	K(L)
Low-quality goods	L
Supplier	Player A
Retailer	Player B
Traditional way	W
Innovative way	Y
Collaborate	S
Not Collaborate	F
Profit of selling H	K_H-C /-C
The payoff of selling L	K_L-C-r/-C-r
Cost	C
Extra cost	r
The money received by B when chooses Y	K
The money received by B when chooses W	Ko

3.3. Players and possible decisions

High-quality products bring the retailer higher payoff and low-quality products bring lower payoff, which would be certain in real situations. High-quality cosmetics bring the consumers pleasure while low-quality products may result in ailments or other negative effects.

Taking the change of selling models during the pandemic into our consideration, we set two actions for the retailer to take. "The Covid-19 pandemic has dramatically changed consumer purchase behavior, and the "stay-at-home order" policy has altered the operations of brick-and-mortar (B&M) retail stores. These changes have induced local B&M retailers to start online retailing with home delivery as an added option." [16]. Like the quote mentioned above, plenty of retailers prefer to have trades online or deliver them. The retailer chooses to either sell products traditionally or sell innovatively. Recently, browsing and purchasing goods on social media has become a common phenomenon. In our game, the retailer could decide to promote and sell on some shopping websites (such as Taobao or Amazon) which would bring payoff of K if the quality of products is excellent, or bring payoff of K ($0 \leq \leq 1$) due to some risks if the quality of products does not meet the standard. This is because their customers maybe not satisfied with the commodities and the after-sale problem requires time and cost to solve. The loss of satisfaction among consumers may also result in a bad reputation that is not easy to solve.

Suppliers always pay the collaboration cost and the extra cost (regarded as r) if they provide L since their reputation is destroyed. The profit of selling H is K(H)-C. By selling L type, suppliers could get the payoff of KL-C-r (all through innovative way Y to sell). Profit for selling L is -C-r (with the possibility 1-p, traditional way-W) then the retailer can avoid the welfare loss of K.

In conclusion, Player A goes first and chooses to collaborate or not due to whatever nature brings them. Player B goes next and chooses between innovative ways of selling and traditional ways of selling (considering the effect of the coronavirus). Different decisions can bring up different payoffs for the player.

4. DISCUSSION AND ANALYSIS

4.1. Perfect Bayesian Equilibrium analysis

Based on the above assumptions, the graph in Figure 1 can be made. In the first stage of the game, natural N acts first and chooses the types of high-quality products (H) and low-quality products (L), which are the private information of suppliers and unknown to retailers. In the second stage of the game, whether A chooses to cooperate with B at different levels depends on the expected benefits brought to A by the cooperation. For a high-quality product, the expected revenue of Y is:

$$E(t \mid H) = P(KHC)(1P)\,C = PKHC \quad (1)$$

In brief, the revenue from sales is supposed to be much greater than the cost of sales. In this case, $E(t \mid H) > 0$, which means the supplier wants high-quality product A to choose Y. Therefore, the probability $P(t \mid H)$ that a high-quality product chooses Y is 1.

For the low-quality products, the expected revenue of Y is:

$$E(t \mid L) = P(KLCr)(1P)(-Cr) = PKLCr \quad (2)$$

Generally, KL is greater than Cr, that is the cost of reputation loss is less than the revenue after innovative sales. Therefore, $E(t \mid L) > 0$, and low-quality products also hope to be sold through the Y channel, the probability is $P(t \mid L) = 1$.

In the third stage of the game, B gets the possibility distribution of A's H and L products in the market based

on relevant experience and big data, B needs to know the probability of H and L to make decisions. According to Bayes' Theorem, we can calculate the probability of H in the cooperation type as:

$$\text{Prob}(H \mid t) = P(H) \quad (3)$$

$$P(t \mid H) = P(t \mid L) = 1, P(H) \quad (4)$$

$$P(H \mid t) = P(H) \quad (5)$$

$$P(L \mid t) = P(L) \quad (6)$$

B cannot know exactly the type of A, and its choice of Y mainly depends on expected income. We can calculate B's expected income as follows:

$$E(B \mid t) = P(H)\,K = P(H)\,K = P(H) \quad (7)$$

Only when the expected return of B is not less than the return Kf without risk, B will choose Y, that is:

$$P(H) \times (1-\alpha)K + \alpha K \geq K_f \quad (8)$$

$$P(H) \geq \frac{Kf-\alpha K}{(1-\alpha)K} = Q \quad (9)$$

When P (H) is greater than or equal to Q, pooling equilibrium occurs in the game, all A will cooperate, and B will select Y with probability Q. At this time, although B's expected income meets the profit requirement, it may still choose L and suffer losses, thus failing to meet the principle of utility maximization.

While we suffer from the pandemic, the number of goods on the market decreases like a rocket, supply falls, the quality of goods in the market fluctuates dramatically, high-quality products in demand and scarce, and the distribution probability P (H) is reduced so that the P (H) is greater than or equal to Q, B will not choose a high-quality product for the sake of risk in a multi-channel mode for sale, therefore the utility of B can't be maximized.

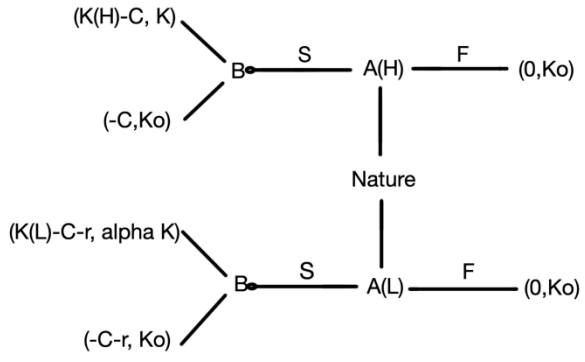

Figure 1 The illustration

4.2. Nash Equilibrium Analysis

The definition of a Nash equilibrium would be a position in which there is no unilateral profitable deviation for any one of the players[17]. At first sight, we may feel as if the action profile F strictly dominates S, but actually, it's not usually the case. -C is a negative number that is less than zero.

The Nash equilibrium of this game can happen on High Quality (0, Ko) only when C is larger than K (H) and K is larger than Ko. That is because only when these conditions are met, there would be no unilateral profitable deviation for any of the players. The Nash equilibrium can also occur on Low quality (0, Ko) when C+r is larger than K(L) and alpha K is smaller than Ko.

It can also occur at (K(H)-C, K) conditioned on C is smaller than K(H) and K is larger than Ko. The action of (K(L)-C-r, alpha K) can only be a nash equilibrium when C+r is smaller than K(L) and alpha K is larger than Ko.

The other options can never be a Nash equilibrium since C and r cannot be negative numbers. Therefore, the actions listed above are the only options where a Nash equilibrium can occur.

4.3. Problems of The Game

Some games include errors even if enough effort was placed into the work. This game's situation is similar: there are still minor problems that may cause inefficiency in the game. The above analysis can reflect the problems in the game process between supplier and retailer under the epidemic situation: in the case of asymmetric information, retailers can cooperate with suppliers for low-quality products. Retailers cannot determine the probability distribution of high and low-quality suppliers, and may still choose low-quality products with their expected revenue as the goal. If retailers choose low-quality products, they will bear huge public opinion risks and economic risks, which will harm the long-term development of enterprises. These problems are quite realistic and might cause the inefficiency of scales in our future studies. Additionally, the main focus on the cosmetics industry still requires extra focus and analysis, and that's what the paper lacks.

5. CONCLUSION

For the different opportunistic behaviors of the supplier before and after cooperation, this paper analyzes the risks in the process of cooperation between suppliers and retailers. According to the existence of information asymmetry, suppliers may adopt various opportunistic behaviors, which make retailer faces great cooperation risks. Due to the behavior characteristics of suppliers in this stage and the Bayesian equilibrium solution of the dynamic game model with incomplete

information, the market retail regulatory agencies should strengthen control and audit to improve the ability of retailers to identify low-quality products and unqualified suppliers and improve the construction of credit system in the supply chain after the epidemic. In this way, the supplier's low-quality products will not be profitable, and the cooperation risk of retailers in the process of building new retail sales channels will be greatly reduced.

In addition, the incentive mechanism is adopted. According to the results of incomplete information dynamic game analysis, retailers cannot rule out the possibility of selling low-quality products. To protect their interests, they can decide the next cooperation mode and sales mode according to the income brought by the goods and give suppliers rebates, which can usually stimulate the level of suppliers 'efforts and provide higher quality products to bring more benefits to enterprises.

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