TAX INCIDENCE OF TWO - SIDED MONOPOLY PLATFORMS[1]

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May 2019

Abstract

Many a market with network externalities is a two-sided platform. The present paper models a monopoly platform with buyers on one side and sellers on the other. The platform charges a fixed membership fee and a variable usage fee from both the sides and the buyers and sellers are heterogeneous in terms of the per unit benefit they derive on the transaction of the product. We characterize the equilibrium and check that whether it matches the results existing in the literature. Then we introduce ad valorem and specific tax on the buyer's side of the platform alone. While the incidence of specific tax turns out to be similar to the standard monopoly case except that the extent of deadweight loss is lower, the incidence of ad valorem tax comes with a surprise. Among the counterintuitive results in case of ad valorem tax, we find that for efficient platforms the increase in tax rate may reduce the deadweight loss and also may lead to an increase in monopoly profit. Nevertheless, the Laffer curve relation holds for both types of taxes and given the efficiency level of the platform, in the case of ad valorem tax the revenue is maximized at a higher rate than in the case of specific tax.

Points for Practitioners

The platforms provide for efficient matching of buyers and sellers. In the digital age, by reducing transaction cost, a platform increases number of transactions manifolds and develops a natural tendency to become a monopoly in the market. The prominent examples of platforms in modern world are the e-commerce firms like Amazon, Flipkart etc., Credit card firms like Mastercard, Visa, Online Dating firms like OKCupid and TrulyMadly etc. But unfortunately, we still do not have a clear idea about welfare implications of such monopolies and the effect of standard tax and regulatory instrument on them. This paper throws some light upon such monopolies. The major contribution of the paper lies in the exploration of the incidence of specific and ad valorem taxation on a monopoly platform. While the incidence of the specific tax is similar to the standard monopoly case except that the extent of deadweight loss is

[1]The usual disclaimer applies.

[2]This research work was supported by a research grant (**File No. CON/518/2018-ICS)** from the Indian Council of Social Science Research (ICSSR) awarded to Sovik Mukherjee being affiliated with the Department of Economics, Jadavpur University, Kolkata, India.

lower, the incidence of ad valorem tax comes with surprise. The results show that for the efficient platforms the increase in the tax rate may reduce the deadweight loss. While the Laffer curve effect holds for both types of taxes, given the efficiency level of the platform, for ad valorem tax the revenue is maximized at a higher rate than in the case of specific tax.

Keywords: Two sided platforms, monopoly, ad valorem tax, specific tax, Laffer curve, deadweight loss

JEL Classification Codes: H21, H22, L11, L12

1. Introduction

Two sided platforms refer to a market situation where two distinct groups interact with each other by means of a common platform. As a third-party, the platform creates a space where two groups, namely, the buyers and the sellers can get together to carry out the transaction. The number of members on the opposite side determines the value of joining the platform which is an example of cross-side externality benefit. The institution of the platform is pertinent and holds well if and only if the agents on both the buyers' side as well as the sellers' side of the platform cannot come to an 'efficient agreement' outside it. In this regard, the role of the platform in achieving efficiency becomes crucial. The matchmaking between a buyer and a seller brings about a reduction in the transaction cost which could have been very high otherwise. A list of motivating examples on various two sided platforms has been given in Table 1 below.

Table 1: Examples of two sided platforms

Platform	Segment 1 (Buyer Side)	Segment 2 (Seller Side)
Video Games	Gamer	Game Publisher
Online marketplace	Buyers	Sellers
Newspapers	Readers	Advertisers
TV Networks	Readers	Viewers
Debit and Credit cards	Cardholders	Merchants
Shopping malls	Consumers	Shops
Dating Platforms	Male (or Females)	Females (or Males)
Portals and Web Pages	Web Surfers	Advertisers
Scientific Journals	Readers	Authors

Source : Compiled by the authors

Let us consider a few of the above examples in details. In a matrimonial website, a match occurs when both the boy and the girl approve of each other within the design of the platform. Platforms like OKCupid and TrulyMadly use questionnaires and tags where users are asked to describe their ideal partners so that the platform can make a feasible match out of the many matches possible. Without the matrimonial website it would have been very costly otherwise. Similarly, when a cardholder uses his credit/debit card to settle a transaction with the seller, the card itself

acts as the platform and reduces the cardholder's burden of carrying cash. Also, for an online marketplace the buyer gets the opportunity to shop faster, pick from a wider range of products offered by different sellers without being physically present at the shop and buy from the seller with the lowest price. The variety of products one can access under one roof in a shopping mall instead of traveling from one place to another greatly reduces the transaction cost. The most sought after two sided platform in the present scenario is the e-commerce sector. Names like Flipkart, eBay, Snapdeal, Amazon, etc. now a days are a familiar name in every household. The motivation for choosing economics of two sided platform as an area of research comes from the rapid growth of the e-commerce sector not only in India but across the globe at a frenzied pace, currently estimated at $22.049 trillion across the globe and is predicted to jump to $38 billion in the next five years (eMarketer Report, 2016). It is an important part of the service sector which is the major contributor to Gross Domestic Product of the major economies.

In the recent times taxation of the service sector has become an important issue, especially after the financial crisis of 2008 and the global recession in 2010 as the governments across the globe are facing a severe constraint in financing their expenditure. Within the service sector, platforms stand out as glaring example of segments which are inadequately taxed: globally very little tax revenue is collected from the online marketplace. Different countries have different regulations regarding taxation of platforms. According to Tremblay (2016), sale of any item via the online marketplace in the United States is untaxed while in the European Union it is taxed to some extent. A recent move to tax online transactions had been proposed for introducing "Google Tax" which is applied on download of songs, movies and apps. It was put forward in Italy as a draft in 2013 but was dropped in 2014 until further progress is made at the international level. A French Expert mission on digital economy (also known as the Collin-Colin Report) proposed a framework for "Google Tax" which was eventually dropped on account of severe criticism by the European Commission. At the end of 2014, the United Kingdom government has announced a "Google Tax" – the Diverted Profit Tax which was launched in 2015 (Bacache et al., 2015). In the developing countries China has introduced an import tax of ad valorem nature on cross-border e-commerce retail imports. In India platform transactions are not taxed and "Google Tax" still remains as a proposal. Consequently service sector companies pay very little in tax. For example, Google's revenue reached about US$ 74.5 billion in 2016 and yet Google is known to be subject to low effective rates of taxation and even accused of deferring taxes on revenues over US$ 24 billion only in the US (Bourreau et al., 2016). In this backdrop, the present paper looks at the incidence of a tax on platforms. To develop the model, on the spirit of theory of optimum commodity taxation we introduce ad valorem and specific tax on the buyer's side of the platform alone. While the incidence of the specific tax is similar to the standard monopoly case except that the extent of deadweight loss is lower, the incidence of ad valorem tax comes with surprise. The results show that for the efficient platforms the increase in the tax rate may reduce the deadweight loss. While the Laffer curve effect holds for both types of taxes, given the efficiency level of the platform, for ad valorem tax the revenue is maximized at a higher rate than in the case of specific tax. But similar effects can be obtained if we introduce ad valorem and specific tax on the seller side alone.

The focus of the present paper is solely on monopoly platforms where agents singlehome similar to the framework of Rochet and Tirole (2006). There are a number of examples of monopoly platforms in reality. Sometimes, yellow pages directory of an incumbent telephone company, shopping malls or restaurants are located far off from others or when there is only one newspaper or a magazine or a journal in a particular market then the monopoly platform paradigm appears appropriate. As the matchmaking market started in India in 1997, we had Bharat Matrimony as the only online matrimonial website. Even the example of Adobe Reader, a few years back, as a software for viewing any form of electronic document in 'Portable Document Format (PDF)' is a very good example in this regard.

The research on tax on two sided platforms so far has remained mostly unexplored. Some recent papers like — Belleflamme and Toulemonde (2016) report counter intuitive results like imposition of a higher tax on the platform transaction may actually be a boon for the platform through the strategic complementarities effects i.e. the effect on the platform's profit through the modification of the other platform's equilibrium prices. However, Belleflamme and Toulemonde (2016) derive this result in the case of competing platforms. This paper makes an attempt to explore the

incidence of taxation on a monopoly platform and checks whether similar results hold. It looks at both the cases of ad valorem tax and specific tax. Interestingly, the results show that in the case of ad valorem tax an increase in the tax rate may well increase the platform's profit and the user base under certain conditions. Thus, this paper provides an explanation to the empirical finding that Adobe being subject to taxes in countries like USA, Canada has increased its profits massively in the last decade when it was actually a monopoly till July'2008 (Google Finance, 2016; McLure, 2003).The rest of the paper is organized as follows. A select literature on issues relating to two sided platforms has been reviewed in Section 2. Section 3 presents the theoretical model and derives the results. The section following concludes.

2. Review of Select Literature

The analysis of two sided platforms in the literature is mostly industry specific. The payment card industry in particular, has been the subject matter in Rochet and Tirole (2002), Schmalensee (2002), Rochet and Tirole (2008) among others. Caillaud and Jullien (2001), Ellison et al. (2004), Jullien (2005) and Katsamakas and Bakos (2008) evaluate internet intermediary platforms. In the present context, their analysis can be thought of as best suited to website based platforms like Flipkart, Snapdeal, Amazon, eBay, OLX, Magicbricks, etc. Moving on to media and telecommunications sector, studies by Ferrando et al. (2003) and Jeon et al. (2004) have their contributions based in this sector while the study by Church et al. (2008) deal mostly with software platforms in the computer market. Schmalensee and Evans (2007) and Ryasman (2009) deliberated on a strategy for platforms, namely, how the platforms should set the prices for consumers on both the buyers' and the sellers' side in the newspaper, payment cards and computer operating system industries. Moving from the sector specific studies to the general studies on pricing theory of competing two sided platforms, the papers include Rochet and Tirole (2003; 2006), Caillaud and Jullien (2003), Armstrong (2006), Hagiu (2007; 2009) and Weyl (2010). The present paper follows the strand of the literature pioneered by Rochet and Tirole (2003).

Rochet and Tirole (2003) although draws its motivation from the study of credit card market, introduces a general theoretical model of monopoly platform and then moves into the paradigm of platform competition. The results bring out the determinants of price allocation and end-user surplus for both profit-maximizing and non-profit platforms. Moreover, it compares the competitive outcome with the integrated monopoly equilibrium on one hand, and the welfare maximizing equilibrium on the other. For much of the work by Rochet and Tirole (2003), the platform levies charges completely on a per-transaction basis, and there are no lump-sum membership fees for either of the sides. But a number of two sided platforms like payment cards such as American Express charges yearly fees to cardholders. Similarly, software platforms like Microsoft Windows charges an amount from the consumers, videogame platforms like Nintendo charge gamers for the videogame consoles, etc. The decision of joining the platform in turn is contingent on the size of the membership fee. Clearly, membership fees also must be an integral part of the pricing structure of a platform. Rochet and Tirole (2003) constructs a game where a platform decides on charges both on the buyer side and the seller side in the first period followed by a simultaneous move game on deciding about joining the platform between the agents on the buyer and the seller side in the next period. The problem is that neither the buyer side nor the seller side will join the platform until and unless the other side under consideration is suitably large. Caillaud and Jullien (2003) have termed this problem as the celebrated "Chicken-and-Egg-Problem" where both sides of the market affect each other and no side can emerge without the other. However, Caillaud and Jullien (2003) did not offer a clarification on how to resolve this "Chicken-and-Egg-Problem". Caillaud and Jullien (2003) deliberate mostly on dating agencies, real estate agents, and "B to B" websites by building up a two-stage model with two platforms. In the first stage, both platforms set the charges simultaneously and non-cooperatively. The resulting price system is publicly observable and in the second stage, the consumers on both the buyer and the seller side decide with which platform they are going to register with. One of

the crucial aspects of their paper is the comparison between singlehoming and multihoming in two sided competing platforms.

The "Chicken-and-Egg-Problem" was theoretically solved by Hagiu (2006) where he develops a model in which the sellers first decide on joining the platform followed by the buyers. The buyers will choose that platform amongst the competing platforms which not only have more supporting sellers but also maximize the buyers' payoff from joining the platform after taking into account the platforms' charges. Hagiu (2006) shows that platforms charge a lower price from the buyer side to attract a larger share of buyers which in turn permits the platforms to charge a higher price from the sellers to maximize its own profit. Hagiu (2006) also points out that the basis of the "Chicken and Egg" problem lies in the asymmetry of information between the agents on both the buyer and the seller side. However, given the frenzied pace of revolution in information technology it seems that asymmetry of information argument is not tenable as both the buyers and the sellers know that there is a market on the other side and the simultaneous move in joining the platform is very reasonable. The present paper departs from the literature by relaxing the sequential move assumption on buyers' and sellers' decision of joining the platform and sticks to the simultaneous move situation.

Moving to the fee structure of platforms, a number of issues have been discussed in the literature. It was for the first time that Armstrong (2006) followed by Rochet and Tirole (2006) brought in the concept of platforms competing in "two-part tariffs" i.e. a fixed fee plus a fee proportional to the number of members on the other side. Armstrong (2006) discusses three different models of two sided markets. First one is a model of monopoly benchmark platform in the context of a dating platform; the second one is a model of competing platforms where agents on both the sides singlehome; and the third one is a model based on a situation where the agents on one side singlehome but on the other side multihome. The emphasis is on the role of relative price elasticities of demand on the two sides of the platform in determining the platform's pricing structures. Under a situation of monopoly platform, he shows that the price charged by the platform on one side falls when the number of agents on the other side increases. In each of the models mentioned above, Armstrong (2006) compares equilibrium prices with regard to the extent of cross group externalities on the platform. It also predicts the effect of introducing competition on the seller side of a monopoly platform and shows that the intra-platform competition leads to charging lower price on the seller side and higher price on the buyer side provided there is a fixed membership fee on the buyer side. Hagiu (2009) fits in product variety in the framework proposed by Armstrong (2006). Two major results proposed by Hagiu (2009) are — first, in the case of a monopoly platform, stronger preferences for product variety make products less substitutable which enable the platform to make a larger profit on producers as opposed to the consumers. Second, in case of competing platforms, more love for variety on part of the consumers leads to more market power in the hands of the producers and reduces the effectiveness of the platform's price cutting strategy on the buyer side. The contribution of Chowdhury and Martin (2013) lies in modeling exclusion on two sided platforms. They do it in the context of newspaper industry by using the framework proposed by Armstrong (2006). In the model a press syndicate supplies a vital complementary good to a duopoly of newspaper network platform that in turn serves the advertisers and readers. The results show that the press syndicate granting a license to any one of the newspaper platforms can make the other one unprofitable and may drive it out from the market subject to a strong reader preference.

Moving to the existing empirical literature on two sided platforms, Goolsbee (2000) discusses the consequences of electronic commerce on fiscal policy for the US economy. It reports findings of a survey which shows that in states where sale tax is higher and buying online is comparatively cheaper, individuals always prefer online transactions controlling for individual characteristics like age, income, education, marital status, minority status, etc. On a similar note, Brynjolfsson and Smith (2000) make use of primary data from individuals' behaviour in online shopping of books and find that individuals strongly favour book sellers in the state with lower tax rate. In another paper, Goolsbee (2000a) argues that allowing the states to apply sales taxes on e-commerce transactions could significantly delay the development of small-sized markets and generate loss twice more than the traditional deadweight loss. This happens because taxing a new technology that has fixed costs associated with adoption can lead to a delay in

adoption and a subsequent loss of consumer and producer surplus as compared to taxing a conventional good. Goolsbee (2001) carries out a study on the purchase decision of buying a computer of 20,000 Americans using two alternatives : either online or through a retail store. The study uses data from a survey *Technographics 99* carried out by a marketing research company named Forrester Research. It comes to a conclusion that the decision to buy the computer online depends not only on the price of the computers online but on the price of the computers in retail stores and varies even with the type of customer (US metro area customers and US non-metro area customers) and brands of computer (like Compaq, IBM, Acer, HP, Dell, Toshiba, etc.). Evans (2003) in the American context discusses two specific case studies relating to Diners Club and American Express cards in the payment cards industry and Palm Operating System in the software industry and highlight on their multi sided platform properties. But empirical research in harmony with the existing theoretical literature is still lacking.

There exists a rich body of theoretical literature on taxation issues on a multi sided platform that has grown up in the recent years starting with the works of Kind, Koethenbuerger and Schjelderup (2008, 2009, 2010) on the impact of ad valorem and unit taxes on both the viewer and the advertiser in case of competing advertising mediums. In their 2010 paper, they show that the imposition of a higher ad valorem tax on the buyers' side does not necessarily lead to a hike in the price charged by the platforms from the buyer side and quite interestingly, Belleflamme and Toulemonde (2016) obtains the same result using unit tax in the context of accommodation platforms in USA like Airbnb. Also, Belleflamme and Toulemonde (2016) comes up with a novel conclusion in the context of competition between two platforms. Their results show that imposing a specific tax on one of the competing platforms may end up increasing the profit of the taxed platform (which they have called 'lucky break') or reducing it twice (called 'double jeopardy'). In another paper Kind, Koethenbuerger and Stähler (2013) motivate their theoretical model from the existence of the low VAT rates on newspapers and lack of high investments in journalism in USA. Their results show that given the media industry operates in a two-sided market, low VAT rates may actually lead to the newspaper prices being higher and investments in journalism lower than what would otherwise have been the case. In the context of a digital monopoly platform, Bourreau, Caillaud and De Nijs (2016) have shown that imposition of an ad valorem tax is passed onto sellers' side (the advertisers) and not on the buyers when there is no charge for data usage on the buyers' side. Nevertheless, at the initial equilibrium if the platform charges subscription fees from the users on the buyer side then the effect of an increase in ad valorem taxes on the platform's profit gets passed on to both the sides. Also, in the context of sequential decisions of entry and transactions, Tremblay (2016) shows that below a critical level of marginal cost, the imposition of an ad valorem tax on the buyer side of a monopoly platform leads to a fall in the prices charged on the buyer side. The present study, unlike its predecessors, looks at the implementation of the two alternative taxation schemes and its impact on the government's revenue collections and the dead weight loss in the context of two-sided monopoly platforms like the dating platforms.

3. The Model & Results

Consider a two sided market. The two sides of the market are denoted by B and S where, B stands for the buyers' side and S stands for the sellers' side of it. The market is served by a monopoly platform. The marginal cost of arranging a transaction between any two members on opposite sides is given by $c < 1$. It has been assumed that on each side $i = B, S$ there exists intra-group heterogeneity in terms of the per transaction benefit b_i derived by the agents. We have assumed that the population of buyers and sellers have a measure of 1 and b_i is uniformly distributed over the continuum [0,1]. The platform charges end-users of each side of the platform a fixed membership fee (*ex ante*) $A_i(\forall\ i = B, S)$, and a usage fee (*ex post*) of $a_i(\forall\ i = B, S)$ per transaction. The number of consumers to the platform on the buyers' side is given by N_B and on the sellers' side is given by N_S. We also assume that no direct transaction between the buyers and the sellers is possible, it happens only through the platform. Also, everyone who joins the platform enters into a transaction on the platform.

The net utility of a particular agent on side i having usage benefit b_i is defined as,

$$U_i = (b_i - a_i)N_j - A_i \quad \forall \quad i,j = B,S;\ i \neq j. \tag{1}$$

We assume that only those agents with non-negative values of their net utility join the platform and carry out transactions. Therefore, the number of agents on side i who wishes to join the platform is derived as,

$$N_i = Pr(U_i \geq 0) \forall\ i = B,S. \tag{2}$$

Substituting from (1) which can be written as :

$$N_i = Pr\left((b_i - a_i) - \frac{A_i}{N_j} \geq 0\right) \forall\ i,j = B,S; i \neq j$$

Following Rochet and Tirole (2004), we assume that the platform sets the per-interaction price as,

$$p_i = a_i + \frac{A_i}{N_j}\ \forall\ i,j = B,S; i \neq j. \tag{3}$$

The number of agents on the ith side of the market must be :

$$N_i = Pr(b_i \geq p_i)\ \forall\ i = B,S. \tag{4}$$

Since b_i is uniformly distributed over [0,1] continuum, (4) implies,

$$N_i = 1 - p_i. \tag{5}$$

Equation (5) can be elaborately expanded by putting $i,j \in \{B,S\}, i \neq j$ to get,

$$N_B = 1 - p_B, \tag{6}$$

$$N_S = 1 - p_S. \tag{7}$$

Equation (6) and (7) denote the buyers' and sellers' demand for platform services respectively. The demand for platform services on each side not only depends negatively on the usage fee charged by the monopoly platform per transaction but also on average fixed fee $\frac{A_i}{N_j}$. Since the average fixed fee falls with the number of agents on the opposite side of the platform, a positive network externality is generated from the other side.

The platform's profit is given by :

$$\pi = A_B N_B + A_S N_S + (a_B + a_S - c)N_B N_S \tag{8}$$

The first term on the right-hand side of equation (8) denotes the revenue earned by the platform from the charge of fixed membership fee from the buyer side. Similarly, the second term represents the revenue earned from fixed membership fee from the seller side. The third term stands for the net revenue earned from the charging of per-transaction usage fee from both the sides, where $N_B N_S$ represents the number of transactions on the platform[3].

Using (3), equation (8) can be rewritten as,

$$\pi = (p_B + p_S - c)N_B N_S \tag{9}$$

Notice that for the purpose of profit maximization what matters for the monopoly platform is not the individual prices p_B and p_S charged to the respective buyers and sellers but the total amount collected per transaction. A transaction is not complete unless a buyer meets a seller. Defining $p = p_B + p_S$ as the amount collected per transaction, from (6) and (7) it follows :

$$p = 2 - N_B - N_S \tag{10}$$

Using (10) in (9), the monopoly platform's problem can alternatively be written as maximization of

$$\pi = (2 - N_B - N_s - c)N_B N_s \tag{11}$$

by choice of $\{\widetilde{N}_B, \widetilde{N}_S\}$.

[3]This has been defined consistent with Hall's Marriage Theorem which states that an efficient pairing exists out of an entire set of pairings if and only if for every subset of boys, the number of girls they collectively like is at least as much as the number of boys in the subset, and similarly for girls. Here, this is exactly how we model it and find the the equilibrium number of efficient matches , i.e. $\widetilde{N}_B \widetilde{N}_S$ out of an entire set of matches.

Proposition 1 : (i) *The total number of transactions on a monopoly platform is given by* $\left(\frac{2-c}{3}\right)^2$. *The platform collects* $\frac{2(1+c)}{3}$ *per transaction and earns a profit of* $\left(\frac{2-c}{3}\right)^3$.

(ii) *The price charged on buyers' side and sellers' side are given by* $(a_B + \frac{3A_B}{2-c})$ and $(a_S + \frac{3A_S}{2-c})$ *respectively.*

(iii) *At the equilibrium one unit reduction in the fixed membership fee increases the per unit usage fee on each side of platform by* $\frac{3}{2-c}$ *units.*

Proof : (i) Assuming existence of an interior solution, the first order condition for platform's maximization exercise yields,

$$\frac{\partial \pi}{\partial N_B} = 0 \implies -N_B + (2 - N_B - N_s - c) = 0, \qquad (12)$$

$$\frac{\partial \pi}{\partial N_S} = 0 \implies -N_s + (2 - N_B - N_s - c) = 0. \qquad (13)$$

that solve for $\widetilde{N}_B = \widetilde{N}_S = \frac{2-c}{3} > 0$. The number of transactions on the platform is given by $\widetilde{N}_B\widetilde{N}_S = \left(\frac{2-c}{3}\right)^2$. The values of $\tilde{p}$ and $\tilde{\pi}$ are derived from equation (10) and (11). The statement of the first part of the proposition follows.

(ii) The second part of the proposition follows by substitution of $\widetilde{N}_B$ and $\widetilde{N}_S$ in (6) and (7) respectively.

(iii) Substituting $\widetilde{N}_j$ in equation (3), given equilibrium value of p_i, we obtain :

$da_i = -\frac{3}{2-c} dA_i \; \forall \; i, j = B, S.$

The statement of the second part of the proposition follows. □

Notice from proposition 1 above that the equilibrium number of transactions ($\widetilde{N}_B\widetilde{N}_S$), the collection of the platform per transaction and profit of the platform are derived as function of the unit cost of arranging transactions. In the comparative static exercise below we have derived the sensitivity of the equilibrium due to the change in the unit cost. Also notice that although the model can solve for the equilibrium prices charged on the two sides of the platform, it cannot derive the unique combination of per unit usage fee and fixed membership fee on either of the sides. However, on either side there exists a trade-off between the fixed fee and per unit usage fee charged by the platform : higher is the fixed fee, lower is the per unit usage fee. The second part of the proposition identifies the exact tradeoff that is going to exist at the equilibrium. Since $c < 1$ the effect of one unit reduction of the fixed membership fee gets multiplied by a factor of $\frac{3}{2-c}$ to increase the rate of per unit usage fee.

Proposition 2 : *As the unit cost of servicing transactions on a platform rises (i) the number of transactions on the platform falls; (ii) the collection of the platform per transaction rises less than the rise in the unit cost; (iii) the price rises on both the sides of the platform; (iv) the profit of the platform falls; (iv) if the membership fee falls, the usage fee per transaction rises at a higher rate on each side of platform.*

Proof : It follows from proposition 1 that $\frac{d\tilde{p}}{dc} = \frac{2}{3}, \frac{d\tilde{p}_B}{dc} = \frac{3A_B}{(2-c)^2}, \frac{d\tilde{p}_S}{dc} = \frac{3A_S}{(2-c)^2}, \frac{d\tilde{\pi}}{dc} = -\left(\frac{2-c}{3}\right)^2$ and $\frac{d(\widetilde{N}_B\widetilde{N}_S)}{dc} = -\frac{2}{3}\left(\frac{2-c}{3}\right)$. Since $c < 1$, $\frac{d(\widetilde{N}_B\widetilde{N}_S)}{dc} < 0$. The statement of the last part of the proposition follows since $c < 1$ and $da_i = -\frac{3}{2-c} dA_i \; \forall \; i, j = B, S.$ □

As the marginal cost of servicing each transaction on the platform rises, given the marginal benefit at the equilibrium, the profit maximizing monopoly platform prefers to restrict number of transactions on the platform. Therefore, it reduces number of members of the platform on both sides which automatically reduces the number of transactions on the platform. But in doing so it raises the price per transaction on the platform : higher is the fixed

membership fee, the sharper is the rise in price. But since the collection per transaction rises less than the rise in transaction cost, the profit of the platform falls. So proposition 2 predicts an inefficient platform will have a lower membership base and a lower profit. Also, if such a platform reduces its membership fee per unit usage fee charged by it increases at a higher rate.

3.1 A tax on the buyers' side

Now we consider imposition of a tax on the buyers' side of the market on transaction of the good from the platform. The absence of tax on the sellers is in line with theory of optimum commodity taxation. In particular we consider two different kinds of taxes : an ad valorem tax at the rate of $t \in (0,1)$ on the price charged by the platform to the buyers; and a specific tax $t \in (0,1)$on per unit of the good sold to buyers. First we consider the case under the ad valorem tax and then we move to the case of specific tax.

<u>Case 1 : Ad valorem tax</u>

With tax the buyer's price of the good becomes $p_B' = p_B(1+t)$ where p_B is the price received by the platform. Consequently, the demand for the platform's service on the buyer's side is given by (from equation (6) above) :
$N_B = 1 - p_B'$.
using $p_B' = p_B(1+t)$ the inverse demand function can be rewritten as :

$$p_B = \frac{1-N_B}{(1+t)}. \qquad (14)$$

From equation (9) the monopoly platform's profit function therefore becomes :

$$\pi = \left(\frac{1-N_B}{(1+t)} + 1 - N_s - c\right) N_B N_s \qquad (15)$$

which is maximized by the choice of $\{\widetilde{N}_B', \widetilde{N}_S'\}$. Substituting $\widetilde{N}_B'$ and $\widetilde{N}_S'$ in (10) gives $\tilde{p}'$at the equilibrium. The platform's profit at the equilibrium is derived as $\tilde{\pi}'$ by substituting $\widetilde{N}_B'$ and $\widetilde{N}_S'$ in (15).

Proposition 3 : (i) *The total number of transactions on the monopoly platform is given by* $\frac{1}{9(1+t)}[2+(1-c)t-c]^2$. *The platform collects* $\frac{2(1+c)+t(1+2c)}{3(1+t)}$*per transaction and earns a profit of*$\frac{1}{(1+t)^2}\left(\frac{2+(1-c)t-c}{3}\right)^3$.
(ii) The price charged on the buyers' side and the sellers' side is given by $\frac{[1-(1-c)t+c]}{3}$ and $\left[\frac{2+c}{3} - \frac{1}{3(1+t)}\right]$respectively.
(iii) *The government collects per transaction revenue of* $\frac{t[1-(1-c)t+c]}{3(1+t)}$.

Proof : (i) Assuming existence of an interior solution, the first order condition for platform's maximization exercise yields,

$$\frac{\partial \pi}{\partial N_B} = 0 \implies -\frac{N_B}{1+t} + \left(\frac{1-N_B}{1+t} + 1 - N_s - c\right) = 0 \qquad (16)$$

$$\frac{\partial \pi}{\partial N_S} = 0 \implies -N_s + \left(\frac{1-N_B}{1+t} + 1 - N_s - c\right) = 0 \qquad (17)$$

that solves for $\widetilde{N}_B' = \frac{1}{3}[2+(1-c)t-c] > 0$ and $\widetilde{N}_S' = \frac{1}{3}\left[\frac{1}{1+t} + 1 - c\right] > 0$. The number of transactions on the platform is given by $\widetilde{N}_B'\widetilde{N}_S' = \frac{1}{9(1+t)}[2+(1-c)t-c]^2$. The values of $\tilde{p}$ and $\tilde{\pi}$ are derived from equation (10) and (11) by substituting $\widetilde{N}_B'$and $\widetilde{N}_S'$. The statement of the first part of the proposition follows.
(ii) $\tilde{p}_B$and$\tilde{p}_S$are calculated by substitution of $\widetilde{N}_B'$ and $\widetilde{N}_S'$ in equation (14) and (7) respectively. Then we calculate $\tilde{p}_B' = \tilde{p}_B(1+t)$.
(iii) Per transaction revenue collected by the government is given by $\tilde{p}_B t = t.\frac{1-\widetilde{N}_B'}{(1+t)}$ (using equation (14)). Since $\widetilde{N}_B' = \frac{1}{3}[2+(1-c)t-c]$ the statement of the second part of the proposition follows. □

Notice from proposition above that although the tax is imposed on the buyers' side, its effects fall not only the buyers' side alone, also affects the price and the membership base on the seller's side. This happens because of the externality that exists between the two sides of the platform. In the comparative static exercise below we derive sensitivity of the equilibrium due to the change in the tax rate.

Proposition 4 : *As the tax rate rises (i) the number of transactions on the platform rises (falls) if* $t > t_T(c) = \frac{c}{1-c}\left(t < t_T(c)\right)$*; (ii) the number of buyers rises while the number of sellers falls; iii) the price charged on the buyer side falls while on the seller side it rises; iv) the platform's collection per transaction rises (falls) if* $t > t_p(c) = \frac{2(1+c)}{3(1+2c)}\left(t < t_p(c)\right)$*; (iv) the profit of the platform rises; v) the revenue of the government rises (falls) if* $t < t_R(c) = \left[-1 + \sqrt{\frac{2}{1-c}}\right]\left(t > t_R(c)\right)$.

Proof : It follows from proposition 3 that $\frac{\partial \tilde{N}_B{}' \tilde{N}_S{}'}{\partial t} = \frac{[2(1+t)(1-c)(2+[1-c]t-c)]-(2+[1-c]t-c)^2}{9(1+t)^2}$ is positive (negative) $if\ t > t_T(t < t_T)$; $\frac{\partial \tilde{N}_B'}{\partial t} = \frac{1-c}{3} > 0$; $\frac{\partial \tilde{N}_S'}{\partial t} = -\frac{1}{3(1+t)^2} < 0$; $\frac{\partial p_B{}'}{\partial t} = -\left(\frac{1-c}{3}\right) < 0$; $\frac{\partial p_S{}'}{\partial t} = \frac{1}{3(1+t)^2} > 0$; $\frac{\partial \tilde{\pi}'}{\partial t} = \frac{(1-c)}{(1-t)^2}\left[\frac{(2+\{1-c\}t-c)^2}{3}\right] + 2\left(\frac{1}{1-t}\right)^3\left[\frac{(2+\{1-c\}t-c)}{3}\right]^3 > 0.$

The platform's collection per transaction rises (falls) with per unit change in *t* is given by $-\frac{2(1+c)}{3(1+t)^2} + \frac{3(1+t)(1+2c)-3(1+2c)}{3(1+t)^2}$ which is positive (negative) if $t > t_p(c)\left(t < t_p(c)\right)$.

Similarly, the change in the government's revenue collection per unit rise in *t* is given by $\frac{3(1+t)[1-2t\{1-c\}+c]-3[t-\{1-c\}t^2+ct]}{3(1+t)^2}$ which can be positive (negative) depending on whether we have $t < t_R(c)\left(t > t_R(c)\right)$.

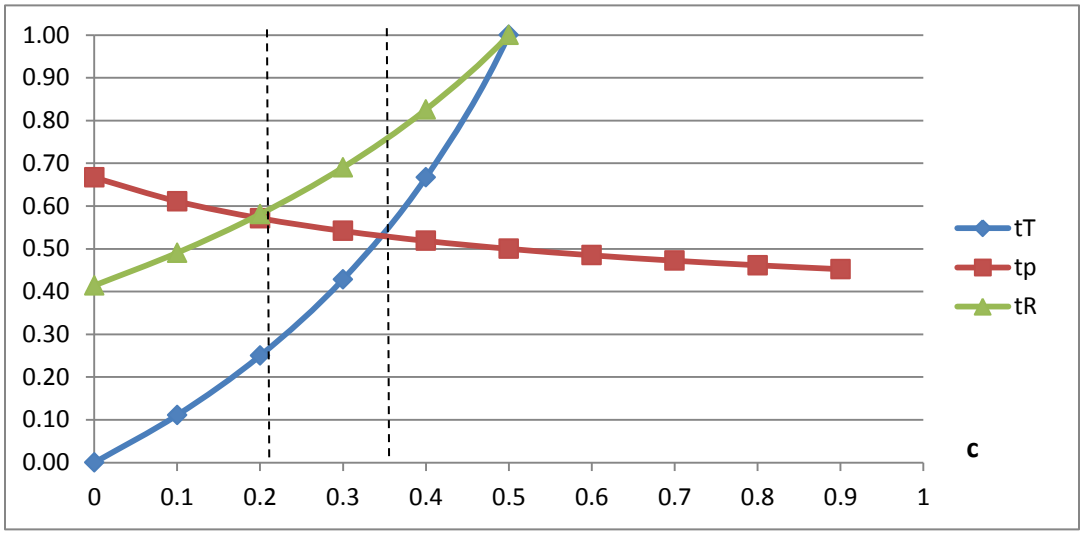
Since $c < 1$, the statement of the proposition follows. □

The results derived in the case of ad valorem tax are not entirely consistent with the standard textbook monopoly results. A rise in the ad valorem tax rate on the buyers' side leads the monopoly platform to serve higher number of buyers. As the tax rate rises it follows from equation (16) that in the direct effect both marginal cost and marginal benefit of choosing higher number of buyers falls. The higher is the membership base on the buyers' side at the initial equilibrium the fall in the marginal cost is higher than the fall in the marginal benefit. Since there is no tax on the sellers' side, it follows from equation (17) that due to rise in the tax on buyers' side, only the marginal benefit from choice of higher number of members on the sellers' side falls (due to lower price per transaction received by the platform). The marginal cost remains unaffected. So the platform chooses less number of members on the sellers' side, which also has an indirect effect on the choice of membership base on the buyers' side. The less number of members on the seller's side raises the marginal benefit for choosing higher number of members on the buyers' side (from equation (16)) which reinforces the fact that with the choice of higher membership base on the buyers' side the fall in marginal cost dominates the fall in marginal benefit. Therefore, the platform chooses higher number of members on buyers' side. So the network effect from one side of platform to the other side has an important bearing on the results derived in Proposition 4. In the context of competing platforms, Koethenbuerger and Schjelderup (2010) and Bourreau, Caillaud and De Nijs (2016) show that the imposition of a higher ad valorem tax on the buyers' side does not necessarily lead to a hike in the price charged by the platforms from the buyer side. Proposition 4 shows that the price charged on the buyers' side definitely falls. Interestingly, the imposition of an ad valorem tax leads to a rise in the profit of the monopoly platform unambiguously. This counterintuitive result supports the case of "lucky break" proposed by Belleflamme and Toulemonde (2016).

Proposition 4 highlights the role the efficiency of the platform plays in the ambiguous behavior of some of the endogenous variables of the model as the equilibrium number of transactions on the platform, the platform's

collection per transaction and the government's revenue from imposition of the tax. To illustrate this we simulate the model with respect to the different possible values of cost of servicing per transaction $c \in [0, 1)$ on the platform. First we plot the $t_T(c)$, $t_p(c)$ and$t_R(c)$ curves in Figure 1 below.

Figure 1 : Effect of raising the tax rate on number of transactions, collection per transaction and the government revenue



The tax rate $t \in [0, 1)$is also represented on the vertical axis. Note $t_p(c)$ intersects with $t_R(c)$ at $c_1 = 0.2$ and with $t_T(c)$at $c_1 = 0.35$. Suppose the platform is very efficient i.e. $0 < c' < 0.2$ and the government raises the ad valorem tax rate starting from a no tax situation. As the tax rate rises from this initial equilibrium, Proposition 4 tells us that it must be case that the volume of total transactions falls, the collection of the platform per transaction falls and the government's revenue rises. Starting from a higher tax rate $t_T(c')$, nevertheless, will increase the volume of transactions on the platform. The number of transactions is minimized at $t_T(c')$. The revenue of the government is maximized at a tax rate corresponding to $t_R(c')$. It is evident that for efficient platforms $c < 0.5$ imposition of ad valorem tax creates the Laffer curve effect. For inefficient platforms ($c \geq 0.5$) the rise in ad valorem tax raises government's revenue from tax but as number of transactions falls, the deadweight loss increases.

Case 2 : Specific tax

With tax the buyers' price of the good becomes $p_B'' = (p_B + t)$ where p_B is the price received by the platform. Consequently from equation (6) above the demand for the platform's service on the buyers' side becomes :

$N_B = 1 - p_B''$.

Using $p_B'' = (p_B + t)$ the inverse demand function can be rewritten as :

$$p_B = 1 - N_B - t \qquad (18)$$

From equation (9) the monopoly platform's profit, now, is :

$$\pi = (1 - N_B - t + 1 - N_s - c)N_B N_s \qquad (19)$$

which is maximized by the choice of $\{\widetilde{N}_B'', \widetilde{N}_S''\}$. Substituting $\widetilde{N}_B''$ and $\widetilde{N}_S''$ in (10) gives $\tilde{p}''$ at the equilibrium. The platform's profit at the equilibrium is derived as $\tilde{\pi}''$ by substituting $\widetilde{N}_B''$ and $\widetilde{N}_S''$ in (19).

Proposition 5 : (i) *The total number of transactions on the monopoly platform is given by* $\left[\frac{2-c-t}{3}\right]^2$. *The platform collects* $\frac{2+2c-t}{3}$ *per transaction and earns a profit of* $\left[\frac{2-c-t}{3}\right]^3$.

(ii) *The price charged on the buyers' side and the sellers' side is given by* $\frac{[1+c+t]}{3}$ *and* $\frac{[1+c+t]}{3}$ *respectively.*

(iii) *The government collects per transaction revenue of* $\frac{t[1+c-2t]}{3}$.

Proof : (i) Assuming existence of an interior solution, the first order condition for platform's maximization exercise yields,

$$\frac{\partial \pi}{\partial N_B} = 0 \implies -N_B + (1 - N_B - t + 1 - N_s - c) = 0 \qquad (20)$$

$$\frac{\partial \pi}{\partial N_S} = 0 \implies -N_s + (1 - N_B - t + 1 - N_s - c) = 0 \qquad (21)$$

that solve for $\widetilde{N}_B'' = \frac{2-c-t}{3} > 0$ and $\widetilde{N}_S'' = \frac{2-c-t}{3} > 0$. The number of transactions on the platform is given by $\widetilde{N}_B''\widetilde{N}_S'' = \left[\frac{2-c-t}{3}\right]^2$. The statement of the first part of the proposition follows.

(ii) p_B and p_S are calculated by substitution of $\widetilde{N}_B''$ and $\widetilde{N}_S''$ in equation (18) and (7) respectively. Then we calculate $p_B'' = (p_B + t)$.

(iii) Per transaction revenue collected by the government is given by $p_B t = t(1 - N_B - t)$ (using equation (18)). Since $\widetilde{N}_B'' = \frac{2-c-t}{3}$ the statement of the third part of the proposition follows. □

Notice from proposition above that similar to the case of ad valorem tax here also the tax imposed on the buyers' side affects both the sides of the platform which is due to the externality existing between them. However, in contrast to the case of ad valorem tax here the effects are symmetric on the two sides of the platform. In the comparative static exercise below we derive sensitivity of the equilibrium due to the change in the tax rate.

Proposition 6 : *As the tax rate rises (i) the number of transactions on the platform falls; (ii) both the number of buyers and sellers falls; iii) the price charged on both the buyer side as well as the seller side rises; iv) the platform's collection per transaction falls; (iv) the profit of the platform falls; v) government revenue rises (falls) if and only if* $t < t_S(c)\big(t > t_S(c)\big)$ *where* $t_S(c) = \frac{1+c}{4}$.

Proof : It follows from proposition 5 that $\frac{\partial(\widetilde{N}_B''\widetilde{N}_S'')}{\partial t} = -\frac{2(2-c-t)}{9} > 0$ since $c < 1$. Also,

$\frac{\partial \widetilde{N}_i''}{\partial t} = -\frac{1}{3}\ \forall\, i = B, S$; $\frac{\partial \tilde{p}_B''}{\partial t} = \frac{1}{3}$; $\frac{\partial \tilde{p}_S}{\partial t} = \frac{1}{3}$; $\frac{\partial \tilde{\pi}''}{\partial t} = -\frac{3(2-c-t)^2}{27}$; $\frac{\partial \tilde{p}''}{\partial t} = -\frac{1}{3}$.

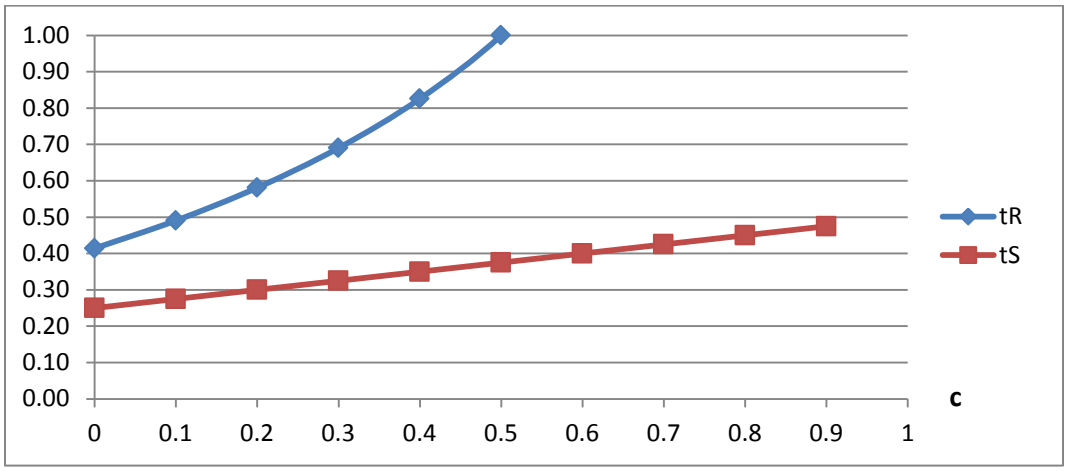
We also know that $\frac{\partial(p_B t)}{\partial t} = \frac{(1+c-4t)}{3}$ which is positive if and only if $t < t_S(c)$ and negative if and only if $t > t_S(c)$. The statement of the proposition follows. □

A rise in the specific tax rate leads to a fall in marginal benefit from choosing higher membership base both on the buyers' side and sellers' side (follows from equations (20) and (21) above). However, the marginal costs do not change. Therefore, equilibrium choice of both N_B and N_S falls, the total number of transactions falls and the prices faced by the agents on both sides of the platform rise. Since price per unit of transaction received by the platform falls as the tax rate rises the effect on per unit revenue received by the government is ambiguous. The results are similar to the standard monopoly case adjusted for the externality effect. Notice that here due to rise in 1 unit of tax rate price on both sides of the platform rise by $\frac{1}{3}$ units which is less than the standard monopoly case of $\frac{1}{2}$ units. This happens because here due to the externality effect as the tax rate rises the extent of fall in marginal benefit from the choice of higher membership base is lower than the standard monopoly case (see equations (20) and (21)). So the fall in membership base is not as much as that would have happened in the standard monopoly case.

In contrast to the case of ad valorem tax Proposition 6 shows that given the efficiency level of the platform as the tax rate rises it is always the case that the deadweight loss rises as the total number of transactions falls. The per unit

revenue collection of the government however shows Laffer curve behavior as the revenue is maximized at $t_S(c)$. In Figure 2 given below we compare $t_R(c)$ and $t_S(c)$ for values of $c \in [0, 1)$. From Figure 2 notice that independent of efficiency level of the platform $t_R(c)$ is higher than $t_S(c)$ which implies: at a given c if the tax rate is increased beyond $t_S(c)$ even if in a specific tax regime per unit revenue collection starts falling, it continues to rise in an ad valorem tax regime. Therefore, the Laffer curve effect holds for both types of tax, given the efficiency level of the platform for ad valorem tax the revenue is maximized at a higher rate than in the case of specific tax.

Figure 2 : Comparison of per unit revenue collection of the government at the same rate of ad valorem and specific tax



4. Conclusion and Future Scope of Research

The central objective of the paper is to study the incidence of two particular forms of commodity taxes *viz.* an ad-valorem and a specific tax on a two-sided monopoly platform. We derive the results on the assumption that the agents are heterogeneous in terms of the per unit benefit they derive on the transaction of the product on both the sides of the platform. The equilibrium choice of transactions and fees charged by the platform reflects the externality that is present between the two sides of the platform. First, we check that the results of the model conform to the existing wisdom about monopoly market: an inefficient platform has lower membership base and charges higher price on both the sides of the platform. Also, we notice if such a platform with higher unit cost reduces its membership fee, per unit usage fee charged by it increases at a higher rate. Then following the intuition of the theory of commodity taxation, we introduce ad valorem and specific tax on the buyer's side of the platform alone. While the incidence of the specific tax is similar to the standard monopoly case except that the extent of deadweight loss is lower, the incidence of ad valorem tax comes with surprise. The results show that for the efficient platforms the increase in the tax rate may reduce the deadweight loss by lowering the price faced by the agents on both the sides of the platforms. It also raises the platform's profit. This counter intuitive result supports the rationale of "lucky break" proposed by Belleflamme and Toulemonde (2016). While the Laffer curve effect holds for both types of tax, given the efficiency level of the platform for ad valorem tax the revenue is maximized at a higher rate than in the case of specific tax. It should be noted that if the government imposes tax on the seller side of the platform instead of the buyer side, similar effects can be observed on the seller side as well.

The future research can extend the paper in many ways. First, the robustness of the results derived in the present paper can be checked by relaxing the some of the crucial assumptions of the model. For example, one can relax the assumptions that everyone who registrars themselves with the platform necessarily finds a match and carries out a transaction, which is not realistic. The model assumes the sellers sell homogeneous products on the platform. One can relax this assumption by introducing heterogeneous products in the model. Second, one can also derive the

conditions under which the co-existence of brick-mortar shops along with the monopoly platforms is possible. Third, despite the rise of several matchmaking platforms, people are finding it difficult to find a match for themselves because of 'platform congestion'. For example, in the process of finding out a partner from a list of potential partners, users generally must go through the profiles of a large number of people they are unlikely to be interested in before they can find a potential partner of their choice. Given the strong preferences people have these days; this can give rise to the concept of a platform broker as Shashidhar (2013) has pointed out. As things stand, it is likely that different platforms will collapse to serve users with different needs. In the case of a highly differentiated market, with a multitude of platforms, it is important that users list themselves on platforms where the likelihood of finding a match is maximized. The market with differentiated platforms can be another interesting area of study. Characterization of these possibilities and studying effectiveness of tax and regulatory instruments in them remain as our future research agenda.

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