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Evolutionary Game Analysis of Online and Offline Drug Retailer Competition Based on Network Externalities

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ABSTRACT Network externality is an important feature of the era of network economy. The competition between online and offline retail pharmacies caused by network externality is getting fiercer and fiercer. In this context, we studied the long-term market competition evolution of two-channel retail pharmacies under the network external environment, in order to obtain higher profits, two-channel retail pharmacies prefer to choose profit maximization marketing strategy or market share maximization marketing strategy. Using evolutionary game theory, an evolutionary game model of two-channel retail pharmacies was established. Through the establishment of the model, obtain the payment matrix of different marketing strategies selected by the two-channel retail pharmacies and the evolution and stability of the selection of marketing strategies. The results show that when the strength of the network externality is within a certain range, the traditional retail pharmacies with higher marketing cost choose to pursue the profit maximization strategy, while online pharmacy with lower marketing costs choose market share maximization strategy to achieve greater profits; when the network externality is large, in order to maintain a certain market share in the long-term market evolution, the traditional retail pharmacy with high marketing cost chooses to pursue the market share maximization marketing strategy in order to obtain greater profits, while the online pharmacy with low marketing cost chooses to profit from the profit maximization marketing strategy.

INDEX TERMS Network externality, profit maximization, market share maximization, evolutionary stability strategy.

I. INTRODUCTION

The development of information technology has promoted the development of the global economy. The network economy has become a new economic form, and the phenomenon of network externalities has aroused widespread concern. When the value of a product to a user increases as the number of users using the same product increases, this phenomenon is called network externality. In the era of network economy, network externality is an important factor that affects retailers' choice of marketing strategies to maximize profits. Profit maximization and market share maximization are two kinds of marketing strategies commonly chosen by retailers. In general, profit maximization marketing strategy is most common in enterprises. However, some studies have found that retailers with stronger competitors have difficulty obtaining the highest profit through profit maximization marketing strategy (Xiao and Yu,2006; Schaffer,1988; Xiao and Yu,2006), mainly because maximize market share is more flexible than profit maximization, regardless of marketing costs.

With the advent of the era of network economy, the marketing model in various fields has undergone tremendous changes, which makes the traditional retail industry pattern change dramatically, especially in the field of medicine studied in this paper, the traditional pharmacy sales channels, which have been highly sought after, are facing the challenge of new channels because of product differentiation and the introduction of relevant national policies. In September 2005, China Food and Drug Administration issued '*Provisional*

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Regulation on the Approval of Internet Drug Business', which indicates that enterprises with corresponding qualifications can provide drug trading services for drug manufacturers, drug dealers, medical institutions and individuals on the Internet. The regulation is the first official introduction of drug network sales in China. It marks that the attitude of the China Food and Drug Administration towards Internet drug business activities has changed from a comprehensive prohibition to a moderate liberalization.

Drug marketing channel is a bridge between pharmaceutical production enterprises and consumers, without perfect and efficient marketing channels and service network, it is difficult to realize the effective sale of drugs, and even more difficult to cope with the complex and changeable pharmaceutical market environment and increasingly fierce market competition. Network marketing channel has the advantages of large choice space, convenience of shopping and simplification of intermediate links, which makes more and more retailers focus on online channel. While online channel attracts consumers, it naturally squeezes offline channel, and channel conflicts become increasingly fierce.In the fierce competition, online and offline channels restrict and suppress each other in order to achieve sales goals, and the benefits of online and offline channels will decline. Compared to offline channels, the advantage of online channels is that the input cost is lower than the offline channel, therefore, in this competition, offline channels are always at a disadvantage. However, the online channel, which seems to have absolute advantages, can not completely replace the offline channel, can not provide more services to consumers, and consumer demand can not be met. In the long run, retailers are bound to lose consumers and even fail on their business channels, while the relationship between online and offline will only continue to consume resources and the interests of consumers, neither for retailers nor consumers. In the current competitive market environment, retail pharmacies want to occupy a place in the market, not only to tap consumers and meet their needs, but also to choose the right marketing strategy to adapt to the changing market environment. Therefore, under the market environment of network externalities, it is a research topic with wide application value to study what marketing strategies the online and offline retail pharmacies adopt to obtain the best profits.

Since Rohlfs (1974) found the phenomenon of network externality in the study of services, some economists such as Katz and Shapiro (1985), Farrell and Saloner (1985), Liebowitz and Stephen (1995) and other economists have raised the network externality to the discussion of economic theory. Many scholars have begun to study the impact of network externality on demand and market. However, the existing literatures show that there are few studies on retailers'marketing strategies based on network externalities. The existing literatures mainly study the influence of network externalities on enterprise pricing decisions, profits and other aspects, but seldom studies the influence of network externalities on retailers' marketing strategies. Most of the existing literatures use evolutionary game theory to study whether two-channel retailers prefer to profit maximization or market share maximization to maximize profits in long-term market competition (Kaneda and Matsui, 2003; Xiao and Chen, 2009). As evolutionary game theory can overcome the difficulties of neoclassical economics and classical game theory in rational hypothesis and multiple equilibrium, and provides a new analytical method for economic research, it is widely used in the research of business decision-making, such as the market competition and decision-making of oligopoly enterprises (Hansen and Samuelson (1988); Tanaka (2000)). However, none of these studies considered the externalities of the network, and the studies on the choice of pharmaceutical retailers' marketing decisions under the network externality environment have not been found. Therefore, this paper uses evolutionary game theory to study the impact of network externalities on the choice of marketing strategies for two-channel retail pharmacies.

Unlike other areas of e-commerce, Chinese drug regulatory agencies have been adopting a cautious attitude towards the establishment of online pharmacies, setting high standards in qualification certification, severely restricting the types of drug sales, and supervising online pharmacies to provide consumers with a variety of safe and effective medicines. Drugs are different from ordinary goods, in general, after the production of drug, it has to go through pharmaceutical companies, hospitals or pharmacies, and finally to the hands of patients. Every link from production to circulation needs to be related to the government or hospitals and other departments, or the need for administrative approval, or the need to market doctors.It takes a lot of money to clear these joints, and every link must be raised substantially. Behind the price increase is a high amount of hidden costs. Compared to the high drug prices of traditional retail pharmacies, online pharmacies use the Internet to break down information barriers, making it easier for consumers to buy the drugs they want, especially those in short supply. At the same time, as online channels greatly reduce circulation and reduce medical costs, retailers are able to reduce their prices while maintaining their own profits, making it easier for consumers to buy low-cost drugs.According to statistics, in the first half of 2018, all online pharmacies in China that obtained Internet drug trading service licenses had sales of 5 billion yuan, a year-on-year increase of 42.5%. The establishment of the online drug sales model not only effectively promotes the development of the entire medical industry, but also greatly improves the efficiency of the use of medical resources, and at the same time promotes the smooth implementation of China's medical reform. In this context, the pharmaceutical industry is deeply integrated with e-commerce. Traditional retail pharmacies face severe challenges of low growth rate and negative corporate profits. How to maintain the online and offline retail pharmacies in the fierce market competition is worthy of further study.

Therefore, under the circumstance of network externality, this paper establishes payment matrix of marketing strategy combination of two-channel retail pharmacies by using evolutionary game theory, and probes into the selection of marketing strategy of two-channel retail pharmacies under network externality and the evolutionary stable strategy under different network externality intensities. The system is a dual-channel supply chain system consisting of a manufacturer and two retail pharmacies. The following issues are mainly discussed: the evolutionary stability conditions of the equilibrium of profit maximization and market share maximization marketing strategies; the influence of network externalities on the evolutionary stability strategies of retail pharmacies.

The rest of this paper is organized as follows. Section 2 reviews relevant research. Section 3 describes the evolutionary game model of two-channel retail pharmacies. Section 4 describes the evolutionary stability strategy of retail pharmacies under different conditions. Finally, the conclusions of this paper with respect to its original contributions and suggested future work are discussed.

II. LITERATURE REVIEW

The concept of network externality was first proposed by Rohlfs (1974), who pointed out that network externality is the source of demand-side scale economy. Subsequently, Katz and Shapiro(1985) provided a more formal definition of network externalities, which refers to the change in the utility of each user from consuming the same product or service as the number of users of the same product or service changes. At first, network externalities were mainly applied to the study of some tangible networks, such as transportation, telecommunications (David,1988; Oren and Smith,1981), etc. However, with the advent of the era of network economy, many other Internet market products and services have shown significant network externalities. When there is network externality in the market, its utility will increase the profit level of retailers, and will also have a certain impact on the competitive behavior of enterprises in the industry, and play an important role in the choice of marketing decisions by enterprises (Li et al.,2018; Conner,1995). Therefore, more and more scholars pay attention to how enterprises get the best profit and gain competitive advantage from the market with network externality. The research shows that the use of network externalities through compatibility strategy enables enterprises to gain more market share (Katz and Shapiro,1985); under the network externality, enterprises can attract more consumers and make more profits through pricing strategy (Cabral and Salant,1999; Cabral,2011; Jullien,2001), and the influence of consumers' demand for products or services and the transfer of market share (Mitchell,2006; Janssen and Mendys, 2007). Yi and Yang (2017) believes that in a market environment of network externalities, retailers must consider changes in market demand caused by network externalities and make corresponding decisions about these changes, such as decisions to adjust prices and order quantities, and ways to maximize profits or market share maximization in order to achieve profits.

Enterprise profit maximization behavior is the most basic hypothesis in economics, but in practice it is not always the profit maximization strategy to make the enterprise get the maximum profit. Since the 1870s, the pursuit of market share has become a focus of marketing strategy. Many economic experts agree that maximizing market share is another way to maximize profits. In real life, maximizing market share may prevail in different markets, such as tourism (Shu et al., 2008), aviation (Danica et al., 2014) etc., but there is less literature to study the field of medicine. Scholars such as Tsao and Campbell (2010); Cassandra and Rice (2015) gain optimal profits by building models and developing strategies to maximize their market share. Nakamura (2015) studied the endogenous choice of price or quantity contracts for mixed duopoly enterprises consisting of a public enterprise with maximum social welfare and a private enterprise with maximum relative benefits. Weian Li, etc. (2017), studies the maximization of competitive profits in social networks by making Profit Maximization Agent (PM-A) game and Profit Maximization Social (PM-S) game model. In the existing literature on the marketing strategy of enterprises, most scholars use evolutionary game theory to analyze what marketing strategies can achieve greater profits. For example, Xiao and Chen(2009) through the establishment of a supply chain single population evolutionary game model with one manufacturer/supplier and multiple retailers, to study how retailers' marketing goals depend on wholesale prices, their observable, and the probability of error; Xiao and Yu(2006) used the evolutionary game method to explain why there is market share maximization behavior, and think that the market share maximization strategy may be a stabilization strategy, and profit maximization strategy may be unstable in the case of the number of unstable goods set duopoly. Their study found that when the wholesale price is high enough (low), the profit (revenue) maximization behavior is an evolutionarily stable marketing strategy.

At the appropriate wholesale price, the profit maximization behavior and the market share maximization behavior in the retailer group coexist; Xiao and Yu (2006) build an indirect evolutionary game model with two vertical integration channels to study and compare the profits of each channel in different markets by using two marketing strategies, profit maximization and profit maximization.Yi and Yang studied the strategy choice of retailers' marketing objectives and the influence mechanism of wholesale pricing in the market of network externalities, and established the evolutionary game model and the best strategy of a single retailer group.However, they only consider the entire market, and the situation in each industry is different.As can be seen from the above studies, the existing literature has not discussed the choice of online and offline retail pharmacy marketing strategy under the network externality environment.Under the background of frequent drug policies, deep adjustment of industry structure and rapid development of China's pharmaceutical e-commerce industry, there is a huge space for online pharmacies to develop. It is very important to study the pharmaceutical e-commerce industry for the long-term development of online and offline retail pharmacies.

Different from the existing literature, this paper, based on the background of pharmaceutical e-commerce industry, considering the impact of online and offline retail pharmacies under the influence of network externality, online and offline retail pharmacies should adopt what effective marketing strategy, in order to seize new opportunities and adapt to new challenges. Therefore, on the basis of the existing research, the idea and method of evolutionary game theory are applied to construct the evolutionary game model of marketing target selection of retail pharmacy, and the choice of channel marketing strategy is regarded as a progressive evolution system of learning, which dynamically deduces the game process of marketing strategy selection under the coexistence of two-channel retail pharmacies on line and online. And pay attention to the study of the network externality that affects the choice of channel marketing strategy, analyze how the network externality will affect the choice of retail pharmacy marketing strategy, and choose which marketing strategy can make the retail pharmacy in the long-term market competition to obtain greater profits, in order to make a marketing strategy choice for two-channel retail pharmacies in the fierce competition, and provide theoretical reference for them to obtain long-term market advantage.

III. MODEL DESCRIPTION and ESTABLISHMENT

This paper considers an online and offline two-channel supply chain consisting of a manufacturer, a traditional retail pharmacy and an online pharmacy. Assume that there are only two retail pharmacies in the entire market, and there is no cooperative behavior between them, but they know each other's actions and determine their own decisions to maximize profits. The manufacturer produces homogeneous medicines and sells them at the same wholesale price ω to traditional retail pharmacies and online pharmacies. Considering the different way of online and offline sales methods, assuming that the sales cost of traditional retail pharmacy is c_1, the sales cost of online pharmacy is c_2. Since the traditional retail pharmacy sales cost includes personnel salary, house rent, utility bill, etc., it is assumed that $c_2 < c_1 < 2c_2$ is used to indicate that there is a difference in the cost of sales between the two-channel.

Assuming that each retail pharmacy has two marketing strategies to choose from-profit maximization (P strategy) and market share maximization (R strategy), so there are 4 strategic combinations between the two-channel retailers, namely PP, PR, RP, and RR strategies.

According to the connotation of network externality defined by Katz etc. (1985), and referring to the modeling ideas about network externality, such as Luis and Cabral (1999), Ernan and Ashutosh (2001) etc., the demand function of two-channel retail pharmacy can be expressed as

$$q_1 = a - p_1 + p_2 + \mu\theta_1$$
$$q_2 = a - p_2 + p_1 + \mu\theta_2$$

where a is the market reserve price, $a > c_1$; p_1 denotes retail prices of traditional retail pharmacies; p_2 denotes the retail price of online pharmacies; $\mu\theta$ denotes the effect of network externality on the retail price of two-channel retail pharmacies, where μ measures the coefficient of network externalities ($0< \mu <1$), and $\theta(\theta >0)$ indicates the extent to which network externalities affect the retail price of each unit of drug, so the demand function of the two-channel retail pharmacies are as follows

$$q_1 = a - p_1 + p_2$$
$$q_2 = a - p_2 + p_1$$

Therefore, in the market with network externalities, the profit function and income function of two-channel retail pharmacies as follows

$$\Pi_i\left(p_{i,}q_i\right) = \left(p_i - \omega - c_i + \mu\theta\right) q_i \tag{1}$$
$$R_i\left(p_i, q_i\right) = \left(p_i - \omega + \mu\theta\right) q_i \tag{2}$$

Hypothesis 1: Both retail pharmacies choose P strategy. According to formula (1), the retail price of the two retail pharmacies under PP strategy combination should meet the first-order conditions

$$a - 2p_1 + p_2 + \omega - \mu\theta + c_1 = 0$$
$$a - 2q_2 + q_1 + \omega - \mu\theta + c_2 = 0$$

as a result, the retail prices of two-channel of retailers can be obtained as follows

$$p_1^{pp} = a + \omega - \mu\theta + \left(2c_1 + c_2\right)/3$$
$$p_2^{pp} = a + \omega - \mu\theta + \left(2c_2 + c_1\right)/3$$

The intersection of the two response functions is the Nash equilibrium of price, and the corresponding equilibrium profit of two-channel retail pharmacies is as follows

$$\Pi_1^{PP} = \left[a - \mu\theta - \left(c_1 - c_2\right)/3\right]^2$$
$$\Pi_2^{pp} = \left[a - \mu\theta + \left(c_1 - c_2\right)/3\right]^2$$

Hypothesis 2: Traditional retail pharmacies choose P strategy and online pharmacies choose R strategy, similar to the solution of strategy combination PP, by the same time the retail price and the equilibrium profit of the two-channel retail pharmacies are as follows

$$p_1^{PR} = a + \omega - \mu\theta + 2c_1/3$$
$$p_2^{PR} = a + \omega - \mu\theta + c1/3$$
$$\Pi_1^{PR} = \left[a - \mu\theta - c_1/3\right]^2$$
$$\Pi_2^{PR} = \left[a - \mu\theta + c_1/3\right]^2$$

Hypothesis 3: Traditional retail pharmacies choose R strategy and online pharmacies choose P strategy. Similarly, the retail price and balanced profit of the two retail pharmacies are as follows

$$p_1^{RP} = a + \omega - \mu\theta + c_2/3$$
$$p_2^{RP} = a + \omega - \mu\theta + 2c_2/3$$
$$\Pi_1^{RP} = \left[a - \mu\theta + c_2/3\right]^2$$
$$\Pi_2^{RP} = \left[a - \mu\theta - C_2/3\right]^2$$

TABLE 1. Game payment matrix for marketing strategy of two-channel retail pharmacies.

Traditional retail pharmacy	Online pharmacy	
	P strategy	R strategy
P strategy	Π_1 PP, Π_2 PP	Π_1 PR, Π_2 PR
R strategy	Π_1 RP, Π_2 RP	Π_1 RR ,Π_2 RR

Hypothesis 4: Traditional retail pharmacies choose R strategy, while online pharmacies choose R strategy. Similarly, the retail price and balanced profit of two retail pharmacies are as follows

$$p_1^{RR} = p_2^{RR} = a + \omega - \mu\theta$$
$$\Pi_1^{RR} = \Pi_2^{RR} = (a - \mu\theta)^2$$

According to the above hypothesis, the game payment matrix of two-channel retail pharmacies marketing strategy can be constructed, as shown in table 1.

From the above equilibrium solution, it can be seen that the retail price and profit of retail pharmacies under the combination of four strategies are all increasing functions of the intensity of network externality μ. In addition, the profit of retail pharmacies follows the following relationships: $\Pi^{PP} > \Pi >^{PR} > \Pi^{RP} > \Pi^{RR}$. This suggests that retail pharmacies that use P strategy to sell drugs get more profit than retail pharmacies that adopt R strategy.

IV. EVOLUTION GAME ANALYSIS OF MARKETING STRATEGY OF RETAIL PHARMACY

Due to the limited rationality and mutual influence of the two-channel of retail pharmacies, the strategy selected at the beginning is not necessarily optimal, but the two-channel of retail pharmacies continue to select and learn over time, and finally determine the optimal and most stable balance strategy. Therefore, this paper will use the replication dynamic mechanism of simulated biological evolution to analyze the evolution game process of retail pharmacy marketing strategy.

A. EVOLUTIONARY EQUILIBRIUM POINT

Assuming that the proportion of the traditional retail pharmacy choosing P Strategy is s_1, the proportion of the R strategy is 1-s_1, and the proportion of the P strategy selected by the online pharmacy is s_2, and the proportion of the R strategy is 1-s_2. From the marketing strategy payment matrix, the expected benefits F_1^P of the traditional retail pharmacy P strategy is calculated. The expected benefits F_1^R and average benefits F_1 of R strategy as follows

$$F_1^P = s_2\Pi_1^{PP} + (1 - s_2)\,\Pi_1^{PR}$$
$$F_1^R = s_2\Pi_1^{RP} + (1 - s_2)\,\Pi_1^{RR}$$
$$F_1 = s_1F_1^P + (1 - s_1)\,F_1R = s_1s_2\Pi_1^{PP} + s_1\,(1 - s_2)\,\Pi_1^{PR} + (1 - S1)\, s_2\Pi_1^{RP} + (1 - s_1)\,(1 - s_2)\,\Pi_1^{RR}$$

Similarly, for online pharmacy, the benefits of P strategy is F_2^P, and the average benefits of R strategy is F_2^R, and the average benefits F_2 are as follows

$$F_2^P = s_1\Pi_2^{pp} + (1 - s_1)\,\Pi_2^{Rp}$$
$$F_2^R = s_1\Pi_2^{PR} + (1 - s_1)\,\Pi_2^{RR}$$
$$F_2 = s_2F_2^P + (1 - s_2)\,F_2^R = s_2s_1\Pi_2^{pp} + s_2\,(1 - s_1)\,\Pi_2^{RP} + (1 - s_2)\, s_1\Pi_2^{PR} + (1 - s_2)\,(1 - s_1)\,\Pi_2^{RR}$$

According to the replication dynamic equation, it is assumed that the traditional retail pharmacy adopts the growth rate of the overall proportion of P strategy to $\dot{s}_1/s_1$, then the Malthusian equation is

$$\dot{s}_1 = s_1s_2\,(1 - s_1)\,\Pi_1^{pp} + s_1\,(1 - s_1)\,(1 - s_2)\,\Pi_1^{PR} - s_1\,(1 - s_1)\,(1 - s_2)\,\Pi_1^{RR} - s_{1s2}\,(1 - s_1)\,\Pi_1^{RP} \quad (3)$$

Similarly, the growth rate of online pharmacies adopting P strategy is $\dot{S}_2/S_2$, while the Malthusian equation is

$$\dot{s}_2 = s_2s_1\,(1 - s_2)\,\Pi_2^{PP} + s_2\,(1 - s_2)\,(1 - s_1)\,\Pi_2^{RP} - s_2s_1\,(1 - s_2)\,\Pi_2^{PR}s_2\,(1 - s_2)\,(1 - s_1)\,\Pi_2^{RR} \quad (4)$$

Formula (3), (4) is the replication power system of two-channel retail pharmacy.

When $\dot{s}_1 = 0$ and $\dot{s}_2 = 0$, the equilibrium points of different equilibrium states in the dynamic evolution game of a symmetric replication of the retail pharmacy are obtained as follows:$(s_1, s_2) = (0, 0)$, $(s_1, s_2) = (1, 0)$, $(s_1, s_2) = (0, 1)$ and $(s_1, s_2) = (1, 1)$.

According to the local stability analysis method of Jacobian matrix (Arno and Engelbert,1996) the progressive stability of the equilibrium point of the system (5) can be analyzed, and the evolutionary Stability Strategy (ESS) is obtained, and the Jacobian matrix of the system is (5), as shown at the bottom of the next page.

B. STABILITY ANALYSIS OF EQUILIBRIUM POINTS

According to the Jacobian matrix, the Matrix determinant Det(J)= $\frac{\partial \dot{s}_1}{\partial s_1}\frac{\partial \dot{s}_2}{\partial s_2} - \frac{\partial \dot{s}_1}{\partial s_2}\frac{\partial \dot{s}_2}{\partial s_1}$, the Matrix trace $Tr(\mathbf{J}) = (1 - 2\,s_1)\,(1 - s_2)\left(\Pi_1^{PR} - \Pi_1^{RR}\right) + s_2(1 - 2\,s_1)\left(\Pi_1^{RP} - \Pi_1^{RR}\right) + (1 - 2\,s_2)\,(1 - s_1)\left(\Pi_2^{RP} - \Pi_2^{RR}\right) + s_1\,(1 - 2\,s_2)\left(\Pi_2^{PP} - \Pi_2^{PR}\right)$ substituting the system equilibrium point values into the matrix determinant and trace expressions, the results are shown in Table 2.

TABLE 2. Expression of matrix determinant and trace corresponding to equilibrium points of system (5).

Equilibrium point	Det(J)	Tr(J)	Local stability
(0,0)	—	±	Saddle
(1,0)	+	—	ESS
(0,1)	+	+	Unstable
(1,1)	—	±	Saddle

TABLE 3. $\mu\theta < a - \frac{c_1}{6}$, **evolutionary stability results of system (5).**

Equilibrium point (s1,s2)	Matrix determinant Det(J) and Matrix trace Tr(J)	
(0,0)	Det(J)	$(\Pi_1^{PR}-\Pi_1^{RR})(\Pi_2^{RP}-\Pi_2^{RR})$
	Tr(J)	$\Pi_1^{PR}-\Pi_1^{RR}+\Pi_2^{RP}-\Pi_2^{RR}$
(1,0)	Det(J)	$(\Pi_1^{RR}-\Pi_1^{PR})(\Pi_2^{PP}-\Pi_2^{PR})$
	Tr(J)	$\Pi_1^{RR}-\Pi_1^{PR}+\Pi_2^{PP}-\Pi_2^{PR}$
(0,1)	Det(J)	$(\Pi_1^{RP}-\Pi_1^{RR})(\Pi_2^{RR}-\Pi_2^{RP})$
	Tr(J)	$\Pi_1^{RP}-\Pi_1^{RR}+\Pi_2^{RR}-\Pi_2^{RP}$
(1,1)	Det(J)	$(\Pi_1^{RR}-\Pi_1^{RP})(\Pi_2^{PR}-\Pi_2^{PP})$
	Tr(J)	$\Pi_1^{RR}-\Pi_1^{RP}+\Pi_2^{PR}-\Pi_2^{PP}$

As can be seen above,

$$\Pi_1^{RR}-\Pi_1^{PR}=\frac{6(a-\mu\theta)c_1-c_1^2}{9},\ \Pi_1^{RP}-\Pi_1^{RR}=\frac{6(a-\mu\theta)c_1+c_1^2}{9},\ \Pi_2^{RP}-\Pi_2^{RR}=\frac{c_2^2-6(a-\mu\theta)c_2}{9},\ \Pi_2^{PR}-\Pi_2^{PP}=\frac{-c_2^2+2c_1c_2+6(a-\mu\theta)c_2}{9}$$

where $\hat{a}>0,\ 0<\mu<1,\ c_1,c_2>0$

In evolutionary game theory, the equilibrium point that satisfies Det (j) > 0 and Tr (j) <0 is the evolutionary stability point. The following is an analysis and discussion of the evolutionary stability strategies in different situations.

Case 1: when $\mu\Theta < a-\frac{c_1}{6}$ the evolutionary stability of the system (5) is shown in Table 3.

From the equilibrium point and stability analysis of the case 1 evolution model, it can be seen that when the network externality intensity μ is small and the network externality has little effect on the retail price ($\mu\theta$ <a-c_1/6), (1,0) is the ESS point, (0,0) and (1,1) are the Saddle points, (0,1) is the Unstable point. At this time, due to the small external strength of the network, the competition between online pharmacies and traditional retail pharmacies is not intense, and the impact on the retail price of pharmaceuticals is not high. Traditional retail pharmacies pay more attention to the profit of the products, and the units that ensure the products are obtained. In order to gain greater profits in the smaller network external market, online pharmacies with low marketing costs will choose to pursue market share maximization strategy to achieve higher profits in order to expand market share, so traditional retail pharmacies choose P strategy, online pharmacy selection R strategy is an evolutionary stability strategy. The evolution dynamics of the system are described by using the phase trajectory diagram, and the specific behavior evolution process is shown in Figure 1.

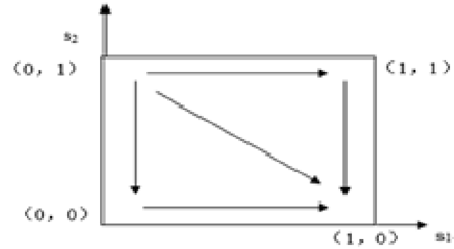

FIGURE 1. **Evolutio phase diagram of system (5) in case 1.**

TABLE 4. $a-\frac{c_1}{6} < \mu\theta < a+\frac{c_2+2c_1}{6}$, **evolutionary stability results of system (5).**

Equilibrium point	Det(J)	Tr(J)	Local stability
(0,0)	+	±	Saddle
(1,0)	+	—	ESS
(0,1)	+	+	Unstable
(1,1)	—	±	Saddle

Case 2: when $a-\frac{c_1}{6} < \mu\theta < a+\frac{c_2+2c_1}{6}$ the evolutionary stability of the system (5) is shown in Table 4.

From the equilibrium point and stability analysis of the case 2 evolution model, it can be seen that when the network externality phenomenon is gradually enhanced, the network externality intensity μ increases ($a-\frac{c_1}{6} < \mu\theta < a+\frac{c_2+2c_1}{6}$), (1,0) is the ESS point, (0,0) and (1,1) are Saddle points, and (0,1) is the Unstable point. At this point, the impact of network externalities on the retail price of the two-channel is within the scope of the two sides, and online pharmacies have little threat to traditional retail pharmacies. In order to attract consumers and expand their own market share, online pharmacies only by lowering prices, choose small profits and quick turnover of marketing strategies to obtain greater profits, and traditional retail pharmacies with high marketing costs will inevitably lose profits if they follow online pharmacies to reduce retail prices. Therefore, the traditional retail pharmacy continues to choose the P strategy, the online pharmacy selection R strategy is the evolutionary stability strategy. Similar to the previous, the evolution dynamics of the system are described by using the phase trajectory diagram, and the specific behavior evolution process is shown in Figure 2.

Case 3: when $\mu\theta > a-\frac{c_2-2c_1}{6}$ the evolutionary stability of the system (5) is shown in Table 5.

From the equilibrium point and stability analysis of the case 3 evolution model, it can be seen that when the network externality phenomenon is strong and the network externality

$$\begin{pmatrix} (1-2s_1)(1-s_2)(\prod_1^{PR}-\prod_1^{RR})+s_2(1-2s_1)(\prod_1^{PR}-\prod_1^{RR}) & s_1(1-s_1)(\prod_1^{PP}+\prod_1^{RR}-\prod_1^{PR}-\prod_1^{RP}) \\ s_2(1-s_2)(\prod_2^{PP}+\prod_2^{RR}-\prod_2^{PR}-\prod_2^{RP}) & (1-2s_2)(1-s_1)(\prod_2^{PR}-\prod_2^{RR})+s_1(1-2s_2)(\prod_2^{PR}-\prod_2^{RR}) \end{pmatrix} \quad (5)$$

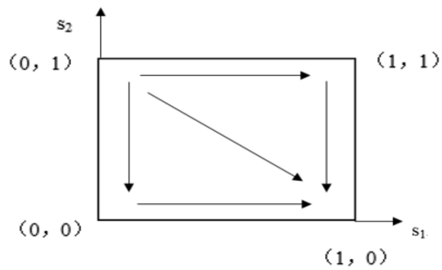

FIGURE 2. Evolution phase diagram of system (5) in case 2.

TABLE 5. $\mu\Theta > a - \frac{c_2 - 2c_1}{6}$, evolutionary stability results of system (5).

Equilibrium point	Det(J)	Tr(J)	Local stability
(0,0)	+	+	Unstable
(1,0)	—	±	Saddle
(0,1)	+	—	ESS
(1,1)	—	±	Saddle

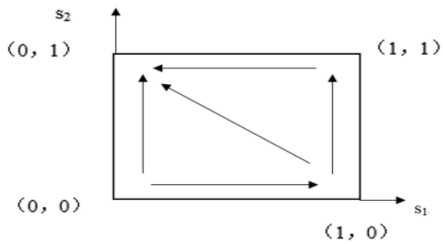

FIGURE 3. Evolution phase diagram of system (5) in case 3.

intensity μ is increased $\mu\theta > a - \frac{c_2 - 2c_1}{6}$ (0,1) is the ESS point, (1,0) and (1,1) are Saddle points, (0,0) is the Unstable point. At this point, as the network externalities have a greater impact on the retail pharmacies of the two-channel and the competitive relationship between the two sides is becoming increasingly fierce, online pharmacies have brought great threats to traditional retail pharmacies. In order to seize the market share, traditional retail pharmacies can only get more profits by lowering the retail price. In this case, online pharmacies with a certain market share of low marketing costs choose P strategy that can achieve higher profits. Therefore, in order to survive and grow in the long-term market evolution, the traditional retail pharmacy chooses the R strategy, and the online pharmacy chooses P strategy is the evolutionary stability strategy. The evolution dynamics of the system are described by using the phase trajectory diagram, and the specific behavior evolution process is shown in Figure 3.

The influence of network externality intensity on the market demand of two-channel retail pharmacy is directly related to the final equilibrium result of two-channel marketing strategy. In the early stage of the phenomenon of network externality, the influence of network externality on the retail price of two-channel retail pharmacies in a certain range, the competitive relationship between the two-channel retail pharmacies is not fierce, and the traditional retail pharmacy with high marketing cost will choose to pursue the profit maximization strategy in order to obtain more profits, and the lower marketing cost of online pharmacies in order to attract consumers, expand market share, will choose R strategy to obtain more profits, so at this time (Profit maximization, Market share maximization) is the evolutionary stable equilibrium point. As the phenomenon of network externality becomes more and more widespread, the influence of network externalities on market demand continues to increase. At this time, online and offline competition is intensifying, and online pharmacies have brought great influence on traditional retail pharmacies. If traditional retail pharmacies still choose to pursue profit maximization strategy, it may cause market share to shift. Therefore, only by reducing retail price can traditional retail pharmacies maintain their original profit and market share in the long-term market evolution competition. And low marketing costs of online pharmacies at this time prefer to choose a more profitable profit maximization strategy, so at this time (Market share maximization, Profit maximization) is the evolutionary stable equilibrium point.

V. CONCLUSION

In the real market, the competition of online and offline retail pharmacies on drug sales is getting fiercer and fiercer, which is not only limited to the competition of price and service, but also includes the competition of marketing strategies that directly affect the profits of retail pharmacies. Therefore, the choice of marketing strategy of retail pharmacy is particularly important for them to obtain more profits in the market competition. At the same time, the network externality caused by the network scale effect has an increasing influence on online and offline retail pharmacies. The strength of network externality will directly affect the choice of retail pharmacies marketing strategy and the profit obtained. Under the environment of network externalities, this paper constructs an asymmetric evolutionary game model of two-channel retail pharmacies, and studies the evolutionary stability of retail pharmacies' pursuit of profit maximization and market share maximization in the long-term market competition with network externalities. Profit maximization is only a marketing strategy, if the competitor's marketing strategy is not taken into account, it will inevitably lead to a decline in profits. The study shows that the ESS of two retail pharmacies is different under different network externalities. It is possible that the profit maximization is the ESS marketing strategy, or the market share maximization is the ESS marketing strategy. The main conclusions of this paper are as follows:

(1)In the two-channel supply chain where marketing costs are not equal, if the research ignores the impact of network externalities on the market demand of two-channel retail pharmacies and only consider their own profits in market competition, the two-channel retail pharmacies will suffer the consequences of losing both sides in the long-term market evolution.

(2)Traditional retail pharmacies with relatively small network externalities and high marketing costs choose to pursue profit maximization strategy, while online pharmacies with low marketing costs choose to pursue market share maximization strategy to obtain greater profits.

(3)When the externality of the network is strong, the externality of the network has a significant impact on the retail price of retail pharmacies. Online pharmacies have greatly affected traditional retail pharmacies, and the competition between the two-channel is fierce.

This paper considers the problem that two-channel retail pharmacies choose pure strategy without cooperation, and the future research can be further expanded, for example: 1) The influence of manufacturer's wholesale price on the marketing strategy choice of two-channel retail pharmacy can be considered; 2) consideration could be given to the impact of online and offline retail pharmacy cooperation on its profits;3) It is also possible to consider the problem of two-channel of retail pharmacy choosing a hybrid strategy according to their own preference for the two pure strategies.

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