Platform Performance Based On The Network Externality

JinJiang Yan  
*Sichuan University, China*, yanjj@scu.edu.cn

JianKai Xing  
*Sichuan University, China*, mukaimu@163.com

ChunXiang Guo  
*Sichuan University, China*, 598803807@qq.com

Kai Zhu  
*Sichuan University, China*, 626417369@qq.com

Follow this and additional works at: [https://aisel.aisnet.org/iceb2016](https://aisel.aisnet.org/iceb2016)

**Recommended Citation**  
[https://aisel.aisnet.org/iceb2016/25](https://aisel.aisnet.org/iceb2016/25)

This material is brought to you by the International Conference on Electronic Business (ICEB) at AIS Electronic Library (AISeL). It has been accepted for inclusion in ICEB 2016 Proceedings by an authorized administrator of AIS Electronic Library (AISeL). For more information, please contact elibrary@aisnet.org.
ABSTRACT

An increasing number of markets today are organized around platforms that enable consumers to access and/or purchase various goods and services. Considering the presence of network externality, we study the precondition in which whether the buyer will join the platform. Moreover, this paper investigates the performances of platform in the supply chain in which the leadership belongs to the retailer. We find the optimal decision-making strategies, and the sellers will join the online platform when the network externality is large enough. In addition, the retailer’s optimal profit and demand on offline platform will increase with the rising of network externality, whereas their demand on online platform will decrease, and the manufacturer’s optimal profit and demand on online platform will increase.

Keywords: online/offline platform, network externality, supply chain, platform performance.

INTRODUCTION

Network effects consumption is becoming very crucial for businesses and has attracted a wide range of economics researchers’ interests. There exist many platform markets, such as online advertising (between web properties and advertisers), job boards (between job seekers and recruiters), and payment card systems (between merchants and consumers), etc. Rochet [13] labels these markets two-sided markets. Some examples of two-sided markets are video game consoles, newspapers, smartphones, e-books, credit cards, shopping malls, and social networking sites. Some of them are offline platforms (for example, shopping malls, credit cards, newspapers) and some others are online platforms such as Uber is also one online platform. Instead of calling a taxi, we can use private car on Uber. Nagi and Chau [10] pointed out that people could get what they want in the sharing economics.

Ravi [12] pointed out the platform providers typically perform two primary function: (1) they match agents on the two sides, enabling transactions between them, and (2) they add to the quality of the transaction in different ways. That means the utility of an agent on both sides depends partly on the number of agents on the other side of the platform, that is cross-market network effects. Dai and Kauffman [3] verified that consumers generated the positive effects on the suppliers and negative effects on the other consumers.

The effect of network externalities on the seller’s investment has long been studied in the economics literature with particular emphasis on the platforms’ profit. Yet this stream of researches typically study direct network effects, and ignore the strategic interactions with the seller side of the market. To some extent, this paper complements this stream of research by using an analytical model to characterize the seller’s choice between offline platform and online platform.

In the real word, many retailers choose the online platform to get more profit. For example, we can buy a same computer in the JD store or on the manufacturer's official website. Many scholars researched the behaviors of the retailers and the manufacturers in the view of supply chain, and focused on the supply chain where the manufacturer joined the online platform. But few of them study the retailer’s behavior to join the online platform. In this paper, we consider a game-theoretic model where the retailer is dominant. The retailer firstly decides their price of unit product, and then the manufacturer makes decisions. The manufacturers can sell their products through the traditional retailers (we call this channel as offline platform) or the Internet (i.e., online platform). The retailers can sell their goods directly or through the online platform. The precondition of joining the online platform is their profit function of manufacturer must be larger than zero (This zero is generated by standard reservation utility, not the real zero. The below is the same). And for the buyer, their utility must be larger than zero.

With the precondition, this paper research the performance of this type of supply chain and analyze why it will exist. At the same time, the seller can make their right decisions when meeting different network externalities.

The remainder of this paper is as follows: Section 2 reviews the related literatures. In section 3, we develop a mathematical model of two different platforms. In section 4, we analyze the outlets of the seller to choose based on their profit function. Finally, section 5 gives some conclusions and managerial implications.

LITERATURE REVIEW

There exist many literatures relative to the platform. Most of researcher study platform form and platform performance. For example, Katsamakas and Bakos [8] studied the effect of platform ownership structures’ influences (independent, consumer-owned, supplier-owned) in a monopoly setting. Andrei and Julian [6] researched the economic tradeoffs that drive organizations to position themselves closer to or further away from a multi-sided platform business model. In this paper, we consider the platform ownership is independent, not belongs to the seller and the buyer.
The economic theory of two-sided markets (Parker and Van Alstyne 2000b, Rochet and Tirole 2003, Parker and Van Alstyne 2005) explores the unique features that set these markets apart from traditional products and services. In particular, two-sided markets exhibit a special form of indirect network effects (Katz and Shapiro 1985) such that the number of users on one side of the market depends on the number of users on the other side. For example, video game developers will develop games only for platforms that have a sufficiently broad installed base of gamers.

In some literatures, researchers study the market competitions in the presence of network externality, which indicates that the buyers’ utility is an increasing function of the number of sellers on the same platform. Ravi and Rajib make their research based on this hypothesis. For instance, buyers can get more profit as the number of buyers increase. The reasons are that there will be more products and transactions on the platform if the number of sellers and buyers both increases. The buyer can get what they want in time and the seller can complete the transactions efficiently. If sellers can provide complementary products, both sides can get higher utility. Little literatures research the choice of platform, and only assume both sides agree to join the platform.

Many literatures focus on the pricing coordination. Andrei and Hanna studied the effect of different levels of information on two-sided platform profits under monopoly and competition. And they showed that platforms with more market power prefer facing more informed users. More information will intensify the price competition and amplify the effect of price. Armstrong M (2006) once studied both monopolistic and competing platform and found that pricing structure was mainly affected by strength of network externality, the costs structures and whether the customers were single-home or multi-homing. Multi-homing is that an entity can join more than one platform simultaneously.

Some literatures studied the coordination of the platform. Andrei and Daniel presented first-party content and coordination in two-sided markets. And they found that the strategic use of first-party content by two-sided platform is driven by two key factors: the nature of buyer and seller expectations. Edward and Anderson researched the platform performance investment in the presence of network externalities. They carried out a full analysis of three distinct settings: monopoly, price-setting duopoly and pricing-taking duopoly. They concluded that the conditions under which offering a platform with lower performance but greater availability of content can be a winning strategy. Ravi and Rajib studied the co-opetition between differentiated platform in two-sided markets. In their study, they highlighted the importance of technology. They pointed that collaboration might provide incentives for a dominant platform. Andrei and Julian presented an article named marketplace or reseller. In their research they clarified how intermediaries to choose between functioning as marketplace (in which suppliers sell their products directly to buyers) or as a reseller (by purchasing products from suppliers and selling them to buyers).

THE MODEL

In this section, firstly, two modes of supply chain will be presented. The first one aims to show a traditional supply chain, without using the platform. The second model will demonstrate where and how these platforms can be applied, in order to make the supply chain more efficient.

The Figure 1 presents the first conceptual mode: a traditional and simplified supply chain.
choose the online and offline platform under the condition that they can bring profit. Based on the consumer's utility function and the influence of network externalities, this article focuses on the retailer’s and the manufacturer’s choices of the online and offline platform.

Secondly, we develop a two-sided market model that we use to analyze platform performance investment decisions in the presence of cross-network externalities. The seller’s choice is based on the profit function: the profit should be larger than zero. The buyer’s strategy is based on the platform’s given price, the number of the seller on the platform and the strength of network effects.

In this model, we assume that the product and the service which two platforms offer are heterogeneous and the manufacturer indirectly choose the offline platform through the retailer. We have also assumed that he manufacturer and the retailer both select the offline platform first and buyers at most can join one platform (single-home). Furthermore, without loss of generality, we consider the buyer only buy one product at a certain time. We denote the number of potential buyers for joining the platform by $n_i$ and $n_j$. While $i = 1, 2$ and $j = 3$ represent the buyer’s choice of offline retailer, online retailer and online manufacturer. Moreover, we assume that product prices are heterogeneous, so we use $p_i$ and $p_j$ represent the price of the per unit product charged by the retailer and manufacturer. Finally, there are $r_i$ retailers and $m_j$ manufacturers on the platform.

The frequently used notations are listed in Table 1.

**Table 1: the notation of the paper**

<table>
<thead>
<tr>
<th>Notation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$i$</td>
<td>The buyer’s choice of offline retailer and online retailer, $i = 1, 2$</td>
</tr>
<tr>
<td>$j$</td>
<td>The buyer’s choice of online manufacturer, $j = 3$</td>
</tr>
<tr>
<td>$n_i$</td>
<td>The number of potential buyers for joining the retailer’s platform</td>
</tr>
<tr>
<td>$n_j$</td>
<td>The number of potential buyers for joining the manufacturer’s platform</td>
</tr>
<tr>
<td>$\theta_i, \theta_j$</td>
<td>The buyers type distribution and complies with $U(0,1)$</td>
</tr>
<tr>
<td>$p_i$</td>
<td>The price of the per unit product charged by the retailer</td>
</tr>
<tr>
<td>$p_j$</td>
<td>The price of the per unit product charged by the manufacturer</td>
</tr>
<tr>
<td>$V_i$</td>
<td>The value estimates of retailer’s unit product</td>
</tr>
<tr>
<td>$V_j$</td>
<td>The value estimates of manufacturer’s unit product</td>
</tr>
<tr>
<td>$r_i$</td>
<td>The number of the retailer on the platform</td>
</tr>
<tr>
<td>$m_j$</td>
<td>The number of the manufacturers on the platform</td>
</tr>
<tr>
<td>$\beta$</td>
<td>The alternative or monopolistic degree relative online platform to offline platform</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>The manufacturer’s degree of credibility in the minds of consumers</td>
</tr>
<tr>
<td>$\omega$</td>
<td>The unit product’s wholesale price</td>
</tr>
<tr>
<td>$l$</td>
<td>The retailer’s earning of unit product and $l = p_i - \omega$</td>
</tr>
</tbody>
</table>
The manufacturer’s cost of unit good on offline platform
\[ c_1 \]

The retailer’s cost of unit good on offline platform
\[ c_2 \]

The manufacturer’s allocation efficiency relative offline platform to online platform
\[ k_1 \]

The retailer’s allocation efficiency relative offline platform to online platform
\[ k_2 \]

The strength of network effects of buyers who select retailer’s platform and belong to (0,1)
\[ \alpha_i \]

The strength of network effects of buyers who select manufacturer’s platform and belong to (0,1)
\[ \alpha_j \]

As shown in Figure 3, The retailer can choose online and offline platform (i.e. multi-home) and buyers only select one platform (i.e. single-home). Buyers and sellers make their own decisions according to a series of parameters.

In particular, first, we assume that the manufacturer and the retailer both select the online platform under certain conditions and we will analysis the prerequisite when we have built the model later. As a result, the net utilities to a consumer on the retailer’s offline platform, the manufacturer’s online platform, the retailer’s online platform are given by:

\[ U_1 = V_1 + r_i \theta_i \alpha_i - p_i - (1 - \beta) V_1 (V_2 + V_3) \]  
\[ U_2 = V_2 + m_i \theta_i \alpha_i - p_i - \beta p V_1 (V_2 + V_3) \]  
\[ U_3 = V_3 + r_i \theta_i \alpha_i - p_i - \beta (1 - \gamma) V_1 (V_2 + V_3) \]

According to equation (1), for retailer’s offline platform, the buyer’s individual rationality (participation) constraint is:

\[ U_1 \geq 0 \]  

So we can get:

\[ \theta_i \geq \frac{p_i + (1 - \beta) V_1 (V_2 + V_3) - V_1}{r_i \alpha_i} \]  

As a result, according to (5), the number of buyers who join retailer’s offline platform is:
\[ D_1 = n_1 \int_{a_1}^{b_1} d\theta = n_1 \frac{r_1 \alpha_1 - p_1 - (1 - \beta)V(V_2 + V_1) + V_1}{r_1 \alpha_1} \quad (6) \]

Similarly, we can get the number of buyers who join the other platform is:

\[ D_2 = n_2 \frac{m_2 \alpha_2 - p_2 - \beta V(V_2 + V_1) + V_2}{m_2 \alpha_2} \quad (7) \]

\[ D_3 = n_3 \frac{r_3 \alpha_3 - p_3 - \beta(1 - \gamma)V(V_2 + V_1) + V_3}{r_3 \alpha_3} \quad (8) \]

In the supply chain structure where the retailer is the leader, the retailer decides the earning of unit product on offline platform and the online platform’s price of unit product to maximize their profits. While also in this supply chain structure, the manufacturer decides the wholesale price and the online platform’s price of unit product to maximize their profits.

The manufacturer’s total profits of offline platform and online platform is:

\[ \Pi_M = (\omega - c_i)D_1 + (p_2 - k_2)c_2 \quad (9) \]

Lemma 1. The manufacturer’s profits function is a concave function of the wholesale price and the online platform’s price of unit product, so when the manufacturer’s profit reaches the maximum, the two prices’ optimal value are:

\[ p_2 = \frac{m_2 \alpha_2 - \beta V(V_2 + V_1) + k_1c_1 + V_2}{2} \quad (10) \]

\[ \omega = \frac{r_3 \alpha_3 - (1 - \beta)V(V_2 + V_1) - l + c_1 + V_1}{2} \quad (11) \]

The retailer’s total profits of offline platform and online platform is:

\[ \Pi_R = (p_1 - \omega - c_2)D_3 + (p_2 - k_2c_2)D_3 \quad (12) \]

Lemma 2. The retailer’s profits function is a concave function of the earning of unit product on offline platform and the online platform’s price of unit product, so when the retailer's profit reaches the maximum, the two prices’ optimal value are:

\[ l = \frac{r_1 \alpha_1 - (1 - \beta)V(V_2 + V_1) + c_2 - c_1 + V_1}{2} \quad (13) \]

\[ p_3 = \frac{r_3 \alpha_3 - \beta(1 - \gamma)V(V_2 + V_1) + k_2c_2 + V_3}{2} \quad (14) \]

So when the manufacturer and retailer both select the online platform, the final optimal value for these parameters are as following:

\[ \omega = \frac{r_3 \alpha_3 - (1 - \beta)V(V_2 + V_1) - c_2 + 3c_1 + V_1}{4} \quad (15) \]

\[ p_1 = \frac{3r_3 \alpha_3 - 3(1 - \beta)V(V_2 + V_1) + c_2 + c_1 + 3V_1}{4} \quad (16) \]

\[ p_2 = \frac{m_2 \alpha_2 - \beta V(V_2 + V_1) + k_1c_1 + V_2}{2} \quad (17) \]

\[ p_3 = \frac{r_3 \alpha_3 - \beta(1 - \gamma)V(V_2 + V_1) + k_2c_2 + V_3}{2} \quad (18) \]
\[ D_1 = n \frac{r_1 \alpha_1 - (1 - \beta) \beta V_1(V_2 + V_3) - c_1c_2 + V_1'}{4r_1 \alpha_1} \]  

(19)

\[ D_2 = n \frac{m_2 \alpha_2 - (1 - \beta) \beta V_2(V_2 + V_3) - k_1c_2 + V_2'}{2m_2 \alpha_2} \]  

(20)

\[ D_3 = n \frac{r_3 \alpha_3 - (1 - \beta) \beta V_3(V_2 + V_3) - k_1c_2 + V_3'}{4r_3 \alpha_3} \]  

(21)

\[ \Pi_m = n_1 \frac{[r_1 \alpha_1 - (1 - \beta) \beta V_1(V_2 + V_3) - c_1c_2 + V_1']^2}{16r_1 \alpha_1} + n_2 \frac{[m_2 \alpha_2 - \beta \gamma V_1(V_2 + V_3) - k_1c_2 + V_2']^2}{4m_2 \alpha_2} + n_3 \frac{[r_3 \alpha_3 - \beta (1 - \gamma) \gamma V_1(V_2 + V_3) - k_1c_2 + V_3']^2}{8r_3 \alpha_3} \]  

(22)

Finally, we need to consider the prerequisite: Both profits should be greater than zero. So for the manufacturer, their optimal profit must be satisfied:

\[ \Pi_m' \geq 0 \]  

(24)

Let \[ A_1 = n_1 \frac{r_1 \alpha_1 - (1 - \beta) \beta V_1(V_2 + V_3) - c_1c_2 + V_1'}{16r_1 \alpha_1} , \]  

\[ A_2 = \beta \gamma V_1(V_2 + V_3) + k_1c_2 - V_2 . \]  

So according to formula (24), we can get:

\[ \alpha_1 \geq \frac{2A_1m_2 - 4m_2A_1}{n_2} \sqrt{\frac{(4m_2A_1)^2 - 4A_1m_2^2 - 4m_2^2A_1^2}{2m_2^2}} \]  

(25)

For the retailer, their optimal profit must be satisfied:

\[ \Pi_r' \geq 0 \]  

(26)

Let \[ A_3 = \beta (1 - \gamma) \gamma V_1(V_2 + V_3) + k_2c_2 - V_3 , \]  

so according to formula (26), we can get:

\[ \alpha_2 \geq \frac{2A_2r_3 - 4r_3A_1}{n_3} \sqrt{\frac{(4r_3A_1)^2 - 2A_2r_3^2 - 4r_3^2A_1^2}{2r_3^2}} \]  

(27)

It means when \( \alpha_2 \) and \( \alpha_3 \) satisfy formula (25) and formula (27), the manufacturer and the retailer will choose the online platform.

**THE NUMERICAL ANALYSIS**

According to previous assumptions, these parameters’ values can be set: \( V_1 = 0.6, V_2 = 0.4, V_3 = 0.5, \gamma = 0.6, k_1 = 0.5, k_2 = 0.1, \)

\( m_2 = 5, \alpha_1 = 0.7, \alpha_2 = 0.6, \alpha_3 = 0.5, r_1 = 5.5, r_1 = 7, c_1 = 0.5, c_2 = 0.3 \) and \( \beta = 0.7 \). In these settings, there are different
values of \( V \), we can see that the estimations of the value of the same products provided by different and same sellers but different platform are not the same. So does the \( C \). Both entities’ allocation efficiencies relative offline platform to online platform are clarified by diverse \( k \). \( \gamma \) express the online platform manufacturer’s degree of credibility in the minds of consumers. \( m \) and \( r \) denote the number of two sellers. Intuitively, the number of retailer is bigger than the manufacture. \( \alpha \) clarifies the strength of network effects. As many consumers are more likely to use the online platform, so the monopolistic degree \( \beta \) is a little higher. According to formula (24) and (26) and controlling other variables constant, we can get these prerequisites are \( 0 < \alpha_x < 1 \) and \( 0 < \alpha_y < 1 \).

So for the retailer, their demand of products on different platform can be shown in Figure 4.

![Figure 4: The retailer’s demand on different platform](image)

As shown in Figure 4, we can conclude that their demand on offline platform will increase with the increase of network externality. But the demand will decrease on online platform with the increase of network externality. Figure 5 shows the retailer’s profit. We can see their profits increase with the increase of network externality. That’s why although the demand on online platform decreases, but they will also choose to introduce the online platform.

![Figure 5: The retailer’s profit](image)

For the manufacturer, as shown in Figure 6, we can see that their demand on online platform and profit both will increase with the increase of network externality. That’s because when there are more consumers on the online platform and in turn the manufacturer’s profit will increase.
Overall, when the prerequisites meet (i.e. the two entities’ profits are satisfied), they will both select to join the online platform. And the consumer can get more conveniences and utilities. That’s why this form of supply chain appears and exists.

CONCLUSION AND MANAGERIAL IMPLICATION

In this paper, we research the platform performance based on the network externality. We consider a realistic structure which the retailer can also choose the online platform. In the structure where the leadership belongs to the retailer, we consider a game-theoretic model to study the platform performance.

Our study of platform performance under the affecting of network influence has yielded several important insights that should be of managerial interest.

Firstly, when the sellers both meet the precondition, the seller’s strategic use of when and whether to join the platform is determined by the relationship with buyers’ participation and the strength of network externality. However, whether the buyer join the platform is determined by their utility that is partially affected by the number of sellers who join the same platform. Secondly, when the manufacturer and the retailer both choose the online platform, we can get the optimal decision-making strategies. For example, the optimal price of per unit product on different platform, the optimal wholesale price and so on. Third, in this supply chain, the retailer’s optimal demand on offline platform and profit will increase with the increase of network externality. However, their optimal demand on online platform will decrease. They will join the online platform to make more profits. The manufacturer’s optimal demand and profit will increase with the increase of network externality. Fourth, as the seller can choose the two platforms, so there exist many different modes of supply chains and generates a new form of supply chain.

We have made a few simplifying assumptions in developing our model. For example, consistent with many literatures, we only study a single-period model and assume the buyer can only choose one platform. While we believe the intuition of our results applies to cases with different assumption, future research might investigate how such assumptions (e.g., independent of sellers’ utility) affect the conditions in the proposition.

Finally, future research could divide the platform into monopoly platform and competitive platform, so we can further discuss the seller’s choice between two platforms or among three platforms. We also might conduct a comprehensive analysis of sellers’ decisions which include different first-party content, technology and market share.

ACKNOWLEDGEMENTS

The authors would like to thank for Science and Technology Department of Sichuan Province (No. 2016ZR0042), the Research Center for Sichuan Liquor Industry Development, China (No. CJY15-03)and Sichuan University (No.sky201648, sky201523).

REFERENCES