OPPORTUNITIES OF PLATFORM NETWORK EFFECTS RESEARCH WITH ARTIFICIAL INTELLIGENCE MACHINE LEARNING ALGORITHMS -A PRELIMINARY MATH MODEL

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Abstract—The traditional network effect research is mainly based on the logic of mathematical formulas to explore the relationship between different factors and different price structure strategies. However, in the actual platform market, the platform companies are faced with complex relationships of many factors, and the traditional deductive logic is almost impossible to solve the practical problem. Therefore, this paper proposes a method based on artificial intelligence machine learning algorithms to integrate multiple variables to establish a more complete prediction model. In order to achieve this goal, this paper first derives several preliminary calculus formulas as the basis of the machine learning algorithms method.

Index Terms- Platform Business Model, Platform Network Effects, Machine Learning Algorithms.

I. INTRODUCTION

Internet technology is changing the way of value creating for customers, the competing rules of the industry, and the boundaries of competition. This transformation affects every industry and even affects the overall economic development[1]. Under this trend, everything in the future will operate a new business model with network technology, and derive the logic of new economic operations. Among them, platform companies are the most important new business model under the trend of network technology. They use network technology to link people, organizations and resources to form an interactive ecosystem that can create and exchange value [2-4].

This revolutionary platform spanning many industries and regions is constantly changing the lives of modern people and playing an important role in global business competition. In 2013, 60 of the world's 100 largest companies generated revenues from platform business models, including Google, Apple, Microsoft, Yahoo, City Bank, etc., which benefited from the platform business model and continued expanding revenue scale [3,5].

The platform is a dis-intermediate model that directly links the final ends between producers and consumers (E2E: end to end) and uses technology to create a positive feedback effect on the community feedback loop [2]. It is the use of group relationships to establish the possibility of infinitely increasing value, called "network effects". The theoretical literature predicts that network effects will have the result of "winner-take-all: WTA" [6-7].

In the past two decades, although the network effect has made many theoretical advances in economics and strategy, the network effect in the bilateral market is far more complicated than the network effect of the traditional unilateral market. Platform companies must address the famous "chicken & egg" problem and be careful to "get both sides on board simultaneous" to allow users in both markets to gradually grow beyond the critical mass, which accelerates the positive cycle of network effects to form an ecosystem that can continue to grow. [3, 5, 8-10].

The development process of the platform market is a typical problem of innovation diffusion and adoption of new technologies. The first stage of the innovation diffusion is from the innovator to the early adopter. There is a big chasm in this diffusion process. The second stage is from the early adopters to the early majorities. There is also a chasm in this diffusion process.. These two chasms must be overcome in order to surpass the critical threshold of critical mass to create a multi-participation environment, in order to have a positive cycle for network effects and develop an effective profitable business model. The traditional innovation diffusion is a process of describing the adoption of new technologies for users. It can basically be regarded as a unilateral market, but it is more complicated for the platform market. How does it get both sides simultaneous adoption and proliferation? Only the platform companies must solve the fundamental problem of the famous chicken-and-eggs problem [8,9].

Previous studies have pointed out that network effects are different in stages which require different business models, and the driving factors accelerating the positive cycle of staged network effects are also different [3,5]. However, previous research has directly explored the business models needed to achieve effective network effects, and did not cut into the perspective of staged network effects. There is a theoretical gap between the network effect and business model of platform companies. There are still many research opportunities to be explored, which also forms the innovation and importance of the research value of this paper.

The traditional network effect research is based on the size assumption, which means that when the network exceeds the critical size Nc, the network size can lead to exponential growth, enabling platform companies to dominate the market [11-12], and the strategy to enhance various network effects is mainly achieved through the operation of price structure [11,13-15].

Previous studies have suggested that the following different factors will affect platform companies to adopt different price structure strategies, which will have different effect network effects: (1) is the same-side NE (SNE: same-side NE) [5, 8, 9]; (2) is Cross-side NE [5,10], (3) is the sensitivity of price elasticity (PE: Price Elasticity) [8,14], (4) is the marginal cost of growth (MCG: Marginal Cost of Growth) [8,9,14]), (5) is the multi-homing transaction cost (TC: Transaction Cost) [8,13,14].

However, the past research is mainly based on the logic of mathematical formulas to explore the relationship between different factors and different price structure strategies. The price structure strategy can be used as a meaningful inference. However, in the actual platform market, the platform companies are faced with complex relationships of many factors, and the traditional deductive logic is almost impossible to solve the practical problem. Therefore, this paper proposes a method based on artificial intelligence machine learning algorithms to integrate multiple variables to establish a more complete prediction model. In order to achieve this goal, this paper first derives several preliminary calculus formulas as the basis of the machine learning algorithms method.

II. LITERATURE REVIEW

A. Platform Company

With the rise of the Internet, every service product that most people live and work with is closely related to the business model of the Internet platform. This is a revolutionary trend that spans many industries and regions, and is constantly changing the modern people. life. It also plays an important role in global business competition.

The typical platform with network technology is to link two different groups. The members in each group are relatively homogeneous, and the members have several relationships with each other [3,4,10]. This is a two-sided platform market as shown in Figure 1.

The emergence of the platform provides an unprecedented opportunity and is hitting the world at an incredible speed and scale, which greatly reduces the distribution cost and subverts the value chain of the original industry. The biggest difference between the platform industry and the traditional industry is that it creates a new industrial model, which is the restructuring of the industrial value chain. The traditional enterprise model is a linear value chain of upstream and downstream relationships. The platform model is a dis-intermediate connection to the final ends among producers and consumers, which can increase the scale more effectively. It also uses internet technology to create the positive effects of the community feedback loop [2]. The focus of business operations must shift from internal activities to external activities. External talents, resources, and functions gradually replace the traditional operations within the enterprise. The strategic logic shifts from controlling unique resources and establishing competitive barriers to how to coordinate external resources and mobilize the active community. The strategic focus is on the governance of the overall ecosystem [3,10,16].

B. Platform Network Effects

Technological innovations after the industrial revolution have boosted productivity, allowing manufacturers to produce more goods at lower unit costs, and as the supply of cheaper goods continues to increase, more demand for goods will be created in the market. This supply economies of scale allows the largest companies to enjoy cost advantages and create competitive advantage [3]. In the era of Internet technology, the rise of the platform business model is the use of group relationships to establish the possibility of increasing value indefinitely, that is, what the academics call "network effects," or "network externalities." Network effects are derived by the demand economy of scale, which brings the competitive advantage that other competitors can't surpass for the largest companies in the platform market. The demand economy of scale is the basis of network effects.

Network effects are new economic phenomena driven by network technology innovation [3]. Metcafe's law can explain the network effect, the network value = (node) square, that is, the value of the network increases with the user node to become a non-linear convex growth. Network effects refer to the impact of the total number of users on the platform on the value created by individual users [3]. Traditionally, the value obtained at the time of consumption is regarded as a personal level, and has nothing to do with others; but when there are many products and services that are used by more and more people together, the value of consumption per user will also increase radically. Therefore, through the network of relationships among users, the benefits of rapid value increasing can be achieved.

In the two-sided platform market, there is a positive and negative same side network effects (SNE) [5,8,9], positive and negative cross-side network effects (CNE) [5,10,17]. The positive SNE is that the users on the A side are attractive to each other, that is, users on one side A will have an influence on users on the same side, and users on the A side will benefit from the increase of similar users [2,8,9]; For example, the number of users on A side of Facebook

grows, and the positive side effect is generated. More and more friends and relatives join together, and the value of users on A side of Facebook is higher. The negative SNE is that the users on the A side have mutual exclusion between each other. The users on the A side bring disadvantages due to the increase of users of the same kind. The more users on the A side join, the other users are less willing to join [5]; Such as google keyword advertising, because the display page is limited in space, it cannot accommodate too many advertisers to pay for exposure; as in the limited space of department stores, too many consumers let the service level lower, thus allowing follow-up consumers not willing to enter the department store. The positive CNE is that users on the A side benefit from an increase in the number of users on the B side [5,17]; such as VISA cards, the flexibility and convenience experienced by A-side consumption will increase due to the increase in the number of VISA cards used by merchants on the B side. The negative CNE is that users on the A side will suffer from the increase in the number of users on the B side [18]; if too many suppliers on the B side send advertisement messages at the same time, the advertisements are too much. to dsturbing people, causing consumers on the B side to leave the platform.

There are also direct network effects (DNE: direct NE) and complementary network effects (CNE: complement NE; or indirect NE) [7,11,19]. The DNE refers to the utility of the user on the A side, and the utility of the quality of the products provided by the platform, that is, the value of the product to the user depends on the benefits of the product itself; for example, the consumer on the side A purchases the phone. The utility obtained in this case obviously depends on the number of other consumers who have joined the telephone network on the A side [7,11,19]. The CNE refers to that the utility of the A side user comes from not only the product itself but also from the number of A side user using the compatible products, such as an email user obtaining from his email software. The value depends not only on the ease of use and other benefits of the software, but also on the other users with which he can communicate with the mail [7,11]. Platform companies operating in the two-sided market must properly manage these six network effects and form a positive cycle ecosystem to survive and profit.

C. Network Effects of Platform Growth

The network effect is the key to the success of platform companies. The positive network effect is the source of platform companies to create value and competitive advantage [3]; the most important challenge for platform companies is how to use positive network effects and mitigate negative network effects [5]. Platform companies must address the famous "chicken & egg" problem and be careful to "get both sides on board simultaneous" to allow users in both sides to gradually grow beyond the critical mass, which accelerates the positive cycle of network effects to form an ecosystem that can continue to grow. [3,5,8-10].

The development process of the platform market is a typical problem of innovation diffusion and adoption of new technologies. Roger's (1983)[20] innovation diffusion model argues that any innovation will spread through specific pipelines and spread over time within the context of a particular social system. Both firms and individuals are considered to have varying degrees of willingness to accept innovation. If the proportion of innovation acceptance will be similar to the normal distribution, depending on the degree of acceptance of new innovation, it can be divided into five groups as shown in Figure 2.

1. Innovators: 2.5%, they are brave pioneers and consciously promote innovation. Innovators play a very important role in the process of innovation communication.
2. Early Adopters: 13.5%. They are respected members of the public and public opinion leaders who are willing to lead fashion and try new things, but be cautious.
3. Early Majority: 34%. They are a group of people who are thinking and cautious, but they are more willing and accepting change than the general population.
4. Late Majority: 34%, they are a group of skeptics who only adopt the new things when the general public accepts new things.
5. Laggards: 16%. They are a group of conservative traditions who are accustomed to being obedient and obsessed with new things. Only when new developments become traditions will they be passively accepted.

The first stage of the innovation diffusion is from the innovator to the early adopter. There is a big chasm in this diffusion process. The second stage is from the early adopters to the early majorities. There is also a chasm in this diffusion process.. These two chasms must be overcome in order to surpass the critical threshold of critical mass to create a multi-participation environment, in order to have a positive cycle for network effects and develop an effective profitable business model.

The stage of innovation diffusion is very important. If it is in the innovator stage, it will obviously encounter great difficulties. It needs to invest more resources, and it will not necessarily cross the huge chasm of the early adopters stage. If it is able to cross the first chasm and enter into the early adopters stage, the first positive loop of network effects will be generated, allowing companies to profit and further develop. The value of innovation at this stage has been confirmed by the innovators. If

company continues to strengthen the value and improve the friendliness of technology, let more people adopt, there will be an opportunity to cross the second chasm, enter into the early majority stage, create a more positive loop of network effects, and create huge commercial benefits.

The traditional innovation diffusion model is a process to describe the adoption of new technologies for users. It can basically be regarded as an one-sided market, but it is more complicated for the two-sided platform market. It is essential to create both sides of the market, but which side do you want to start from? How can you attract users on the other side when there are no users on the side? Therefore, platform companies are very concerned about the business model strategy at different stages, that is, how to chase each side while making money overall, gradually forming the first and second positive loop of network effects, and creating a strong ecosystem [9,8,16].

For platform companies, this is a typical strategy for staged growth. Platform companies need different business models at different stages to promote effective network effects. Platform companies must not only cross the first chasm of the innovator stage to enter the early adopter stage, but also need to further overcome the second chasm of the early adopter stage into the early majority stage, which can form an effective network effect and create a healthy ecosystem to continue expanding economies of scale.

Previous studies have pointed out that network effects are different in stages which require different business models, and the driving factors accelerating the positive cycle of staged network effects are also different [3,5]. However, previous research has directly explored the business models needed to achieve effective network effects, and did not cut into the perspective of staged network effects. There is a theoretical gap between the network effect and business model of platform companies. There are still many research opportunities to be explored, which also forms the innovation and importance of the research value of this paper.

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III. OPPORTUNITIES OF PLATFORM RESEARCH WITH ARTIFICIAL INTELLIGENCE

The study of traditional network effects is based on the assumption of size, that is, if a network has N members, when N grows large, the possible number of connections is N (N-1) = N^2-N, when N is large, N^2-N is close to N^2, and the value of the network increases exponentially [11]. The meaning of the size hypothesis is : When the network exceeds the critical mass Nc, the network size can be exponentially growing, enabling platform companies to dominate the market or win standards, downgrade competitors to niche markets or be ignored [11,12]. The following four assumptions are implied in the size-based network effects literature [11,19]. Hypothesis 1: Each member of the network can trade with each other member and trade with each member is equal; Hypothesis 2: Resource/capability homogeneity exists between network members and network providers; Hypothesis 3: All network members are rational and have the same information in all possible transactions within the network; Hypothesis 4: Information flows seamlessly from member to member. Therefore, when the assumption 1-4 is established, the expectation value of each network member and provider from the network effect increases with the square of the network size, and the strategy of improving various network effects is mainly through the operation of the price structure. [11,13-15].

The research method proposed in this paper is to use the machine learning algorithms in artificial intelligence. Machine learning can find a calculation algorithms suitable for computer to make predictions or mathematical model classification [21-23]. This kind of algorithms mainly builds the corresponding training model by collecting a large amount of raw data and standard answers, and at the same time, by verifying the data comparison calculation results, constructing an effective prediction model to enhance the value and effectiveness of the practical scene application [23-26].

In order to achieve this goal, this paper first derives several preliminary calculus formulas as the basis of the machine learning algorithms method. The following is a description of the research issues of using different price structure strategies to achieve l network effects under different business models.

Previous studies have suggested that the same-side network effect (SNE) is an important research issue. The more the SNE represents the market users of an A-side market, the greater the effect on each other [5,8,9]. If there is a positive SNE, the platform company ill usually adopt a subsidy price structure strategy. The choice of this business model will make the positive network effect of the side grow rapidly. The above is the derivation of theoretical view-point, this paper be expressed by the following formula:

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$Q^{A}_{SNE,t}$: Representing number of users on the A side of the SNE at a certain time t

$P^{A}_{SNE,t}(-)$: Representing the price structure of the SNE of the A-side user at a certain time t is a subsidy strategy

Assuming other factors remain the same, at this time

then $Q^{A}_{SNE,t} = f_1\ (\ P^{A}_{SNE,t}(-)\ )$ ----------(1)

The CNE is also an important research issue in the platform market. When the market has a positive CNE, the platform company must choose an appropriate price structure. Platform companies can balance the different needs from each side by creating subsidies on one side and generating profit-generating mechanisms on the otheside to generate a positive loop of network effects [5,10]. For a side with a positive CNE, the platform company will be more aggressive in reducing the price of this side [6]. Rysman (2009) [27]found that if there is a significant positive CNE on both sides, the third-side advertisers will focus on attracting more readers. Wilbur (2008) [28]found that the number of TV ads (A side) has a negative impact on the size of the audience (B side) (the audience is opposed), which is the negative CNE, and the audience (B side) size for advertising needs (A side) which is the positive CNE. The above is the derivation of theoretical view-point, this paper be expressed by the following formula:

$Q^{A}_{CNE,t}$: Representing number of users on the A side of the CNE at a certain time t

$P^{A}_{CNE,t}(-)$: Representing the price structure of the CNE of the A-side user at a certain time t is a subsidy strategy

$P^{B}_{CNE,t}(+)$: Representing the price structure of the CNE of the B-side user at a certain time t is a charging strategy

Assuming other factors remain the same, at this time

then $Q^{A}_{CNE,t} = f_2(\ P^{A}_{CNE,t}(-),\ P^{B}_{CNE,t}(+)\ )$----------(2)

It may also be $Q^{B}_{CNE,t} = f_3(\ P^{A}_{CNE,t}(+),\ P^{B}_{CNE,t}(-)\ )$ -- (3)

In addition, the sensitivity of price elasticity (PE) also affects the price structure strategy adopted by platform companies [8,14]. Price elasticity represents the multiplier of a user who intends to purchase when the price of a particular item changes. When the price elasticity is high, if the platform enterprise raises the price of the goods on one side, the loss of users on one side will be particularly serious. When the platform company lowers the price of the goods, the user group on one side will be adopted in large quantities. Therefore, the A user group with high price elasticity sensitivity is suitable as a side of subsidies. Conversely, a user group with low price elasticity sensitivity is suitable as a side of charging. The above is the derivation of theoretical view-point, this paper be expressed by the following formula:

E^{A}_{t} : Representing the price elasticity of the user at side A at a certain time t

$$E^{A}_{t} = \frac{-\Delta Q^{A}_{t}/Q^{A}_{t}}{\Delta P^{A}_{t}/P^{A}_{t}}$$

Assuming that other factors remain unchanged, when the price elasticity of the user on the A side is greater than η, the price structure of the user on the A side $P^{A}_{E,t}$is the subsidy strategy,

then $Q^{A}_{E,t} = f_4(\ P^{A}_{E,t}(+),\ \text{if}\ E^{A}_{t} > \eta\ )$ ----------(4)

When the price elasticity of the B-side user is less than η, the price structure of the B-side user $P^{B}_{E,t}$ is the charging strategy,

then $Q^{B}_{E,t} = f_5\ (\ P^{B}_{E,t}(-),\ \text{if}\ E^{B}_{t} < \eta\ )$ ----------(5)

Another factor, the marginal cost of growth (MCG), also affects the price structure strategy of platform companies [8,9,14]. The marginal cost of growth refers to the cost that needs to be added when a platform company is to serve a new user on one side. If the new cost increased can be maintained at a lower level, the user group on this side is suitable as a subsidy side. At this time, the Ramsey pricing method can promote the rapid growth of the user group on the side [8]; When the number of users grows, a user group that requires high marginal cost is suitable as a charging side. Because when the platform ecosystem grows rapidly, platform companies certainly don't want marginal costs to soar. The above is the derivation of theoretical view-point, this paper be expressed by the following formula:

MC^{A}_{t} : Representing the marginal cost of growth on A side at a certain time t

$$MC^{A}_{t} = \frac{\Delta\ C^{A}_{t}}{\Delta Q^{A}_{t}}$$

Assuming that other factors remain the same, when the marginal cost of growth on the A-side approaches γ, the price structure of the user on the A side $P^{A}_{MC,t}$.is the subsidy strategy

then $Q^{A}_{MC,t} = f_6(\ P^{A}_{MC,t}(+),\ \text{if}\ MC^{A}_{t} -> \gamma\ ,\ \text{else})$ ---(6)

It is also possible that when the marginal cost of growth on the B-side user approaches γ, the price structure of the B-side user $P^{B}_{MC,t}$. is the subsidy strategy

then $Q^{B}_{MC,t} = f_7(\ P^{B}_{MC,t}(+),\ \text{if}\ MC^{B}_{t} -> \gamma,\ \text{else}\ )$ ---(7)

In addition to the cross-side network effect affecting the price structure strategy adopted by platform companies, platform companies also face multi-homing problems in different platforms [8,13-15], for example, many merchants accept both American Express and Visa; in addition, some

consumers have American Express and Visa cards in their pockets. Multi-homing issues also affect the price structure strategy. This is not only a question of how the platform company retains the user's stickiness, but also a mutual competition between the platforms. A competitive price one side of the market depends on the degree of multi-homing on the other side of the market. In general, the multi-homing on the A side exacerbates the price competition on the B side, because the platform companies will use the low price strategy to try to attract users on the B side to become a proprietary relationship, that is, platform companies can only effectively improve the stickiness to the B side through the price strategy.

The indicator of the possibility of multi-homing behavior, ie the transaction cost (TC) of multi-homing behavior, affects the price structure strategy of platform companies [8,13,14]. The transaction cost refers to the cost of a user on the X platform jumping to the Y platform. When the transaction cost is higher, the platform can prevent users from arbitrarily hopping to other platforms, that is, the platform company will have higher monopoly power. It is easier for the platform to win. The above is the derivation of theoretical view-point, this paper be expressed by the following formula:

TC_t^A : Representing the transaction cost of multi-homing behavior on the A-side at a certain time t

Assuming that other factors remain unchanged, when the transaction cost of multi-homing behavior on the A-side is greater than a certain value θ, the price structure of the A-side user $P_{TC,t}^A$ is the charging strategy.

then $Q_{TC,t}^A = f_8\ (\ P_{TC,t}^A(-),\ \text{if}\ TC_t^A > \theta,\ \text{else}\ )$ ------(8)

It is also possible that when the transaction cost of multi-homing behavior on the B-side is less than a certain value θ, the price structure of the B-side user $P_{E,t}^B$ is a subsidy strategy.

then $Q_{TC,t}^B = f_9\ (\ P_{E,t}^B(+),\ \text{if}\ E_t^B < \theta,\ \text{else}\ )$ ---------(9)

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