International Journal of u-and e-Service, Science and Technology
Vol.7, No.5 (2014), pp.39-50
http://dx.doi.org/10.14257/ijunnesst.2014.7.5.04

Seller Investment Incentive on Heterogeneous Platforms Under Competition

Xuan Jiang and Shiming Deng

Huazhong University of Science and Technology
Wuhan, 430074, China
judyx.jiang@gmail.com

Abstract

This paper sets an analytical model to study the scenario that two differentiated sellers simultaneously trade on two competitive heterogeneous platforms—for-profit platform and open platform. Three research questions are discussed: (1) If sellers trade on both competitive heterogeneous platforms, how should he/she price on the different platforms and what are the impact factors? (2) How do the fees charged by for-profit platforms to sellers and consumers affect sellers' pricing and consumers' selection on platforms? (3) What is the difference of seller's investment incentives between for-profit platforms and open platforms? This paper finds that if the total fees charged by for-profit platforms keep constant, the split-up between the fees to sellers and consumers will not affect consumers' selection of platforms. Both the fees charged by the for-profit platform and consumers distribution between platforms will affect sellers' decision on pricing and investment on heterogeneous platforms.

Keywords: *Heterogeneous platform, Competition, Investment, Pricing, Two-sided market*

1. Introduction

With the prevalence of B2B, B2C and C2C E-commerce, many Internet commercial platforms are undergoing fierce competition. Internet commercial platforms can be divided into two groups, one is for-profit platforms and another is open platforms. For-profit platforms obtain revenues by charging for access and usage of the platform. This kind of intermediaries not only exists in trading platforms, but also in software platforms, which grant licenses to application software developers and charge users for access, for example, Apple app store and Google Play store. Amazon and EBay as the most popular worldwide E-commerce platforms belong to the for-profit platforms on which sellers need to pay referral fees for one item being sold through the platforms. Open platforms can be accessed without charge. Famous electronic commercial platforms like Taobao and Tencent Paipai belong to open platforms. To reach more consumers, sellers would like to join different kinds of platforms including for-profit platforms and open platforms, for examples, many sellers trade on EBay in China also sell through Taobao simultaneously.

Sellers' investments on the platforms always take the form of advertisement, online store decoration and free shipping. These always benefit consumers for searching and buying products. In a real world, sellers are always restricted to the fund for investment when they are multi-home, so they are involved to choose on which platform to invest. This decision relates to the characteristic of platform, i.e., fees that charged to sellers and consumers, prices on the platforms and consumers' distribution in market.

ISSN: 2005-4246 IJUNESST

Based on the above phenomenon, this paper focuses on three research questions: (1) If sellers trade on both competitive heterogeneous platforms, i.e., for-profit platforms and open platforms, how should he/she price on the different platforms and what is the impact factor? (2) How do the fees charged by for-profit platforms to sellers and consumers affect sellers' pricing and consumers' selection on platforms? (3) What is the difference of seller's investment incentives between for-profit platforms and open platforms?

This paper connects to the literatures on two-sided markets. Seminal contributions to this literature include Caillaud and Jullien (2003), Rochet and Tirole (2003, 2006), and Armstrong (2006). Hagiu (2006) and Noke et al. (2007) have compared for-profit platforms with open platforms. Boudreau (2010) points out that the degree of openness of the platform may affect the sellers' incentive of investment in innovation in the computer industry. However, there is little research on the comparison of sellers' investment incentive on heterogeneous platforms under cross competition. Belleflamme and Peitz (2010) shows that for-profit platform may lead to overinvestment while open platform would lead to underinvestment. Different from their research, first we study the sellers' investment incentives in the scenario that the for-profit platform compete with the open platform while Belleflamme and Peitz (2010) just focus on the scenario where competition only exists between homogeneous platforms; Second we allow sellers and consumers to be both mutihome while Belleflamme and Peitz (2010) only allow one part of the two sided market multihome. Our setup of models are borrowed from Wismer (2013) with three differentiated sellers selling products through two competing channels. Different from his work, we consider two differentiated sellers simultaneously trading on two competitive heterogeneous platforms--a for-profit platform and an open platform. Moreover, we model the additional value for consumers buying from the platform on which seller make an investment. We set the case that sellers do not invest any of the heterogeneous platforms as a benchmark and compare it with the cases that sellers only invest on either the for-profit platform or the open platform, and then we discuss the difference of sellers' investment incentives.

2. Model Set-up

2.1. Framework

This paper assumes that there are two competitive platforms platform A and platform B (abbreviated as PLA and PLB hereafter). PLA is a for-profit platform on which sellers and consumers are charged fees equal to f_s and f_b respectively. On the contrary, PLB is an open platform meaning that no fee will be paid by sellers or consumers to the platform when making a deal on it. In the real world EBay and Amazon belong to PLA, whereas Taobao is alike PLB.

PLA has a consumer group denoted as N_A, and similarly PLB's consumer group is denoted as N_B. There is a spill-over effect between these two consumer group which means consumers on PLA can buy product from PLB and vice-versa.

Two sellers s_1 and s_2 sell differentiated goods both on these two heterogeneous platforms. This paper assumes that s_1 and s_2 is located at the extreme points of the unit interval for platform $n \in \{A, B\}$. A consumer who is located at x would like to choose the seller who is located at y that belongs to the consumer's platform. The distance is $d(x, y) = \min\{|x - y|, 1 - |x - y|\}$ which leads to a cost $td(x, y)$.

Consumers who buy a product from PLA will obtain additional value v based on the same initial reservation value u_0 (not including the transportation cost) for both PLA and PLB without considering the value generated by seller's investment. This paper assumes that the additional benefits are distributed according to a differentiable cumulative distribution function $F(v)$. Therefore, the utility of a consumer buying from PLA and PLB is as following respectively:

$$u_A = u_0 + v - p_A - td(\mathrm{x}, \mathrm{y}),\ u_B = u_0 - p_B - td(\mathrm{x}, \mathrm{y})$$

If a seller $k \in \{1, 2\}$ invests on the platform $n \in \{A, B\}$, consumers will obtain additional value Δu (we assume that $\Delta u \geq 0$). Hence, the value of a consumer buying a product from a platform that is invested by the seller is equal to $u_0 + \lambda v + \Delta u - p - td(\mathrm{x}, \mathrm{y})$, where $\lambda = 1$ if the platform is PLA otherwise $\lambda = 0$.

2.2. Timing

In this paper, seller's investment choice is analyzed at stage 0, where sellers choose simultaneously and non-cooperately whether to invest and which platform to invest. In a real world, sellers are always restricted by the limitation of fund. They do not have enough money to invest all the projects. They need to judge which project is more profitable with the investment. Hence, sellers in this paper are assumed to have two options one is investing none of the platforms, and the other is investing only one of them. This research view the seller's decision on investment is a long-term decision which can be considered as independent of the realized preferences in regard to via which platform to trade.

To focus on the research question of sellers' investment incentive on heterogeneous platforms under competition and simplify the modelling, this paper assumes that the fee charged by PLA to sellers and consumers denoted as f_s and f_b is exogenous. A two stage game is studied as following: At stage 1, sellers on each platform set the price $p_{k,n}$ ($k \in \{1, 2\}$ and $n \in \{A, B\}$) simultaneously and non-cooperately. At stage 2, consumers make a decision on which product and platform to choose. In this stage, the seller first compare s_1 and s_2 on his/her own platform and decide which product to buy, and then decide from which platform (PLA or PLB) to buy this product.

3. Model Analyses

3.1. Consumers' Decision

3.1.1 Selection of platform: If a consumer chooses to buy a product from PLA, he/she will obtain additional value v which follows a differentiable cumulative distribution function $F(v)$ and probability density function $f(v)$. There are three possible cases for the seller to choose a platform according to sellers' decision of investment. We set the first case that sellers invest none of the platforms as a benchmark.

(I) Case1 (Benchmark): Seller invests none of PLA and PLB

If a seller does not invest any of for-profit platform A or open platform B, the seller choose

PLB to buy product $k \in \{1,2\}$ only if $u_0 - p_{k,B} \geq u_0 + v - f_b - p_{k,A}$, or equivalently if $v \leq p_{k,A} - p_{k,B} + f_b$. Hence, if a unit mass of customers wants to buy product $k \in \{1,2\}$, a (expected) mass of $P_r(v \leq p_{k,A} - p_{k,B} + f_b) = F(p_{k,A} - p_{k,B} + f_b)$ buys on PLB and the remainder mass of $1 - F(p_{k,A} - p_{k,B} + f_b)$ buys on PLA.

(II) Case2: Seller only invest on PLA

In this case, seller $k \in \{1,2\}$ only invests on PLA and PLB acquires no investment. Similar to the benchmark case, a mass of $F(p_{k,A} - p_{k,B} + f_b - \Delta u)$ buys the product from seller k on PLB and the remainder mass of $1 - F(p_{k,A} - p_{k,B} + f_b - \Delta u)$ buys on PLA.

(III) Case3: Seller only invest on PLB

In this case, seller $k \in \{1,2\}$ only invests on PLB and PLA acquires no investment. Similar to the benchmark case, a mass of $F(p_{k,A} - p_{k,B} + f_b + \Delta u)$ buys the product from seller k on PLB and the remainder mass of $1 - F(p_{k,A} - p_{k,B} + f_b + \Delta u)$ buys on PLA.

3.1.2 Selection of product: Consumers' selection of product depend on the price and transportation cost. There is no difference between the products of s_1 and s_2 to a consumer belonging to platform $n \in \{A, B\}$ if his/her location fulfills $p_{1,n} + tx = p_{2,n} + t(1-x)$, or equivalently if $x = \frac{1}{2} + \frac{p_{2,n} - p_{1,n}}{2t}$. Hence, given the price of seller k and seller l (where $l, k \in \{1,2\}, l \neq k$), a fraction of $q_{k,n} = \frac{1}{2} + \frac{p_{l,n} - p_{k,n}}{2t}$ chooses product of seller k form platform n. Taking account both the platforms PLA and PLB, the number of consumers buying product from seller k is as following

$$Q_k(\mathbf{p_A}, \mathbf{p_B}) = N_A q_{k,A}(\mathbf{p_A}) + N_B q_{k,B}(\mathbf{p_B})$$

Where $\mathbf{p_A} = (p_{1,A}, p_{2,A})$ and $\mathbf{p_B} = (p_{1,B}, p_{2,B})$.

3.2 Sellers' Pricing Decision

(I) Case1(Benchmark): Seller invests none of PLA and PLB

In this case seller $k \in \{1,2\}$ invests none of the two platforms. Hence, a fraction of $F(p_{k,A} - p_{k,B} + f_b)$ consumers buy on PLB and a fraction of $1 - F(p_{k,A} - p_{k,B} + f_b)$ buys on PLA. Let $\Delta p_k = p_{k,A} - p_{k,B}$, the profit of seller $k \in \{1,2\}$ is as following:

$$\pi_k(\mathbf{p_A}, \mathbf{p_B}) = Q_k(\mathbf{p_A}, \mathbf{p_B})\{F(\Delta p_k + f_b)p_{k,B} + (1 - F(\Delta p_k + f_b))(p_{k,A} - f_s)\}$$

$$= (N_A q_{k,A}(\mathbf{p_A}) + N_B q_{k,B}(\mathbf{p_B}))\{F(\Delta p_k + f_b)p_{k,B} + (1 - F(\Delta p_k + f_b))(p_{k,A} - f_s)\}$$

$$= \{N_A(\frac{1}{2} + \frac{p_{l,A} - p_{k,A}}{2t}) + N_B(\frac{1}{2} + \frac{p_{l,B} - p_{k,B}}{2t})\}\{F(\Delta p_k + f_b)p_{k,B} + (1 - F(\Delta p_k + f_b))(p_{k,A} - f_s)\}$$

Then we have

$$\frac{\partial \pi_k(\mathbf{p_A}, \mathbf{p_B})}{\partial p_{k,A}} = -\frac{N_A}{2t}\{F(f_b + \Delta p_k)p_{k,B} + (1 - F(f_b + \Delta p_k))(p_{k,A} - f_s)\}$$
$$+ [N_A(\frac{1}{2} + \frac{p_{l,A} - p_{k,A}}{2t}) + N_B(\frac{1}{2} + \frac{p_{l,B} - p_{k,B}}{2t})]\{f(f_b + \Delta p_k)p_{k,B}$$
$$- f(f_b + \Delta p_k)(p_{k,A} - f_s) + 1 - F(f_b + \Delta p_k)\}$$

Since seller $l, k \in \{1, 2\}, l \neq k$ is symmetric on a same platform (PLA or PLB), it is easy to derive $p_{l,n} = p_{k,n}$, then the profit of seller $k \in \{1, 2\}$ can be simplified as following

$$\frac{\partial \pi_k(\mathbf{p_A}, \mathbf{p_B})}{\partial p_{k,A}} = -\frac{N_A}{2t}\{F(f_b + \Delta p_k)p_{k,B} + (1 - F(f_b + \Delta p_k))(p_{k,A} - f_s)\}$$
$$+ \frac{N_A + N_B}{2}\{1 - F(f_b + \Delta p_k) - f(f_b + \Delta p_k)(\Delta p_k - f_s)\}$$

Let $\frac{\partial \pi_k(\mathbf{p_A}, \mathbf{p_B})}{\partial p_{k,A}} = 0$, then we have

$$\frac{N_A}{t}\{F(f_b + \Delta p_k)p_{k,B} + (1 - F(f_b + \Delta p_k))(p_{k,A} - f_s)\}$$
$$= (N_A + N_B)\{1 - F(f_b + \Delta p_k) - f(f_b + \Delta p_k)(\Delta p_k - f_s)\} \quad (1)$$

Similarly we let $\frac{\partial \pi_k(\mathbf{p_A}, \mathbf{p_B})}{\partial p_{k,B}} = 0$ and then we derive

$$\frac{N_B}{t}\{F(f_b + \Delta p_k)p_{k,B} + (1 - F(f_b + \Delta p_k))(p_{k,A} - f_s)\}$$
$$= (N_A + N_B)\{F(f_b + \Delta p_k) + f(f_b + \Delta p_k)(\Delta p_k - f_s)\} \quad (2)$$

We make $(1) \times \frac{t}{N_A}$ and $(2) \times \frac{t}{N_B}$ then we deduce

$$N_A\{F(f_b + \Delta p_k) + f(f_b + \Delta p_k)(\Delta p_k - f_s)\}$$
$$= N_B\{1 - F(f_b + \Delta p_k) - f(f_b + \Delta p_k)(\Delta p_k - f_s)\}$$

Hence, we have $f(f_b + \Delta p_k)(\Delta p_k - f_s) + F(f_b + \Delta p_k) - \frac{N_B}{N_A + N_B} = 0$ (3)

We equivalently have

$$\Delta p_k = \frac{\frac{N_B}{N_A + N_B} - F(f_b + \Delta p_k)}{f(f_b + \Delta p_k)}$$

Based on the former assumption, if the additional value for buying on PLA is $\tilde{v}_1 = \Delta p_k + f_b$, a consumer is indifferent for buying from PLA and PLB. Next we explore how the fees that charged by PLA to sellers and consumers, i.e., f_s and f_b, affect the consumers' selection of platforms. To achieve this, we need to analyze the variation of $\tilde{v}_1$

with f_s and f_b respectively.

$$\frac{\partial \tilde{v}_1}{\partial f_s} = \frac{\partial \Delta p_k}{\partial f_s} \qquad (4)$$

$$\frac{\partial \tilde{v}_1}{\partial f_b} = 1 + \frac{\partial \Delta p_k}{\partial f_b} \qquad (5)$$

Use equation (3) and take a derivative with respect to Δp_k, f_s and f_b, then we have

$$\frac{\partial f(.)}{\partial \Delta p_k} = f'(f_b + \Delta p_k)(\Delta p_k - f_s) + 2f(f_b + \Delta p_k)$$

$$\frac{\partial f(.)}{\partial f_s} = -f(f_b + \Delta p_k)$$

$$\frac{\partial f(.)}{\partial f_b} = f'(f_b + \Delta p_k)(\Delta p_k - f_s) + f(f_b + \Delta p_k)$$

Application of the implicit function theorem deduce that

$$\frac{\partial \Delta p_k}{\partial f_s} = -\frac{\partial f(.)/\partial f_s}{\partial f(.)/\partial \Delta p_k} = \frac{f(f_b + \Delta p_k)}{f'(f_b + \Delta p_k)(\Delta p_k - f_s) + 2f(f_b + \Delta p_k)} \qquad (6)$$

$$\frac{\partial \Delta p_k}{\partial f_b} = -\frac{\partial f(.)/\partial f_b}{\partial f(.)/\partial \Delta p_k} = -\frac{f'(f_b + \Delta p_k)(\Delta p_k - f_s) + f(f_b + \Delta p_k)}{f'(f_b + \Delta p_k)(\Delta p_k - f_s) + 2f(f_b + \Delta p_k)} \qquad (7)$$

We take (6) and (7) back to (4) and (5) respectively, then we derive

$$\frac{\partial \tilde{v}_1}{\partial f_s} = \frac{\partial \tilde{v}_1}{\partial f_b}$$

Proposition 1 If $f_s + f_b$ is a constant, the split-up between f_s and f_b will not affect consumers' selection of platforms.

This result is in line with many extant literatures. The deep reason is that sellers can internalize fees charged to consumers in their price setting. The price difference reflects the cost difference, consumers' preference of product and the different valuation of platforms, which leads to redistribution of consumers between PLA and PLB.

For the sake of tractability, this paper restricts the analysis by an assumption on the distribution $F(.)$, which will not affect the generality of Proposition 1. We assume the additional value v and Δu resulting from buying on PLA and the sellers' investment respectively follow a uniform distribution with support $[\underline{v}, \bar{v}]$ hereafter. Hence, we can derive

$$\Delta p_k = \frac{1}{2}\{\frac{N_B}{N_A + N_B}(\bar{v} - \underline{v}) + \underline{v} + f_s - f_b\} \qquad (8)$$

Proposition 2 When sellers make a decision on the price for a same product on a for-profit platform and an open platform, they not only need to consider the fees charged by the platform but also the consumer distribution between platforms. Price gap between the for-profit platform and open platform is increasing with the fraction of consumers on an open platform.

Based on the distribution assumption, we also could derive the following

$$\tilde{v}_1 = \Delta p_k + f_b = \frac{1}{2}\{\frac{N_B}{N_A + N_B}(\bar{v} - \underline{v}) + \underline{v} + f_s + f_b\} \tag{9}$$

$$\begin{aligned} p_{k,A,1}{}^* &= t + f_s + \frac{(f_b + \Delta p_k - \underline{v})\Delta p_k - f_s}{\bar{v} - \underline{v}} \\ &= t + f_s + F_u(\tilde{v}_1)\frac{\bar{v} - \underline{v}}{2}\{\frac{N_B}{N_A + N_B} - \frac{f_b + f_s - \underline{v}}{\bar{v} - \underline{v}}\} \end{aligned} \tag{10}$$

$$p_{k,B,1}{}^* = t - (1 - F_u(\tilde{v}_1))\frac{\bar{v} - \underline{v}}{2}\{\frac{N_B}{N_A + N_B} - \frac{f_b + f_s - \underline{v}}{\bar{v} - \underline{v}}\} \tag{11}$$

Equation (10) and (11) reflect that the optimal prices set on the for-profit platform and open platform not only depends on the cost, but also on the competition within platform as well as across platforms. In the next two propositions, we analyze the relations between the optimal prices and the basics prices ($t + f_s$ and t) which derive from an independent market, and the relationship of the two optimal prices on heterogeneous platforms.

Proposition 3 The optimal price for a seller to make on the For-profit platform and open platform under a competitive market is the same with the price to be set under independent market when $\frac{N_B}{N_A + N_B} = \frac{f_b + f_s - \underline{v}}{\bar{v} - \underline{v}}$.

Proposition 4 The optimal price on a for-profit platform is the same with that on an open platform as long as $f_s = \frac{\bar{v} - \underline{v}}{2}\{\frac{f_b + f_s - \underline{v}}{\bar{v} - \underline{v}} - \frac{N_B}{N_A + N_B}\}$.

(II) Case2: Seller only invest on PLA

In this case, sellers only invest on PLA. Consumers are indifferent between the choice of PLA and PLB when the additional value $\tilde{v}_2 = \Delta p_k + f_b - \Delta u$. Similar to the benchmark case, we can derive the optimal prices that sellers set on PLA and PLB.

$$p_{k,A,2}{}^* = t + f_s + F_u(\tilde{v}_2)\frac{\bar{v} - \underline{v}}{2}\{\frac{N_B}{N_A + N_B} - \frac{f_b + f_s - \underline{v} - \Delta u}{\bar{v} - \underline{v}}\} \tag{12}$$

$$p_{k,B,2}{}^* = t - (1 - F_u(\tilde{v}_2))\frac{\bar{v} - \underline{v}}{2}\{\frac{N_B}{N_A + N_B} - \frac{f_b + f_s - \underline{v} - \Delta u}{\bar{v} - \underline{v}}\} \tag{13}$$

(III) Case3: Seller only invest on PLB

In this case, sellers only invest on PLB. Consumers are indifferent between the choice of PLA and PLB when the additional value $\tilde{v}_3 = \Delta p_k + f_b + \Delta u$. Similar to the benchmark case, we can derive the optimal prices that sellers set on PLA and PLB.

$$p_{k,A,3}{}^{*}=t+f_s+F_u(\tilde{v}_3)\frac{\bar{v}-\underline{v}}{2}\{\frac{N_B}{N_A+N_B}-\frac{f_b+f_s-\underline{v}+\Delta u}{\bar{v}-\underline{v}}\} \quad (14)$$

$$p_{k,B,3}{}^{*}=t-(1-F_u(\tilde{v}_3))\frac{\bar{v}-\underline{v}}{2}\{\frac{N_B}{N_A+N_B}-\frac{f_b+f_s-\underline{v}+\Delta u}{\bar{v}-\underline{v}}\} \quad (15)$$

3.3. Sellers' Investment Incentive on Heterogeneous Platforms

In the Benchmark Case 1, sellers invest none of the for-profit platform A and the open platform B. In Case 2 and Case 3, sellers either only invest on PLA or only invest on PLB. Comparing sellers' profit in these three cases, we analyze sellers' investment incentive on the for-profit platform and open platform. Profits of the seller obtain from PLA in the three cases are as following respectively

$$\pi_{k,A,1}{}^{*}=\frac{1}{2}(N_A+N_B)(1-F_u(\tilde{v}_1))(p_{k,A,1}{}^{*}-f_s) \quad (16)$$

$$\pi_{k,A,2}{}^{*}=\frac{1}{2}(N_A+N_B)(1-F_u(\tilde{v}_2))(p_{k,A,2}{}^{*}-f_s) \quad (17)$$

$$\pi_{k,A,3}{}^{*}=\frac{1}{2}(N_A+N_B)(1-F_u(\tilde{v}_3))(p_{k,A,3}{}^{*}-f_s) \quad (18)$$

Profits of the seller obtained from PLB in the three cases are as following respectively

$$\pi_{k,B,1}{}^{*}=\frac{1}{2}(N_A+N_B)F_u(\tilde{v}_1)p_{k,B,1}{}^{*} \quad (19)$$

$$\pi_{k,B,2}{}^{*}=\frac{1}{2}(N_A+N_B)F_u(\tilde{v}_2)p_{k,B,2}{}^{*} \quad (20)$$

$$\pi_{k,B,3}{}^{*}=\frac{1}{2}(N_A+N_B)F_u(\tilde{v}_3)p_{k,B,3}{}^{*} \quad (21)$$

The relationship among the additional values of choosing PLA at which consumers are equally to choose PLA and PLB are shown as follows

$$\tilde{v}_3=\tilde{v}_1+\frac{1}{2}\Delta u\geq\tilde{v}_1\geq\tilde{v}_2=\tilde{v}_1-\frac{1}{2}\Delta u \quad (22)$$

We use I_A to denote sellers' investment incentive on PLA which means the difference between sellers' profit from PLA under investment and no investment. Case 2 shows the scenario that sellers only invest on PLA, whereas the benchmark case shows the scenario that sellers invest none. Hence, we have $I_A=\pi_{k,A,2}-\pi_{k,A,1}$. Although in Case 3 sellers also choose non-investment for PLA, we do not use this case as a benchmark for the reason that the investment on PLB should be consistent on Case 2 and Case 3 otherwise the variation of investment on PLB affects the profit of PLA. We solve for I_A based on equations (10)-(13), (16) , (17) and (22) as following

$$I_A = \pi_{k,A,2} - \pi_{k,A,1}$$

$$= \frac{1}{2}(N_A + N_B)\{\frac{t\Delta u}{2(\bar{v} - \underline{v})} + \frac{(\tilde{v}_1 - \frac{1}{2}\Delta u - \underline{v})(\bar{v} - \tilde{v}_1 + \frac{1}{2}\Delta u) - (\tilde{v}_1 - \underline{v})(\bar{v} - \tilde{v}_1)}{2(\bar{v} - \underline{v})}$$

$$\times [\frac{N_B}{N_A + N_B} - \frac{f_b + f_s - \underline{v}}{2(\bar{v} - \underline{v})}] + \frac{(\tilde{v}_1 - \frac{1}{2}\Delta u - \underline{v})(\bar{v} - \tilde{v}_1 + \frac{1}{2}\Delta u)\Delta u}{2(\bar{v} - \underline{v})^2}\}$$

Similar to I_A, we use I_B to denote sellers' investment incentive on PLB which means the difference between sellers' profit from PLB under investment and no investment. Case 3 shows the scenario that sellers only invest on PLB, whereas the benchmark case shows the scenario that sellers invest none. Hence, we have $I_B = \pi_{k,B,3} - \pi_{k,B,1}$. We solve for I_B based on equations (10)-(13), (19), (21) and (22) as following

$$I_B = \pi_{k,B,3} - \pi_{k,B,1}$$

$$= \frac{1}{2}(N_A + N_B)\{\frac{t\Delta u}{2(\bar{v} - \underline{v})} + \frac{(\tilde{v}_1 - \underline{v})(\bar{v} - \tilde{v}_1) - (\tilde{v}_1 + \frac{1}{2}\Delta u - \underline{v})(\bar{v} - \tilde{v}_1 - \frac{1}{2}\Delta u)}{2(\bar{v} - \underline{v})}$$

$$\times [\frac{N_B}{N_A + N_B} - \frac{f_b + f_s - \underline{v}}{2(\bar{v} - \underline{v})}] + \frac{(\tilde{v}_1 + \frac{1}{2}\Delta u - \underline{v})(\bar{v} - \tilde{v}_1 - \frac{1}{2}\Delta u)\Delta u}{2(\bar{v} - \underline{v})^2}\}$$

For comparing sellers' investment incentives for the for-profit platform and the open platform, we need to compare I_A and I_B.

$$I_A - I_B = \frac{1}{2}(N_A + N_B)$$

$$\times \{\frac{(\tilde{v}_1 - \frac{1}{2}\Delta u - \underline{v})(\bar{v} - \tilde{v}_1 + \frac{1}{2}\Delta u) + (\tilde{v}_1 + \frac{1}{2}\Delta u - \underline{v})(\bar{v} - \tilde{v}_1 - \frac{1}{2}\Delta u) - 2(\tilde{v}_1 - \underline{v})(\bar{v} - \tilde{v}_1)}{2(\bar{v} - \underline{v})}$$

$$\times [\frac{N_B}{N_A + N_B} - \frac{f_b + f_s - \underline{v}}{\bar{v} - \underline{v}}]$$

$$+ \frac{\Delta u[(\tilde{v}_1 + \frac{1}{2}\Delta u - \underline{v})(\bar{v} - \tilde{v}_1 - \frac{1}{2}\Delta u) - (\tilde{v}_1 - \frac{1}{2}\Delta u - \underline{v})(\bar{v} - \tilde{v}_1 + \frac{1}{2}\Delta u)]}{2(\bar{v} - \underline{v})^2}\}$$

$$= \frac{1}{2}(N_A + N_B)\{\frac{\Delta u^2(2\tilde{v}_1 - \bar{v} - \underline{v})}{2(\bar{v} - \underline{v})^2} - \frac{\Delta u^2}{4(\bar{v} - \underline{v})}[\frac{N_B}{N_A + N_B} - \frac{f_b + f_s - \underline{v}}{\bar{v} - \underline{v}}]\}$$

Take equation (9) back into this formula, we have

$$I_A - I_B = \frac{1}{2}(N_A + N_B)\frac{\Delta u^2}{2(\bar{v} - \underline{v})}\{\frac{N_B}{N_A + N_B} - \frac{2\bar{v} + \underline{v} - 3(f_b + f_s)}{2(\bar{v} - \underline{v})}\}$$

From the above formula, we find that when the heterogeneous platforms compete with each other, the difference between investment incentives on the for-profit platform and open platform depends on the distribution of consumers on the two platforms and the total fees charged to sellers and consumers by the for-profit platform. This result differs from that of Belleflamme and Peitz (2010) which shows for-profit platforms always give stronger investment incentives for sellers than open platform does under the background that there is no competition across for-profit platforms and open platforms.

Proposition 5 When $\frac{N_B}{N_A + N_B} = \frac{2\bar{v} + \underline{v} - 3(f_b + f_s)}{2(\bar{v} - \underline{v})}$, the investment incentives on for-profit platform and open platforms are the same with each other; When $\frac{N_B}{N_A + N_B} \geq \frac{2\bar{v} + \underline{v} - 3(f_b + f_s)}{2(\bar{v} - \underline{v})}$, for-profit platforms give sellers stronger investment incentives than open platforms; When $\frac{N_B}{N_A + N_B} < \frac{2\bar{v} + \underline{v} - 3(f_b + f_s)}{2(\bar{v} - \underline{v})}$ open platforms give sellers stronger investment incentives than for-profit platforms.

From Proposition 5 we can see that when the fraction of consumers on an open platform is larger or the total fee charged by the for-profit platform is larger, the for-profit platform is more likely to give sellers stronger investment incentives than the open platform, which is counter-intuitive. This is because sellers sell products on both of the competitive heterogeneous platforms. When the fees on for-profit platforms is high or the consumers' rate belong to the for-profit platform is low, few consumers would like to buy on for-profit platform. Hence, sellers prefer to invest on for-profit platform than to invest on open platform, since attracting more consumers buying products on for-profit platform will help sellers to maximize the total profit from the two competitive platforms. Similarly, open platforms is more likely to give sellers stronger investment incentives than for-profit platforms when the fraction of consumers on an open platform is smaller or the total fee charged by the for-profit platform is lower.

4 Conclusions

This paper sets an analytical model to study the scenario that two differentiated sellers simultaneously trade on two competitive heterogeneous platforms—for-profit platform and open platform. This paper finds that if the total fees charged by for-profit platforms keep constant, the split-up between the fees to sellers and consumers will not affect consumers' selection of platforms. When sellers make a decision on the price for a same product on a for-profit platform and an open platform, they not only need to consider the fees charged by the for-profit platform but also the consumer distribution between platforms. Price gap between the for-profit platform and open platform is increasing with the fraction of consumers on an open platform. The difference between investment incentives on the for-profit platform and open platform depends on the distribution of consumers on the two platforms and the total fees charged to sellers and consumers by the for-profit platform. When the fraction of consumers on an open platform is larger than a threshold, sellers would more likely to invest on for-profit platforms. Otherwise, they prefer to invest on open platforms. This is because sellers would like to balance the sales on the heterogeneous platforms and maximize the total profit.

Acknowledgements

This paper is sponsored by the National Natural Science Foundation of China (Project No. 70971047, 71371078). The author would like to appreciate the financial support from the projects.

References

[1] K. Boudreau, "Open platform strategies and innovation: Granting access vs. devolving control", Management Science, vol. 56, no.10, **(2010)**, pp. 1849-1872.
[2] B. Caillaud and B. Jullien, "Chicken & egg: Competition among intermediation service providers", RAND journal of Economics, vol. 34, no. 2,**(2003)**, pp. 309-328.
[3] M. Armstrong, "Competition in two-sided markets", The RAND Journal of Economics, vol. 37, no. 3, **(2006)**, pp. 668-691.
[4] J. C. Rochet and J. Tirole, "Platform competition in two-sided markets", Journal of the European Economic Association, vol. 1, no. 4, **(2003)**, pp. 990-1029.
[5] J. C. Rochet and J. Tirole, "Two-sided markets: a progress report", The RAND Journal of Economics, vol. 37, no.3, **(2006)**, pp. 645-667.
[6] A. Hagiu, "Proprietary vs. open two-sided platforms and social efficiency", Division of Research, Harvard Business School, **(2007)**.
[7] V. Nocke, M. Peitz and K. Stahl, "Platform ownership", Journal of the European Economic Association, vol. 5, no.6, **(2007)**, pp. 1130-1160.
[8] P. Belleflamme and M. Peitz, "Platform competition and seller investment incentives", European Economic Review, vol. 54, no. 8, **(2010)**, pp. 1059-1076.
[9] S. Wismer, "Intermediated vs. Direct Sales and a No-Discrimination Rule. Annual Conference (Duesseldorf): Competition Policy and Regulation in a Global Economic Order", German Economic Association, **(2013)**.