Seller competition on two-sided platforms

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Abstract

Two sided platforms connect two user groups to each other. We study how negative within group externality amongst one user group can affect the profit of a monopoly platform through change in the optimal number of users on both sides. We find that an exogenous increase in seller competition (negative within group externality amongst sellers) leads to more number of buyer and sellers and thus an increase in the platform's profit. In the case of two competing platform, increased seller competition leads to increase in the profits of each platform with a decrease in subscription charge paid by sellers and an increase in subscription charge of buyers.

Keywords:Two-sided platforms; network effects; cross-group externalities; seller competition; negative within group externality

1 Introduction

Two-sided platforms are intermediaries that facilitate transaction between two types of agents. There are many examples of such platforms across different industries, from online cab hailing services (Uber) to payment card companies (Visa) and from digital market places (Amazon) to shopping malls. Each platform connects two different types of users and are characterised by the presence of cross group externalities, where utility of one user group depends upon the presence of the other user group on the platform. For instance, more cab drivers join Uber if it has more riders using its application; higher number of merchants accept a payment card if it has higher usage amongst consumers. Similarly, more riders are willing to use Uber if it hosts more cab drivers and consumers use a payment card more frequently if it is easily accepted by various merchants. This demonstrates that such cross group externalities usually go both ways, which gives the two sided characteristic to these platforms. Although, much of the standard literature refer to these platforms as two-sided markets (Armstrong (2006)), I call them two-sided platforms following Spulber (Spulber (2019))[1]. I use the terms 'two-sided platforms' and 'platforms' interchangeably in the paper.

Much of the research on two-sided platforms has focused on cross group externalities and its effect on the platform's pricing and non-pricing decisions (Armstrong (2006),Liu and Serfes (2013)). However, within group externalities, that arise amongst the same group of users, also play an important role in the decision making of platforms. A seller on Amazon takes into account the competition he faces from other sellers operating on it. An Uber driver's willingness to ply rides for the platform not only depends upon the number of riders but also on the competition he faces from other drivers. This behaviour in-turn affects the optimal number of buyers and sellers joining the platform. The paper focuses on this aspect of a two-sided platform and discusses its impact on various economic outcomes.

Higher competition amongst sellers dissuade more sellers from entering a market. This conclusion holds true in the case of two-sided platforms as well when consumers have a preference for product diversity (Belleflamme and Peitz (2019)). Belleflamme and Peitz (2019) discuss how seller competition affect outcomes on a two-sided platform. They use a standard CES utility function where the number of sellers represent the amount of product diversity. Increase in the substitutability parameter negatively affects the product variety and decreases the utility of the consumer. In this case, an exogenous increase in the substitutability of goods sold on the platform leads to more competition amongst sellers and a reduction in product diversity. This negatively affects the utility of buyers which dissuade them from joining the platform leading fewer sellers to join. This is how an increase in competition leads to a lower number of sellers on the platform. It is the interplay of cross group externality between the two groups that finally determines the number of buyers and sellers joining the platform. However, there can be cases where increase in product substitutability does not affect the amount of product diversity offered by the platform.

Following Belleflamme and Peitz (2019), we use a CES utility function to model competition among different sellers on the platform(Dixit and Stiglitz (1977)). However, we modify it to put less emphasis on the product variety. In other words, we remove the effect that change in substitutability has on the product diversity. Thus, change in substitutability

[1] I make such a distinction for better clarity. Any market with its set of buyers and sellers is essentially two-sided and one can rightly argue for the presence of cross group externalities on them. The difference is that in case of two-sided markets/platforms, it is the platform or the intermediary that determines the optimal number of buyers and sellers operating on it unlike in the case of normal markets where market forces determine the same.

does not alter the product variety available.

$$U = {n_s}^{\theta}\left(\int_0^{ns} {q_i}^{\rho}\right)^{\frac{1}{\rho}} \text{where} \theta = k - \frac{1}{\rho} + 1 \tag{1}$$

As it will become clear in the following discussions, a change in ρ would not change how product diversity affects the utility of the consumer. The demand function derived from the utility function remains the same as in the case of a standard CES utility function and so does the elasticity of substitution. Ethier (1982) uses a similar functional form to describe a production function where intermediate inputs combined to form the final good. He places no emphasis on the distinction between different intermediate goods and they all enter the production function in a symmetric fashion.

Examples of such preferences are not hard to find. Some buyers prefer to shop at a farmer's market (local sabzi mandi) than at a grocery shop. Goods sold there are highly substitutable but that does not affect how product diversity enters the utility function of the consumer. Put differently, higher number of sellers translate into higher product variety in the utility function of the consumer independent of the degree of substitution between the goods. In effect, more sellers make such a market more attractive for the buyer. Distinction between products of different sellers does not matter to the consumer. Same is the case with shopping malls. Most brands under a single category are effectively indistinguishable from one another, however it is precisely because of the availability of different sellers that one chooses to go to the mall in the first place. Consumers buying products from Amazon Pantry can also exhibit similar preferences.

Given the utility function of the consumer, we find that increase in product substitutability leads more sellers to join the platform. This result is in contrast to Belleflamme and Peitz (2019) where increased product substitutability leads to decrease in the number of sellers. As explained above, this difference arises due to a particular specification of the CES utility function. Increase in the product substitutability parameter ρ increase competition amongst the sellers. However it also puts a downward pressure on the prices which increase the utility of the consumer and more buyers join the platform. This leads more sellers to join as well.

An example I would like to discuss in particular is the case of digital ride hailing services like Uber. The aggregate preferences of riders on the platform can be represented as a CES utility function where product variety is independent of the substitutability parameter. In other words, riders do not care of the distinction between different drivers but the actual number of drivers present on the platform. According to our model, a change in the exogenously given parameter that increases competition amongst drivers actually leads more consumers to join the platform and because of presence of cross group externalities more drivers to join as well.

We also confirm our results for the case of two competing platform when both buyers and sellers single-home. We lay down our model in the following section and explain our main result. In the third section, we confirm our findings when two platforms compete with each other for buyers and sellers and we conclude in the fourth section.

2 Model

In this section, we analyse competition amongst sellers on a monopoly platform. Two groups - sellers (n_s) and buyers (n_b)- join the platform by paying a subscription fee. The surplus derived by sellers and buyers can be defined as $v_s = r_s + \pi(n_b, n_s) - m_s$ and $v_b = r_b + u(n_b, n_s) - m_b$ (the subscript s and b representing sellers and buyers respectively), where r_b and r_s are the stand-alone utilities that both derive from joining the platform and m_b and m_s are the subscription fees paid by them (Belleflamme and Peitz (2019)). The functions $\pi(n_b, n_s)$ and $u(n_b, n_s)$ represent the profit and utility accruing to sellers and buyers, both potentially depending upon the number of buyers and sellers. We elaborate this point further by calculating the profit and utility functions.

Given the utility function in (1), the demand for the product of each individual seller i is given by $q_i = y{p_i}^{\frac{-1}{1-r}}\mathbf{P}^{-1}$ where $\mathbf{P}$ is the price index of the market (in this case the marketplace or the platform) that each individual seller takes as given and y represents the income of each individual consumer. Based on the demand function every seller maximises his profit and the profit maximising price for each seller is given by $\frac{c}{r}$. The maximum profit for each seller is $\pi(n_b, n_s) = n_b(1-\rho)y/n_s$. The profit is increasing in the number of buyers whereas more number of sellers decrease profit as competition increases. The former is a manifestation of cross-group externality whereas the latter is a form of within group externality and is negative in the above example. Furthermore, the utility is given by $u(n_s) = \frac{{n_s}^k \rho y}{c n_s}$. Following Belleflamme and Peitz (2019), the buyers face no negative utility from other buyers joining the platform and their utility only depends upon the number of sellers.

We assume that both sellers and buyers have an outside option that is uniformly distributed between 0 and Z with $Z > v_s, v_b$ and Z being a very large number (Belleflamme and Peitz (2019)). This ensures that there are always some sellers and buyers that join the platform. The number of buyers and sellers on the platform is determined by $n_S = r_s + \pi(n_s, n_b) - m_s$ and $n_b = r_b + u(n_s, n_b) - m_b$. The platform maximises $(m_s - f_s) * n_s + (m_b - f_b) * n_b$ where f_s and f_b are the marginal costs of hosting each seller and buyer on the platform. The objective function of the platform can also be written as

$$\Pi = (r_s + \pi(n_s, n_b) - n_s - f_s)n_s + (r_b + u(n_s) - n_b - f_b)n_b \tag{2}$$

In the first stage of the game, the platform admits the optimal number of buyers and sellers and the subscription fees clear the market. Alternatively a subscription charge is set by the platform to admit the optimal numbers of buyers and sellers. In the second stage, both groups of users enter the platform and realise their surplus. There is one more important thing happening in the second stage. The sellers also compete with one another to determine the optimal market price of each unit of good being sold on the platform and their price index $\mathbf{P}$. The first order conditions for the platform's maximisation problem can be written as

$$\frac{\partial \Pi}{\partial n_s} = [r_b + \pi(n_b, n_s) - 2n_s - f_s] + \frac{\partial u(n_b, n_s)}{\partial n_s} n_b + \frac{\partial \pi(n_b, n_s)}{n_s} n_s = 0$$
$$\frac{\partial \Pi}{\partial n_b} = [r_b + u(n_s) - 2n_b - f_b] + \frac{\partial \pi(n_b, n_s)}{\partial n_b} n_s = 0$$

Also, $\frac{\partial^2 \Pi}{{n_b}^2} < 0$, $\frac{\partial^2 \Pi}{{n_s}^2} < 0$ and $\frac{\partial^2 \Pi}{{n_b}^2}\frac{\partial^2 \Pi}{{n_s}^2} - (\frac{\partial^2 \Pi}{\partial n_b \partial n_s})^2 > 0$ due to second order conditions. For the second order conditions to be fulfilled $0 < k < 1$.

2.1 Seller competition on a monopoly platform

In the first exercise, we determine how change in the substitutability parameter ρ affects the optimal number of buyers and sellers on the platform and thus its profit.In our model, ρ is an exogenously given parameter that represents the extent of seller competition on the platform. A higher value of ρ indicates more substitutability amongst goods sold by different sellers and thus higher competition among them. A lower value indicates that the good are independent of each other and the sellers have more market power. Referring to the profit function of the sellers, as derived in the previous paragraph, one can see that a higher value of ρ negatively affects the profit whereas a lower value of it increases the profit of the platform.

If the optimal number of buyers and sellers are given by ${n_b}^*$ and ${n_s}^*$, we ascertain how $\frac{d{n_s}^*}{d\rho}$ and $\frac{d{n_b}^*}{d\rho}$behave. These expressions have been arrived at by totally differentiating $\frac{\partial \Pi}{\partial n_s}$ and $\frac{\partial \Pi}{\partial n_b}$ against n_s,$n_b$and ρ and re-arranging the resulting equations.

$$\frac{d{n_s}^*}{d\rho} = \frac{1}{K}(-\frac{\partial^2 \Pi}{\partial n_s \partial \rho}\frac{\partial^2 \Pi}{{n_b}^2} + \frac{\partial^2 \Pi}{\partial n_b \partial \rho}\frac{\partial^2 \Pi}{\partial n_b \partial n_s})$$
$$\frac{d{n_b}^*}{d\rho} = \frac{1}{K}(-\frac{\partial^2 \Pi}{\partial n_b \partial \rho}\frac{\partial^2 \Pi}{{n_s}^2} + \frac{\partial^2 \Pi}{\partial n_s \partial \rho}\frac{\partial^2 \Pi}{\partial n_b \partial n_s})$$

where $K = \frac{\partial^2 \Pi}{{n_b}^2}\frac{\partial^2 \Pi}{{n_s}^2} - (\frac{\partial^2 \Pi}{\partial n_b \partial n_s})^2 > 0$ given the second order conditions.

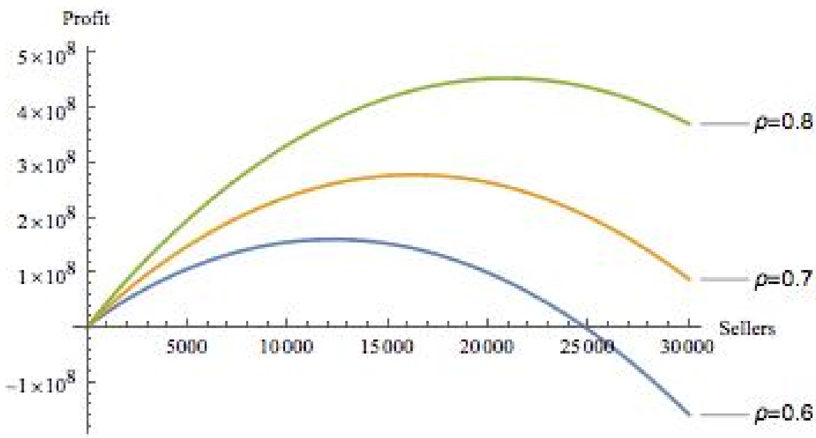
Let $\eta_s = -\frac{\partial^2 \Pi}{\partial n_s \partial \rho}\frac{\partial^2}{{n_b}^2} + \frac{\partial^2 \Pi}{\partial n_b \partial \rho}\frac{\partial^2 \Pi}{\partial n_b \partial n_s}$ and $\eta_b = -\frac{\partial^2 \Pi}{\partial n_b \partial \rho}\frac{\partial^2}{{n_s}^2} + \frac{\partial^2 \Pi}{\partial n_s \partial \rho}\frac{\partial^2 \Pi}{\partial n_b \partial n_s}$. In order to understand how $\frac{d{n_s}^*}{d\rho}$ and $\frac{d{n_b}^*}{d\rho}$ behave, we need to determine the signs of η_s and η_b.

$$\eta_b = \frac{k^2 n_b {n_s}^{2k-2} \rho y^2}{c^2} + (y - \frac{{n_s}^k y}{c})(\frac{-2 + (k-1) k n_b {n_s}^{k-2} \rho y}{c})$$
$$\eta_s = \frac{2k n_b {n_s}^{k-1} y}{c} + \frac{k {n_s}^{k-1} \rho y^2 (\frac{{n_s}^k}{c} - 1)}{c}$$

We find that $\eta_s, \eta_b > 0$, for $0 < k < 1$ and $(n_s)^k > c$. This is because the consumers value substitutability more than the product diversity. An increase in ρ leads to increased substitutability between the goods that puts a downward pressure on the price. This leads more consumers to join the platform which encourage more number of sellers to join as well. This explains why an increase in competition among sellers can lead to more sellers joining the platform.Given that the equilibrium number of buyers and sellers increase for an exogenous increase in ρ, the profits of the platform also increase.

It is straightforward to understand why an increase in competition would attract more number of buyers as it increases their utility. However, increased seller competition leading more sellers to join comes across as a bit surprising. It is here that one needs to appreciate the effect of cross group externalities explained above. The following figures help us better explain our point. Given that it is straightforward to understand that increase in ρ leads more buyers to join the market, we plot a platform's profit against the number of sellers for different values of ρ.

As one can see in Fig. 1, as the value of ρ increases the number of sellers at which



the platform maximises its profit also increases leading to an increase in the profit of the platform. This is because increased seller competition leads more buyers to join the platform. The negative effect of increased competition among sellers is overshadowed by more buyers joining the platform.We are now ready to summarise our first result.

Proposition 1: Increased seller competition in the form increased substitutability between the goods leads more sellers and buyers to join the platform and thus increase the profits made by the platform.

In the next section we discuss the case of two competing platforms.

2.2 Seller competition on competing platforms

We study seller competition in the case of two competing platforms. Our analysis brings forth a specific microfoundational example of the general framework presented by Belleflamme and Toulemonde (2016). The sellers and consumers single-home, meaning they can join only one platform at one time. Following Belleflamme and Peitz (2019), the surplus of buyer and sellers by joining a platform can be written as$v_b{}^i = r_b + u(n_s{}^i, n_b{}^i) - m_b$ and $v_s{}^i = r_s + \pi(n_s{}^i, n_b{}^i) - m_s$ where $i = \{1, 2\}$ represents the two competing platforms.

Using the hotelling's model of imperfect competition, where t_s and t_b are the transportation costs for buyers and sellers, we find the indifferent buyer and seller between the two platforms, which can be written as follows.

$$\mathrm{n}_b = \frac{1}{2} + \frac{1}{2t_b}(\Delta u({n_s}^i, {n_b}^i)) - \frac{1}{2t_b}({m_b}^i, {m_b}^j)$$

$$\mathrm{n}_s = \frac{1}{2} + \frac{1}{2t_s}(\Delta \pi({n_s}^i, {n_b}^i)) - \frac{1}{2t_s}({m_s}^i, {m_s}^j)$$

where

$$\Delta u({n_s}^i, {n_b}^i) = u({n_s}^i, {n_b}^i) - u(1 - {n_s}^i, 1 - {n_b}^i)$$
$$\Delta \pi({n_s}^i, {n_b}^i) = \pi({n_s}^i, {n_b}^i) - \pi(1 - {n_s}^i, 1 - {n_b}^i)$$

We look at the case of symmetric equilibrium, where buyers and sellers are equally divided between the two platform. Given that both platforms maximise their own profits, the equilibrium subscription charges are given by the following expressions

$${m_s}^* = f_s + t_s - \frac{1}{2}(\Delta u_s({n_s}^i, {n_b}^i) + \pi_s({n_s}^i, {n_b}^i))$$
$${m_b}^* = f_b + t_b - \frac{1}{2}(\Delta u_b({n_s}^i, {n_b}^i) + \pi_b({n_s}^i, {n_b}^i))$$

where $\Delta u_s({n_s}^i, {n_b}^i) \equiv \frac{\partial \Delta u({n_s}^i, {n_b}^i)}{\partial n_s}$, $\Delta \pi_s({n_s}^i, {n_b}^i) \equiv \frac{\partial \Delta \pi({n_s}^i, {n_b}^i)}{\partial n_s}$, $\Delta u_b({n_s}^i, {n_b}^i) \equiv \frac{\partial \Delta u({n_s}^i, {n_b}^i)}{\partial n_b}$ and $\Delta \pi_b({n_s}^i, {n_b}^i) \equiv \frac{\partial \Delta \pi({n_s}^i, {n_b}^i)}{\partial n_b}$. At the symmetric equilibrium, ${n_s}^i = \frac{1}{2}$ and ${n_b}^i = \frac{1}{2}$. Given the utility and profit function defined in the previous sections, the resulting expressions for ${m_s}^*$ and ${m_b}^*$ can be written as follows.

$$\mathrm{m}_s^* = f_s + t_s - \frac{1}{2}(2k\frac{\rho}{c}y(\frac{1}{2})^{k-1} + 4y(\rho - 1))$$
$$\mathrm{m}_b^* = f_b + t_b - \frac{1}{2}(4y(1 - \rho))$$

As described by Belleflamme and Peitz (2016), an increase in ρ decreases the subscription charge of seller. Increase in ρ positively affects the utility of the consumer per seller because of which the cross group externality that the sellers exerts on consumers goes up reducing their subscription charge. Increase in ρ also increases the negative within group effect amongst sellers which also reduces the subscription charge. This result is in contrast to Belleflamme and Peitz (2019) where increase in seller competition has an ambiguous effect on the membership fee paid by sellers. On the other hand, the subscription charge paid by buyers go up as the cross group externality that buyers exert on sellers go down.

Given the subscription charges for buyers and sellers move in opposite directions, one cannot immediately conclude the effect on platform profits. The expression for equilibrium profits for a platform can be written as $\Pi^* = \frac{1}{2}\left(\frac{1}{2}\left(-\frac{2^{2-k}k\rho}{cy} - 4(\rho-1)y\right) + f_s + t_s\right) + \frac{1}{2}(f_b + t_b - 4(1-\rho)y)$, which means $\frac{\partial \Pi^*}{\partial \rho}$ is positive. Thus the equilibrium profits also go up. The increase in the fees that the platform charges the buyer outweighs the decrease in the subscription fees paid by sellers. We summarise our findings in the following proposition.

Proposition 2: In the case of two competing platforms, increased seller competition leads to a decrease in the subscription charges paid by sellers and an increase in subscription charges paid by buyers and increase in the profit of each platform

3 Conclusion

Our analysis can explain as to why some platforms might push for higher standardisation of the products offered on them as it can lead to an increase their profits. The conclusions drawn would hold true where consumers do not value the distinction amongst the products of different sellers.

Appendix A

Some of the intermediate calculations for Section 2.1 are given here.

$$\frac{\partial^2 \Pi}{\partial {n_s}^2} = \frac{(k-1)kn_b\rho y{n_s}^{k-2}}{c} - 2$$
$$\frac{\partial^2 \Pi}{\partial {n_b}^2} = -2$$
$$\frac{\partial^2 \Pi}{\partial n_s \partial \rho} = \frac{kn_b y{n_s}^{k-1}}{c}$$
$$\frac{\partial^2 \Pi}{\partial n_s \partial n_b} = \frac{kry{n_s}^{k-1}}{c}$$
$$\frac{\partial^2 \Pi}{\partial n_s \partial \rho} = \frac{y{n_s}^{k}}{c} - y$$

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