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Taxing Platforms or Suppliers?*

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Abstract

This study analyzes who should the government impose tax obligations on for online service transactions on the platform; suppliers, platforms, or (albeit difficult in practice) consumers? Under a single-homing platform model depicting competitive suppliers, multinational platforms, and governments in tax competition, the study shows that taxing suppliers, not consumers or platforms, leads to maximizing tax revenue.

Keywords: Platform, tax, network externalities

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1 Introduction

Public economists are beginning to look at how taxation should respond to the development of transactions through the Internet. There are two main research directions. The first direction analyzes the impact of the development of e-commerce on local public finance, especially on local tax levels and tax revenues, and to evaluate the change in taxation principles for e-commerce from origin-based to destination-based from an efficiency perspective (Agrawal and Wildasin, 2020; Aiura and Ogawa, 2023).[1] In these studies, the platforms that are the main actors in the digital economy are not explicitly modeled, however. In the second direction, they explicitly model the strategic behavior of platforms and address the issue of taxation. They are particularly interested in examining the classic topic of the tax incidence in a platform model.[2] For example, Bourreau et al. (2018) analyze the effect of introducing an ad valorem tax on data collection in a model where platform offers personalized services to users and targeted advertising to sellers. Belleflamme and Toulemonde (2018) study the impact on the payoffs of platforms themselves, consumers, and suppliers when various taxes, including unit and ad valorem taxes, are imposed on duopolistic platforms. Kind and Koethenbuerger (2018) show that the effect of a tax on a platform providing the media service, e.g., a newspaper, on prices and profits is different when it is a printed product versus a digital newspaper.

This study aims to provide a new perspective by answering the question of which economic agents should be taxed under the second stream of the model framework. The studies referred to above mainly analyze the effects of taxation under the assumption that taxation is levied on specific economic agents, especially platforms. However, it seems that the real world is not so simple. Various apps and online game services are examples of services that are traded across borders online, and each country struggles to decide who to tax. Consider the example of Japan, whose market size is the third largest in the world after the U.S. and China. In fact, 30-40% of Japanese online games and apps are purchased from overseas suppliers through platforms (Asahi Newspaper, 2023). Prior to 2015, however, Japanese consumption tax was not applied when services were purchased from overseas suppliers while it was applied when services were purchased online from domestic suppliers. Since 2015, the tax law has been revised so that foreign suppliers above a certain size who supply services online to Japan are now subject to pay consumption tax, even if they do not have a PE in Japan. Most recently, however, the government is considering shifting the obligation to pay consumption tax to platforms rather than suppliers (Asahi Newspaper, 2023). Apps and online games are provided by suppliers, and platforms merely provide a place for consumers and suppliers to transact. However, the government plans to impose a consumption tax payment obligation on platforms, in effect deeming the platforms to be selling services delivered by suppliers to consumers. In an economy where three parties - platforms, suppliers, and consumers - transact online, who exactly should the government impose tax obligations on?

This study answers this question by developing a framework that integrates the multinational platform model and the two-country tax competition model. Platforms based in different countries are competing on a global scale and do not keep their activities only within a closed

[1] Agrawal and Wildasin (2020) present a model showing that the expansion of e-commerce lowers tax rates and tax revenues in areas where e-commerce firms are located and increases them in other areas. This theory is later tested empirically by Agrawal (2021) and Agrawal and Shybalkina (2023) using U.S. data. Studies with similar objectives to Aiura and Ogawa (2023) include Bacache-Beauvallet (2018), Birg (2019), and Wang and Ogawa (2023).

[2] Some other studies reexamine the superiority of an ad valorem tax over a unit tax as shown by Suits and Musgrave (1953) in a platform model: Kind et al. (2008) show that ad valorem subsidies and unit taxes can be efficiency improvement policies in a two-sided market and Kind et al. (2009) show that the superiority of ad valorem taxes over unit taxes in terms of larger tax revenues and fewer welfare losses may not hold in a two-sided market.

country. It is true that digital platforms are dominated by U.S.-based companies. However, in e-commerce, Shopify (Canada), Rakuten (Japan), and Alibaba (China) also compete with US-based e-commerce firms, and in music streaming, Spotify (Sweden) and SoundCloud (Germany) offer digital services on a global scale. In taxing such multinational digital platforms, governments will also be forced to compete in tax across the countries. The tax competition model framework is useful for analyzing this situation. In comparison to previous studies, our study can be positioned as a step forward in elucidating the principles of taxation by relaxing the assumption of taxing specific economic agents and providing policy implications on which economic agents the governments should tax in terms of securing tax revenues in the global market.

The main finding of this study is that a government seeking to secure as much tax revenue as possible would be best served by imposing tax obligations on suppliers, not domestic consumers or platforms, and that imposing such obligations on platforms would minimize the tax revenue. The implication of this result is that the change of taxpayer from supplier to platform that Japanese government is currently considering is not necessarily an effective policy change in terms of maximizing tax revenues.

Closest to our interest is a study by Sánchez-Cartas (2021). He finds that platform openness and the duration of patent protection vary depending on whether the taxation of intellectual property on two-sided digital platforms is levied on the developer side (supplier) or the user side (consumer). While his study and ours share a clear distinction in analyzing the cases in which the government taxes suppliers and users, there are notable differences in the following respects. First, while Sánchez-Cartas (2021) adopts a positive approach to capture differences in the effects of taxing different economic agents through comparative statics analysis, our study takes a normative approach to taxation by considering the behavior of revenue-maximizing governments that choose optimal tax levels. Second, while his model analyzes the case of two competing platforms within a single country, we extend the research to the framework of a multi-country tax competition model by constructing a multinational platform model with a platform and government in each of the two countries. This contributes to expanding the scope of platform analysis to allow analysis of non-cooperative tax competition that is problematic in policy practice.

This paper is organized as follows. Section 2 sets up the basic model. Section 3 examines the equilibria, in which tax liability is imposed on the supplier and the platform respectively. Section 4 extends the analysis to the equilibrium, in which tax liability is imposed on the consumer. Section 5 concludes.

2 Model

2.1 Model Setup

We consider an economy consisting of two countries ($i = 1, 2$) shown in Figure 1. The population of both countries is normalized to 1. Each country has one digital platform and one government. The platform may be based outside the country, in which case the platform has a permanent establishment (PE) in the country that may be subject to tax liability. The model assumes single homing for all participants to the platform. Consumers register with one of the platforms, either in their own country or abroad, to buy one unit of digital service. Each country has competitive suppliers that participate in the platform and sell a unit of online services to consumers. They also compete with competitive foreign suppliers based abroad who participate in the platform and sell online services.

Government, platform, supplier, and consumer decisions are each made in the following order.

In the first stage, for transactions on the platform, each government chooses whether to impose tax liability on its own platform or on suppliers who supply services to consumers through the platform in the country. When the government imposes tax obligations on suppliers, the same tax rate is applied without distinguishing between domestic and foreign suppliers. In the second stage, the government determines the tax rate, given the choices made in the first stage. In the third stage, the platform determines the price of the services traded in the online space it offers. In the fourth stage, suppliers decide whether to join the platform and supply services, and consumers decide whether to register on the platform and purchase services in their home country or abroad. The equilibrium solution is obtained using the standard backward induction approach.

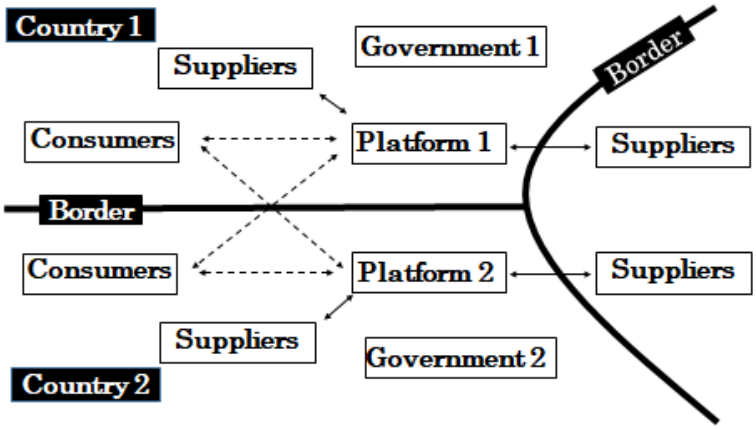

Figure 1. Multinational Platform Model

2.2 Consumers

The platform in country i provides a space on the internets for transactions where the quality of service is represented by a_i. Consumers receive quality-based benefits and have a home bias against using the platform. Specifically, they are heterogeneous in their preferences for using platform in other country: The willingness to pay for consumers in country i for using home and foreign platforms is a_i and ka_j, respectively, where k represents the home bias and is uniformly distributed between 0 and 1. The consumers of type $k = 0$ have a strong preference for using platforms in their home country, while consumers of type $k = 1$ perceive no difference between their country and other countries' platforms other than the quality of service.

Consider a type k consumer in country i. He purchases one unit of online service sold on his home platform or on a foreign platform. The payoffs he obtains for using the platform in his country are $u_{ii} = a_i - p_i + \beta r_i$, where p_i is the price of online service, e.g., online game apps, and r_i is the number of services supplied on platform i. Each supplier supplies one unit of online service, so r_i equals the number of suppliers participating in platform i. The subscript of u_{ii} means that consumers in country i use the platform in country i. Following the standard platform model, consumers shall have a higher willingness to pay for platforms with a larger number of services. β is a parameter representing interests in the number of services, often defined as the intensity of network externalities (Armstrong, 2006). $\beta = 0$ means that network externalities do not work. We assume that β is sufficiently small to guarantee non-negative prices, $\beta \in [0, 1/2)$. The payoff to this consumer in country i for using the platform in country $j(\neq i)$ is $u_{ij} = ka_j - p_j + \beta r_j$.

Since consumers will choose the platform that yields higher utility, the share of consumers in country i who use their country's platform is given by

$$k_i = \frac{a_i - p_i + p_j + \beta(r_i - r_j)}{a_j}. \tag{1}$$

All consumers of the type with k less than k_i will use the platform in country i, and all consumers with k greater than k_i will use the platform in country j, meaning that the share of consumers in country i who use the platform in country j is $1 - k_i = [a_j - a_i - p_j + p_i - \beta(r_i - r_j)]/a_j$. Denoting d_{ii} and d_{ji} are the number of users participating from countries i and j on the platform in country i, the total number of users who register on platform i is

$$d_{ii} + d_{ji} = k_i + 1 - k_j. \tag{2}$$

Consumers participating in platform i are k_i from country i and $1 - k_j$ from country j.

2.3 Suppliers

The depiction of suppliers is based on an extension of the competitive entry model of Liang et al. (2023) to a two-country framework. In the fourth stage, competitive suppliers register on either platform to supply a service to consumers online. Suppliers in country i shall participate in their own platform and not in the platform of country $j(\neq i)$. Each supplier in country i develops a service at a sunk cost, γ. Let us assume that the development cost, γ, is heterogeneous across suppliers and that it is uniformly distributed with a density of $1/2$. Platforms in countries i and j will also include suppliers based abroad to compete with domestic suppliers. Assuming that the development costs of foreign suppliers include the entry costs of joining the platform, let their costs be $(1 + e)\gamma$, where $e = 0$ means that domestic and foreign suppliers with the same γ face the same cost conditions. We basically assume that foreign suppliers will incur additional costs in development costs and in entry costs than domestic suppliers, but the following analysis does not rule out $e \in (-1, 0]$.

The payoff for a supplier of type γ in home country, i.e., country i, who registers on the platform i and sells one unit of service at a price of p_i to consumers is given as $v_i^h = p_i(1 - \theta_i) - \eta_i \delta t_i - \gamma$, where the superscript h denotes suppliers participating in the platform of their home country. θ_i is the commission rate of platform i and δ is a parameter representing the tax collection leakage. If the government places tax liability on small competitive suppliers, it will be technically difficult to collect taxes entirely from them, which is represent by allowing δ to take a value less than 1. We assume that δ is strictly greater than zero in the following analysis, $\delta \in (0, 1]$, since there is no point in imposing a tax liability on suppliers if $\delta = 0$. t_i is the tax rate in country i and η_i is the dummy variable. If $\eta_i = 1$ ($\eta_i = 0$), tax is (not) imposed on suppliers.[3] Since the tax is made on transactions, even in the case of $\eta_i = 1$, if a supplier registers on the platform but cannot sell online services, no tax is due. Competitive suppliers based in country i that can participate in platform i are those with a development cost γ lower than a certain low level, γ_i^h, which is given as follows.

$$v_i^h = 0 \quad \rightarrow \quad \gamma_i^h = p_i(1 - \theta_i) - \eta_i \delta t_i. \tag{3}$$

A supplier with type γ that satisfies $\gamma \leq \gamma_i^h$ earns a non-negative payoff for entering, so it registers on platform i.

The payoffs for a supplier of type γ that participates in platform i from foreign country is given by $v_i^f = p_i(1 - \theta_i) - \eta_i \delta t_i - (1 + e)\gamma$, where the superscript f denotes the payoffs of foreign

[3] We assume that network externalities do not act on the supplier side. However, the main conclusions of this study remain exactly the same if we incorporate network externalities into the model in the form that the greater the number of consumers using platform i, the greater the incentive for suppliers to participate in that platform.

suppliers. The type of foreign suppliers that can participate in the platform in country i is determined by

$$v_i^f = 0 \quad \rightarrow \quad \gamma_i^f = \frac{p_i(1-\theta_i) - \eta_i \delta t_i}{1+e}. \tag{4}$$

Since suppliers are conditioned by development costs that are uniformly distributed at density $1/2$ in the country where each is based, the number of suppliers participating in platform i is given by[4]

$$r_i = \frac{1}{2}\gamma_i^h + \frac{1}{2}\gamma_i^f. \tag{5}$$

Without loss of generality to simplify the notation, let $a_i = a_j = 1$ and $\theta_i = \theta_j = \theta$ in the following analysis, assuming two symmetric countries. Then, substituting (3) and (4) into (5), and then using with (1), the number of consumers using platform in country i can be rewritten as follows.

$$k_i = 1 - \frac{(p_i - p_j)\Phi}{2(1+e)} - \frac{\beta\delta(2+e)(\eta_i t_i - \eta_j t_j)}{2(1+e)}, \tag{6}$$

where $\Phi \equiv (1-\beta+\beta\theta)(2+e)+e > 0$. (6) captures the feature that higher tax rate t_i and price p_i in country i reduce the number of consumers using the platform in country i, $\partial k_i/\partial t_i \leq 0$ and $\partial k_i/\partial p_i < 0$.

2.4 Platforms

In the third stage, the platform maximizes its own payoffs. The platform earns commission revenue on supplier sales, and the net payoffs of the platform in each country are given by $\pi_i = [\theta p_i - (1-\eta_i)t_i] \cdot (d_{ii} + d_{ji})$, where $1-\eta_i$ is a dummy variable explained; the platform is taxed if $\eta_i = 0$, and the suppliers, not the platform, is taxed if $\eta_i = 1$. Platforms can take into account the behavior of participants from both sides of the trade in the online space they offer.[5] Then, using (2), the optimization problem for platform i is given as follows.

$$\max \quad \pi_i = [\theta p_i - (1-\eta_i)t_i] \cdot (k_i + 1 - k_j),$$

where k_i is given by (6). Following Liang et al. (2023), the platform determines consumer price p_i, traded on its own online space with a given commission fee.[6] Then, we have the reaction function for competing platforms as follows.

$$p_i = \frac{p_j}{2} + \frac{1+e}{2\Phi} + \frac{(1-\eta_i)t_i}{2\theta} + \frac{\eta_j t_j - \eta_i t_i}{2} \cdot \frac{\beta\delta(e+2)}{\Phi}. \tag{7}$$

[4] $e = 0.5$ in our model depicts a situation where 40% of online game app purchases are from suppliers based abroad.

[5] In the model of Liang et al. (2023), there are suppliers that register on the platform but cannot sell their services to consumers. Even such suppliers have no incentive to deregister to the platform as they are not obligated to pay taxes without sales and γ is a sunk cost.

[6] One might think that suppliers set the price. However, suppliers will face a given price since they are competitive. Instead, the platforms have market power and can exert influence on the price through discount campaigns, etc.. Therefore, we denote the consumer price of services sold on platform i as p_i (= const.$+\epsilon_i$). If ϵ_i is positive, the consumer is offered a price slightly higher than the price offered by the supplier, and if $\epsilon_i < 0$, a discount is offered to the consumer. Each platform controls e_i, and therefore consumer price p_i.

Solving (7) for i and j, the prices are given by

$$p_i = \frac{1+e}{2\Phi} - \frac{\eta_i t_i \beta\delta(e+2)}{3\Phi} + \frac{2(1-\eta_i)t_i}{3\theta} + \frac{\eta_j t_j \beta\delta(e+2)}{3\Phi} + \frac{(1-\eta_j)t_j}{3\theta}. \tag{8}$$

It should be noted in (8) that, whereas an increase in tax in country j invariably raises the price of services in country i, $\partial p_i/\partial t_j > 0$, the direction of the price change in country i when the tax rate in country i is varied depends on whether the tax liability is imposed on the platform or the supplier, which can be summarized in Lemma 1.

Lemma 1. *If tax liability is imposed on the platform, i.e. $\eta_i = 0$, then $\partial p_i/\partial t_i > 0$ and $\partial(p_i - p_j)/\partial t_i > 0$. Conversely, if the tax liability is imposed on the supplier, i.e. $\eta_i = 1$, then $\partial p_i/\partial t_i < 0$ and $\partial(p_i - p_j)/\partial t_i < 0$.*

In the former case ($\eta_i = 0$), prices increase due to higher tax rates as platform with market power passes on the cost of higher tax to price. In the latter ($\eta_i = 1$), since higher taxes in country i will lead to less supplier participation through lower payoffs, which in turn will lead to fewer users, the platform i will lower its prices to limit the impact on the number of consumers.

Substituting (8) into (6), the share of consumers who use their own country's platform is obtained as follows.

$$k_i = 1 - \frac{\eta_i t_i \beta\delta\,(e+2)}{6(1+e)} - \frac{(1-\eta_i)\,t_i\Phi}{6\theta(1+e)} + \frac{\eta_j t_j \beta\delta\,(e+2)}{6(1+e)} + \frac{(1-\eta_j)\,t_j\Phi}{6\theta(1+e)}. \tag{9}$$

(9) shows that the number of consumers using the platform in country i decreases when the government in country i raises the tax rate, regardless of who the tax obligation is imposed on, $\partial k_i/\partial t_i < 0$ for $\eta_i = 0$ and $\eta_i = 1$. However, the impact of tax changes on it is greater when the tax liability is imposed on the platform ($\eta_i = 0$): $|\partial k_i/\partial t_i|_{\eta_i=0} > |\partial k_i/\partial t_i|_{\eta_i=1}$. Since this is an critical characteristic to answer the question of who the government should impose tax obligations on, we summarize these results below.

Lemma 2. *The number of platform users is more sensitive to tax when the tax liability is imposed on the platform than when the tax liability is imposed on the supplier: $|\partial k_i/\partial t_i|_{\eta_i=0} > |\partial k_i/\partial t_i|_{\eta_i=1}$.*

Proof. The comparison of the impact of tax changes on k_i gives

$$\left|\frac{\partial k_i}{\partial t_i}\right|_{\eta_i=0} - \left|\frac{\partial k_i}{\partial t_i}\right|_{\eta_i=1} = \frac{[1-\beta+\beta\theta(1-\delta)](e+2)+e}{6\theta(1+e)} > 0.\square$$

Returning to (6) helps in understanding why this feature appears. First assume $\eta_i = 0$. In this case, the only impact that a change in the tax rate has on the number of users on the platform is through the path of price changes due to the tax change. As shown in Lemma 1, taxation on platform, i.e., $\eta_i = 0$, leads to an increase in p_i (and an increase in $p_i - p_j$). This decreases the number of users participating on platform i, and hence $\partial k_i/\partial t_i|_{\eta_i=0} < 0$. Next, we consider the case of $\eta_i = 1$. In this case, the taxation on suppliers reduces the incentive for suppliers to participate in the platform. Since users receive network benefits, $\beta > 0$, from the number of suppliers, a decrease in number of suppliers would reduce the number of users participating in platform i.[7] As shown in Lemma 1, however, the tax increase has the opposite effect of

[7]It is clear from (8) that when tax liability is imposed on suppliers ($\eta_i = 1$), the tax is neutral to the tax base when $\beta = 0$, suggesting that the tax on suppliers dominates the tax on platforms. Here we show that this is true even if $\beta > 0$ because of price reduction effect of higher taxes appearing when $\eta_i = 1$.

increasing the number of users through price changes when $\eta_i = 1$. This effect is not present when $\eta_i = 0$, and because of this price effect, the decrease in the number of users following a tax increase is smaller when government imposes tax obligations on suppliers, i.e., $\eta_i = 1$.

Platform pricing plays a decisive role in leading to this mechanism. Platforms are often oligopolies, and the model in this study follows that situation. Therefore, oligopolistic platforms with market power change prices price over changes in tax rates. Let us assume, hypothetically, that the platforms are competitive and they have no market power over prices. Then the price effect that acted in the two cases described above, $\eta_i = 1$ and $\eta_i = 0$, disappears. Thereby, the number of platform users is completely inelastic with respect to changes in tax rates, $\partial k_i = \partial t_i = 0$, when government imposes tax obligation on the platform, i.e., $\eta_i = 0$. In contrast, if the government of country i imposes tax liability on suppliers participating in the platform in country i, i.e., $\eta_i = 1$, the reduction in suppliers due to tax increases still has the effect of lowering the incentive for consumers in country i to participate in platform i, $\partial k_i = \partial t_i < 0$. In this case, the number of platform users will be more sensitive to the tax than when the government taxes suppliers, and therefore we will have $|\partial k_i/\partial t_i|_{\eta_i=0} < |\partial k_i/\partial t_i|_{\eta_i=1}$. Thus, we see that one of the factors leading to our results is an environment in which platforms are oligopolistic to the extent that they have market power to influence prices.

Using (9) for i and j, we obtain the following relationship for the change in the total number of users of platform i when the tax rate changes:

$$\frac{\partial(k_i + 1 - k_j)}{\partial t_i} = -\frac{\eta_i \beta\delta(2+e)}{3(1+e)} - \frac{(1-\eta_i)\Phi}{3\theta(1+e)},$$

which yields

$$\left|\frac{\partial(k_i + 1 - k_j)}{\partial t_i}\right|_{\eta_i=0} - \left|\frac{\partial(k_i + 1 - k_j)}{\partial t_i}\right|_{\eta_i=1} = \frac{[1-\beta+\beta\theta(1-\delta)](2+e)+e}{3\theta(1+e)} > 0. \tag{10}$$

This means that the total number of users of the platform in country i is more sensitive to the tax rate t_i if the tax liability is imposed on the platform ($\eta_i = 0$) than if the tax liability is imposed on the supplier ($\eta_i = 1$).

3 Tax choices

We assume that the government maximizes tax revenues. The government maximization problem for country i in the second stage is defined as follows.

$$\max_{t_i} \quad T_i = \eta_i \delta t_i \cdot (k_i + 1 - k_j) + (1-\eta_i) t_i \cdot (k_i + 1 - k_j),$$

where k_i is given by (9). $k_i + 1 - k_j$ represents the total number of consumers utilizing the platform that comprises the tax base in country i, i.e., $d_{ii} + d_{ji} = k_i + 1 - k_j$. Solving the problem, tax reaction function is obtained as

$$t_i = \frac{t_j}{2} \cdot \frac{\theta\beta\delta\eta_j\,(e+2) + (1-\eta_j)\,\Phi}{\theta\beta\delta\eta_i\,(e+2) + (1-\eta_i)\,\Phi} + \frac{3}{2} \cdot \frac{\theta(1+e)}{\theta\beta\delta\eta_i\,(e+2) + (1-\eta_i)\,\Phi}, \tag{11}$$

which suggests that countries are strategic complement in determining tax rates. The tax rate in the equilibrium is obtained as follows:

$$t_i = \frac{3\theta(1+e)}{\theta\beta\delta\eta_i\,(e+2) + (1-\eta_i)\,\Phi}. \tag{12}$$

The comparison gives

$$t_i|_{\eta_i=1} - t_i|_{\eta_i=0} = \frac{1+e}{\theta\beta\delta\,(e+2)} \cdot \frac{[1-\beta+\theta\beta(1-\delta)]\,(e+2)+e}{\Phi} > 0,$$

suggesting that the government can ease the competition to lower taxes and set higher taxes when it imposes tax obligations on suppliers ($\eta_i = 1$) rather than platforms ($\eta_i = 0$). The reason for this is that the tax base is less sensitive to taxes when $\eta_i = 1$ than when $\eta_i = 0$, as indicated by (10). Substituting (12) into (9) yields $k_i = 1$ in the equilibrium. Using this with (9) and (12), we have the tax revenues in the equilibrium:

$$T_i = \frac{3\theta(1+e)\,(1-\eta_i+\delta\eta_i)}{\theta\beta\delta\eta_i\,(e+2)+(1-\eta_i)\,\Phi}. \tag{13}$$

In the first stage, the government i decides whether to impose a tax obligation on the platform ($\eta_i = 0$) or on the supplier ($\eta_i = 1$). By solving this problem, we obtain the following main proposition.

Proposition 1. *Taxing suppliers is the dominant strategy, and therefore the government imposes a tax obligation on suppliers, which is Pareto efficient.*

Proof. From (13), tax revenue gaps are given by

$$T_i|_{\eta_i=1} - T_i|_{\eta_i=0} = \frac{3(1+e)}{\beta\Phi} \cdot \frac{(1-\beta)\,(e+2)+e}{e+2} > 0.$$

Noting that $T_i(1,1) - T_i(0,0) = T_i(1,0) - T_i(0,0) = T_i(1,1) - T_i(0,1)$, we have $T_i(1,1) > T_i(0,0)$, $T_i(1,0) > T_i(0,0)$, and $T_i(1,1) > T_i(0,1)$, where the first number in parentheses is η_i and the second is η_j. □

The intuition of the results is simple. As in Lemma 2, when tax liability is imposed on the supplier, the number of consumers is less sensitive to tax compared with the case of taxing the platform, meaning that the tax base loss is smaller when country i marginally increases its tax rate on the suppliers than when it taxes on the platform. Hence, the tax rate set by the government is higher when taxing suppliers than when taxing platforms, thereby bringing in more tax revenue.

Finally, we touch on the equilibrium price faced by consumers. Substituting (12) into (8) and taking the price difference, we obtain $p_i|_{\eta_i=0} - p_i|_{\eta_i=1} = 3(1+e)/\Phi > 0$, meaning that the price is lower when the government imposes tax obligation on suppliers. Thus, imposing tax obligations on suppliers, more tax revenues, more registrants to the domestic platform, and lower prices can be realized.

4 Taxing consumers

The government can monitor the sales of services on the platform by observing the sales of suppliers and the platform. Thus, it is practicable for the government to impose tax obligations on them. Although difficult to implement a system in which the government imposes a tax obligations on consumers and forces them to self-report taxes owed based on the volume of purchases would be difficult to implement in practice, the government could theoretically impose a tax obligation on consumers. In this section, we derive tax revenues in that case and compare them to the tax revenues that would be generated if the platform and suppliers were obligated to follow the tax.

Assume that consumers who purchase services on platform i are obligated to pay tax to country i. The payoffs the consumer in country i obtains for using the platform in country i are now given by $u_{ii} = 1 - p_i - \delta t_i + \beta r_i$ and the payoff to this consumer for using the platform in country $j(\neq i)$ is $u_{ij} = k - p_j - \delta t_j + \beta r_j$, where $\delta \in (0, 1]$ is a parameter that represents the percentage of consumers paying taxes. Note that we continue to assume symmetric countries and set $a_i = 1$.[8] Then, (1) is modified as follows.

$$k_i = 1 - p_i + p_j - \delta(t_i - t_j) + \beta(r_i - r_j). \tag{14}$$

Since suppliers are not taxed, (3) and (4) are now modified as follows.

$$v_i^h = 0 \quad \rightarrow \quad \gamma_i^h = p_i(1 - \theta). \tag{15}$$

$$v_i^f = 0 \quad \rightarrow \quad \gamma_i^f = \frac{p_i(1 - \theta)}{1 + e}. \tag{16}$$

Inserting (15) and (16) with $\gamma_i = 0.5(r_i^h + r_i^f)$, $d_{ii} = k_i$, and $d_{ji} = 1 - k_j$ into (14), the number of users is given by

$$k_i = 1 - \frac{\Phi(p_i - p_j)}{2\Lambda} - \delta(t_i - t_j). \tag{17}$$

(17) is used to solve the profit maximization problem of the platform to yield the reaction function as follows.

$$p_i = \frac{1}{2}p_j + \frac{\delta(1 + e)(t_j - t_i)}{\Phi} + \frac{(1 + e)}{2\Phi}. \tag{18}$$

Solving (18) for i and j, the prices are given by

$$p_i = \frac{1 + e}{\Phi} - \frac{2\delta(1 + e)(t_i - t_j)}{3\Phi}, \tag{19}$$

which is substituted into (17) to have the share of consumers in country i who use platform i is as follows.

$$k_i = 1 - \frac{\delta(t_i - t_j)}{3}. \tag{20}$$

Since (20) corresponds to (9), these two equations yield the following results regarding the sensitivity of the tax base to tax changes.

Lemma 3. *The sensitivity of the number of platform users to tax changes when tax liability is imposed on consumers is smaller than when tax liability is imposed on platforms and larger than when tax liability is imposed on suppliers.*

Proof. From (9) and (20), we have $|\partial k_i/\partial t_i|_{\eta_i=0 \text{ in } (9)} > |\partial k_i/\partial t_i|_{(20)} > |\partial k_i/\partial t_i|_{\eta_i=1 \text{ in } (9)}$.

The sensitivity of the total number of users to the tax rate is also of the same order as in Lemma 3; $|\partial(k_i + 1 - k_j)/\partial t_i|_{\eta_i=0 \text{ in } (9)} > |\partial(k_i + 1 - k_j)/\partial t_i|_{(20)} > |\partial(k_i + 1 - k_j)/\partial t_i|_{\eta_i=1 \text{ in } (9)}$. These signs can be intuitively understood as follows. If consumers are liable to pay taxes, an increase

[8] The origin principle taxation is assumed here, and the tax would be neutral to consumer choice if destination principle taxation is applied.

in taxes in country i directly reduces the number of users participating in platform i because of the increased tax burden for consumers. On the other hand, if suppliers are obligated to pay taxes, $\eta_i = 1$, an increase in taxes in country i will reduce the number of suppliers participating in platform i and indirectly reduce the number of users participating in platform i through a reduction in the benefit from network externalities. As long as $\beta < 1$, the indirect effect is smaller than the direct effect. Specifically, if there are no network externalities ($\beta = 0$), there is no reduction in the number of users associated with taxation through this channel. Unlike (9), the absence of a term containing β in (20) indicates that this path is absent when the tax liability is imposed on consumers. Thus, the tax base is less sensitive to taxation in the case of imposing tax liability on suppliers than in the case of imposing tax liability on consumers, resulting in higher tax rate in the former than in the latter.

When tax liability is imposed on the platform, $\eta_i = 0$, the only impact of the tax on the tax base is the path through the price increase associated with the tax increase. In contrast, when the tax liability is imposed on the consumer, it includes the effect of the platform lowering its prices to offset the impact of lower demand for participation in its own platform due to higher taxes. This effect does not appear when $\eta_i = 0$, so the tax base is less sensitive to taxes when consumers are obligated to pay taxes.

By going through the same analysis of tax revenue maximization of the governments as in the previous sections, the tax rate and the tax revenues in the equilibrium can be obtained as $t_{ic} = 3/(2\delta)$ and $T_{ic} = 3/2$, where the subscript ic means when taxing consumers in country i. The comparison of tax rates yields $t_i|_{\eta_i=0} < t_{ic} < t_i|_{\eta_i=1}$, which leads to the following proposition.

Proposition 2. *If the government imposes a tax liability on consumers, it will generate greater tax revenues than if it imposes a tax liability on platforms, but less tax revenues than if it imposes a tax liability on suppliers:* $T_i(0,0) < T_{ic} < T_i(1,1)$.

Proof. The comparison gives

$$\begin{aligned} T_i|_{\eta_i=1} - T_{ic} &= \frac{3\Lambda}{2} \cdot \frac{(2-\beta)e + 2(1-\beta)}{\beta(1+e)(2+e)} > 0, \\ T_i|_{\eta_i=0} - T_{ic} &= -\frac{3(1+e)(1-\theta)}{\Phi} \cdot \frac{(2-\beta)e + 2(1-\beta)}{2(1+e)} < 0. \square \end{aligned}$$

The reason for this result is evident in Lemma 3. The tax base sensitivity to the tax when the tax liability is imposed on consumers is smaller than when the tax liability is imposed on platforms and larger than when the tax liability is imposed on suppliers. Tax rate is set in the reverse order of this tax base sensitivity, and the size of the tax revenue is determined accordingly.

5 Conclusion

The study presents an analytical framework that extends the standard platform model to situations where cross-border online transactions are possible and examines revenue-maximizing tax policies for the governments. When platforms and suppliers operate multinationally and consumers are also able to purchase services across borders in the Internet space, it becomes more difficult for governments to collect taxes. This study identifies whether governments should make suppliers, consumers, or platforms the taxpayers, and reveals the efficiency of the government's choices.

The main findings are as follows. First, it is consistent with the principle of tax revenue maximization for the government to make suppliers, rather than platforms or consumers, taxpayers.

This is because, while raising taxes lowers the tax base, the sensitivity of the tax base to taxes is smallest when suppliers are made taxpayers, and governments facing tax competition have the smallest incentive to lower taxes. Second, the Nash equilibrium in which the government makes the supplier a taxpayer is efficient. In other words, by taxing suppliers, greater tax revenues can be secured than if other economic agents were made taxpayers.

This conclusion is reached in light of the difficulties in collecting taxes from consumers and some suppliers located outside the country. The assumption that consumers are only allowed to participate on domestic platforms is eliminated; they can participate on platforms in any country depending on price and tax levels. In addition, heterogeneous consumers are assumed in the analysis, and they are allowed to have home-bias preferences for domestic platforms. For the supply side, the number of suppliers of services is endogenized and the number of firms participating in the platform is allowed to vary according to price and tax levels. Under this generalized model, this study shows the superiority of taxation on suppliers from the perspective of securing tax revenues, as opposed to the way taxation should be done on platforms, which is being considered by some governments.

There are two important factors that guide our results. One is the network externality we express in β, which works in the form that the number of suppliers participating in a platform affects consumers' willingness to participate in the platform. The second is the assumption that platforms are oligopolistic and have market power to the extent that they influence prices. If network externalities do not operate at all, taxing platforms and taxing suppliers would be indifferent. In addition, if the platform is competitive and does not affect prices in any way, taxes are more neutral to the tax base if platforms are subject to tax liability. The validity of these two assumptions is a highly empirical question, and while there is no guarantee that our assumptions will hold in general, they do provide a policy implication that, contrary to our results, the government is justified in imposing tax obligations on platforms if such assumptions do not hold.

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