Discussion Papers In Economics And Business

VAT Reform via Monopolistic Platformer in Borderless Economy:

Price Pass-Though and Efficiency Consequences

Shigeo Morita, Yukihiro Nishimura

Discussion Paper 25-02-Rev.2

July 2025

Graduate School of Economics
The University of Osaka, Toyonaka, Osaka 560-0043, JAPAN

VAT Reform via Monopolistic Platformer in Borderless Economy: Price Pass-Though and Efficiency Consequences*

Shigeo Morita† Yukihiro Nishimura‡

Abstract

The development of online markets has raised ongoing concerns that foreign app service developers are avoiding value-added tax (VAT) in destination countries. To address this issue, some countries have introduced tax reforms that require platforms to pay VAT on behalf of foreign firms based on the sales generated by each firm. This study investigates whether preventing tax leakage through platform taxation improves welfare in the destination country. We first show that taxing foreign firms leads to a reduction in the commission fees charged by the platform to the sellers (developers) which replaces exited foreign developers with domestic ones. However, the increased tax burden also decreases the size of the network user base. Given this trade-off, we demonstrate that whether the domestic welfare increases after the tax reform depends critically on how responsive the sellers' market entry is to network size. When the tax reform brings welfare gain, it increases with the tax rate and reduces with the initial share of foreign developers. Finally, we show that digitalization mitigates both welfare loss and the platform's tax avoidance.

Keywords: Value-added tax; Tax reform; Digital economy; Platform; Network externality

JEL classification number: H25; H26; F23; L13; L86

*The previous version of this paper was presented at Center for Operations Research and Econometrics (CORE, Belgium), Kansai Public Economics Workshop, Public Economics Study Group and Osaka University. Hirofumi Okoshi was involved in the early stage of this broader research project, and the authors gratefully acknowledge his collaboration during that period. The current manuscript reflects only the contributions of the listed authors and has been extracted and substantially restructured from the earlier joint work.

We wish to thank Paul Bellflame, Takanori Adachi, Takero Doi, Andreas Haufler, Hirokazu Ishise, Jun-ichi Itaya, Hayato Kato, Francois Maniquet, Kazuki Onji, Fuyuki Saruta and Shiko Maruyama for their valuable suggestions. This research made progress when Yukihiro Nishimura was a short-term researcher at Fukuoka University and at CORE. The authors fully acknowledge the members and staff of these institutions for their hospitality and support. Yukihiro Nishimura is grateful for financial support from MEXT/JSPS KAKENHI JP23K22126.

†Fukuoka University; E-mail: shmorita@fukuoka-u.ac.jp

‡Osaka University and CESifo; E-mail: ynishimu@econ.osaka-u.ac.jp

1 Introduction

The development of technology has enabled firms to conduct business online. In 2022, the total worldwide revenue of the app market was 437 billion U.S. dollars, and the market volume is expected to reach 781 billion U.S. dollars by 2029.[1] Although this rapidly growing market represents a significant source of consumption tax revenue, governments face challenges in enforcing tax compliance by foreign firms — particularly when these companies generate profits without establishing stand-alone subsidiaries in the destination country. In the context of cross-border transactions, there has recently been a shift toward the *destination principle* (e.g., Agrawal and Fox (2017)). However, because some foreign companies do not have a legal entity in the destination country, it is difficult for the local tax authority to collect value-added tax (VAT) from them. For example, in 2022, more than half of the top 100 smartphone games were developed and released by foreign firms, yet many of these companies avoided paying VAT to Japan.[2] As the overall share of consumption taxes including VAT in Organisation for Economic Co-operation and Development (OECD) countries are around 30% (OECD, 2024), such tax avoidance behavior reduces welfare by diminishing the provision of public goods.

To address the issue of tax leak, several new tax reforms have recently been implemented. For example, the Japanese government plans to introduce a new tax rule in 2025 that requires online platformers to pay the VAT owed by foreign app developers. Apple has agreed to collect VAT on apps sold in Japan by businesses based outside the country and remit it to the Japanese National Tax Agency. This move is in response to the rapid expansion of the smartphone app market in Japan. [3] The purpose of using the platform tax is to rigorously enforce the destination principle. Under the new rule, foreign app developers (with online apps as a representative example) can no longer avoid VAT payments, and the Japanese government estimates that this measure will increase annual tax revenues by 154 million U.S. dollars. Canada has introduced a similar regulation that requires platforms to report information on foreign sellers and their sales, thereby assisting tax authorities in collecting revenue from foreign online vendors.[4]

---

[1]See https://www.statista.com/outlook/amo/app/worldwide, accessed 2025 February 5th.

[2]See https://www.nikkei.com/article/DGKKZO67632310X10C23A1MM8000/, accessed 2025 February 5th. Japan introduced VAT in 1989 amid strong political opposition. As a result, the system had relatively lax enforcement for cross-border transactions in its early stages, leading to an unfair but lower tax burden on foreign firms. Recently, the Japanese tax authority penalized Epic Games, a United-States (U.S.) company that supplies the online game *Fortnite*, with a fine exceeding 23 million U.S. dollars for underreporting its tax obligations (https://www.nikkei.com/article/DGXZQOUE253190V21C23A0000000/, accessed 2025 February 5th).

[3]See https://www.nikkei.com/nkd/company/us/AAPL/news/?DisplayType=1&ng=DGXZQOGN080A2008022025000000 and https://news.bloombergtax.com/daily-tax-report-international/japans-vat-reforms-will-impact-major-digital-platform-operators, accessed 2025 April 5th. Under this platform tax system, the tax authority of the destination country does not require foreign vendors to establish a representative entity within its jurisdiction.

[4]See https://www.canada.ca/en/revenue-agency/news/newsroom/tax-tips/tax-tips-2024/operating-

Although this policy shift is expected to address unfair tax treatment among online platformers operating in different countries, understanding the broader welfare effects of such tax reforms — beyond their impact on tax revenues — is critically important in the context of digital markets. Online markets are often characterized by oligopolistic structures, dominated by a few large firms with price-setting power. As a result, the tax incidence and welfare effects of a shrinking platform market may be more pronounced than under perfect competition. Moreover, the size of so-called two-sided markets — online platforms such as the App Store and Google Play — (examined by Armstrong (2006), Caillaud and Jullien (2003), Rochet and Tirole (2003), Rochet and Tirole (2006)), is shaped by network externalities. The interaction of the activeness of the network by size and the profitability for app developers cause positive spillovers formalized as indirect network externalities (Rasch and Wenzel (2013), Hayakawa et al. (2025) , Wu et al. (2023) and Zodrow (2003)). Consequently, consumers and even domestic app developers may be worse off under tax reforms if such policies lead to a downsizing of the platform. Nevertheless, the removal of the preferential treatment to foreign firms encourages the entry of domestic firms, which is often regarded desirable by fair trade commissions.

In this paper, we address the following questions: First, how does a monopolistic platform respond to tax reform in increasing the tax burdens to the foreign developers? Second, how does the downsized market through reinforcing network users and the developers on the platform counteract with the fair-trade effect in welfare evaluation?

With these concerns, we develop a model incorporating app developers from both home and foreign countries offering their apps for home-country consumers, who access the platform through a network good (iPhone). To participate, app developers must pay a commission fee to the platformer, who sets the monopoly price for this fee. These fees have come under increased scrutiny by antitrust authorities due to concerns over fair pricing.[5]

Before the tax reform is implemented, more foreign app developers enter the online market than domestic app developers because foreign app developers can avoid VAT obligations. Once the tax reform is in effect and foreign app developers are subject to taxation via the platformer, this location-based tax advantage disappears, and the platformer responds by lowering the commission fee. This effect encourages the entry of domestic firms due to the removal of tax-based location

digital-platform.html, accessed 2025 February 5th. Similar to the case of Japan we discussed in footnote 2, Canada introduced VAT in later year, 1991, under fierce political opposition.

[5]For example, in 2024, the European Commission found that the fees charged by Apple to app developers exceeded fair levels. See https://ec.europa.eu/commission/presscorner/detail/en/ip_24_3433, accessed 2025 February 13th. In response to the Commission's recommendations, Apple announced a policy to reduce its fees. See https://developer.apple.com/jp/support/dma-and-apps-in-the-eu/\#app-analytics, accessed 2025 February 13th.

advantage mentioned above. In contrast, the offsetting nature of the other effect occurs by smaller market size which reduces the entry of domestic developers. We show that whether or not the downsized-market effect dominates the fair-trade effect depends on the degree of responsiveness of the app developers' entry to the number of users, which we call *entry responsiveness*. We also show that this value of entry responsiveness is determined by the number of potential app developers and firm heterogeneity. As the mechanism originates from the indirect network externalities, this result is specific to two-sided markets and relevant for online platforms.

Furthermore, this entry responsiveness also affects the consumer surplus and the tax revenue. If entry responsiveness is low, the domestic firms' entry referred to above as the fair-tax effect is stronger than the exit response due to the downsized market, so the decline in consumer surplus by the network-good users is mitigated. In addition, lower entry responsiveness increases tax revenue as a result of tax reform. These gains are greater when the tax rates are higher. We then examine how the tax reform affects the home country, and formalize the trade-off between the welfare loss by market participants and increased tax revenue, by using the Marginal Value of Public Funds (MVPF) formula.

In the smartphone game industry in Japan we mentioned above, a high share of foreign developers before tax reform may also from the foreigner's initial share. In such a case, we show that the welfare gains or losses decreases as the initial foreign share becomes greater. We finally show that digitalization, as, according to the conventional definition, the shift from direct to indirect externalities, reduces the welfare loss and tax avoidance behavior of the platformer.

The contributions of this paper to the related literature are as follows. First, by highlighting the case of recent tax reforms, we add new insights into the growing literature on international tax and the digital economy.[6] Regarding the destination principle, Aiura and Ogawa (2024) compare outcomes under the destination and origin principles and concluded that tax competition on e-commerceis more intense under the destination principle than under the origin principle. On the tax incidence of a monopolistic supplier, Weyl and Fabinger (2013) demonstrate neutrality of the physical incidence of taxes (i.e., who pays the tax). Weyl and Fabinger (2013) and Adachi and Fabinger (2022) quantitatively assess tax burdens under imperfect competition. Kind et al. (2008), followed by several others (see Belleflamme and Toulemonde (2018) and Kind and Koethenbuerger (2018)), analyze taxation in two-sided markets and show that ad valorem taxes are sometimes superior to unit taxes. In this paper, with a focus on cross-group externalities and ad valorem

[6] See Agrawal and Fox (2017) for a discussion on the destination principle as the appropriate taxation rule for consumption taxation in cross-border trade.

taxation, we examine the tax incidence of the commission fee and the entry behavior of domestic developers. Second, some studies examine the impact of taxing the platfomer on the entry and exit behavior of consumers and developers. Bourreau (2018) shows that under certain conditions, taxation of data collection by the platformer can increase tax revenues through the entry of users. Tremblay (2018) demonstrates that differential taxation on sales of a platformer encourages the entry of agents on one side but discourages the entry of agents in the other. Unlike these studies, our study provides implications of taxing the platformer and its impact on developer entry behavior, particularly that of domestic developers. Third, it has become increasingly evident empirically that closing tax loopholes for bookkeeping-based profit manipulation by multinational enterprises (MNEs) can lead to distortions in real economic variables, such as production and investment.[7] Bösenberg and Egger (2017) showed that stricter enforcement of transfer pricing regulations increases MNEs' effective tax rates and reduces their incentives to invest in research and development. Despite the growing interest and mounting empirical evidence, theoretical analyses remain scarce. One notable exception, and the study closest to ours, is Mukunoki and Okoshi (2025), who examined a multi-country two-sided market model with transfer pricing (TP) regulation. They showed that tighter TP regulation harms high-tax countries by weakening firms' incentives to invest in online technologies.[8] In contrast to Mukunoki and Okoshi (2025), our model demonstrates positive effects on tax revenue, albeit at the cost of fewer app developers. This reduction affects the entry and exit of domestic firms through equal-footing competition and the endogenous adjustment of network size via network externalities — an interaction this study aims to explore in depth.

The remainder of the paper is organized as follows. Section 2 introduces the model; Section 3 derives the equilibrium. Section 4 examines welfare effects. Section 5 argues some extensions. The final section concludes. The proofs are provided in the Appendix.

2 Basic setup

Our model is illustrated in Figure 1. Consider the following digital economy. A foreign firm, referred to as the *platformer*, has its own online technology to operate its platform, such as App Store,

[7] Although this is in the context of profit shifting, Johansson et al. (2017) showed that MNEs exploit mismatches between tax systems and preferential tax regimes to reduce their tax burden. This implies that a tax reform aimed at closing loopholes would simply increase the tax burden unilaterally on the host country and make it unattractive for the MNEs' global tax planning.

[8] In their model, TP regulation increases (corporate) tax revenues from MNEs but reduces MNEs' investments in online technology, thereby affecting sizes of network externalities.

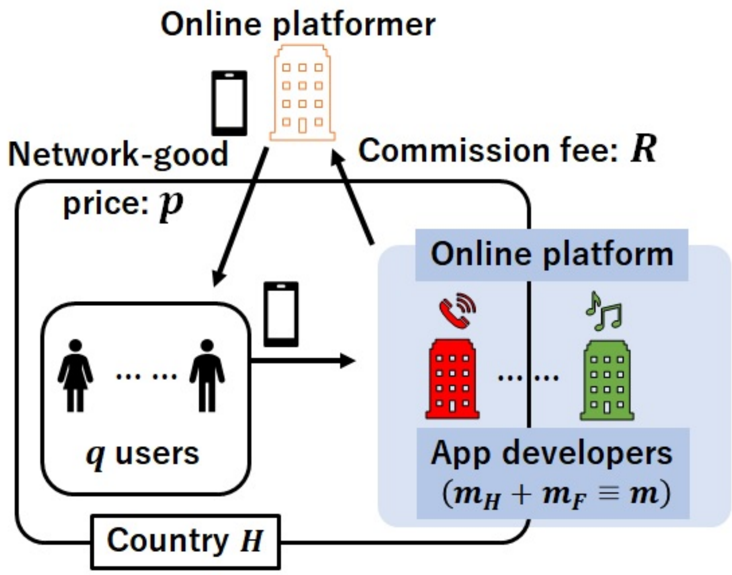


Figure 1: Model

in the home country (country H). Consumers in country H have access to the platform through a platform-specific network good, such as iPhone, which the platformer sells to the consumers. The platformer then facilitates in transactions in country H involving a relation-specific good which we call, for an illustration, *online apps*.

The tax liability varies depending on the location of the app developers. A Prior to the tax reform, foreign developers are able to avoid tax liability, as the tax authority in country H lacks the jurisdiction to enforce tax collection or impose compliance costs on those foreign firms. The platform-based tax mentioned in Introduction fills this enforcement gap.

We consider the following two-stage game. In Stage 1, the platformer sets the price p of the network good and the commission fee R for the entry of the app developers. In Stage 2, consumers, app developers, and the app users make their adoption decision simultaneously. When variables associated with network externalities are simultaneously determined, each party forms rational expectations about the others' behavior. The comparison of the outcomes before and after tax reform is our interest.

2.1 Demand for the network good

Following Wu et al. (2023), consumers are heterogeneous in their preferences for the network good and decide whether to buy one unit of the good or not. The aggregate demand — equivalently, the number of consumers — is derived using a conventional microfounded model by (see Appendix

A):

$$q(p) = \nu + \alpha m - p. \tag{1}$$

where ν and p represent, respectively, the maximum willingness to pay for the good and its price.

The second term, αm, captures the network effects from app variety:[9] m represents the total number of apps sold on the platforms, and α is the degree of network externality. Because more apps provide consumers of the good with a wider variety of options and allow them to use their favorite apps, they increase the willingness to pay for the network good.[10] Note that such an increase in willingness to pay for the good depends not only on the number of apps but also on the speed of internet connection. Online apps such as online games and video meetings often require a high-speed internet connection. Therefore, consumers receive larger gains from the network good if they are in a better digitalized environment. The network parameter α reflects the level of digitization, and we interpret an exogenous increase of α as digitization — for example, the introduction of 6G, which allows high-speed data transfer.[11]

Alternatively, (1) represents the demand function of a standard good sold online (produced with the constant marginal cost in (6) below), where m is the number of relation-specific good defined in the next subsection.

2.2 App's prices and developers' entry

Apps sold in the platform are developed by a potentially large pool of app developers, M, in country H and an equally sized pool M in a foreign country, labeled country F. These app developers are assumed to supply one app each and are heterogeneous in terms of the fixed costs of developing and maintaining apps, denoted by f_S, which is uniformly distributed over $[0, \overline{f}]$.

The apps are demanded by a potentially large pool of app users in the home country. Some network participant may purchase more than one unit of the apps, and others may not buy any app. App i generates the marginal utility of consumption as $a_i = \phi q$ to the consumer. Following Rasch and Wenzel (2013) and Wu et al. (2023), ϕ is regarded as network-size externality. The developers invent app i through, for example, online algorithms or technologies that better match consumers

[9] We assume that $\nu > p$ holds in the equilibrium throughout the analysis. This means that some consumers still want to consume the network good even in the absence of additional utility from network effects. This is a realistic assumption, as such indirect externalities arise when a base level of consumers exists and app developers find it profitable to enter the market . Following the literature, including Katz and Shapiro (1985) and Wu et al. (2023), we assume that each consumer makes their decision based on the expected number of the apps in the market. This expectation is in equilibrium, i.e., $m_e = m$ holds.

[10] This is known as the indirect network externality. We discuss a direct network externality in Section 5.2.

[11] In the last two decades, the percentage of individuals using the internet has grown: It was 7% in 2000 and 67% in 2023. See `https://data.worldbank.org/indicator/IT.NET.USER.ZS`, accessed 2025 February 5th.

with apps based on individual consumption or search histories. The app's price for i, p_{ai}, becomes $p_{ai} = \phi q$ (Nishimura (2025b)). Therefore, a larger ϕ reflects a different measure of digitization than α. In addition, app developers must pay a commission fee, R, to the platformer to sell their apps on the platform. We allow R to be either positive or negative, where a negative R is interpreted as a subsidy from the platformer to the app developers.[12] The platformer's choice of the commission fee R is a policy-relevant issue (see footnote 5 in Introduction).

As in Hayakawa et al. (2025), taxation reduces the after-tax value of app production externalities by increasing the cost of providing online services. In our model, $p_{ai} = \phi q$ is subject to a VAT at rate τ and it generates tax revenues. Prior to the tax reform, only domestic app developers in country H are liable to pay the VAT. In contrast, foreign developers located in country F are able to avoid such taxation. After the tax reform is implemented, domestic (home) app developers remain subject to VAT, whereas foreign developers pay a VAT-inclusive commission fee to the platformer. Let τ denote the VAT rate in country H, and let η be a binary indicator equal to zero before the tax reform and one after its implementation. Then, the entry conditions for app developers from each country based on their (expected) post-tax profits, π_{SH} and π_{SF} for app developer S in each country, are given by:

$$\pi_{SH} = \phi q - R - \tau \phi q \geq f_S \equiv \overline{f}_{SH}, \tag{2}$$

$$\pi_{SF} = \phi q - R - \eta \tau \phi q \geq f_S \equiv \overline{f}_{SF}, \tag{3}$$

As for the network-entry fee, R exhibits standard buyer-seller independence: whether the platform charges the fee R to the app developers or to its consumers is irrelevant for incidence. In the latter case, the developer sets a price of $(1 - \eta\tau)p_{ai} - R$ for consumer i, who then decides whether to accept the price.

Prior to the tax reform, only the domestic app developers are subject to VAT, whereas foreign app developers receive the tax-inclusive value ϕq without paying the VAT. In contrast, after the tax reform, the foreign app developers must charge a VAT-inclusive price, with the VAT amount remitted to the platformer alongside the commission fee R. Assuming that f_S is uniformly distributed over the interval $[0, \overline{f}]$, these conditions yield the following entry levels of

[12] A negative R can be interpreted as a non-pecuniary subsidy, such as technical support offered to app developers — for instance, by providing development toolkits. Apple, for example, allows developers to apply for an Apple Vision Pro Developer Kit (see `https://developer.apple.com/visionos/developer-kit/`, accessed 2025 February 5th). Rysman (2009) provides another example: Microsoft, as a supplier of computer operating systems, makes it very easy to become a software developer for the Windows OS and arguably subsidizes this activity through tutorials and dedicated support websites.

app developers:

$$m_H = \left(\frac{\overline{f}_{SH}}{\overline{f}}\right) M = \frac{M[(1-\tau)\phi q - R]}{\overline{f}}, \tag{4}$$

$$m_F = \left(\frac{\overline{f}_{SF}}{\overline{f}}\right) M = \frac{M\left[(1-\eta\tau)\,\phi q - R\right]}{\overline{f}}, \tag{5}$$

where the first parenthesis represents the entry rate. By summing up the entries from domestic and foreign developers, we obtain the total number of apps on the platform, $m = m_H + m_F$. The number of app users, as previously formulated, satisfies $\int_{A_i=1} 1di = m_H + m_F$.

2.3 Induced demand and platformer's profit

The two-stage game is solved backwards. To characterize the equilibrium outcome od the two markets in in Stage 2, we solve (1), (4) and (5) for three unknowns q, m_H and m_F, with $m_e = m_H + m_F$ by consumers and $q_e = q$ by app users and the app developers. We then derive them as functions of p and R (determined in Stage 1) and τ (given by the government) as follows:

$$q(p,R) = \frac{\overline{f}(\nu - p) - 2\alpha MR}{\overline{f} - \alpha M\phi\{2-(1+\eta)\tau\}}, \tag{1'}$$

$$m_H(p,R) = \frac{M\left[\{1-\tau\}\,\phi q(p,R) - R\right]}{\overline{f}}, \tag{4'}$$

$$m_F(p,R) = \frac{M\left[\{1-\eta\tau\}\,\phi q(p,R) - R\right]}{\overline{f}}, \tag{5'}$$

The resulting expressions reveal that $m_H - m_F \leq 0$ given $q > 0$, indicating that the number of app developers in country H is smaller than in country F prior to the tax reform. This asymmetry arises because only domestic developers are subject to VAT, creating a location-based tax advantage for foreign developers. The tax reform removes this asymmetry by applying VAT uniformly, thereby equalizing the number of developers across countries.

Regarding the platformer's cost structure, we assume that the network good is produced with a constant marginal cost c and the platform itself operates with zero marginal cost. The platformer's post-tax profit is then given by:

$$\pi_P = (p-c)q + R(m_H + m_F) \tag{6}$$

where q, m_H and m_F are determined by (1), (4') and (5'). In Regime T, the platformer collects the VAT from the foreign app developer $\tau\phi q m_F$ and remits this to the home tax authority. The revenue to receive from the app developers are $R(m_H + m_F)$, where the values of R, m_H and m_F depend on the tax regime. In this analysis, we assume that VAT is levied solely on app usage. However, the core results are robust even if the network good is also subject to VAT (consistent with Kind et al. (2008), Belleflamme and Toulemonde (2018) and Kind and Koethenbuerger (2018), in taxing q, we can show that ad valorem taxes are superior to unit taxes in two-sided markets). Also, since our primary focus is on tax reform, it is useful to revisit the principle of physical-incidence neutrality (e.g., Weyl and Fabinger (2013)). Details of such analyses are available upon request to the authors.

To ensure an interior solution throughout the analysis, we adopt the following assumption:

Assumption 1. $\frac{\overline{f}}{M}$ is sufficiently high to satisfy

$$\frac{\overline{f}}{M} \geq \frac{\{2\alpha + \phi(2-\tau)\}^2}{8} + \frac{(2\alpha + 2\phi + \tau\phi)(\nu - c)}{8M} \equiv A(\alpha, \phi, \tau, \nu - c, M). \tag{A-1}$$

The first component of condition (A-1), $\frac{\overline{f}}{M} > \frac{\{2\alpha+\phi(2-\tau)\}^2}{8}$, ensures that the induced demand function (1′) is downward-sloping in p (see "Meaning of the SOCs" in Appendix B). The second part, involving $\frac{\nu-c}{M}$, is that the potential number of app developers M is sufficient to absorb the market demand arising from the net market size $\nu - c$ (see (11) in the next section). In following section, we solve for the platformer's optimal pricing strategy, (p, R), under both the pre- and post-tax reform regimes.

3 Equilibrium

3.1 Entry responsiveness and equilibrium values

Let us begin our analysis with the case without the tax reform, which we use "O" for the superscript. By differentiating $\pi_P^O = (p - c)q^O + R(m_H^O + m_F^O)$ with respect to p and R, and taking into account (1′), (4′) and (5′), the first-order condition (FOC) $\frac{\partial \pi_P^O}{\partial p} = 0$ yields (see Appendix B for the derivation),[13]

$$\begin{aligned} &\frac{\partial \pi_P^O}{\partial p}\left(\frac{\overline{f} - \alpha M\phi(2-\tau)}{2\overline{f}}\right) = -p + c + \frac{\nu - c}{2} - \frac{\{2\alpha + (2-\tau)\phi\}MR}{2\overline{f}} \equiv FOC_p^O = 0, \\ &\iff p^O = c + \frac{\nu - c}{2} - \frac{\{2\alpha + (2-\tau)\phi\}MR^O}{2\overline{f}} \end{aligned} \tag{7}$$

[13]If we have the aggregate demand function as $q = \mu + \alpha m - dp$ with d representing the slope of the demand, then $\nu = \frac{\mu}{d}$, and the third term of the right hand side of (7) becomes $-\frac{\{2\alpha/d+(2-\tau)\phi\}MR^O}{2\overline{f}}$.

In the above formula, the price is composed of two key components: market power and network externality. Without network externality, the platformer sets the price above marginal cost by a monopoly markup, reflected in the second term on the right-hand side. With network externalities, an additional effect emerges. If the commission fee R is positive, the last term on p^O lowers the equilibrium price, as the commission fee discourages entry by app developers, thereby reducing the platformer's profits. Through the opposite reason, the product's price increases when $R^O < 0$, meaning that the platformer's subsidization to app developers pushes up the product's revenue-maximizing price.

In general, (i) m's sensitivity to q in (4') and (5'), $\frac{\partial m}{\partial q} = \frac{M}{\overline{f}}(2 - (1+\eta)\tau)\phi$, which is increasing in responsiveness of the app developers from the number of users and decreasing in firm heterogeneity $\overline{f}$, matters for production side, and (ii) the number of app developers ($\alpha \frac{M}{\overline{f}}$ increasing in M) matters for consumption side. From this perspective, hereafter we call the corresponding parameter $\frac{M}{\overline{f}}$ as *responsiveness of entry*, and its inverse, $\frac{\overline{f}}{M}$, as *inverse responsiveness of entry*.

The FOC for R is decomposed to the cross-market effects and the own price effect to yield the following formula:[14]

$$\frac{\partial \pi_P^O}{\partial R} = -4R\frac{M/\overline{f}}{\gamma} + (2-\tau)\frac{\phi(\nu - p)}{\gamma}\frac{M}{\overline{f}} - 2\alpha\frac{M/\overline{f}}{\gamma}(p-c) \equiv \frac{M/\overline{f}}{\gamma}FOC_R^O = 0. \tag{8}$$

$$\iff R^O = \frac{\overline{f}(\nu - c)(2\phi - \tau\phi - 2\alpha)}{8\overline{f} - M\{2\alpha + \phi(2-\tau)\}^2} \gtreqless 0 \Leftrightarrow (1 - 0.5\tau)\phi \gtreqless \alpha$$

In the first line of (8), the net gain by consumers ($\nu - p$) and by developers $(p - c)$ are weighted by two externalities, for the apps' price effect by ϕ and for the consumption-side effect by $-\alpha$. Substituting the expression for p from (7) yields the second line of (8). Assumption 1 warrants $8\overline{f} - M\{2\alpha + \phi(2-\tau)\}^2 > 0$.

If the network-size externality is sufficiently strong such that $(1 - 0.5\tau)\phi > \alpha$, the motive to charge app developers dominates in determining R^O, resulting in a positive equilibrium commission fee $R^O > 0$. Conversely, if app-variety externality is strong and $\alpha > (1 - 0.5\tau)\phi$ holds, the platformer subsidizes app developers to expand the demand for the network good through increased variety and to increase demand for the network good. The decision in (8) then feeds back into the pricing channel in (7). When the network-size externality is strong ($(1 - 0.5\tau)\phi > \alpha$), the platformer reduces the equilibrium price to stimulate consumption. Otherwise, the equilibrium price for the good

[14]For $\frac{\overline{f}}{\overline{f} - \alpha M\phi\{2-(1+\eta)\tau\}} \equiv \frac{1}{\gamma} > 0$, we have the revenue base $m_H + m_F \equiv m \propto (2-\tau)\phi q - 2R$ in (4') and (5') in Regime O, a semi-elasticity $R\frac{\partial m}{\partial R} = -2R\frac{M/\overline{f}}{\gamma}$ and $-2\alpha\frac{M/\overline{f}}{\gamma}(p-c) = (p-c)\frac{\partial q}{\partial R}$ in (1').

exceeds the standard markup but the entry of app developers and the consumption externality still allow the expansion of the network.

By substituting the equilibrium price of the good and commission fee, we have,

$$q^O = \frac{4\overline{f}(\nu - c)}{\left[8\overline{f} - M\{2\alpha + \phi(2-\tau)\}^2\right]} \equiv \frac{\nu - c}{den^O} \quad \text{for} \quad den^O = 2 - (\alpha + \phi - 0.5\tau\phi)^2 \frac{M}{\overline{f}} > 0 \tag{9}$$

$$m_H^O = \frac{M(\nu - c)(2\alpha + 2\phi - 3\tau\phi)}{\left[8\overline{f} - M\{2\alpha + \phi(2-\tau)\}^2\right]} < \frac{M(\nu - c)(2\alpha + 2\phi + \tau\phi)}{\left[8\overline{f} - M\{2\alpha + \phi(2-\tau)\}^2\right]} = m_F^O \ (\leq M) \tag{10}$$

where $m_F^O \leq M$ implies:

$$\frac{\overline{f}}{M} - \frac{\{2\alpha + \phi(2-\tau)\}^2}{8} \geq \frac{(2\alpha + 2\phi + \tau\phi)(\nu - c)}{8M}, \tag{11}$$

which is Assumption 1. To secure a positive number of app developers in H, we need $2\alpha + 2\phi - 3\tau\phi > 0$ or $\tau < \frac{2}{3} + \frac{2\alpha}{3\phi}$.

Electric devices getting access to online platform require are often characterized as a knowledge intensive industry, firms are sometimes criticized of using its high market power and setting their high prices.[15] In the present context, the platformer's sales corresponding to the extra part in pricing in (7) would cancel out with the commission fee in (8) and (10). Namely, from $p^O - c = \frac{\nu - c}{2} - \frac{\{2\alpha + (2-\tau)\phi\}MR^O}{2\overline{f}}$ and $R^O(m_H^O + m_F^O) = R^O \frac{M}{\overline{f}}\{(1 - 0.5\tau)\phi + \alpha\}q^O$:

$$\pi_P^O = \left(\frac{\nu - c}{2} - \frac{\{2\alpha + (2-\tau)\phi\}MR^O}{2\overline{f}}\right)q^O + \frac{M}{\overline{f}}\{(1 - 0.5\tau)\phi + \alpha\}R^O q^O = \frac{\nu - c}{2} q^O. \tag{12}$$

After tax reform (with the superscript "T") we have $\pi_P^T = \frac{\nu - c}{2} q^T$ (see Section 4).

3.2 Price incidence of tax reform ($\eta = 0$ to 1)

Now, we introduce the tax-reform that the platformer is in charge of tax liability from sales of online apps instead of app developers, and we use the superscript "T" for the case.

The post-tax profits of the platformer are reformulated as $\pi_p^T = (p - c)q^T + R(m_H^T + m_F^T)$. Using

[15] For example, the U.S. department of Justice accused Apple of monopolizing Smartphone market. See https://www.reuters.com/legal/us-takes-apple-antitrust-lawsuit-2024-03-21/, accessed 2025 February 5th. European Union has the digital market act in 2023 to ensure for all businesses, contestable and fair markets in the digital sector. Inspired by the digital market act, Japan also enacted so called the Smartphone act to stop large companies such as Google and Apple from taking advantage of their position to give their own products "a competitive advantage" and from "imposing disadvantages on business users". See https://eu-renew.eu/is-the-eus-digital-markets-act-going-global-how-japan-is-crafting-its-own-version-of-digital-regulation-with-the-smartphone-act/, accessed 2025 February 5th.

(7) and (8) in the previous subsection, the FOCs, $\frac{\partial \pi_P^T}{\partial p} = 0$ and $\frac{\partial \pi_P^T}{\partial R} = 0$, yield,

$$\frac{\partial \pi_P^T}{\partial p}\left(\frac{\overline{f} - \alpha M\phi(2-2\tau)}{2\overline{f}}\right) = 0 \Rightarrow$$

$$p^T = p^O + \frac{\{\alpha + (1-\tau)\phi\}M}{\overline{f}}(R^O - R^T) + \frac{0.5\tau\phi M}{\overline{f}}R^O. \tag{7'}$$

$$\frac{\partial \pi_P^T}{\partial R}\left(\frac{\overline{f} - \alpha M\phi(2-2\tau)}{M}\right) = FOC_R^O - \tau\phi(\nu - p) = 0. \tag{8'}$$

As in Copestake and Bellon (2022), the burden of tax reform is passed on to prices. When $R^O \geq 0$, the tax reform raises price and lowers the commission fee. More specifically, the following formula for reduction of the commission fee is obtained. Let $den^T = 2 - (\alpha + \phi - \tau\phi)^2 \frac{M}{\overline{f}} > 0$ be the value that appears in the denominator of R^T,

$$R^* = \frac{(\nu - c)(2\phi - (1+\eta)\tau\phi - 2\alpha)}{4den^*} \Rightarrow$$

$$R^O - R^T = \frac{(\nu - c)}{4den^T}\{\tau\phi + \frac{(2\phi - \tau\phi - 2\alpha)(den^T - den^O)}{den^O}\} \tag{13}$$

Intuitively, tax reform deters some foreign app developers from entering the platform due to the newly imposed tax burdens, prompting the platformer to lower its profit-maximizing commission fee ($R^T < R^O$). In (13), with $den^T > den^O > 0$, $R^O > R^T$ when $2\phi - \tau\phi - 2\alpha \propto R^O \geq 0$, and, even when $R^O < 0$, (13) is still positive when $\frac{M}{\overline{f}}$ is sufficiently low. Intuitively, when there is high heterogeneity among firms ($\overline{f}$) and a limited pool of potential entrants (M), app developers' entry decisions become less sensitive to price changes. Consequently, after the reform, the increase in developer entry occurs even when $R^O < 0$. Referring to (A-1), the larger net market size $\nu - c$ also confirms $R^T < R^O$.

(7') shows the cross-market pass through to the rise of the network-good's price ($p^T > p^O$). The second term of the right-hand side is positive due to $-R^T > -R^O$, and the last term either reinforces the positive effect when $R^O \geq 0$, or it does not conflict with $p^T > p^O$ when entry responsiveness is low.

The foreign firms' tax-inclusive commission fee to pay to the platformer (the last two terms of (3), as the sum of the commission fee and the VAT payment) has the following structure:

$$\frac{R^T + \tau\phi q^T - R^O}{R^O - R^T} = \frac{3\frac{den^O}{\alpha + (1-0.75\tau)\phi} - (2\phi - \tau\phi - 2\alpha)\frac{M}{\overline{f}}}{\frac{den^O}{\alpha + (1-0.75\tau)\phi} + (2\phi - \tau\phi - 2\alpha)\frac{M}{\overline{f}}} \tag{14}$$

The platformer gives twice the increase in the tax-inclusive fee than the decrease in its own receipt ($R^T + \tau\phi q^T - R^O \approx (2+1)(R^O - R^T)$ when $\frac{M}{f}$ is small). In addition, a higher value of $(2-\tau)\phi - 2\alpha$ (in the numerator of R^O and the second term of (13), the value indicating a charge to producing firms) implies larger decrease of the commission fee.

The above discussion shows the following proposition regarding the effects of the tax reform on the equilibrium price of the network good and commission fee to the platform.

Proposition 1. *(i) Under any of the following conditions: (a) The pre-reform commission fee (R^O) is nonnegative; or (b) entry responsiveness ($\frac{M}{f}$) is sufficiently low (i.e., app developers' are not sensitive for entry to prices); or (c) the net market size ($\nu - c$) is sufficiently large. The VAT reform increases the price of the network good and reduces commission fee charged to domestic app developers.*

(ii) Under any of the following conditions: (a) Entry responsiveness is sufficiently low; or (b) The net market size ($\nu - c$) is sufficiently large. The VAT reform increases the tax-inclusive commission fee charged to foreign app developers.

This result is in line with a standard discussion on a pass through of imposing VAT on prices. In our model, the platform is newly taxed and, therefore, a pass through for the commission fee arises. As foreign inefficient app developers captured by high fixed costs are eliminated by tax reform, the surviving developers can bear the tax burden. Taking advantage of these surviving firms, the platformer, as the mediator, chose to charge higher tax-inclusive commission fee from the formerly tax-evading firms.

Contrary to this standard effect for foreign developers, the proposition also shows two new mechanisms which are specific to our setup. First, because such a new tax burden for foreign app developers induces an exit from the platform, the platformer sets lower commission fee due to lower profitability after tax reform. At the first look, the reduction of the commission fee seems to benefit home app developers, but network externality makes another effect which we analyze in the next section. Second, beyond the content market which is directly impacted with the tax reform, our result shows that such a pass through also spreads to the price of the network good for the access to the platform since the markets are two-sided.

4 Cross-market effects, firm entry, and welfare

Tax reform changes the platformer's pricing strategies. These affect the equilibrium consumption of the network good and the number of app developers. Although the tax reform is expected to increase tax revenues in home country as argued in Introduction, results in this section reveal concerns on consumers and home app developers. In our model, the link between prices on different sides makes consumers better-off, and tax reform affects such links. Thus, this section explores the welfare effects of the tax reform beyond tax revenues.

4.1 Cross-market effects on the network good and consumer surplus

To see the whole welfare effects, let us first show the decline of the equilibrium consumption of the network good (or the standard good for online transactions with positive network effects). By substituting the equilibrium price of the good and commission fee, we have $q^* = \frac{\nu - c}{den^*}$ for $* = O,\ T$, for the equilibrium consumption of the network goods under each regime with $\frac{1}{den^O} > \frac{1}{den^T}$: it reflects the downward shift of the induced demand (1′) by η changing from 0 to 1, the increase of p and the partially-offsetting effect of the decrease of R.

$$\frac{q^T - q^O}{q^T} = \frac{den^O - den^T}{den^O} < 0. \tag{9′}$$

This implies that tax reform reduces the consumption and leads to the shrinkage of the product market. The lower multiplier relates not only to the increase in the price of the good but also to less attractive platform reflected in the lower number of total apps.[16]

Our specification yields the conclusion that consumer surplus decreases (see Appendix A). Intuitively, the loss of consumer surplus appears in its square term because the real burden of tax occurs in *the number of goods/apps* (the reduction of q^* in (9′)) and the reduction of *per-unit surplus* as $p(q) - p \equiv (\nu + \alpha m - q) - p,\ q \leq q^*$, in (1) after tax reform, as $m^T < m^O$ is confirmed in the next section.[17]

4.2 Entry and exit of app developers and domestic producer surplus

Once we identify of the tax reform on the product markets, we see the decline of the whole sizes of the app market, from $m^* = \frac{M}{f}\{(1 - 0.5(1+\eta)\tau)\phi + \alpha\}q^*$, as follows:

$$m^T - m^O = -0.5\tau\phi q^T \frac{M}{f} + \{(1 - 0.5\tau)\phi + \alpha\}(q^T - q^O)\frac{M}{f} < 0. \tag{15}$$

[16] In (1) and the decrease of m which we show later, the decrease of the network-good's consumption occurs in the greater extent than the response from (endogenized) price p's increase.

[17] Weyl and Fabinger (2013, Section III) and Adachi and Fabinger (2022) showed that the sum of buyers' and the (monopolistic) seller's burdens from the consumption tax is, as the product of the horizontal coordinate q^* and the incidence on the product's price.

The negative first term corresponds to the direct negative effects on foreign app developers due to the new tax burden. In the platform, the difference in the number of the network device $q^O > q^T$ is aggravated by the fact that tax reform hinders foreign developer's entry. Therefore, as a result of the tax reform, both markets shrink in the sense of less consumption of the good and less apps. From (15), we have $R^T m^T = R^T \frac{M}{\overline{f}}\{(1-\tau)\phi + \alpha\}q^T$ and from (7′) we have $p^T - c = \frac{\nu - c}{2} - \frac{\{\alpha + (1-\tau)\phi\}MR^T}{\overline{f}}$. We therefore show that a variant of (12) in the last section is valid in Regime T.

We next identify the impacts of the tax reform on app developers in each country. We can derive the following equilibrium number of app developers;

$$m_H^T = m_F^T = \frac{(\alpha + \phi - \tau\phi)M/\overline{f}}{2} q^T = \frac{M(\nu - c)(\alpha + \phi - \tau\phi)}{2\left\{2\overline{f} - M\{\alpha + \phi(1-\tau)\}^2\right\}} < \frac{M(\nu - c)(\alpha + \phi + \frac{\tau\phi}{2})}{\left[4\overline{f} - M\frac{\{2\alpha + \phi(2-\tau)\}^2}{2}\right]} = m_F^O. \tag{10′}$$

Regarding the app developers in country F, the tax reform decreases the number of foreign app developers ($m_F^T < m_F^O$ in (10′)) and equalizes it to that of the home app developers ($m_F^T = m_H^T$) due to the equalized tax burdens in Regime T. This result is intuitive because the tax reform eliminates unfair tax burden and location advantage of foreign apps as well as the less attractive platform as mentioned above. Both heavier commission fee ($R^T + \tau\phi q^T > R^O$) and shrinking market ($\phi q^T < \phi q^O$) clearly reduce profits of foreign surviving app developers. In other words, the producer surplus in country F clearly declines through both extensive (the number of foreign surviving developers) and intensive (per-firm profits) margin.

Once we explore the impacts on app developers in H, such a concern related to competition can extend to app developers. Regarding producer surplus in each country H, we derive,

$$PS_H = \int_0^{\overline{f}_{SH}} \{(1-\tau)\phi q - R - f_S\} \frac{M}{\overline{f}} df_S = \frac{m_H^2 \overline{f}}{2M}$$

and, thus, whether the tax reform increases producer surplus depends on the direction of a change in app developers of country H. Formally, $PS_H^T \gtreqless PS_H^O$ holds if and only if $m_H^T \gtreqless m_H^O$ holds.

Notably, although the tax reform appears to increase the number of home app developers and domestic producer surplus by eliminating the unfair tax burden between app developers in H and F, whether the tax reform induces more home app developers ambiguous. The reason is less app developers in country F causes the reduction of consumers' willingness to pay for the network good and the value of the platform from the viewpoint of the home app developers. Conceptually, denoting $\Delta q = q^T - q^O$ and $\Delta R = R^T - R^O$, one can decompose:

$$m_H^T - m_H^O = \frac{M}{\overline{f}} \left[\{1-\tau\} \phi \Delta q - \Delta R \right].$$

Namely, the sign of the above formula depends on whether or not the incidence of the lower commission fee ($-R^T > -R^O$) is more dominant than the effect of the downsized number of users ($q^T < q^O$). We have $m_H^* = (\alpha + \phi - (1.5 - 0.5\eta)\tau\phi)\frac{M}{2\overline{f}}q^*$ and therefore:

$$m_H^T - m_H^O \propto \frac{\nu - c}{4den^T}\tau\phi - \frac{(\alpha + \phi - 1.5\tau\phi)}{2}(q^O - q^T) \gtreqless 0 \tag{16}$$
$$\Leftrightarrow \frac{\overline{f}}{M} \gtreqless \frac{\{2\alpha + \phi(2-\tau)\}^2}{8} + \frac{(2\alpha + 2\phi - 3\tau\phi)(4\alpha + 4\phi - 3\tau\phi)}{8} \equiv K(\alpha, \phi, \tau).$$

The first term of the right-hand side of (16) is interpreted as the replacement of domestic app developers with the exited app developers in country F due to the tax reform. The reduction of R after tax reform, $R^O - R^T > 0$ in Proposition 1, encourages entry of domestic firms. The second term of the right-hand side reflects the shrinkage of the network, $q^T - q^O < 0$.[18]

Compared with the value of $\frac{\overline{f}}{M} \geq A(\alpha, \phi, \tau, \nu - c, M) \left(> \frac{\{2\alpha + \phi(2-\tau)\}^2}{8} \right)$, $K(\alpha, \phi, \tau) > \frac{\overline{f}}{M}$ holds when $A(\alpha, \phi, \tau, \nu - c, M)$ is sufficiently small (either $\frac{\overline{f}}{M}$ or $\nu - c$ is small), whereas the sign could be reversed otherwise. This equation means that, when $\frac{\overline{f}}{M}$ is high (app developers' sensitivity of entry decision to prices is low), the tax reform is likely to induce more entry of home app developers so $PS_H^T > PS_H^O$, whereas when $\frac{\overline{f}}{M}$ is small, tax reform induces the exit of home app developers. Quite interestingly, the emergence of entry in (16) reveals a less proportional reduction of demand (low $\frac{q^O - q^T}{q^T}$), so the entry or exit of domestic firms is informative to see the welfare loss in the product's market.

Note that we can derive the following effects of VAT rate on the thresholds:

$$\frac{\partial K(\alpha, \phi, \tau)}{\partial \tau} = -\frac{(11\alpha + 11\phi - 10\tau\phi)\phi}{4} < 0$$

When τ is relatively large (small), the tax reform increases (*reduces*) app supply and producer surplus in country H through $A(\alpha, \phi, \tau, \nu - c, M) \leq \frac{\overline{f}}{M} < K(\alpha, \phi, \tau)$. This result provides an important implication on the effects of the tax reform from the viewpoint of VAT rates. In general, European countries tend to impose a high VAT rate whereas a VAT rate in Asian countries are

[18] The first term of (16) is identical to the first term of (13). The second term of (13) is $\frac{(\phi - 0.5\tau\phi - \alpha)(\nu - c)(den^T - den^O)}{2den^O den^T} = \frac{(\phi - 0.5\tau\phi - \alpha)}{2}(q^O - q^T)$. Adding to $-(1-\tau)\phi(q^O - q^T)$ will have $\frac{(-\phi + 1.5\tau\phi - \alpha)}{2}(q^O - q^T)$, which is the second term of (16).

low,[19] and our result suggests that the reduction of app supply after tax reform tends to happen in countries with low VAT rate.

Proposition 2. *(i) The VAT reform increases the number of domestic (home) app developers if* $\frac{\bar{f}}{M} > K(\alpha, \phi, \tau)$*, meaning that entry of developers is not very sensitive to changes in market conditions.*

(ii) Under a low VAT rate, the tax reform is more likely to discourage entry by home app developers. Conversely, under a higher VAT rate, the tax reform is more likely to encourage entry of home app developers.

(iii) The emergence of exit (entry) of domestic firms after tax reform reveals high (low) proportional shrinkage of the product market.

It is also worth noting that a smaller number of users after the tax reform ($q^T < q^O$) does not necessarily mean fewer home app developers. As Proposition 2 shows, more home app developers enter the platform when the VAT rate is sufficiently high because eliminating unfair tax burden is a dominant effect.

4.3 Tax revenue and welfare in country H

Although the above discussion casts some welfare effects of the tax reform due to the tax incidence, the reform is expected to increase tax revenues in H. As the tax revenues in each scheme are formulated as $TR^O = \tau\phi m_H^O q^O$ and $TR^T = \tau\phi(m_H^T + m_F^T)q^T$, we can compute the effects of the tax reform on tax revenue in country H is

$$TR^T - TR^O = \tau\phi \left(2m_H^T q^T - m_H^O q^O\right)$$

As shown above in Proposition 2, $q^T < q^O$ holds and thus the tax reform has a negative channel for tax revenues through less consumers in the platform. However, as foreign app developers are subject to VAT payments indirectly through the platformer in the post-reform scheme, the tax reform also can increase tax revenues.[20] The following proposition is originally shown when the network good is also subject to VAT (details are available upon request to the authors). Online Appendix B.1 shows the following:

[19] See `https://www.globalvatcompliance.com/globalvatnews/world-countries-vat-rates-2020/` for the list of VAT rates, accessed 2025 February 5th. For example, VAT rates in France and Germany in 2024 are, in the expression for consumers' burden $\frac{1}{1-\tau} - 1$, 20% and 19% whereas those in Japan and Vietnam are 10% and 8%.

[20] Under the post tax-reform, the total number of app developers subject to tax payments can increase from m_H^O to $m_H^T + m_F^T$ and one might expect that the tax reform can increase tax revenues in country H more than the amount of taxes avoided by foreign app developers. However, because $m_H^O + m_F^O > m_H^T + m_F^T$ and $q^O > q^T$ hold, we have

$$\tau\phi q^O(m_H^O + m_F^O) > \tau\phi q^T(m_H^T + m_F^T) = TR^T \iff \tau\phi q^O m_F^O > TR^T - \tau\phi q^O m_H^O = TR^T - TR^O$$

which means that the tax revenue gains are less than the amount of tax avoidance by foreign app developers under pre tax-reform.

Proposition 3. *Tax reform increases the tax revenue if: (i)* $\tau < 0.3$ *(a regular VAT) and (ii)* $2\{\frac{\overline{f}}{M} - A(\alpha, \phi, \tau, \nu - c, M)\}/(\alpha + (1+0.5\tau)\phi) + (\nu - c)/(2M) \geq \phi$ *(either the inverse responsiveness of entry or the net market size is sufficiently larger than the network externality).*

As shown in footnote 13, footnote 16 and Section 4.2 before (16), the behavioral effects on demand and supply involve endogenized prices and external effects. Proposition 2 and Proposition 3 showed that the tax reform brings both positive and negative effects in country H. To see its total impacts and conditions for welfare improvement, Figure 2 and Figure 3 draw numerical examples on the effects of the tax reform on entry of domestic firms and domestic welfare in country H. Conceivably, the host government does not take into account the foreign firms' profit PS_F,[21] and the profit of the platformer (π_P) for the domestic welfare: the latter is typically a foreign multinational enterprise which does not bring benefits apart from the platform services. To analyze the tax incidence, it is sufficient to examine the developers' side, as the app users' net benefit in Section 2.2 remains unchanged — specifically, zero — both before and after the tax reform. Therefore, the domestic welfare is defined as :

$$W_H = CS + PS_H + TR.$$

As an equivalent analysis, Nishimura (2025b) examined Marginal Value of Public Funds, defined as the ratio of the private sector's marginal burden to the increase in tax revenue (MVPF $= \frac{-\Delta CS - \Delta PS_H}{\Delta TR}$). The MVPF is less than 1 if and only if W_H increases following the tax reform.[22]

4.4 Numerical Illustrations

In Fig.2,[23] changes in q and m_i due to the tax reform are illustrated. The red and green curves capture reductions of consumption of the network good and foreign app developers after the tax reform.[24] As mentioned in Nishimura (2025b) and Etro (2023), higher entry response is beneficial for the market size. However, what matters here is its *decline after the tax reform* which is increasing in

[21] Analogous to derivation of producer surplus in country H, from (10) and (10′), $PS_F = \frac{m_F^2 \overline{f}}{2M}$. Following Nishimura (2025b), in the app market, consumers' bargaining power is zero so that consumer surplus is zero before and after the tax reform.

[22] The numerator and the denominator are expressed in discrete form, reflecting the nature of the tax reform, which is conceptually modeled as a change in η from 0 to 1. Unlike Proposition 3 by Adachi and Fabinger (2022), the instrument for tax reform is not the tax rates but tax enforcement. The denominator (which is positive) corresponds to enforcement elasticity by Keen and Slemrod (2017). Nishimura (2025b) shows a comprehensive treatment of the MVPF and extended discussions, including empirical challenges and proposed resolutions.

[23] We use the following parameters: $\nu = 2$, $c = 0$, $M = 1$, $\alpha = \phi = 0.25$, and $\overline{f} = 0.33$.

[24] Here we mention the overall effect of changing τ, so it will be worthwhile to mention the incidence of the tax increase. We have $\frac{\partial R^*}{\partial \tau}\frac{1}{R^*} = -(\frac{\{\alpha + (1-0.5(1+\eta)\tau)\phi\}}{\nu - c}\frac{M}{\overline{f}} + \frac{1}{4}\frac{1}{R^*})(1+\eta)p^*_{ai}$ as the semi-tax elasticity of the commission fee, coming from entry response, network-size externalities and the apps' price p_{ai} in Section 2.2. Therefore, when $R^* \geq 0$, an increase in τ decreases R (a loss for the supplier of the online platform, which is twice greater after tax reform). The pass through effect is the increase of p, by $\frac{\partial p^*}{\partial \tau} = \{0.5(1+\eta)\phi\}R^*\frac{M}{\overline{f}} - \{\alpha + (1-0.5(1+\eta)\tau)\phi\}\frac{\partial R^*}{\partial \tau}\frac{M}{\overline{f}}$.

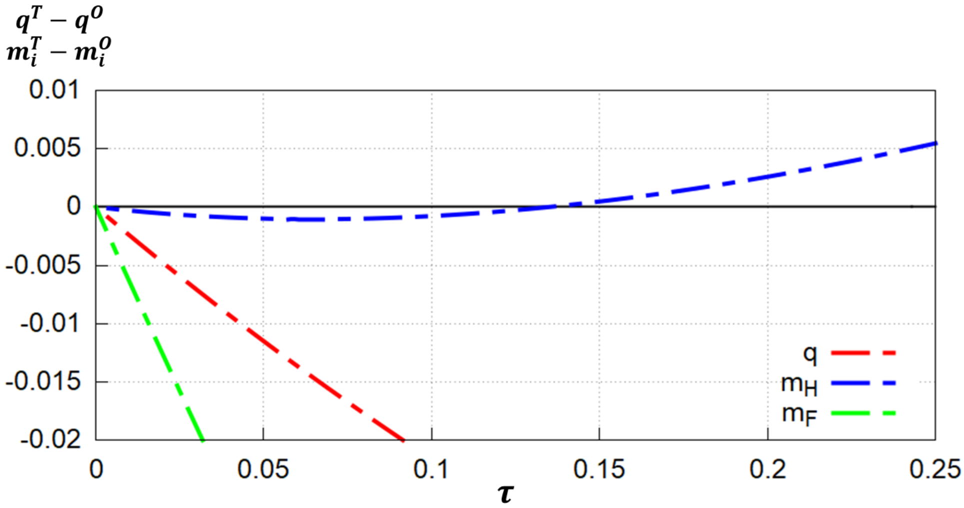


Figure 2: Effects of tax reform on q and m_i

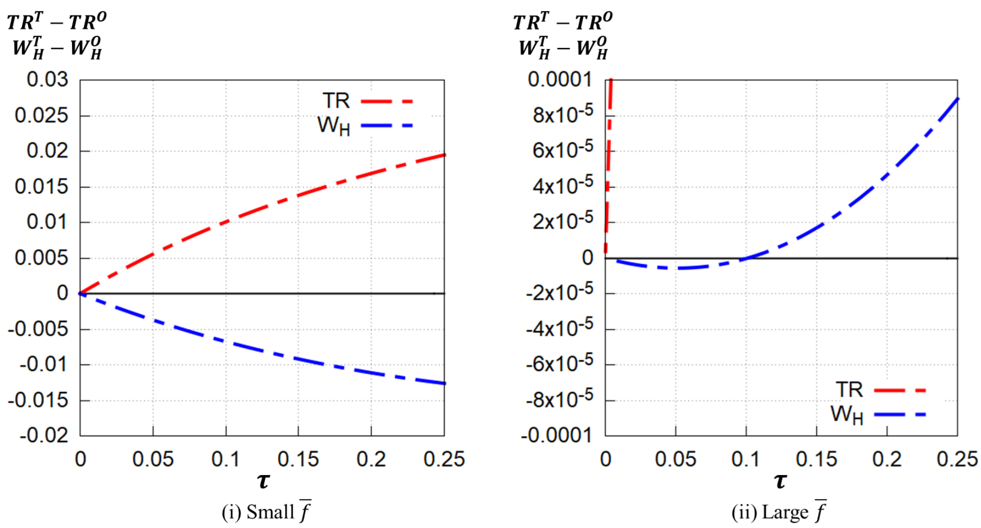


Figure 3: Effects of tax reform on TR and W_H

entry responsiveness. The blue curve in Fig.2 depicting the change in home app developers shows non-monotonic effects of tax reform shown in Proposition 2.(i). Under a low tax rate (which may indicate countries such as Japan and Vietnam), the dominant effect is the shrinkage of the network users and subsequently a decline in home app developers. Under a high VAT rate (as in European countries), however, the tax reform induces more entry of home app developer. When the VAT rate is high, the equilibrium entrants of the home app developers are efficient ones who can bear tax burdens. The addition of the tax liability to the foreign app developers in Regime T eliminates unfair tax burden of the home app developers, and this effect allows the additional entries of the home app developers (as a replacement of the exit of inefficient foreign app developers).

In Fig.3, we use the same parameter for the left panel as used in Fig.2 whereas higher $\overline{f}(= 0.85)$ is used for the right panel. As we showed, lower entry responsiveness $\frac{M}{f}$ (the right panel) means that the reduction of q and m_H after tax reform will be less and in turn, country H's tax revenue increases greater than the case of higher $\frac{M}{f}$ (the left panel). In each panel, tax revenues increased due to the tax reform and is moreover positive over greater VAT rate, which is in line with Proposition 3. However, because the tax reform reduces consumers surplus and potentially producer surplus in country H, the welfare effect (depicted with the blue curve) can be negative and decreasing in the VAT rate as in panel (i). In panel (i)'s case, the MVPF is between 1.64 and 1.67 and it is hump-shaped with respect to τ. In panel (ii)'s case, the MVPF is below 1 if τ is greater than 0.11.[25]

The above welfare analysis has a policy implication. As expected, the introduction of the tax reform increases tax revenue in a consumption country, and, thus, it seems one solution to the problem of international taxation in the digitalized world. However, in a wider scope of total welfare, the tax reform

- can deteriorate welfare in the country (which results in, equivalently, the MVPF greater than 1), because it generates negative network externalities driven by exits of foreign app developers.
- tends to increase domestic welfare, and the gain increases (or the gain is U-shaped) with τ when the entry responsiveness is low (Proposition 2.(i) and the right panel of Fig.3).
- tends to reduce domestic welfare, and the loss increases with τ when entry responsiveness is high (Proposition 2.(iii) where the loss of consumer surplus would be increasing in τ).

Because consumers lose in both the product and app markets, evaluating the tax reform solely

[25] When the MVPF becomes greater than 1, the comparison with the MVPF determined by other tax instruments serves as a cost-benefit criterion of the present enforcement reform. Laffont (2001) assumes that MVPF is between 1.1 and 1.3, and Dahlby's (2008) estimates are even greater in some cases. Our MVPF can be less than 1 partly because the reform taxes non-residents as in tax exporting effects in the literature of the MVPF.

based on tax revenues is misleading. Also, the rate of the VAT may matter whether tax reform improves or worsens domestic welfare.

5 Illustrative variations in the app market and network externalities

5.1 The share of foreign firms

In the smartphone game industry in Japan we mentioned in Introduction, a high share of foreign developers in Regime O may not only come from the location advantage but also from the foreigner's initial share (we assumed that the potential number of entrants M are the same at home and abroad). In the general case where M_H and M_F are the respective number of potential entrants at home and abroad (16) becomes, for $M = \frac{M_H+M_F}{2}$ and $s = \frac{M_F}{M_H+M_F}$,

$$m_H^T - m_H^O = \frac{M}{\overline{f}}\phi\tau q^T(1-s)s\left[1 - [\{1-(1+s)\tau\}\phi + \alpha]\frac{(2\alpha + 2\phi - \{2(1-s)+s\}\tau\phi)}{2 - \frac{M}{\overline{f}}\{\alpha + \phi(1-(1-s)\tau)\}^2}\frac{M}{\overline{f}}\right]. \quad (16s)$$

The first term in the square bracket is the fair-trade effect, and the second term summarizes the downsized-market effect. Both are multiplied by $(1-s)s$, since m_H intrinsically relates to $M_H \propto 1-s$ and the marginal inflow and outflow relate to $M_F \propto s$.

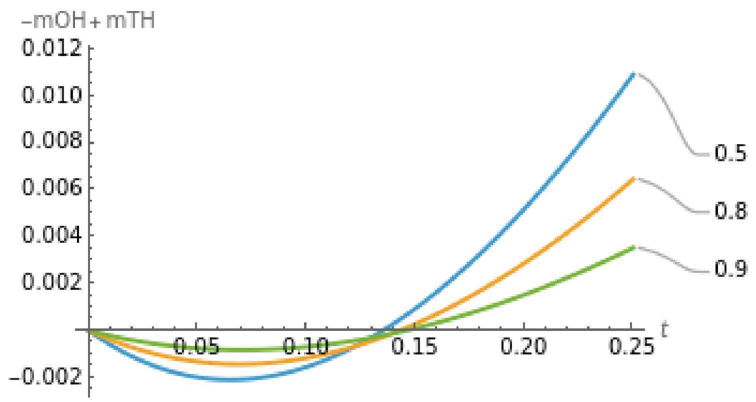


Figure 4: Effects of tax reform by s

Figure 4 used the case of $\overline{f} = 0.33$, so the light-blue curve is the same as the blue curve in Figure 2. When the VAT rates are low and the exit occurs among domestic firms, the increase of the foreign initial share curves the exit. In contrast, when the VAT rates are high and the entry happens after tax reform, then the number of entry becomes lower as s increases. Intuitively, when $1-s$ is small, the entry of the domestic developers after the tax reform is small. Interestingly, this would lower the exit of the foreign firms so that both the positive effect and the negative effect of the tax reform become smaller.

5.2 Evolution of externalities and tax avoidance behavior in the digital era

The advent of two-sided market creates new business opportunities via app markets and the interactions between the users of smartphone and app developers as we have analyzed. However, network goods such as smartphones also have another type of network externality from the direct link through the good itself via communication among friends (direct network externality or traditional network externality). Let us modify the demand function as,

$$q(p) = \nu + \alpha m + \alpha_D q_e - p,$$

where α_D represents a parameter of direct network externality and $q_e(= q)$ shows expected numbers of consumers in the equilibrium (see footnote 9). Recent development of digitization increases α (digitalization externality) to the greater extent than α_D. Our results so far qualitatively hold by adding the direct network externality into the benchmark analysis. In the following, we discuss the transition from the society with traditional linkage to digitalized society as a decline in α_D and a rise in α on the entry of domestic developers and on the platformer's pricing changes[26] (for the reduction of its profit loss).

In the product market, the traditional channel works for q so if, as a natural extension of Assumption 1, we have $\{\alpha + \phi(1 - 0.5\tau)\}\frac{M}{\overline{f}} < 1$,[27] then we have $\frac{\partial q^*}{\partial \alpha_D} > \frac{\partial q^*}{\partial \alpha}$, and the following holds (Appendix D):

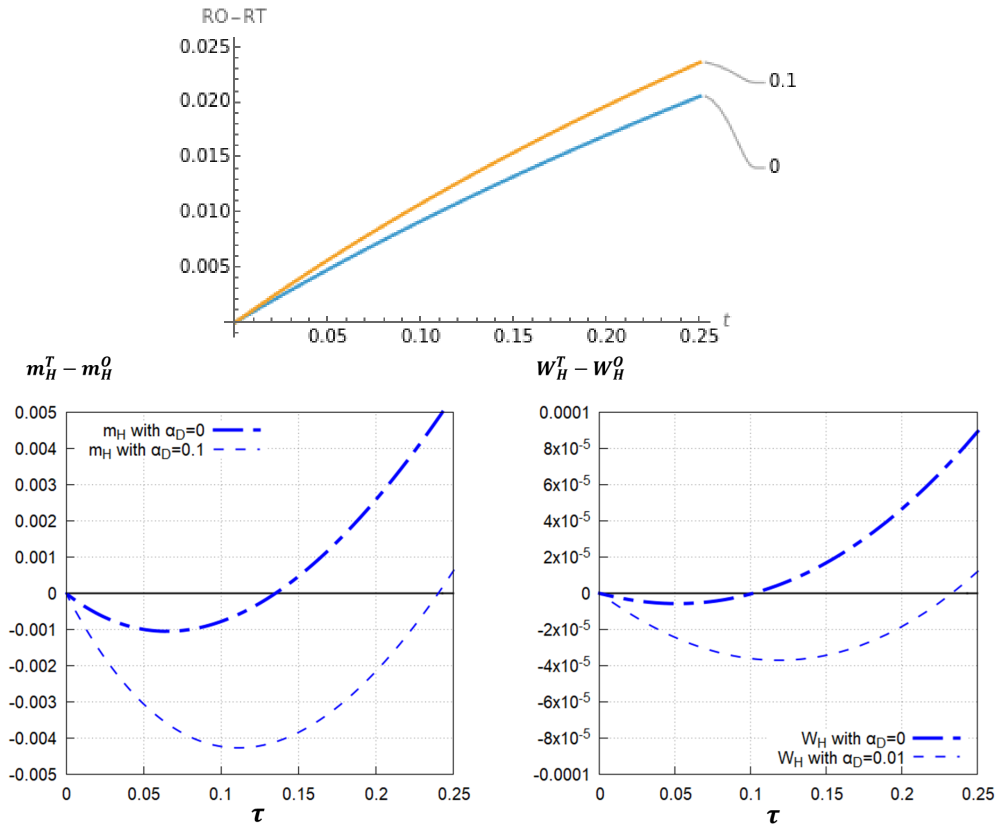
Proposition 4. Suppose that $\{\alpha + \phi(1 - 0.5\tau)\}\frac{M}{\overline{f}} < 1$ holds. If the externalities and entry elasticity allow $\frac{\partial \ln(q^O - q^T)}{\partial \alpha} < \frac{\partial \ln(q^O - q^T)}{\partial \alpha_D}$ to happen and $R^T \geq 0$, digitalization reduces the extent of tax planning on the fall of R and the rise of p due to the tax reform.

Intuitively, the increase of α works to reduce the entry fee $R^* = \frac{(1-0.5(1+\eta)\tau)\phi - \alpha}{2} q^*$ of each regime that mitigates the magnitude of the price changes. The first panel of Figure 5 illustrates $R^O - R^T$ with an example same as Figure 3 with $\overline{f} = 0.33$, which corresponds to ones shown in Figure 2 and the right panels of Fig.3. The blue curve is the case of $\alpha_D = 0$ (the benchmark scenario) and the orange curve illustrates the case of $\alpha_D = 0.1$ where $R^O - R^T$ locates above the case without direct externalities.

Regarding the entry of domestic app developers in (16), recall that the domestic developers' entry is encouraged by the fair tax burden but deterred by the shrinkage of the product market.

[26] Tax reform reduces the platformer's profit in (12), and the platformer is the physical taxpayer in Regime T. Therefore, it has an incentive for reducing burdens from the VAT. We call such incentive as tax avoidance in this section.

[27] Assumption 1 is now $1 \geq (\frac{(\alpha+\phi-0.5\tau\phi)}{2(1-\alpha_D)} + \frac{(\alpha+\phi+0.5\tau\phi)(\nu-c)}{(\alpha+\phi-0.5\tau\phi)4M(1-\alpha_D)})(\alpha + \phi - 0.5\tau\phi)\frac{M}{\overline{f}}$. So $\alpha_D + \max\{\alpha, (1 - 0.5\tau)\phi\} \leq 1$, or sufficiently high net market size, will warrant this assumption.



(i) Number of home app producers (ii) Welfare in H under large $\overline{f}$

Figure 5: Effects of tax reform on R, m_H and W_H with direct network externality

Consumption and direct externalities are both active in shrinking the app provision in the second term of (16). The second and the third panels of Fig.5 illustrates the case of $\alpha_D = 0.1$ for the left panel and $\alpha_D = 0.01$ for the right panel at which $m_H^T < m_T^O$ occurs with low τ. The left panel shows the impacts of tax reform on the number of home app developers whereas the right one draws those on domestic welfare in country H. In each panel, the thick dot-dashed curve represents the case without direct network externalities. The thin dashed curve depicts the change in the presence of the direct network externalities, which is below the thick curve of respective case. Since the product-shrinkage effect is more prominent through traditional externality, the turning point for the increase of $m_H^T - m_H^O$ in traditional society occurs only with higher VAT rates than the case where digital externality is stronger. The market size on the traditional channel hinges on the consumption of the network good and, hence, it magnifies the negative effects of tax reform and tends to cause greater reactions in pricing by the platformer. In summary, digitalization:

- reduces the extent of tax avoidance (reducing real burdens coming from tax reform) on the fall of R and the rise of p due to the tax reform.
- increases the domestic developers' entry, when $m_H^T < m_T^O$ occurs with low τ.

6 Conclusion

Value-added tax (VAT) has become a major revenue source in many countries, while the forms of consumption have grown increasingly complex. A growing concern in international taxation is how to collect consumption taxes from foreign firms given that foreign developers are located outside the destination country and provide services remotely — such as digital content — through online platforms. This paper theoretically investigates the impact of a tax reform that enables countries to collect VAT from an online platform operator on behalf of foreign content developers.

We find that this platform tax to charge VAT from foreign online apps reduces the number of apps in the platform, which reduces the network size (the number of consumers of the network good). The reason is that the tax reform makes the platformer to raise tax-inclusive commission fee which affects the network size. This is in line with the standard discussion of pass through of taxation. As the market are two-sided, the pass through of tax reform happening in app developer side spreads to the market of the network good side.

However, the tax reform benefits the domestic developers due to fairer tax treatment. We found that the extent of the trade-off between tax burden between reduced consumption and domestic developers' participation depends on entry responsiveness in the app market. Such a trade-off also happens between increased tax revenue for the host country and a decline in surplus for consumers and developers. We show that low entry elasticity works to increase domestic total surplus through the tax reform. The positive effects can become more pronounced at higher VAT rates, suggesting that countries with low VAT rates may inadvertently harm their domestic developers. We also show that digitalization, defined as the shift from direct to indirect externalities, mitigates welfare losses and reduces tax avoidance behavior by the platform operator.

These findings may initially appear to justify antitrust intervention by the host government. However, caution is warranted. Our model offers real-world explanations for the monopolist's behavior, such as reducing product prices or stimulating supply and demand in multi-sided markets. As Rysman (2009) noted, monopoly pricing is not inherently an antitrust violation. Nevertheless, we emphasize the importance of analyzing pricing before and after the reform because the benefit of the reduction of prices through network externalities diminish after the tax reform. A promising future research is to explore the effects of price-ceiling policies that could target not only the commission fee R (as recently scrutinized by the European Commission in cases involving Amazon and Apple), but also p, the price of the network good (e.g., iPhone by Apple). Nishimura (2025a) have addressed such issues.

Appendix

A. Derivation of (1) and consumer surplus

Consumers are heterogeneous in their preference over the network good. Specifically, consumer k has the following net utility from purchasing the good,

$$u_k = b_k + \alpha m - p,$$

($u_k = b_k + \alpha m + \alpha_D q_e - p$ with direct externality in Section 5.2) where b_k is fundamental willingness to pay for the good and is assumed to be uniformly distributed, $b_k \in (-\infty, \nu]$ whereas the last term p is the price for the good. We assume that consumers decide to buy one unit of the good or not. This means that consumer k buys the good if $u_k \geq 0$ or equivalently $b_k \geq p - \alpha m \equiv \underline{\nu}$ holds, which implies that consumers having higher fundamental willingness to pay than $\underline{\nu}$ buy the good, leading to $q(p) = \int_{\underline{\nu}}^{\nu} 1 db_k = \nu - \underline{\nu}$, which is (1).

With the above features, we have the following formulation about the consumer surplus:

$$CS = \int_{\underline{\nu}}^{\nu} (b_k + \alpha m - p)\, db_k = \frac{1}{2}(\nu^2 - \underline{\nu}^2) - \underline{\nu}(\nu - \underline{\nu}) = \frac{1}{2}(\nu - \underline{\nu})^2 = \frac{q^2}{2}.$$

B. Derivation of (7), (7′) and Second Order Conditions

From (1′) we have $\frac{\partial q}{\partial p} = \frac{-\overline{f}}{\overline{f} - \alpha M \phi\{2-(1+\eta)\tau\}} \equiv -\frac{1}{\gamma} < 0$, $q = \frac{1}{\gamma}\left(\nu - p - \frac{2\alpha R M}{\overline{f}}\right)$ and from (4′) and (5′), we have $\frac{\partial m}{\partial p} = \{2 - (1+\eta)\tau\}\phi \frac{-1}{\gamma} \frac{M}{\overline{f}}$. Therefore, the FOC for p in the platformer's problem is written as (7). (7′) is analogously derived.

For the second-order condition, we have $\frac{\partial^2 \pi_P}{\partial p \partial p}\gamma^{-1} = -2$, $\frac{\partial^2 \pi_P}{\partial R \partial R}\gamma^{-1} = -4\frac{M}{\overline{f}}$, $\frac{\partial^2 \pi_P}{\partial p \partial R}\gamma^{-1} = -\frac{2\alpha M}{\overline{f}} - \frac{\{2-(1+\eta)\tau\}\phi M}{\overline{f}}$. Therefore,

$$\overline{f} - \frac{M\left[2\alpha + \{2 - (1+\eta)\tau\}\phi\right]^2}{8} > 0.$$

Note that $\frac{M(2\alpha+2\phi-\tau\phi)^2}{8} > \frac{M(\alpha+\phi-\tau\phi)^2}{2}$ holds. Condition (A-1) subsumes the above condition, so Assumption 1 warrants the interior optimum of the benchmark model.

Meaning of the SOCs

Surrounding the benchmark gains-of-trade value of $\frac{\nu - c}{2} = \nu - p^O|_{R=0}$ in (7), meaning also that $(1 - 0.5\tau)\phi = \alpha$, one can equate (9) with the function before platformer's optimization (1′) as:

$q^O = \frac{\overline{f}(\nu-c)/2}{\overline{f}-M\frac{\{2\alpha+\phi(2-\tau)\}^2}{8}} = \frac{\overline{f}(\nu-p)-2\alpha MR}{\overline{f}-\alpha M\phi\{2-\tau\}}$. Intuitively, utilizing externalities for pricing, the multiplier (self-enforcing) effect of the product's demand with respect to the retained benefit $\nu - p$ or $\frac{\nu-c}{2}$ is stronger in the optimized demand function than the effect in the price-taker's induced demand. $\frac{\{2\alpha+\phi(2-\tau)\}^2}{8} > \alpha\phi(2-\tau)$ when $R^O \neq 0$.

C. Proof of Proposition 1

The formula (9′) and the formula of R^T show that $R^T + \tau\phi q^T = \frac{\overline{f}(\nu-c)(\phi+\tau\phi-\alpha)}{2\{2\overline{f}-M\{\alpha+\phi(1-\tau)\}^2\}}$. From the formula of R^* ($* = O,\ T$) and (7′), with $den^* = 2 - (\alpha + \phi - 0.5(1+\eta)\tau\phi)^2 \frac{M}{\overline{f}} > 0$ for $\eta = 0,\ 1$:

$$p^T - p^O = \frac{(\alpha + (1-\tau)\phi)(\nu - c)M}{4den^T\overline{f}}\tau\phi\left\{1 + \frac{(2\phi - \tau\phi - 2\alpha)(\alpha + (1-0.75\tau)\phi)M}{den^O\overline{f}}\right\} + 0.5\tau\phi\frac{(\nu-c)(\phi - 0.5\tau\phi - \alpha)M}{2den^O\overline{f}} \quad \text{(A-2)}$$

$$R^T + \tau\phi q^T - R^O = \frac{\tau\phi(\nu-c)}{4den^T}\left\{3 + \frac{\{2\alpha - (2-\tau)\phi\}\{\alpha + (1-0.75\tau)\phi\}}{den^O}\frac{M}{\overline{f}}\right\}. \quad \text{(A-3)}$$

The signs of (A-2) and (A-3) depend on the last term of the numerator $2\alpha - 2\phi + \tau\phi$. From (13) and (A-2) , $2\alpha - 2\phi + \tau\phi \leq 0$ or $p^T > p^O$ implies $R^O > R^T$. Therefore, Assumption 1 secures $p^T > p^O$ and $R^T < R^O < R^T + \tau\phi q^T$ if

$$\frac{\frac{\overline{f}}{M} - A(\alpha,\phi,\tau,\nu-c,M)}{2\alpha + 2\phi + \tau\phi} + \frac{\nu - c}{8M} \geq \frac{(4\alpha + 4\phi - 3\tau\phi)(-2\alpha + 2\phi - \tau\phi)}{24(2\alpha + 2\phi + \tau\phi)} \quad \text{when } -2\alpha + 2\phi - \tau\phi \geq 0,$$

$$\frac{\frac{\overline{f}}{M} - A(\alpha,\phi,\tau,\nu-c,M)}{2\alpha + 2\phi + \tau\phi} + \frac{\nu - c}{8M} \geq \frac{(4\alpha + 4\phi - 3\tau\phi)((2\alpha)^2 - (2-\tau)^2\phi^2)}{8\{4 - 3\tau\}\phi(2\alpha + 2\phi + \tau)} \quad \text{when } 2\alpha - 2\phi + \tau\phi \geq 0,$$

holds. *Q.E.D.*

D. The Case with Two Externalities

For $* = O,\ T$ for $\eta = 0$ and 1, respectively (see Online Appendix B.2):

$$q^* = \frac{\overline{f}(\nu - c)}{2\overline{f}(1-\alpha_D) - \{\alpha + \phi(1 - 0.5(1+\eta)\tau)\}^2 M}, \quad q^O > q^T, \text{ and } R^* = \frac{(1 - 0.5(1+\eta)\tau)\phi - \alpha}{2}q^*.$$

The traditional channel works for q and $\frac{\partial q^*}{\partial\alpha} < \frac{\partial q^*}{\partial\alpha_D}$ if, as a natural extension of Assumption 1, $\{\alpha + \phi(1-0.5\tau)\}\frac{M}{\overline{f}} < 1$. When $\frac{\partial \ln(q^O - q^T)}{\partial\alpha_D} - \frac{\partial \ln(q^O - q^T)}{\partial\alpha} > 0$ and $(1-0.5\tau)\phi - \alpha \geq 0$, we have $\frac{\partial(R^O - R^T)}{\partial\alpha_D} = \frac{(1-0.5\tau)\phi - \alpha}{2}\frac{\partial(q^O - q^T)}{\partial\alpha_D} + \frac{0.5\tau\phi}{2}\frac{\partial q^T}{\partial\alpha_D} > \frac{\partial(R^O - R^T)}{\partial\alpha} = \frac{(1-0.5\tau)\phi - \alpha}{2}\frac{\partial(q^O - q^T)}{\partial\alpha} + \frac{0.5\tau\phi}{2}\frac{\partial q^T}{\partial\alpha} - \frac{1}{2}(q^O - q^T)$. Likewise, we can show $\frac{\partial(p^T - p^O)}{\partial\alpha_D} > \frac{\partial(p^T - p^O)}{\partial\alpha}$.

References

Adachi, T., Fabinger, M., 2022. Pass-through, welfare, and incidence under imperfect competition. Journal of Public Economics 211, 104589.

Agrawal, D.R., Fox, W.F., 2017. Taxes in an e-commerce generation. International Tax and Public Finance 24, 903–926.

Aiura, H., Ogawa, H., 2024. Does e-commerce ease or intensify tax competition? destination principle versus origin principle. International Tax and Public Finance 31, 702–735.

Armstrong, M., 2006. Competition in two-sided markets. RAND Journal of Economics 37, 668–91.

Belleflamme, P., Toulemonde, E., 2018. Tax incidence on competing two-sided platforms. Journal of Public Economic Theory 20, 9–21.

Bösenberg, S., Egger, P.H., 2017. R&D tax incentives and the emergence and trade of ideas. Economic policy 32, 39–80.

Bourreau, M., 2018. Taxation of a digital monopoly platform. Journal of Public Economic Theory 20, 40–51.

Caillaud, B., Jullien, B., 2003. Chicken & egg: Competition among intermediation service providers. RAND journal of Economics , 309–328.

Copestake, A., Bellon, M., 2022. Supply and demand determinants of heterogeneous VAT pass-through. SSRN `https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4207882`.

Etro, F., 2023. Platform competition with free entry of sellers. International Journal of Industrial Organization 89, 102903.

Hayakawa, K., Kao, K.F., Mukunoki, H., 2025. Optimal trade policies on a monopoly platform in two-sided markets. Review of International Economics , forthcoming.

Johansson, Å., Skeie, Ø.B., Sorbe, S., Menon, C., 2017. Tax planning by multinational firms: Firm-level evidence from a cross-country database. OECD Economics Department Working Papers No. 1355 .

Katz, M.L., Shapiro, C., 1985. Network externalities, competition, and compatibility. The American Economic Review 75, 424–440.

Keen, M., Slemrod, J., 2017. Optimal tax administration. Journal of Public Economics 152, 133–142.

Kind, H.J., Koethenbuerger, M., 2018. Taxation in digital media markets. Journal of Public Economic Theory 20, 22–39.

Kind, H.J., Koethenbuerger, M., Schjelderup, G., 2008. Efficiency enhancing taxation in two-sided markets. Journal of Public Economics 92, 1531–1539.

Laffont, J.J., 2001. Incentives and Political Economy. Oxford University Press.

Mukunoki, H., Okoshi, H., 2025. Tax avoidance in digital economy: Network externalities and transfer pricing regulations. Presented at PET 2024 International Conference on Public Economic Theory .

Nishimura, Y., 2025a. A novel argument on regulating prices in two-sided markets: Finding win-win policy correctly. Presented at Center for Operations Research and Econometrics (CORE, Belgium) and Osaka University .

Nishimura, Y., 2025b. Tax incidence of VAT enforcement reform for foreign services and small businesses in two-sided markets. Presented at Center for Operations Research and Econometrics (CORE, Belgium) and Osaka University .

OECD, 2024. Consumption Tax Trends 2024: VAT/GST and Excise, Core Design Features and Trends. OECD Publishingm, Paris. doi:https://doi.org/10.1787/dcd4dd36-en.

Rasch, A., Wenzel, T., 2013. Piracy in a two-sided software market. Journal of Economic Behavior & Organization 88, 78–89.

Rochet, J.C., Tirole, J., 2003. Platform competition in two-sided markets. Journal of the European Economic Association 1, 990–1029.

Rochet, J.C., Tirole, J., 2006. Two-sided markets: a progress report. RAND Journal of Economics 37, 645–667.

Rysman, M., 2009. The economics of two-sided markets. Journal of Economic Perspectives 23, 125–143.

Tremblay, M., 2018. Taxing a platform: Transaction vs. access taxes. SSRN 20, 1–21.

Weyl, E.G., Fabinger, M., 2013. Pass-through as an economic tool: Principles of incidence under imperfect competition. Journal of political economy 121, 528–583.

Wu, T.C., Yen, C.T., Chang, H.W., 2023. Network externalities, trade costs, and the choice of commodity taxation principle. International Tax and Public Finance 30, 1203–1224.

Zodrow, G.R., 2003. Network externalities and indirect tax preferences for electronic commerce. International Tax and Public Finance 10, 79–97.

Online Appendix for
"VAT Reform via Monopolistic Platformer in Borderless Economy: Price Pass-Though and Efficiency Consequences "

Shigeo Morita Yukihiro Nishimura

B.1. Proof of Proposition 3

A simple calculation shows:

$$
\begin{aligned}
& sign(TR^T - TR^O) = \\
& sign\Bigg\{ \ 2\{\alpha + (1-\tau)\phi\} \left(2 - \frac{M}{\overline{f}}\{(1-0.5\tau)\phi + \alpha\}^2\right)^2 \\
& \quad - \{\alpha + (1-\tau)\phi\} \left(2 - \frac{M}{\overline{f}}\{(1-\tau)\phi + \alpha\}^2\right)^2 + 0.5\tau\phi \left(2 - \frac{M}{\overline{f}}\{(1-\tau)\phi + \alpha\}^2\right)^2 \ \Bigg\}
\end{aligned}
$$

Therefore, $TR^T > TR^O$ holds when $\sqrt{2}(2 - \frac{M}{\overline{f}}((1-0.5\tau)\phi + \alpha)^2) \geq 2 - \frac{M}{\overline{f}}((1-\tau)\phi + \alpha)^2$. For the variable $A(\cdot)$ we have defined, we have:

$$
(\sqrt{2}-1) \left[2\frac{\overline{f}}{M} - 2A(\alpha, \phi, \tau, \nu - c, M) + \frac{\alpha + \phi + 0.5\tau\phi}{2}\frac{\nu - c}{M} \right] \geq \tau\phi\{\alpha + (1-0.75\tau)\phi\} \Rightarrow TR^T \ > \ TR^O
$$

Since $\frac{\overline{f}}{M} > A(\cdot)$, sufficient conditions are $\sqrt{2} - 1 \approx 0.414 > \tau$ and $2\{\frac{\overline{f}}{M} - A(\alpha, \phi, \tau, \nu - c, M)\}/(\alpha + (1+0.5\tau)\phi) + (\nu - c)/(2M) \geq \phi$. *Q.E.D.*

B.2. Equilibrium values of direct externality model

When there is direct externality α_D (Section 5.2), the induced demand function is now $q(p, R) = \frac{\overline{f}(\nu - p) - 2\alpha MR}{\overline{f}(1-\alpha_D) - \alpha M\phi\{2-(1+\eta)\tau\}}$. With this modification, (7) is unchanged but (8) is changed to:

$$
\frac{\partial \pi_P}{\partial R}\left(-\frac{\partial q}{\partial p}\right)^{-1}\frac{\overline{f}}{M} = (2-(1+\eta)\tau)\phi(\nu - p) - 2R(1-\alpha_D) - 2R(1-\alpha_D) - 2\alpha(p - c) = 0,
$$

which corresponds to the benchmark formula where R and $\overline{f}$ are multiplied by $1 - \alpha_D$, so $R^* = \frac{\overline{f}(\nu - c)((1-0.5(1+\eta)\tau)\phi - \alpha)}{4(1-\alpha_D)\overline{f} - 2M\{\alpha + \phi(1-0.5(1+\eta)\tau)\}^2} = \frac{R_B^*(\overline{f}(1-\alpha_D))}{1-\alpha_D}$ to be written with the benchmark value R_B^* in (8) as a function of $\overline{f}$. Substituting this and (7) (with $R = R^*$) into the new demand system, we have $q^* =$

$\frac{q_B^*(\overline{f}(1-\alpha_D))}{1-\alpha_D}$.