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Taxation scheme planning in multi-sided platforms, a case of application platform

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Abstract

Digital transformation plays an increasingly important role in shaping the current business landscape and contributing to economic development. Using digital platforms and various technologies, companies can compete on a global scale with the help of digitization and industry 4.0 technologies. Global firms are benefiting from the rise of the digital economy. Facebook, Alibaba, and Uber compete in a new multi-sided platform world. Businesses such as media companies, banks, and software companies are among the many multi-sided platform firms that serve distinct groups of customers connected by interdependent demand. In this study, we analyze price-setting behavior in a multi-sided platform. As a well-known result of tax incidence by this article, consumers of more heavily taxed goods pay a higher price and buy fewer goods. A multi-sided market does not necessarily hold this result based on our findings. A higher ad valorem tax may actually lower end-user prices and boost sales. Due to this fact, multi-sided platforms may not engage in tax shifting by raising prices. The analysis is followed by a real-life case study of a diet application. The results and discussion are then presented for the proposed real-life case study.

Keywords: Multi-sided platform (MSP), pricing, application platform, taxation, game theory

1-Introduction & literature review

For over several centuries, multisided platforms (MSPs) have been around. MSPs have become well known in the economy in recent years, especially as the internet and digitization wave spread across many industries (Abdelkafi, Raasch, Roth, & Srinivasan, 2019). According to Filistrucchi et al. (2010) and D. S. Evans, Schmalensee, Noel, Chang, and Garcia-Swartz (2011), neither is there an "industry of platforms" included in official statistics that might serve as a reference, nor are multisided platforms/markets defined clearly and universally.

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D. S. Evans and Noel (2008) defined Multi-Sided Platforms as: "[platforms that] provide goods and services to several distinct groups of customers who need each other in some way, and who rely on platforms to intermediate transactions between them."

Platforms are not a new concept. In the early stages of its development, platforms were defined as technologies that reduced transaction costs or as technologies facilitating transactions that would never have occurred otherwise. (D. Evans & Schmalensee, 2005). The essence of the concept of platforms is putting two or more groups of people who need each other in touch (Sanchez- Cartas & León, 2021). Facebook, Netflix, Amazon, Uber, Apple, and Google are only a few examples of these platforms nowadays.

In order to succeed, MSPs must attract users. The more users there are on a platform, the more valuable it becomes for them. Therefore, MSPs must create network effects. They grow in value as more and more users use them (Abdelkafi et al., 2019).

It is called same-side or direct network effects when users from one side cause more users to join the platform on the same side (Rochet & Tirole, 2003). For instance, a direct network effect can be seen when people join Facebook in search of online social interactions due to the growing number of users (Abdelkafi et al., 2019). On the other hand, an indirect or cross-side network effect occurs when one market side attracts another side of the market, such as complementary product sellers or developers (Täuscher & Abdelkafi, 2018; Zhu & Iansiti, 2012). For example, the more users join Facebook, the more advertisers, and game developers get interested in this platform, allowing them to reach a wider audience (Abdelkafi et al., 2019). Benzell and Collis (2019) perceive Facebook's level of advertising to be insufficient relative to their revenue-maximizing strategy, which indicates they likewise place a premium on maintaining a huge user base. They replicate six suggested government laws for digital platforms while accounting for Facebook's optimal reaction. The conclusion is that taxes have a minimal effect on consumer excess.

Particularly, MSPs enable indirect network effects to be realized. Generally, by reducing transaction costs, they enable value-creating exchanges that would not otherwise take place (Lin & Wang, 2022). It is crucial to manage intergroup network effects as part of the business model. In the context of Google, with an increasing number of users, advertisers are willing to pay a higher price, while users might find superfluous advertising as an irritating nuisance and turn away from it (Alipour-Vaezi, Tavakkoli-Moghaddam, & Mohammadnazari, 2022; Behdinian, Amani, Aghsami, & Jolai, 2022; Kind & Koethenbuerger, 2018; Mamoudan, Mohammadnazari, Ostadi, & Esfahbodi, 2022). Trabucchi, Muzellec, Ronteau, and Buganza (2021) suggest that the value provided by these digital platforms is dependent not only on their ability to lower transaction costs and eliminate strife between the sides, but also on four other drivers, namely environments of trustworthiness, data-driven growth, personalized services, and engagement methods.

Various authors have strived to categorize multisided platforms by different criteria. A theoretical and empirical taxonomy proposed by Filistrucchi (2008) is as follows:

(1) Two-sided no transaction markets or media type: In this type of market, there would not be an obvious transaction. Only membership fees will be set in these markets. For instance, newspapers contain some ads. But the newspaper does not get informed whether a transaction is being conducted between readers and advertisers.

(2) Two-sided transaction markets or payment card type: In these markets, the transactions between both sides are observable, and it can be detected by the platform, like payments with debit or credit cards. These markets can set both transaction and adoption fees.

Another taxonomy for two-sided markets by Belleflamme and Toulemonde (2018) is exemplified as follows: The interaction between application developers and end-users is enabled by hardware and software systems (e.g., Android and PlayStation); The use of transaction systems provides a method for buyers and sellers to make payments (e.g., Visa, Bitcoin, and PayPal); Using matchmakers, members of one group can find their "match" within another group (e.g., Alibaba, Monster, and Meetic); Exchanges facilitate the search for feasible contracts and the best prices between "buyers" and "sellers" (e.g., eBay, Booking.com, Wiley, and edX); Using crowdfunding platforms, entrepreneurs can raise money from a "crowd" of investors (e.g., Kickstarter, Indiegogo, and LendingClub); Marketplaces for peer-to-peer transactions facilitate the exchange of services and goods between "peers". (e.g., Airbnb, Uber, EatWith, and TaskRabbit); Social networks, search engines, and other digital media offer content to users and sell their attention to advertisers (e.g., Facebook and Google Search).

There are three main categories of papers in this area: (1) design, (2) dynamics, and (3) performance of MSPs (Abdelkafi et al., 2019). Design relates to the technological architecture of a platform, technology (software and hardware) for making a platform function, and governing elements related to a platform, that is, the rules guiding the different sides of the platform. Dynamic refers to how a platform develops over time within its ecosystem by attracting users and adding new capabilities., while performance pertains to the ability of the platform to succeed in competition (Golovianko, Gryshko, Terziyan, & Tuunanen, 2022; Zhao, Von Delft, Morgan-Thomas, & Buck, 2020).

Across the multisided literature, pricing is the most studied subject. Two approaches can thus be distinguished. On the one hand, works that have analyzed factors that govern platform pricing, and on the other hand, works that have explored the different pricing policies platforms can employ (Mamoudan et al., 2022; Sanchez- Cartas & León, 2021). Many early studies studied the "unusual pricing scheme" of multisided platforms, including Rochet and Tirole (2003).

Rochet and Tirole (2003) studied how the price allocation between the two sides of the market is affected by a) platform governance (for-profit vs. not-for-profit), b) end users' cost of multihoming, c) platform differentiation, d) platforms' ability to use volume-based pricing, e) the presence of same-side externalities, and f) platform compatibility. It also investigated how privately optimal pricing structures compare with socially optimal ones. Platforms with multiple sides have a tendency to set asymmetric pricing structures in which there are profitable and losing sides, however differences in pricing don't exclusively result from the asymmetric balance (Sanchez- Cartas & León, 2021).

The prices can be disconnected from marginal costs, as it is pointed out by D. S. Evans (2003). As a result of the interrelation between the sides, an increase in costs on one side may increase prices on the other side. Rysman (2009) points out that: theoretically, it is often difficult to determine whether a given price in a two-sided market is higher or lower than socially optimal or if greater competition could raise or lower the price. The use of digital platforms and the provision of digital products have certain characteristics that distinguish them from conventional transactions. Although the cost of creating the first unit of a digital product might be significant, a second copy of a digital newspaper or e-book is free. The marginal cost of production and distribution is zero (Kind & Koethenbuerger, 2018). There is no doubt that taxes fundamentally affect price structure in classical markets, and they do so in multisided markets too, but their manner of affecting them is different.

The nature of digital platforms is often two-sided. The taxation of digital platforms can be more complex than the taxation of one-sided markets, and in some cases, it requires a completely new design (Sanchez- Cartas & León, 2021). Consumers of heavily taxed products pay a higher price and buy less of them, but the same is not true for Multi-Sided Platforms. Kind, Koethenbuerger, and Schjelderup (2008) stated that a higher value-added tax on one side may be profitable for the platform to shift revenue from that side to the other one (from the heavily taxed to the untaxed side). The output on both sides may increase as a result of this balance.

Generally, an ad valorem tax is a tax based on an item's assessed value, such as a piece of land or personal property. Real estate taxes are among the most common ad valorem taxes. However, ad valorem taxes can also apply to various tax applications, such as import duty taxes on foreign goods.

A few papers have addressed the issue of taxation in two-sided markets. Nevertheless, they do so in different settings or with different objectives. Kind, Koethenbuerger, and Schjelderup (2006) research is related to a growing body of work in Industrial Organizations that examines how companies in two-sided markets determine their prices. One of the most important findings in this research is that two-sided platform businesses can make money by charging negative prices or prices below marginal cost for one product (customer group). The further point is that a rise in marginal costs on one side of the market does not automatically result in a higher price on that side of the market.

This stands in contrast to one-sided (traditional) markets, where the rule that price should be set at the point where marginal costs equal marginal revenues seems to be well. A study conducted by Bourreau, Caillaud, and De Nijs (2018) investigated the impact of taxing data collection and advertising on the pricing strategies of a two-sided platform offering personalized services to users and targeted advertising to sellers. Kotsogiannis and Serfes (2010) discussed two-sided platforms in terms of tax competition between countries, but our study is dedicated to a multi-sided platform, including product sides and advertisement sides. Bloch and Demange (2018) focused on the impact of taxes on privacy protection (They created monopolistic platforms that collect user data and make money either by exploiting that information or by selling it to third parties). The effects of taxes on newspaper differentiation were studied by Kind, Schjelderup, and Stähler (2013).

Kind, Koethenbuerger, and Schjelderup (2009) show that, in contrast to what happens in one-sided markets, shifting from ad valorem to unit taxes, which keeps monopoly output constant, may result in more tax revenue. They also find that unit taxes may be more beneficial in two-sided marketplaces than ad valorem taxes. This study contributes to the effects of an increase in ad valorem tax on the end-user price of each side in an application platform.

The aforementioned surveys indicate that there is not a great deal of research available on the subject of MSP taxation. Taxation affects multi-sided markets, but that effect manifests itself in a different way than it does on other types of markets. Furthermore, a multi-product MSP has not been properly investigated to the best of our knowledge.

Within the scope of this study, we investigated the impact of taxes on a digital multi-sided platform. In contrast to one-sided markets, digital platforms face a greater number of challenges regarding taxation, and in some instances, a new organizational framework is required. Because digital platforms have a unique property, the effects of taxes and the optimal way for them to be designed may be altered in unexpected ways. In this article, we made an effort to investigate this problem. We attempted to develop a mathematical model to demonstrate how imposing taxes on an MSP can both maximize the profit level and even result in increased revenue.

Because of the interconnectedness of the sides, the impact of taxation cannot be limited to only considering the side upon which the tax is levied. As a result of network effects, platforms will respond by shifting revenue from the sides, which may conflict with the intent of the tax. As a result, it is going to be emphasized that taxes have the potential to affect the profits of businesses positively.

On the topic of the users' reactions towards advertisements (aversion, keenness, and neutrality), three different scenarios are analyzed in order to determine how an increase in taxation will affect the affiliation on each side. In addition, our methodology is defined using the example of an application platform that offers multiple products or services at varying pricing. We will investigate the interaction between the selling of advertisements and the sale of goods or services and the effect of taxation on them.

The rest of this research is structured as follows. The research methodology is presented in the next section. In the third section, we further expand the conducted analysis in the methodology section with a numerical example. At last, some managerial insights and conclusions are discussed.

2-Methodology

Multi-sided platforms bring together the demands of many groups of consumers who are interconnected in some way. As an MSP, computer operating system makers supply software that may be used by application users, developers, and hardware providers. In developing pricing and investment strategies, multi-sided platforms must consider interactions between various groups of consumers.

In principle, there is no markup formula like Lerner's condition [1]to determine the best price for customers on one side of the platform, and pricing does not follow marginal costs. When demand is interdependently linked across seemingly disparate consumer groups, and the platform acts as an intermediary, the platform internalizes the associated indirect network externalities, leading to platform competition.

2-1-Notations

In table 1, the notations are described.

[1] This refers to the premise that the devaluation of a country's currency will only improve its balance of trade with the rest of the world if the sum of its export and import price elasticities is greater than one.

Table1. List of notations

Notation	Description
J	Type of product or service
X_j	Good or service j
P^{X_j}	Price of good or service X_j
x_j	The quantity of X_j
A	In-app ad
P^A	Price per ad display
a	Number of the times ads will be displayed
T	Ad valorem tax
T'	Value-added tax
ρ	Profit level function
c	Cost function
t	Time interval
H	The Hessian matrix
$P_{x_j}^{X_j}$	$\frac{\partial P^{X_j}}{\partial x_j}$
$P_a^{X_j}$	$\frac{\partial P^{X_j}}{\partial a}$
P_a^A	$\frac{\partial P^A}{\partial a}$
$P_{x_j}^A$	$\frac{\partial P^A}{\partial x_j}$

2-2-Assumptions

- The profit level function applies to a specific time interval, for example, a week or a month.
- The prices and quantities are non-negative.
- For the sake of simplicity VAT " T' " is assumed 0.
- The marginal profitability of publishing ad A is increasing in the output of the good or service X_j, and vice versa ($\rho_{ax_j} > 0$)
- In all the calculations, $\left(aP_{x_j}^A - c_{x_j}\right) > 0$.
- The platform's marginal cost of producing good X_j is independent of the output of ad A, and vice versa ($c_{a,x_j} = 0$ in equation (2))

2-3-Basic model

For more clarification, consider a single-product application platform that earns revenue from two distinct customer groups; application users who purchase service or good "X" at the price P^X and advertisers who publish in-app ad "A" at the price P^A . Let "x" and "a" represent the quantities of X and A, respectively. Regarding the inverse demand function, price is a decreasing function of x and a:

$$P_x^X = \frac{\partial P^X}{\partial x} < 0;\ P_a^A = \frac{\partial P^A}{\partial a} < 0 \tag{1}$$

(subscripts henceforth denote partial derivatives)

An ad valorem tax " T " is levied on in-app purchases " X ", which signifies that each application user pays the price $\frac{P^X}{1+t}$ per purchase. For the sake of simplicity VAT " T' " is assumed 0. The purpose of this study is to dissect the impact of a change in T, holding T' fixed.

In this methodology, we have amplified the equations presented in Kind, Koethenbuerger, and Schjelderup (2010) and developed a model which applies to multi-product platforms. That means there are n products or services. Each of these products or services has a different price. Good or service X_j and advertising A are published at price P^{X_j} and P^A respectively. P^A function depends on how many times the ad will be displayed on the application. For this case, we can rewrite formula 1 as bellows:

$$P_{x_j}^{X_j} = \frac{\partial P^{X_j}}{\partial x_j} < 0; \ P_a^A = \frac{\partial P^A}{\partial a} < 0 \qquad (2)$$

Defining $c(x, a)$ as the cost function with $c(x, a) \geq 0$ and $c_{xa} \geq 0$, the profit level of an application platform is calculated as follows:

$$\rho = \max_{x_j, a} \sum_j [aP^A(a, x_j) + \frac{x_j P^{X_j}(x_j, a)}{1+T} - c(x_j, a)] \qquad (3)$$

We will explain the interrelationship between the sales of ads and goods or services and the effect of taxation on them by investigating the one between the sale of just one ad and services. Obviously, we can generalize this effect to all of the products and advertisements on the platform.

- The first-order condition for ad A ($\rho_a = 0$) implies:

$$[P^A + aP_a^A] - c_a = -\sum_{j=1}^{n} \frac{x_j P_a^X}{1+T} \qquad (4)$$

The phrase inside the bracket is marginal revenue of selling the advertising space A. If we were talking about a one-sided market, this term would be equal to marginal cost (c_a) so the left-hand side would be 0. But in a multi-sided platform, there is an extra term that indicates advertisement sales affect the in-app purchases. However, it is negative if advertising raises the demand for in-app purchases.

- The first-order condition for good or service X_j ($\rho_{x_j} = 0$) similarly implies:

$$[\frac{P^X + x_j P_{x_j}^X}{1+T}] - c_{x_j} = -aP_{x_j}^A \qquad (5)$$

The phrase inside the bracket is marginal revenue from an in-app transaction for good or service j . In a one-sided market optimum mode, it would be equal to c_{x_j} ($P_{x_j}^A = 0$).

As we know, in order to reach the optimum value of a maximization objective function, we should also hold the second-order condition, which means the second partial derivatives have to be negative. In our case, we have $\rho_{x_j} < 0$ and $\rho_{x_j x_j} < 0$. The one further thing we need to consider in terms of the second-order condition is the Hessian Matrix.

$$H(x) = \begin{bmatrix} \rho_{aa} & \rho_{ax_j} \\ \rho_{ax_j} & \rho_{x_j x_j} \end{bmatrix} \Rightarrow \rho_{aa}\rho_{x_j x_j} > \rho_{ax_j}^2$$

Let $H \equiv \rho_{aa}\rho_{x_j x_j} - \rho_{ax_j}^2$ and $H > 0$.

Before we deliberate the effects of ad valorem tax on pricing, it is better to review the derivation of the relationship between quantities and ad valorem taxes.

According to equations (4) and (5) we have:

$$\rho_{aa}\frac{da}{dT}+\rho_{ax_j}\frac{dx_j}{dT}=\sum\nolimits_{j=1}^{n}(\frac{1}{1+T})^2 x_j P_a^{X_j}$$

$$\rho_{ax_j}\frac{da}{dT}+\rho_{x_jx_j}\frac{dx_j}{dT}=\sum_{j=1}^{n}\left(\frac{1}{1+T}\right)^2\left(x_jP_{x_j}^{X_j}+P^{X_j}\right)$$

Using the first-order condition (5), the impact of the tax on quantities is:

$$\frac{da}{dT}=\sum_{j=1}^{n}\left(\frac{1}{1+T}\right)^2\frac{\rho_{ax_j}(1+T)\left(aP_{x_j}^{A}-c_{x_j}\right)+\rho_{x_jx_j}x_jP_a^{X_j}}{H} \tag{6}$$

And

$$\frac{dx_j}{dT}=-\left(\frac{1}{1+T}\right)^2\frac{\rho_{aa}(1+T)\left(aP_{x_j}^{A}-c_{x_j}\right)+\rho_{ax_j}x_jP_a^{X_j}}{H} \tag{7}$$

It is rational that the larger the number of application users is, the more advertisers are willing to have their ads on the platform ($P_{x_j}^{A}>0\ and\ \rho_{a_ix_j}>0$). Each user may react differently to the advertising; they might be averse, keen, or neutral to them. We are going to examine these three possible scenarios:

1. $P_a^{X_j}=0 \quad (j=1,\dots,n)$

In this scenario, the users are neutral to the ads. In other words, their willingness to do in-app transactions does not get affected by changes in advertising level. Therefore, by letting $P_a^{X_j}=0$ in equations (6) and (7), we have:

$$Equation\ (6)\ \overset{P_a^{X_j}=0}{\Longrightarrow}\ \frac{da}{dT}=\sum_{j=1}^{n}\frac{\rho_{ax_j}\left(aP_{x_j}^{A}-c_{x_j}\right)}{H(1+T)} \tag{8}$$

If $\left(aP_{x_j}^{A}-c_{x_j}\right)>0$, then equation (8) would be positive, so we can imply that a higher tax increases the sale on the advertising side of the market.

$$Equation\ (6)\ \overset{P_a^{X_j}=0}{\Longrightarrow}\ \frac{dx_j}{dT}=-\frac{\rho_{aa}\left(aP_{x_j}^{A}-c_{x_j}\right)}{H(1+T)} \tag{9}$$

As we mentioned before $\rho_{aa}<0$, so equation (9) is positive. Hence an increase in tax raises the sale on the user side of the platform. And also:

$$\left.\frac{dP^{X_j}}{dT}\right|_{P_a^{X_j}=0} = P_{x_j}^{X}\left.\frac{dx_j}{dT}\right|_{P_a^{X_j}=0} \tag{10}$$

According to equation (1) ($P_{x_j}^{X_j} < 0$), equation (10) is negative, which means a higher tax diminishes the end-user price.

As we proved above, the result is in contrast with what happens in a one-sided market. For better understanding, defining a as total advertising volume, $aP_{x_j}^{A}$ equals to the added value from attracting one extra user. If $aP_{x_j}^{A} > c_{x_j}$, which means that the added value is greater than the marginal cost of serving one user, it is profitable for the application firm to control its tax burden by shifting revenue to the side of a platform where the tax rate is fixed (here the advertising side) by charging the users a lower price. The lower the prices, the more users will purchase in the application, so the advertisers become more eager to publish their advertisements in the application. This method is optimized in comparison with increasing the price of in-app services and reducing in-app purchases.

2. $P_a^{X_j} < 0$

In this case, there is a negative externality from advertisement to in-app transactions. Let us examine what will happen if the tax increases.

$$\left.\frac{da}{dT}\right|_{P_a^{X_j}<0} = \underbrace{\sum_{j=1}^{n}\frac{\rho_{ax_j}\left(aP_{x_j}^{A} - c_{x_j}\right)}{H(1+T)}}_{\left.\frac{da}{dT}\right|_{P_a^{X_j}=0}} + \left(\frac{1}{1+T}\right)^2\frac{\overbrace{\rho_{x_jx_j}x_jP_a^{X_j}}^{+}}{H} \tag{11}$$

$$\left.\frac{dx_j}{dT}\right|_{P_a^{X_j}<0} = \underbrace{-\frac{\rho_{aa}\left(aP_{x_j}^{A} - c_{x_j}\right)}{H(1+T)}}_{\left.\frac{dx_j}{dT}\right|_{P_a^{X_j}=0}} + \left(\frac{1}{1+T}\right)^2\frac{\overbrace{(-\rho_{ax_j}x_jP_a^{X_j})}^{+}}{H} \tag{12}$$

As argued above, we confront the paradoxical result that a higher value-added tax does not bring about fewer in-app transactions. The first term in equations (11) and (12) is what we have discussed in section 1 (with the same assumptions), so it is positive. The second terms in both equations and hence the whole two phrases are obviously positive. To see why to recall that if $P_a^{X_j} < 0$, the application firm is incentivized to set a lower advertising level than the optimized volume. But this impetus becomes weaker with a higher tax level on selling in-app services or goods, changing the optimal state into selling more ad spaces. To achieve this goal, we should boost the in-app purchases, which requires an abatement in the price of the application’s goods or services. This price plunge is more tangible when $P_a^{X_j} < 0$ than when $P_a^{X_j} = 0$.

3. $P_a^{X_j} > 0$

When $P_a^{X_j} > 0$, the demand for the application’s services or goods depends positively on the advertising level. It means that the users like the commercials. Just like the previous section, we have:

$$\left.\frac{da}{dT}\right|_{P_a^{X_j}>0} = \underbrace{\sum_{j=1}^{n} \frac{\rho_{ax_j}\left(aP_{x_j}^{A} - c_{x_j}\right)}{H(1+T)}}_{\left.\frac{da}{dT}\right|_{P_a^{X_j}=0}} + \left(\frac{1}{1+T}\right)^2 \frac{\overbrace{\rho_{x_jx_j}x_jP_a^{X_j}}^{-}}{H} \tag{13}$$

$$\left.\frac{dx_j}{dT}\right|_{P_a^{X_j}>0} = \underbrace{-\frac{\rho_{aa}\left(aP_{x_j}^{A} - c_{x_j}\right)}{H(1+t)}}_{\left.\frac{dx_j}{dT}\right|_{P_a^{X_j}=0}} + \left(\frac{1}{1+T}\right)^2 \frac{\overbrace{(-\rho_{ax_j}x_jP_a^{X_j})}^{-}}{H} \tag{14}$$

Considering the two equations above and assuming $\left(aP_{x_j}^{A} - c_{x_j}\right) > 0$, we will have two states:

I) If $P_a^{X_j}$ is not sufficiently high, equations (13) and (14) will be positive, implying a higher tax on the user side of the platform enriches sales on both sides of the market and dwindles the price of the application's services or goods.

II) If $P_a^{X_j}$ is high enough, equations (13) and (14) will be negative which means a higher tax on the user side of the platform detracts sales on the both sides but we cannot make a clear deduction about the prices.

3- Case study

In this section, we will implicate the proposed methodology in the previous sections on a case study to evaluate its performance and functionality in the real world. In addition, a numerical example would be carried out to better understand the problem and reach a practical implication based on the real problem. Eventually, some managerial insights will be presented.

The case study is an application in the field of diets and counting food calories. The users enter the amount and type of food they consume daily in the application, and it will count the calories and the consumed protein accordingly. These calculations are done for free, but if you want the application to calculate the amount of consumed fat and carbohydrate, you have to make a transaction. The app employs a database of over 7 million items to measure their calorie content, ensuring that you obtain precise calorie information for every meal you consume. This software remembers specific favorite items as well as entire meals. The calorie will be added to the person's daily intake using a barcode or scanner. The software will track a user's weight for them, but the alarming thing is that it will predict their weight based on their eating patterns for that day. Hence, this is a fantastic reason to eat more healthily.

There are some features within this app that are quite bold; being synced with its website to monitor calories across platforms, the ability to quickly add a large number of products, and a recipe calculator that allows users to see the nutritional value of a handmade meal. There is a free version of this software. However, some of its features are only available in the premium edition. Additionally, there are some advertisement spaces in this application. Companies or individuals can have their ads displayed in these spaces. The proposed methodology will pave the path for decision-makers in the case of what they advertise and how they manage their advertisements. The challenge that the application management faces is determining the optimal price of each side due to a tax increase.

3-1- Numerical results and discussion

The following section illustrates our findings by considering a simple linear demand curve example, where the inverse demand curves for ad A and service or good X_j are given by:

$$P^A = 1 - a + \sum_{j=1}^{n} \frac{x_j}{2} \tag{15}$$

$$P^{X_j} = 1 - x_j + \gamma a \tag{16}$$

Since $P^A_{x_j} = \frac{1}{2}\left(P^A_{x_j} > 0\right)$, by using this specification, we will have positive externalities from good or service X_j to ad A means the more audiences are, the more willing advertisers to publish their ads on the platform.

According to equation (16), we have $P_a^{X_j} = \gamma$, which shows the externality of advertisement on good or service X_j. If this term is positive, it means the users are ad lovers; otherwise, they are ad haters. In this study, we assumed $\gamma > 0$ (the third scenario).
Our platform profit is now given by:

$$\rho = aP^A + \sum_{j=1}^{n} \frac{x_j P^{X_j}}{1+T} - c(a + x_j) \tag{17}$$

As a further step, to get the simplest algebraic solutions, we set k = 0. Maximizing (17) subjected to (15) and (16), for ad A and good or service X_j, the first-order condition for equilibrium price and output is:

$$P^A = 2\frac{5(1+T) - \gamma(3+T) - 2\gamma^2}{(1+T)(15-T) - 4\gamma(\gamma+1+T)}, \qquad a = 2\frac{5(1+T) + 2\gamma}{(1+T)(15-T) - 4\gamma(\gamma+1+T)} \tag{18}$$

$$P^{X_j} = \frac{(1+T)(5-3T+2\gamma)}{(1+T)(15-T) - 4\gamma(\gamma+1+T)}, \qquad x_j = \frac{2(1+T)(5+T+2\gamma)}{(1+T)(15-T) - 4\gamma(\gamma+1+T)} \tag{19}$$

The following analysis is restricted to the effects of a small increase in the ad valorem tax rate from t = 0, even though equations (18) and (19) apply as long as the tax rate is not so high as to yield negative output or profits. It can be proven that second-order conditions and all non-negativity constraints hold for β ∈ (−5/2, 1) in the neighborhood of t = 0.

In our example, we have:

$$\rho_{ax_j}\Big|_{T=0} = \frac{\partial^2 \rho}{\partial a \partial x_j}\Big|_{T=0} = \frac{1+2\gamma}{2} > 0 \;\; if\; \gamma > -\frac{1}{2}$$

According to section 2-2 we assumed that $\gamma \in (-\frac{1}{2}, 1)$ because we wanted our example to be in line with the assumption $\rho_{ax_j} > 0$.
The effect of an ad valorem tax on prices (tax incidence) can be found by varying (18) and (19) with respect to t in the neighborhood of t = 0, which means:

$$\frac{dP^A}{dT}\Big|_{T=0} = -2\frac{2\gamma^2 - 5\gamma - 1}{(3-2\gamma)^2(5+2\gamma)} < 0 \; for\; \gamma < \frac{1}{4}\left(5 - \sqrt{33}\right) \approx -0.19 \tag{20}$$

$$\left.\frac{dP^{X_j}}{dT}\right|_{T=0} = -2\frac{2\gamma^2 - 3\gamma + 4}{(3-2\gamma)^2(5+2\gamma)} < 0 \;\; \forall\gamma \tag{21}$$

Equation (20) indicates that a higher tax rate on good X_j reduces the end-user price ($\frac{dP^{X_j}}{dT} < 0$). The left-hand side panel of figure 1 illustrates this tax incidence result. According to the left panel, the platform bears the full burden of tax for $P_a^{X_j} = \gamma \leq -0.19$. From the previous analysis in section 2-3 we know that if ad A imposes a strong negative externality on buyers of goods or service X_j, the platform sells a smaller quantity and sets a higher price than what maximizes profit on the A−side of the market. However, the incentive to set a high price on ad A at the expense of the low output of that good is less pronounced as a result of taxing good X_j more heavily. We will have the opposite result if the externalities of ad A are positive. This explains why $\frac{dP^A}{dT}$ is upward-sloping and eventually becomes positive for sufficiently high values of γ.
We know that by shifting profits from sales of goods or service X_j to sales of ad A, the platform will reduce its tax burden (Kind et al., 2010) regardless of the size of γ. For our linear demand example, this is shown by the curves $\frac{daP^A}{dT}$ and $\frac{d}{dT}(\frac{x_jP^{X_j}}{1+T})$ in the right-hand side panel of figure 1, where:

$$\left.\frac{d}{dT}aP^A\right|_{T=0} = 8\frac{1+2\gamma^2-\gamma}{(3-2\gamma)^3(5+2\gamma)} > 0$$

$$\left.\frac{d}{dT}\left(\frac{x_jP^{X_j}}{1+T}\right)\right|_{T=0} = -2\frac{19+4\gamma^2-8\gamma}{(3-2\gamma)^3(5+2\gamma)} < 0$$

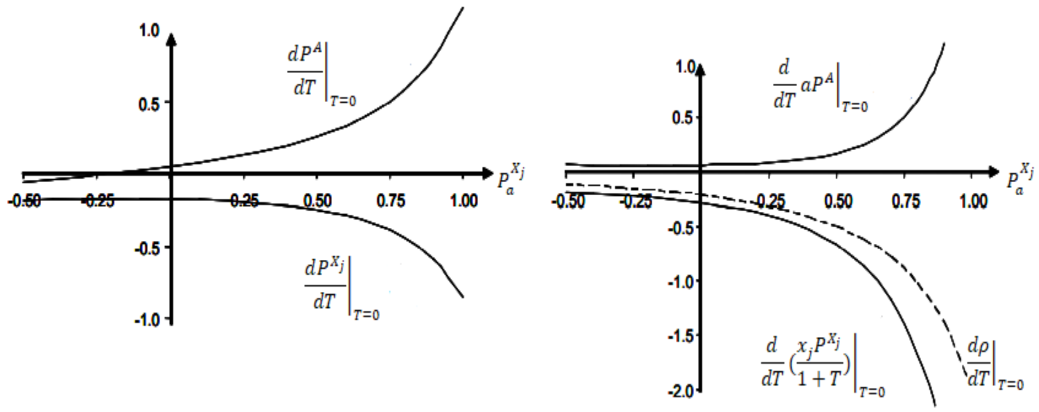

Fig1. Tax shifting vs Profit shifting

4- Conclusion and managerial insights

Taxation is a key factor that impacts price structure in every kind of market, and multi-sided markets are not an exception, but they are differently influenced. There are more taxation issues on digital platforms than in one-sided markets, and in some cases, it requires a brand-new structure. Due to the inherent attribute of digital platforms, taxes' effects and best design may be altered in unexpected ways. In this article, we sought to investigate this problem in a multi-sided platform and showed that we might increase outputs and revenue on all sides by shifting the taxation on the price of one side of the platform. Because of the interconnectedness of the sides, the impact of taxation cannot be limited to only considering the side upon which the tax is levied. By virtue of network effects, platforms will react by moving revenue from the sides, which may be at odds with the motivations of the tax. Hence, it was highlighted that taxes could affect the enterprises' income positively if only they implement an appropriate strategy like the one proposed in this study.

In section 1, an introduction was rendered on the context and significance of multi-sided platforms (MSPs) at first. A definition of the platforms was given, and then the possible network effects were introduced by exemplifying Facebook. To continue, we tried to represent some taxonomies on MSPs and their issues by reviewing the literature on this concept. In the last paragraph, the gap, the issue of taxation in MSPs, was stated. In section 2, we tried to propose a mathematical model to show how applying taxation on an MSP can maximize profit and even lead to higher revenue. The notations and assumptions were represented in sections 2.1 and 2.2, respectively. In section 2.3, in addition to the basic model, three scenarios were analyzed on the subject of the users' reactions towards advertisements (aversion, seeking, and neutrality) to determine how an increase in taxation will affect the affiliation in both sides. In section 3, we introduced an application platform that is an MSP, and the proposed methodology applies to that. We conducted a numerical example and an evaluation of the analysis in section 3.2 by assuming simple linear demand curves for advertisement and services or goods inverse demand functions. Ultimately, this section contributes to the conclusion, and managerial insights will be presented in the following paragraphs.

Pricing and taxation of digital and multi-sided platforms follow more complex patterns than those of traditional or one-sided markets. One of the most crucial challenges that the management is exposed to, is holding the profit level maximized by making a balance in the prices of both sides. What was found and proved in this study was that not only taxes might cause a decrease in profit, but also it can be even deployed to earn more profit in a multi-sided market. We considered a digital multi-product application with two sides, including advertisers and users. The application's revenue is earned by selling advertisement spaces to advertisers and goods or services to users. As proved in previous sections, when applying taxes in determining the price of advertisement spaces and goods or services, the management should create a balance to maintain the maximized revenue.

Imagine that the management is confronted with a higher ad valorem tax to clarify how it works. In this case, they shift the tax on products in a one-sided market (in which there is no advertisers' side). The demand and total revenue will decrease with a higher price of products. Quite the contrary, in a multi-sided platform, the management should shift the tax on the advertisers' side and charge users with lower prices. The lower prices are presented to users, the more users will be attracted to the application. Typically, by increasing the users of the application, the demand for advertisement spaces will also grow, and more advertisers will be enthusiastic about paying for them. We should note that even if users are averse to ads, a tax aimed at lower ad levels might negatively affect goods or services' demand. Therefore, the described methodology applies to all three types of users' reactions toward advertisements.

MSPs can only flourish if it can attract a large number of users. This is a required but not sufficient prerequisite for the success of a platform. However, the mechanisms that lead to achieving such a critical mass are poorly understood. Our research contributes by offering guidelines and techniques for addressing the open decision-making process while launching complex mobile MSPs. We also contribute a greater grasp of how to choreograph the specific and complex connections that exist between the players and the technology in mobile ecosystems. Overall, our contribution is to provide a more complete explanation and preliminary confirmation of how openness at various levels of a multi-sided platform might influence the market potential needed to improve the possibility of ignition. During the pre-ignition stage of multi-sided platforms, more attention should be paid to the complex and dynamic spreading processes. Our ideas may be expanded upon and empirically tested with other complicated Multi-Sided Platforms in different sectors. As we see several costly failures every year, it's critical to understand better what variables may make technology platforms more likely to succeed. Regarding the research limitation we need to include internet outages or other technical issues is the first limitation of our real-life case study. Having too many people logged in to our network, and the issues in handling them and VPN issues can be considered in the second step. Some experts in our systems also face difficulty having access to the hardware.

New capacities to exploit the potential interaction of artificial intelligence, big data, and advanced analytics with digital business platforms might be a fantastic stream for future research. In order to do so, businesses must create a technology-enabled innovation value chain that focuses on data-driven human-machine connections and employs artificial intelligence at various stages of data-driven automation maturity. New big-data driven value dimensions can help company leaders and management teams deliver more effective evaluation and management of their intellectual and information capital assets in the present digital era when intangible assets are becoming increasingly important for a firm's performance.

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