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Tax Incidence of VAT Enforcement Reform for Foreign Services and Small Businesses in Two-sided Markets*

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Abstract

To close gaps in VAT enforcement, governments have increasingly adopted new rules assigning tax-collection responsibilities to digital platforms. We study the incidence and welfare consequences of this platform-based VAT enforcement in a two-sided market. Taxing previously untaxed foreign developers of relation-specific goods induces the platform to raise the price of the standard good, generating cross-market tax incidence on consumers. We derive a formula characterizing its magnitude and show that cross-market pass-through generates an adverse welfare effect that enters the Marginal Value of Public Funds (MVPF). The MVPF can be below one when developer entry responses are low. Extending the analysis to SMEs, we show that entry responsiveness determines whether the existing formal sector benefits or suffers from SME inclusion in the VAT regime. We also show how platform pricing differs between ad valorem and unit taxation, and examine negative externalities from firm entry, and competition between platforms.

Keywords: Digital economy; Platform; Network externality

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1 Introduction

Fiscal capacity depends not only on statutory tax rates but also on the effectiveness of tax enforcement and compliance. This distinction is particularly important when political constraints make further increases in statutory tax rates difficult. In such circumstances, governments may seek to raise effective tax capacity by closing enforcement gaps rather than by changing tax rates themselves.[1] VAT enforcement nevertheless remains difficult in two important areas. The first is the taxation of foreign vendors that supply goods or services without local subsidiaries. The second is the taxation of small and medium-sized enterprises (SMEs) with limited reporting obligations.[2] These enforcement gaps also created tax advantages on some platform-based businesses, such as Uber and Airbnb in their early stages, whose transactions were difficult to monitor under conventional rules.

To close these enforcement gaps, governments have increasingly adopted new rules by assigning tax-collection responsibilities to digital platforms. Starting in 2025, for example, Japan requires platforms such as Apple to collect and remit VAT on sales by foreign app developers. Canada has introduced similar measures (see Nihon Keizai Shimbun (2025)).[3] Such platform-based enforcement can implement the destination principle without requiring each foreign supplier to establish or register a local entity. The same institutional development is relevant to small and informal businesses.[4]

At first sight, closing these enforcement gaps appears desirable for implementing countries: it promotes fairer tax treatment between previously taxed and untaxed competitors and increases tax revenue. This reasoning, however, ignores a central feature of digital markets. Platform operators possess price-setting power and simultaneously determine prices or fees on multiple sides of the market. A change in the tax treatment of one group of participants can therefore induce the platform to re-optimize its entire price structure. As a result, the economic incidence of an enforcement

[1] To illustrate the potential importance, in Japan, for example, data from the Japanese Ministry of Finance indicate that revenue collected per 1 percentage point of the value-added tax (VAT) rose by 10 percent over the past two decades, illustrating the potential importance of improvements in enforcement.

[2] A well-known example of tax leakage under the formerly adopted *source principle* is the case of e-books and digital music content provided via Amazon.jp. Because these services were delivered through the American entity Amazon.com Int'l Sales, Inc., Amazon.jp was exempt from paying VAT on purchases made by Japanese customers. This unequal treatment of domestic and foreign content producers was addressed in 2015, when Japan changed the digital VAT nexus from the seller to the customer, thereby applying the destination principle of consumption taxation to digital services.

[3] Japan and Canada introduced VAT relatively late, in 1989 and 1991, respectively, amid strong political opposition.

[4] In the context of Airbnb, for example, the Japanese government has sought to leverage information from platforms that manage bookings and payments to improve regulatory oversight. This issue is of particular interest in developing countries, where online platforms increasingly intermediate transactions by informal or unregistered firms (e.g., Bussolo et al. (2025)). The visibility generated by online transactions may have regulatory implications beyond VAT. For example, labor authorities may use platform information to monitor employment conditions, while competition authorities may use it to examine business practices.

reform need not remain in the market in which the statutory tax liability changes.

As a tax instrument for cross-border services,[5] we examine platform-based VAT and its enforcement. We emphasize the importance of economic incidence on prices and participation on both sides of the market, using the framework of Armstrong (2006), Hagiu (2009), and Wu et al. (2023). We consider a foreign monopoly platform, such as Apple, Amazon, or eBay, that serves domestic consumers and intermediates two types of transactions: a standard good sold on the platform and relation-specific goods, such as online applications operating through an online marketplace (the App Store), supplied by domestic and foreign developers. These developers pay a commission fee to the platform, which has come under increased scrutiny from antitrust authorities due to concerns over fair pricing. Importantly, transactions in the developer market generate network externalities for consumers of the standard good. The platform jointly chooses the commission fee and the price of the standard good. This structure allows a new tax-enforcement obligation imposed on foreign developers to affect prices and participation decisions on both sides of the market.[6]

Our first main result is that platform-based VAT enforcement generates *cross-market tax incidence*. When the government closes the enforcement gap for foreign developers, the platform reduces its commission fee but raises the price of the standard good. Consequently, even though the statutory VAT rate on the standard good does not change, consumers of that good bear an additional tax burden through the platform's endogenous repricing. In the benchmark model, the additional per-unit tax burden arising in the standard-good market is fully passed on to its consumers. Moreover, the magnitude of this cross-market incidence relative to the newly collected VAT from foreign developers depends on the platform's pricing and network responses, which is synonymous with recent empirical work by Fox et al. (2022). Our numerical simulations show that the magnitude of cross-market tax incidence ranges from 38% to 73% across alternative specifications. We also identify its key determinants.

This result complements the literature on tax pass-through under imperfect competition, including Weyl and Fabinger (2013), Adachi and Fabinger (2022) and Copestake et al. (2026). The distinction is that the policy experiment studied here is not a conventional change in a statutory tax rate. Instead, it is a change in enforcement that alters which firms are effectively subject

[5]See Hebous et al. (2026) for a comprehensive assessment of tax instruments for cross-border services.

[6]For example, the U.S. Department of Justice has accused Apple of monopolizing the smartphone market. The European Union introduced the Digital Markets Act in 2023 to promote contestable and fair digital markets, and Japan subsequently enacted the so-called "Smartphone Act." Platform commission fees have also attracted regulatory scrutiny. In 2024, for example, the European Commission found that fees charged by Apple to developers exceeded fair levels, after which Apple announced a policy to reduce its fees.

to an existing VAT. The platform then transmits the burden of tax liability associated with this enforcement across markets through its endogenous pricing decisions.

Our second result is to present the welfare consequences of enforcement reform through Marginal Value of Public Funds (MVPF) associated with VAT-enforcement reform, building on Laffont (2001) and Bastani (2025). The reform combines three components that are usually studied separately: taxation of non-residents, as in Dahlby (2008), and improvements in tax enforcement, as in Keen and Slemrod (2017), and the fiscal externality to the standard-good market. We provide sufficient conditions under which the reform raises total tax revenue, and identify an adverse fiscal externality in the standard-good market. Since taxing previously untaxed foreign developers reduces their participation and contracts the network, under the stated conditions, consumer surplus falls, while tax revenue in that market either declines or increases by less than the loss in consumer surplus. When *entry responsiveness* (defined as the responsiveness of developer entry to the size of the user network) is sufficiently low, domestic producers benefit from the reform and the MVPF can fall below one. With high entry responsiveness, stronger network contraction raises the private-sector welfare cost. Our analysis also indicates that, due to the simultaneity of price and firm entry decisions and network effects, recent parsimonious reduced-form methods may prove insufficient (e.g., Miyauchi (2024)).

Our third result is to examine the removal of VAT thresholds for SMEs. We show that we can apply the same mechanism of the basic model. Platform-based registration can make previously exempt or unregistered small firms subject to VAT, raising a familiar concern that the reform may induce SME exit while generating windfall gains for firms that were already registered. Our model shows that these effects again depend on entry responsiveness and network contraction. An increase in the profits of pre-reform registered firms is associated with a relatively modest decline in the number of network users and limited SME exit. By contrast, when entry responsiveness is high, the platform contracts more sharply, the windfall gain can disappear, and SME exit becomes more pronounced. Thus, the SME application illustrates that the same cross-market mechanism governing the taxation of foreign digital suppliers also matters for the formalization of small businesses.

Several additional results establish the scope of the mechanism. We examine the incidence neutrality of alternative assignments of statutory tax liability. We also compare ad valorem and unit taxation in the two-sided market, allow for negative entry externalities, and consider platform competition. These extensions clarify the scope of the pricing and incidence mechanisms under alternative tax instruments, entry externalities, and market structures.

Our analysis builds on Nishimura and Morita (2026),[7] who establish that platform-based VAT enforcement reduces the commission fee and may increase domestic developer entry when entry responsiveness is low. Taking these pricing and entry responses as a starting point, the present paper addresses distinct questions: how enforcement reform generates tax incidence across markets, how the resulting adjustments affect tax revenue and the Marginal Value of Public Funds, how the mechanism applies to the removal of VAT exemptions for small businesses, and whether the cross-market incidence mechanism persists under platform competition. These incidence and welfare results constitute the main contributions of the present paper.

The remainder of the paper is organized as follows. Section 2 introduces the model; Section 3 derives the equilibrium. Section 4 examines tax incidence and evaluates the MVPF. Section 5 applies the analysis to the taxation of SMEs previously exempt under the VAT threshold. Section 6 examines additional properties. Section 7 concludes. The proofs are provided in the Appendix.

2 A model with an enforcement gap and platform-based enforcement

Consider the following digital economy. A large foreign firm has its online technology to operate its *platform*, such as Amazon, eBay, and the App Store, in the home country (country H). The platform facilitates transactions in country H involving two types of goods: a standard good and a relation-specific good (or a specific good). Online apps are examples of specific goods.

We consider the following two-stage game. In Stage 1, the platform sets the price p of the standard good and the commission fee R for the specific-goods' developers. In Stage 2, consumers, specific-goods' developers, and specific-good 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 tax liability varies depending on the location of the specific-goods' developers. For example, in 2022 in Japan, 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. See Nihon Keizai Shimbun (2023). As mentioned in the Introduction, the 2025 Tax Reform introduced platform-based taxation to eliminate the location-based advantage of foreign developers. We introduce a formal

[7]The present model also differs from Nishimura and Morita (2026) in several respects. First, we introduce heterogeneity in developers' sales volumes, represented by h_S, with an explicit distribution. Second, we allow demand for specific goods to be downward-sloping with respect to the volume of app transactions. Third, we consider competing platforms (Section 6.3). These extensions provide a richer framework for analyzing firm entry, market contraction, and cross-market tax incidence.

model that captures changes in equilibrium transactions and the Marginal Value of Public Funds.

2.1 Demand for the standard good

The standard goods are sold on the platform. Following Wu et al. (2023), consumers of the standard goods[8] have the following heterogeneous preferences. Consumer k has the following net utility from purchasing the good:

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

where b_k is a fundamental willingness to pay for the good and is uniformly distributed over $(0, v]$, while p is the price of the good. Consumers decide whether to buy one unit of the good or not. This means that consumer k buys the good if $u_k \geq 0$, or equivalently, $b_k \geq p - \alpha m \equiv \underline{v}$ holds. Thus, consumers whose fundamental willingness to pay exceeds $p - \alpha m$ buy the good, leading to the following aggregate demand:

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

where v and p represent, respectively, the maximum willingness to pay for the good and its price. In the second term, m represents the total number of specific goods on the platform and α is the degree of this network externality. The term αm captures the indirect network effect generated by the transactions in the specific-good market (à la Katz and Shapiro (1985)) — a larger ecosystem (in terms of total transactions) signals platform quality, complementary richness, and future support, raising consumers' willingness to pay for the standard good.[9]

Note that such an increase in willingness to pay for the good depends not only on the number of specific goods but also on the speed of the internet connection. The network parameter α reflects the level of digitization, and we interpret technological progress, such as the introduction of 6G, which allows high-speed data transfer, as an exogenous increase in α. Such network externalities generate extra surplus specific to this platform.

As for production, we assume that the standard good is produced with a constant marginal cost c. The platform either charges sellers of the standard good a negative per-unit access price of $-c$ or outsources production. In either case, the platform sets the price p.

As shown below, the standard good has a network-specific price p^*, which is marked down from the monopoly price when the commission fee introduced below is positive. This markdown

[8] We use *consumers* or *network users* synonymously for the standard good, and distinguish them from *users of specific goods* below.

[9] We assume that $v > p$ in the equilibrium throughout the analysis. This implies that some consumers choose to consume the standard good even in the absence of additional utility from network externalities.

is platform-specific and depends on the network externalities generated by the platform. Platform retailers such as Amazon and eBay routinely set channel-specific prices for the same underlying good.

2.2 Specific-good prices

The relation-specific goods (or "specific goods" for short) sold on the platform are developed by a potentially large pool of developers, M, in country H and an equally sized pool M in a foreign country, labeled country F. In both H and F, developers are heterogeneous in app popularity, denoted by h_S over $[\underline{h}, \infty)$, which are distributed by a density $g(h_S) = M/(h_S)^3$.[10] Specific goods differ in their popularity across firms, but not in the per-unit utility they generate: each good provides the same unit utility $a_i > 0$ to user i. Thus, h_S captures heterogeneity in usage rather than in quality.

The products are demanded by a potentially large pool of users in the home country. For the number of users m, user i has the utility of consumption as $a_i = \phi q - \psi_i m$, with ψ_i being uniformly distributed in $[0, \psi]$. Note that q is the number of the network good and, equivalently, the number of consumers participating in the online platform. Following Rasch and Wenzel (2013), the willingness to pay for the app is dependent on a network size, so $\phi > 0$ is regarded as a network-size externality. This network externality captures, for example, improvements in online algorithms or other technologies that better match customers with products based on individual consumption or search histories — features that help predict users' preferences. Therefore, a larger ϕ reflects a different aspect of digitization from α. The term $-\psi m < 0$ is interpreted as a downward-sloping demand. The app's price p_a equals the lowest willingness to pay among active buyers: $p_a = \phi q - \psi m$. Alternatively, as the number of developers increases, competition is intensified, and profits per developer decrease. See Section 6.2.

In the following analysis, we mainly focus on network-size externality, so we assume $\phi > 0$ and $\psi = 0$. For the robustness of Lemma 1 and the tax-incidence simulation in Section 4.2, we consider a case of $-\psi < 0$. Also, in Section 4.2, we use an alternative case where the developer-entry function incorporates $p_a = \phi q^{1-\kappa}/(1-\kappa)$, allowing for diminishing marginal returns to network size.

In addition, in the Supplementary File for review only, we analytically generalize (i) the main pricing mechanism and (ii) the price-spillover effect of closing opportunities for tax evasion examined in Section 4.2 to arbitrary demand and entry functions. Thus, the baseline specification

[10] As shown below, the demand side can depend on the price of the good, which determines the entry margin endogenously.

provides a tractable framework for identifying the underlying economic mechanisms.

2.3 Commission fee and developer entry

In addition, developers incur a fixed cost $\overline{f}$ of developing and maintaining apps, and they must pay a commission fee, R, to the platform to sell their product on the platform. We express the commission as a per-unit fee R, which is equivalent to an ad valorem commission rate β (following Rochet and Tirole (2003)), where $R = \beta p_a$. Thus, the total commission paid by developer S is $Rh_S = \beta p_a h_S$. We allow R to be either positive or negative, where a negative R is interpreted as a subsidy from the platform to the developers.[11] The platform's choice of R has come under increased scrutiny due to concerns over fair pricing. See Appendix A for a proof that choosing the per-unit commission R and choosing the ad valorem commission rate β yield the same outcome in the platform's profit maximization problem.

As in Hayakawa et al. (2025), taxation reduces the after-tax value of production externalities by increasing the cost of providing online services. In our model, $p_a = \phi q$ is subject to a VAT at a rate τ that generates tax revenue for the home country. Before the tax-enforcement reform, only domestic developers in country H are liable to pay the VAT. In contrast, foreign developers located in country F avoid such taxation, due to the enforcement limitations in country H. After the enforcement reform, domestic (home) developers continue to be required to pay VAT, whereas foreign developers remit the VAT amount to the platform along with the commission fee R, and thus effectively face a *tax-inclusive commission fee*, imposed by the platform under the new regime. We define:

- τ: the VAT rate in country H,
- $\eta \in \{0, 1\}$: policy regime indicator (0 = before reform, 1 = after reform).

The entry conditions and the resulting numbers of specific goods sold by domestic and foreign

[11] A negative R can be interpreted as a non-pecuniary subsidy, such as technical support offered to developers — for instance, by providing development toolkits. Apple, for example, allows developers to apply for an Apple Vision Pro Developer Kit. 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. In the following, as a sufficient condition, we sometimes use the case of a positive commission fee presented in footnote 6.

developers are then given as:

$$\pi_{SH} \geq 0 \iff (\phi q - R - \tau\phi q)h_{SH} \geq \overline{f} \rightarrow m_H = \int_{h_S \geq h_{h_{SH}}} h_S \frac{M}{(h_S)^3} dh_S = \frac{M[(1-\tau)\phi q - R]}{\overline{f}}, \quad (2)$$

$$\pi_{SF} \geq 0 \iff (\phi q - R - \eta\tau\phi q)h_{SF} \geq \overline{f} \rightarrow m_F = \int_{h_S \geq h_{h_{SF}}} h_S \frac{M}{(h_S)^3} dh_S = \frac{M[(1-\eta\tau)\phi q - R]}{\overline{f}}, \quad (3)$$

As for the platform commission fee, R exhibits the standard buyer-seller independence: whether the platform charges the fee R to the developer of the specific good or its buyer is irrelevant for incidence. In the latter case, the developer sets a price $(1-\eta\tau)p_a - R$ for a specific-good's user, who then decides whether to accept the price. By summing up the sales of domestic and foreign developers, we obtain the total number of specific products sold on the platform, $m = m_H + m_F$.

2.4 Induced demand and profit of the platform

We solve the two-stage game by backward induction. In Stage 2, the standard-good and the specific-good markets are mutually dependent, so (1), (2) and (3) jointly determine q, m_H and m_F, with $m_e = m_H + m_F$ and $q_e = q$. We then derive them as functions of p and R (determined in Stage 1) and τ (given by the government) as follows:

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

and $m_H(p,R) = \frac{M[\{1-\tau\}\phi q(p,R)-R]}{\overline{f}}$ and $m_F(p,R) = \frac{M[\{1-\eta\tau\}\phi q(p,R)-R]}{\overline{f}}$.

We assume that consumption of q is taxed with full compliance.[12] At the end of Section 4.3, we briefly comment when some q-producers are foreign untaxed firms before the tax-enforcement reform. In addition, the platform operates with zero marginal cost. Let t be the VAT rate in country H on the standard good, where we have $t = \tau$ since we consider a general consumption tax. We use separate notation for clarity in the analysis that follows. The platform's post-tax profit is then given by:

$$\pi_P = (p(1-t) - c)q + R(m_H + m_F) \quad (4)$$

where q, m_H and m_F follow (1'), $m_H(p,R) = \frac{M[\{1-\tau\}\phi q(p,R)-R]}{\overline{f}}$ and $m_F(p,R) = \frac{M[\{1-\eta\tau\}\phi q(p,R)-R]}{\overline{f}}$. The tax liability on the standard good is explicit in the first term, whereas that on the specific good is incorporated implicitly in (2) and in (3). In Regime T, the platform collects the VAT from the

[12]The standard good is produced by either domestic (and large) firms, or the platform outsources the production and complies with tax obligations in country H.

foreign developer $\tau\phi q m_F$ and remits this to the home tax authority. The revenue to be received from the developers is $R(m_H + m_F)$, where R, m_H and m_F depend on the tax regime.

To ensure an interior solution throughout the analysis, we adopt the following assumption. We use a tilde to denote a variable divided by $1-t$; for example, $\widetilde{\phi} \equiv \frac{\phi}{1-t}$:

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

$$\frac{\overline{f}}{(1-t)M} \geq \frac{\{2\alpha + \widetilde{\phi}(2-\tau)\}^2}{8} + \frac{(2\alpha + (2+\tau)\widetilde{\phi})(\nu - \widetilde{c})\underline{h}}{8M} \tag{5}$$

The first component of condition (5), $\frac{\overline{f}}{(1-t)M} > \frac{\{2\alpha+\widetilde{\phi}(2-\tau)\}^2}{8}$, ensures the second-order condition of the platform's problem. The second part involving $\frac{\nu-\widetilde{c}}{M}$ ensures that the pool of potential developers M is sufficiently large to accommodate the market demand. In the following section, we solve for the platform's optimal pricing strategy, (p, R), under both the pre- and post-reform regimes.

3 Platform repricing

In this section, we characterize the equilibrium commission fee R and the price p of the standard good.

3.1 Entry responsiveness and equilibrium prices

We denote the pre-reform regime by the superscript O and the post-reform regime by the superscript T. By differentiating $\pi_P^* = (p(1-t) - c)q^* + R(m_H^* + m_F^*)$ for $* = O$ and T with respect to p: From (1'), we have $\frac{\partial q}{\partial p} = \frac{-\overline{f}}{\overline{f} - \alpha M\phi\{2-(1+\eta)\tau\}} \equiv -\frac{1}{\gamma} < 0$, $q = \frac{1}{\gamma}\left(\nu - p - \frac{2\alpha RM}{\overline{f}}\right)$ and from (2) and (3), we have $\frac{\partial m}{\partial p} = \{2-(1+\eta)\tau\}\phi\frac{-1}{\gamma}\frac{M}{\overline{f}}$. Therefore:[13]

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

$$\nu - p^* = \frac{\nu - \widetilde{c}}{2} + \{\alpha + (1 - 0.5(1+\eta)\tau)\widetilde{\phi}\}\frac{M}{\overline{f}}R^*. \tag{6}$$

In (6), when $R^* > 0$, consumers benefit from the cross-market markdown represented by the second term on the right-hand side (RHS). However, the platform's incentive to internalize network

[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 (6) becomes $\frac{\{2\alpha/d + (2-(1+\eta)\tau)\widetilde{\phi}\}MR^*}{2\overline{f}}$.

externalities, $\{\alpha + (1 - 0.5(1+\eta)\tau)\widetilde{\phi}\}\frac{M}{\overline{f}}$, is weakened when foreign services are taxed in Regime T.

Turning to the first-order condition for the commission fee R, in Appendix A we show:

$$R^* = \frac{(\nu(1-t) - c)\big((2 - (1+\eta)\tau)\widetilde{\phi} - 2\alpha\big)}{8 - (2\alpha + (2 - (1+\eta)\tau)\widetilde{\phi})^2\frac{(1-t)M}{\overline{f}}}: \quad R^* > 0 \iff (1 - 0.5(1+\eta)\tau)\phi > (1-t)\alpha \qquad (7)$$

In the Supplementary file for review only, for a general function $m_J = m_J((1-\eta_J\tau)\phi q, R) \equiv m_J((1-\eta_J\tau)\Phi, R)$, and $\eta_J = 0$ only under Regime O with $J = F$ and $\eta_J = 1$ otherwise, $q = q_1(p) + \alpha m$, $R^* > 0 \iff \phi((1-\tau)\frac{\partial m_H}{\partial \Phi} + (1-\eta\tau)\frac{\partial m_F}{\partial \Phi})\frac{-\partial q_1}{\partial p} > (1-t)\alpha(\frac{-\partial m}{\partial R})$.

That is, $R^* > 0$ when the externality channel operating through p via the after-tax network-size externality is stronger than the channel operating through R via the after-tax app-variety externality.[14] As (A-3) in Appendix A shows:

$$\frac{R^*}{p_a} = 0.5\frac{(1 - 0.5(1+\eta)\tau)\phi - \alpha(1-t)}{\phi}.$$

This relationship shows that the platform can capture through the commission fee R^* part of the surplus generated in the specific goods' market. This property has an important implication for cross-market tax incidence, which we revisit in the next section.

Two aspects further influence the pricing outcome: (i) the sensitivity of developer entry m to consumption q, given by $\frac{\partial m}{\partial q} = (2 - (1+\eta)\tau)\widetilde{\phi}\frac{(1-t)M}{\overline{f}}$, which increases with the number of potential entrants M and decreases with heterogeneity $\overline{f}$; and (ii) the effect of app transactions on consumers of the standard good, given by $\alpha\frac{M}{\overline{f}}$, which increases with α and M and decreases with $\overline{f}$. For clarity, we refer to the corresponding parameter $\frac{(1-t)M}{\overline{f}}$ as the *entry responsiveness*.

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

In (7), tax-enforcement reform deters some foreign developers from entering the platform, so the platform lowers the commission fee ($R^T < R^O$). This occurs when $R^O \geq 0$, which by (7) corresponds to $(1 - 0.5\tau)\phi \geq (1-t)\alpha \geq 0$. We also have $R^T < R^O$ when entry responsiveness $\frac{(1-t)M}{\overline{f}}$ is low and the tax rate t is high (see Appendix A). Appendix B further shows that the standard-good price moves in the opposite direction, $p^T - p^O > 0$, as implied by (6).[15]

[14] The effective average tax rates for the specific good and the standard good are $0.5(1+\eta)\tau$ and t . The after-tax values of ϕ and α represent the charging and subsidizing incentives of the platform.

[15] Lemma 1 is due to Nishimura and Morita (2026), which assumes $t = 0$ and focuses on the tax incidence of τ in the two markets. The present paper examines the incidence of a general consumption tax regime $t = \tau$. The novelty lies in the use of this property in our Proposition 1 below.

Lemma 1. *Suppose that any one of the following conditions holds: (a) the after-tax network-size externality is at least as strong as the after-tax app-variety externality ($R^O \geq 0$); (b) entry responsiveness, $\frac{(1-t)M}{\overline{f}}$, is sufficiently low (i.e., developers' entry is not very responsive to prices); or (c) the net market size, $\nu - \frac{c}{1-t}$, is sufficiently large. Then the VAT-enforcement reform increases the price of the standard good and reduces the commission fee: $p^T > p^O$ and $R^T < R^O$.*

For cases of $p_a = \phi q - \psi m$ (the downward-sloping demand for the specific good), we numerically verify $p^T > p^O$ and $R^T < R^O$, for example, in the case of Parameters $\nu = 2$, $c = 0$, $M = 1$, $\alpha = \phi = 0.25$, $\overline{f} = 0.33$, and $\tau = t$, varying $\psi = 0.01,\ 0.05,\ 0.1$.

In contrast to Cui (2019), even though the platform characteristically faces zero or very low marginal operating costs, a sales tax such as a VAT is not equivalent to a specific tax on firms' rents. The burden of the VAT is passed on to developers, those whose entry decisions are more responsive, including developers located in the tail of the cost distribution.

Hereafter, we assume that at least one of conditions (a), (b), and (c) holds so that $p^T > p^O$ and $R^T < R^O$.

4 Cross-market incidence and the Marginal Value of Public Funds

The VAT-enforcement reform alters the platform's pricing behavior, which in turn affects both the sales of the standard good and entry of app developers. While the reform is intended to increase tax revenues for the home country, it may also have unintended consequences for consumers and domestic developers due to changes in platform size and participation. The ratio of the tax burden of the private sector to the increase in tax revenue by the tax-enforcement reform can be measured by the Marginal Value of Public Funds (MVPF) summarized by network externalities and parameters that determine entry and exit of firms.

4.1 The incidence of tax-enforcement reform on the consumers of the standard good

Electronic devices used to access online platforms are supplied by knowledge-intensive firms, which are sometimes criticized for exercising substantial market power. In the present context, from (6) we have $p^*(1-t) - c = \frac{\nu(1-t)-c}{2} - \{\alpha + (1 - 0.5(1+\eta)\tau)\widetilde{\phi}\}\frac{(1-t)M}{\overline{f}}R^*$. From (A-3) in Appendix A,

$\pi_P^* = (p^*(1-t)-c)q^* + R^*(m_H^* + m_F^*)$ becomes:

$$\pi_P^* = \Big(\frac{(1-t)\nu - c}{2} - \frac{\{2\alpha + (2-(1+\eta)\tau)\widetilde{\phi}\}(1-t)MR^*}{2\overline{f}}\Big)q^* + \frac{(1-t)M}{\overline{f}}\big\{(1-0.5(1+\eta)\tau)\widetilde{\phi} + \alpha\big\}R^*q^*$$
$$= \frac{\nu(1-t)-c}{2}q^*. \tag{8}$$

That is, the price reduction corresponding to the second term on the RHS of (6) is exactly offset by revenue from the commission fee. The same conclusion holds when the commission fee is negative. The relevant measure of the real burden borne by the supplier of the standard good is therefore the reduction in π_P^* relative to the case without a tax on q. The gains from trade,

$$\nu - c = (\nu - p^*) + (p^*(1-t)-c) + tp^*,$$

can be decomposed into: (i) $\nu - p^*$ which decreases after the VAT reform in (6), (ii) $p^*(1-t)-c = \frac{\nu(1-t)-c}{2} - \{\alpha + (1-0.5(1+\eta)\tau)\widetilde{\phi}\}\frac{(1-t)M}{\overline{f}}R^*$ of which, by (8), only the amount $\frac{t\nu}{2} = \frac{\nu-c}{2} - \frac{\nu(1-t)-c}{2}$ is the loss of the platform,[16] and (iii) tp^* which increases by Lemma 1.

Lemma 2. *Tax-enforcement reform does not change the platform's per-unit tax burden, $\frac{t\nu}{2}$.*

Importantly, the tax-enforcement reform does not increase the supplier's tax burden per unit of the good, although the tax payment per unit, tp^*, *increases* because $p^T > p^O$. Instead, this increase appears as an additional burden on consumers of the standard good, while the platform's per-unit burden remains unchanged. Thus, *consumers bear the entire increase in the per-unit tax payment induced by the reform*.

Returning to the expression of consumers' willingness to pay in (1), we see that, on top of $p^T > p^O$, since we show in Appendix C that $m^T < m^O$, we conclude that consumers are worse off because consumption falls, the price rises, and network externalities weaken.

Proposition 1. *(i) Consumption of the standard good, q^*, increases with entry responsiveness. However, greater entry responsiveness also leads to a greater proportional decline in consumption, $\frac{q^O - q^T}{q^T}$, and discourages domestic-firm entry.*

(ii) The monopolistic supplier only partially bears the burden of the VAT imposed on the standard good. Furthermore, the platform's effective tax burden does not increase under the VAT-enforcement reform; instead, the entire increase in the unit tax burden $tp^T - tp^O > 0$ is passed on to consumers of the standard good.

[16] The last term in the first line of (8) is $+R^*(m_H^* + m_F^*)$ which cancels out with $-\{\alpha + (1-0.5(1+\eta)t)\widetilde{\phi}\}\frac{(1-t)M}{\overline{f}}R^*$ described in (ii) (see Appendix A).

Part (i) of the proposition follows from (A-8) in the Appendix. Part (ii) is shown in Lemma 2. In a setting different from that of Etro (2023), our model shows that greater entry responsiveness increases market size. However, greater entry responsiveness also magnifies the decline in market size following the VAT-enforcement reform. The full pass-through of the increased tax burden to consumers is synonymous with recent work by Fox et al. (2022).

4.2 Tax evasion closure and price spillover

The tax incidence of the enforcement reform in the standard-good market is quite substantial. Combining (6), which links $p^T - p^O$ to $R^O - R^T$ through network externalities, we obtain in Appendix A:

$$\frac{(p^T - p^O)q^T}{\tau p_a m_F^T} \geq \frac{R^O - R^T}{0.5\tau p_a} \geq \frac{\frac{1}{(1-\tau)(\phi-\alpha)}R^T}{\frac{1}{\phi}p_a} \quad \text{when } R^O \geq 0. \tag{9}$$

(9) quantifies the effect of formalizing foreign developers through platform-based taxation. The denominator is the additional tax revenue generated by the enforcement reform,[17] and the numerator measures the burden of price increase on the q^T units consumed. The ratio $\frac{R^T}{(1-\tau)(\phi-\alpha)}$ simplifies to $0.5q^T$ for $\phi \neq \alpha$, and its continuous extension is well-defined at $\phi = \alpha$.

The formalization of foreign developers raises the price of the standard good from p^O to p^T. This echoes the key insight of Doerrenberg and Duncan (2026), who show that closing tax evasion opportunities removes implicit cost subsidies and raises market prices. We show that a similar effect arises in the presence of network externalities and cross-market pass-through.

Although this ratio depends on the structure of the model, it illustrates the extent to which network externalities transmit the effects of the enforcement reform across markets. Appendix A further examines the mechanism underlying (9), drawing on the general model developed in the Supplementary File. In particular, the magnitude of the cross-market incidence depends on the extent to which the platform can capture app-market surplus through the commission fee R^T.

In the present model, $\frac{R^T}{(1-\tau)(\phi-\alpha)} = 0.5q^T$ and $\frac{1}{\phi}p_a = q^T$, so that (9) is above 0.5 (50%). To provide a guide to the implications beyond the present stylized model, we conduct simulations with $\nu = 2$, $c = 0$, $M = 1$, $\alpha = \phi = 0.25$, and $\overline{f} = 0.33$. We set $\tau = t$ equal to 0.1, 1/6, and 0.2, corresponding to consumption-tax rates of 0.11, 0.2, and 0.25, respectively. In addition to the benchmark case, in which incidence ranges from 59% to 70% and increases with τ, we consider two extensions:

- $p_a = \phi q^{0.8}/0.8$ (referred to as Case 2): there are diminishing marginal returns to network size

[17] the per-unit tax is $\tau\phi q^T = \tau p_a$, and m_F^T units are newly subject to taxation.

(Section 2.2). They weaken the multiplier effect operating through the network externality in the denominator of (1′), thereby reducing cross-market incidence.

- $p_a = \phi q - 0.01m$ (referred to as Case 3): the app demand is downward-sloping, or there is a negative externality of entry (Sections 2.2 and 6.2). The resulting decrease in the denominator of (9) increases cross-market incidence.

The results are shown in Table 1:

Case	$\tau = 0.1$	$\tau = 1/6$	$\tau = 0.2$
benchmark	0.588	0.661	0.703
Case 2	0.379	0.434	0.467
Case 3	0.616	0.687	0.729

Table 1: **Tax Incidence**, $\dfrac{(p^T - p^O)q^T}{\tau p_a m_F^T}$. The benchmark is compared with Case 2 (diminishing returns to network size) and Case 3 (negative entry externalities). Parameters are $\nu = 2$, $c = 0$, $M = 1$, $\alpha = \phi = 0.25$, $\overline{f} = 0.33$, and $\tau = t$.

MNEs operating internationally sometimes support taxation based on the country of final consumption. A platform may have an incentive to assume VAT collection responsibility because its price-setting power in the multi-sided market allows it to offset part of the additional burden through adjustments in commission fees. At the same time, part of the burden is shifted to consumers of the standard good (network users).

4.3 Marginal value of public funds

The tax-enforcement reform has positive and negative effects on country H. It is clear that consumer surplus decreases through the reform of taxing foreign developers ($\Delta CS < 0$) (formally, see Appendix C). More importantly, we consider the following value:

$$\frac{-\Delta CS}{t(p^T q^T - p^O q^O)} \equiv A,$$

as *fiscal externality* in the terminology of the Marginal Value of Public Funds (MVPF). The numerator and the denominator are expressed in discrete form, reflecting the nature of the tax-enforcement reform. The tax-enforcement reform primarily affects the app market, but as we see in the last two subsections, its effects on both consumer surplus and tax revenue in the standard-good market are significant. In Appendix C, we show that A is either greater than 1 or negative: consumer surplus decreases, while tax revenue either increases by less than the loss in consumer surplus, or decreases.

For the producer surplus:

$$\frac{-\Delta PS_H}{\tau\phi m_H^T q^T + \tau\phi(m_H^T q^T - m_H^O q^O)} \equiv \frac{-\Delta PS_H}{\Delta TR_P} \equiv B.$$

In the numerator, we consider the domestic producers' surplus (PS_H).[18] The VAT-enforcement reform causes the replacement of the developers in country F with domestic entrants. However, the VAT-enforcement reform also reduces the market size. Appendix C, following Nishimura and Morita (2026), shows that the numerator is negative (and hence the domestic developers gain after the enforcement reform) if entry responsiveness is sufficiently low, and vice versa. The first term in the denominator captures the mechanical tax-base expansion generated by the reform, $\tau\phi m_H^F = \tau\phi m_H^T$, which is a tax on non-residents as in Wildasin (1987) and Dahlby (2008). As for the associated behavioral effect, we have $q^T < q^O$ (by substituting the equilibrium price of the good and the commission fee; see Appendix D), whereas the sign of $m_H^T - m_H^O$ depends on entry responsiveness as mentioned. The denominator of B is shown to be positive under certain conditions (Appendix C).

Now, the MVPF (Bastani (2025)) is the ratio of the loss of the private sector in country H (the sum of the decrease in consumer surplus and the decrease in domestic producer surplus) to the increase in tax revenue TR. Unlike Proposition 3 by Adachi and Fabinger (2022), the instrument for tax reform is not tax rates but tax enforcement:

$$MVPF = \frac{-\Delta CS - \Delta PS_H}{\Delta TR} = \left(1 - \frac{\Delta TR_P}{\Delta TR}\right) A + \frac{\Delta TR_P}{\Delta TR} B. \tag{10}$$

The domestic total surplus ($CS + PS_H + TR$) increases if and only if MVPF is less than 1.

The denominator of the MVPF is $\Delta TR = \tau\phi m_H^T q^T + \tau\phi(m_H^T q^T - m_H^O q^O) + t(p^T q^T - p^O q^O)$. In Appendix C, we provide sufficient conditions for $\Delta TR > 0$.

Laffont (2001) assumes that the MVPF is between 1.1 and 1.3, and Dahlby's (2008) estimates are even larger in some cases. The analysis so far implies the following:

Proposition 2. *(i) Tax-enforcement reform increases tax revenue ($\Delta TR > 0$) if (a) $R^O \geq 0$ (the network-size externality is a dominant force in determining the commission fee), (b) $0.3 > t$, and (c) the market size with distorted marginal cost is still large: $(1-t)(\nu - \frac{c}{1-t})/(2M) \geq \phi$ and $0.5(\nu - \frac{c}{1-t}) > \frac{c}{1-t}$.*

(ii) $\Delta PS_H > 0$ (and thus it reduces the MVPF) if and only if the entry responsiveness is sufficiently low.

[18] Conceivably, the host government does not take into account the foreign entrants' profit (π_{SF}) in its welfare calculations. The platform, which may or may not be a foreign multinational, decreases its profits π_P from (6) and the fact that $q^T < q^O$. Its inclusion to the numerator raises the MVPF.

The denominator of B is positive under conditions (a)-(c) in Proposition 2(i).

(iii) The numerator of A is positive $(-\Delta CS > 0)$*. The fiscal externality of enforcement reform (A) is either greater than 1 or negative, if* $t < 0.5$ *and* $p^T q^T - p^O q^O \neq 0$*.*

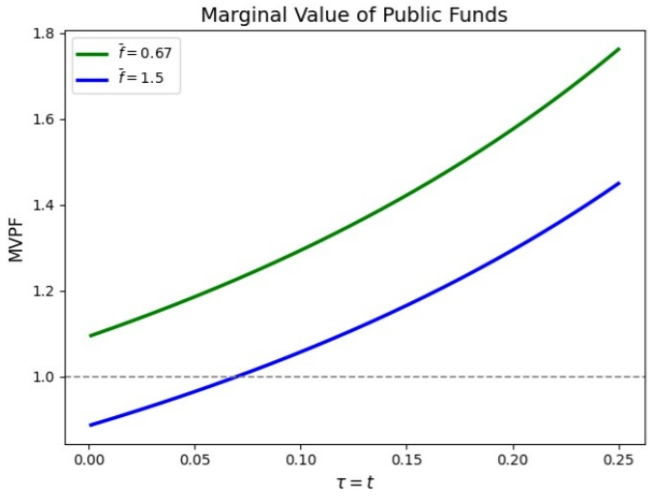

Figure 1: **Effects of VAT Enforcement Reform on MVPF.** The figure compares high versus low entry responsiveness: parameters are $\nu = 2$, $c = 0$, $M = 1$, $\alpha = \phi = 0.25$, $\overline{f} = 0.67$ (higher entry responsiveness) and $\overline{f} = 1.5$ (lower entry responsiveness). The horizontal axis shows $\tau = t$ ranging from 0 to 0.25. Blue line corresponds to lower entry responsiveness where MVPF falls below 1 at low τ. Green line corresponds to higher responsiveness.

Taking the argument so far into account, Figure 1 illustrates two cases: one in which the MVPF can fall below 1 (the blue line, with lower entry responsiveness) and another in which the MVPF is higher (the green line, with higher entry responsiveness). In the former case ($\overline{f} = 1.5$), the contraction in foreign developers does not significantly reduce the network size. The domestic developer surplus P_{SH} increases due to reduced developer competition. Tax revenue TR increases. In total, domestic welfare increases, indicating $MVPF < 1$. In contrast, the green line ($\overline{f} = 0.67$) shows the case of high entry responsiveness. There is a sharp reduction in network size, which adversely affects domestic entry and consumer surplus. Although tax revenue increases, the loss in consumer surplus dominates. The MVPF is larger than 1, indicating a decrease in domestic total surplus as defined above. When the MVPF becomes larger than 1, the comparison with the MVPF determined by other tax instruments serves as a cost-benefit criterion of the present enforcement reform.

The features shown are different from the usual excess-burden analysis. Typically, behavioral effects are captured by demand and supply elasticities. However, in the present analysis, we do not model elasticity as a sufficient statistic because prices are endogenously determined. Instead, entry responses ultimately depend on the extent of network contraction and the strength of

network externalities. In our setting, the behavioral responses relevant for excess burden cannot be summarized by conventional demand and supply elasticities because prices, entry, and network size are jointly determined. The numerator of MVPF captures it. As shown in Proposition 1 and Proposition 2,[19] the behavioral effects on demand and supply involve endogenized prices and external effects. It is worth pointing out that, due to the simultaneity of price and firm entry decisions and network effects, recent parsimonious reduced-form methods may prove insufficient.[20] The simultaneous determination of the market size and market outcome (the endogenous number of buyers and sellers in related markets) was analyzed by a recent study by Miyauchi (2024), and Birke (2009) reviews empirical studies that estimate observed demand as a function of market size and variety.

When some of the producers of the standard good are foreign untaxed producers before the reform,[21] the private-sector welfare loss (the numerator of the MVPF) becomes larger but the tax revenue (the denominator) may not increase as much after reform. So one can reasonably expect that the MVPF will be higher.

The key policy takeaways are as follows:

- When the platform imposes tax obligations on foreign firms, it neutralizes the increased burden through commission fees, whereas the platform shifts the increased burden on the standard-good market entirely to consumers (platform users).
- When entry responsiveness is small (large), platform-based VAT-enforcement reform encourages or deters domestic firms' entry. As a result, when entry responsiveness is small (large), MVPF can be below one (higher than one).
- Optimal policy design in two-sided markets requires structural analysis rather than reduced-form estimates. The latter may misstate welfare effects.

[19] See also footnote 13.

[20] This is because the analogue of the supply elasticities in a competitive market corresponds to entry responses of a finite number of firms equipped with distinct technologies. A more fully fledged structural analysis, such as multi-stage least squares, may therefore be necessary.

[21] The "Tax Surprise" approach by Einav et al. (2014) is instructive: online shoppers click on an item before knowing if it is taxed, with applicable VAT depending on the seller's registration status. One may model such transactions, incorporating a "home bias", either by the buyer or the platform operator. Our (6) is modified to incorporate the expected post-tax price. These biases exist before the reform, and we further assume that inertia persists after the reform, preventing immediate adjustments in the share of foreign or small unregistered sellers.

5 Taxing SMEs through the platform

As a related application, we examine the taxation of SME transactions, an issue of particular relevance in developing countries. Platforms sometimes promote transactions with small businesses as part of their marketing strategy. Such promotion is partly motivated by the fact that small sellers receive preferential tax treatment. Platforms may guide consumers toward these sellers through algorithmic allocation, and the lower consumer prices induced by preferential tax treatment reinforce such a strategy. By bringing SMEs into the VAT system, this tax advantage is removed, which alters the platform's pricing incentives. In a two-sided market, the welfare effect of lowering the VAT threshold operates through changes in the platform's sales strategy taking network externalities into account.

The formulation of this paper can be readily adapted to the case in which firms below the VAT threshold receive preferential tax treatment.

Suppose that the number of potential entrants of the relation-specific good is $2M$. Before reform, VAT-registered firms (a group of sellers called group r) have sales of at least the threshold $v > 0$. Let $\frac{v}{\phi q} \equiv h_v$ be the threshold quantity such that $m_r = \dfrac{2M}{v/(\phi q^{Vt})}$ where the superscript Vt represents the regime with a VAT threshold.[22] See an explanation around footnote 21 for the tax treatment on the standard good. The other group of entrants, group u, is exempt from VAT. $m_u = \frac{2M[(1-\eta\tau)\phi q - R]}{\overline{f}} - m_r$. With the notation of the basic model, we have $m_r^{Vt}(p,R) + m_u^{Vt}(p,R) = 2m_F^O(p,R)$ for the regime with the VAT threshold Vt. The tax reform removes this VAT threshold, so every firm is required to pay the VAT.

After the elimination of the threshold, $(1-\tau)\phi q - R - \overline{f}/h_S \geq 0$ for entry of firm S. For firms that were already registered before the reform (those whose sales are greater than $h_S \geq h_v$ units), their gross profit changes:

$$\left[\{1-\tau\}\,\phi\Delta q^* - \Delta R^*\right] h_S.$$

The profit of a pre-reform registered firm increases if the reduction in the commission fee R^* more than offsets the adverse effect of the decline in network size q^*. Otherwise, its profit decreases. We continue to assume that the sellers of the network good fully comply with their tax obligations before and after the reform.

The analysis of the main model is applicable. We conclude with the following proposition (see

[22] Since our analysis is the effect of eliminating the VAT threshold, the firm distribution in Onji (2009) and Saez (2010) before tax reform is treated as given. The firms' reaction after reform does not involve endogenous firm-size choice, so the firm distribution is treated as invariant in the present analysis.

Appendix D):

Proposition 3. *Consider a model in which a country eliminates the VAT threshold through a platform-based tax, where network externalities are present. An increase in the profits of pre-reform registered firms following the tax-enforcement reform is associated with a small proportional decline in network users and limited exit of firms. Higher entry responsiveness reverses these effects.*

Regarding new tax burdens on the SMEs, critics often express concern that the reform may induce SME exit and generate windfall gains for pre-reform registered firms. Our model shows how the magnitude of these effects depends on entry responsiveness. In this setup, an increase in the per-unit profit $(1-\tau)\phi q^* - R^*$ implies a windfall gain for firms that were already registered before the reform, but such a gain does not necessarily arise in the presence of network externalities. The absence of such a gain suggests a substantial contraction of network users after the tax-enforcement reform, whereas the presence of a gain indicates only a modest reduction in users and limited SME exit.

5.1 Implications from studies of tariffs

Our contribution relates to the growing literature on import tariffs. We analyze the effects of VAT de minimis thresholds and the removal of preferential treatment for SMEs. Related to our analysis, Du et al. (2025) document that, under the U.S. de minimis rule on import tariffs before April 2025, small-value shipments, particularly those of SMEs, faced zero tariffs. They estimate a tariff volume elasticity of approximately 0.3–0.7 for these low-value channels. Interpreting the abolition of the pre-reform VAT threshold as a 10 percentage-point VAT on SMEs and applying Du et al.'s elasticity implies a 3–7% decline in formerly exempt parcels. In our context, several additional factors need to be considered, including endogenous platform pricing and network contraction due to network externalities.

6 Extensions and additional properties

As extensions, we examine neutrality with respect to alternative assignments of statutory tax liability, repricing under unit taxation, negative externalities of firm entry, and competition between platforms. Our results highlight that using platforms to improve VAT enforcement can have important consequences throughout two-sided digital markets.

6.1 Incidence neutrality and the choice of commodity tax

Here, we revisit two features that are consistent with the previous literature. First, since our main focus is on tax reform, it is useful to revisit the principle of physical incidence neutrality (e.g., Weyl and Fabinger (2013)), which we confirm in Appendix E. Second, in Appendix F, we show that the unit-tax case has different implications for tax incidence (Kind et al. (2008), Belleflamme and Toulemonde (2018) and Kind and Koethenbuerger (2018)).

Lemma 3. (i) *Consider an alternative regime, T', in which the platform is legally responsible for collecting and remitting VAT on transactions by both domestic and foreign developers. All real equilibrium variables are identical to those in Regime T.*

(ii) *Consider a unit tax $\hat{t}$ on q, with an equivalent scaling $\hat{t} = \widetilde{c} - c$, if $(1 - 0.5(1+\eta)\tau)\phi > (1-t)\alpha$, then a unit tax yields a lower R^* and a higher p^* than an ad valorem tax.*

6.2 Negative externality of entry

As the number of developers increases, competition intensifies, and profits per developer decrease. For example, each developer finds it more difficult to acquire customers when m increases. Following Hagiu (2009) and Belleflamme and Peitz (2019) (the latter provides many examples of sellers' congestion problems, such as lower prices resulting from monopolistic competition with an increasing number of competitors), we consider $a_i(q, m)$ with $\partial a_i / \partial m < 0$ to be represented as a linear version, $a_i = \phi q - \psi m$. We yield the following formulation:

$$m = \frac{M}{\overline{f}}[\{2 - (1+\eta)\tau\}(\phi q - \psi m_e) - 2R].$$

That is, we take into account that the firms' profits π_{SH} and π_{SF} decrease in the expected number of apps sold in equilibrium $m_e (= m)$ by factor $\psi > 0$. The congestion term enters developers' after-tax revenues with a coefficient of $1 - \tau$ for domestic developers and $1 - \eta\tau$ for foreign developers. This case is also equivalent to the downward-sloping app demand $p_a = \phi q - \psi m$, where the individual willingness to pay is distributed over $[\phi q - \psi m,\ \phi q]$.

These formulations generate $m^* = \frac{M/\overline{f}}{1+\{2-(1+\eta)\tau\}\psi M/\overline{f}}[\{2 - (1+\eta)\tau\}\phi q^* - 2R^*] \equiv \frac{M^*(\tau)}{\overline{f}}[\{2 - (1+\eta)\tau\}\phi q - 2R]$. Notably, the post-reform regime ($\eta = 1$) mitigates this negative externality ($M^T(\tau) > M^O(\tau)$). This mechanism can mitigate the adverse effects of network contraction on domestic producers.

6.3 Pricing structure and tax incidence with competing platforms

The cross-market price-incidence result extends to a setting with competing platforms. Suppose now that consumers of the standard good with willingness to pay b_k are differentiated by the attachment parameter θ, which is uniformly distributed on a segment $[0,1]$. The marginal rate of substitution between attachment to the platform and the utility of consumption is z. The utility of type (b_k, θ) from adopting platform 1 is given by $b_k + \alpha m_1 - p_1 - z\theta + \int\{a_k - p_{ak}\}dS_k$ where $a_k = \phi q$, and S_k is a vendor which invents and sells the product to this consumer, whereas that from adopting platform 2 is $b_k + \alpha m_2 - p_2 - z(1-\theta) + \int\{a_k - p_{ak}\}dS_k$. Following Hagiu (2009), we restrict ourselves to the case where consumers always coordinate in the equilibria in which no consumer multihomes. $p_{ak} = \phi q$ holds as in the basic section.

Denote by q_j consumer demand for the standard good on platform j. A foreign developer of the specialized good with fixed cost $\overline{f}$ makes profits $[(1-\eta\tau)\phi q_j - R_j]h_S$ on platform j as in (3) and the same formulation in (2) applies to the domestic firm. They will generate $m_j = \frac{M\left[(2-(1+\eta)\tau)\phi q_j - 2R_j\right]}{\overline{f}}$. ν is assumed to be large enough so that the consumer market is always entirely covered. With a unit mass of consumers, we have $q_1 = 0.5 + \frac{1}{2z}(\alpha(m_1 - m_2) - (p_1 - p_2))$ as in Hagiu (2009), and for $\gamma \equiv 1 - (2-(1+\eta)\tau)\frac{\alpha\phi}{z}\frac{M}{\overline{f}}$, Appendix G shows that:

$$p^*(1-t) - c = (1-t)\gamma z - R^*\frac{M}{\overline{f}}(2-(1+\eta)\tau)\phi \tag{11}$$

which has, similar to (6) in the benchmark model, a mark-down increasing in the network externalities and in R. Additionally, the mark-up is decreasing in platform mobility $1/z$. As to the commission fee:

$$R^* = \frac{\{1 - 0.5(1+\eta)\tau\}\phi - (1-t)\alpha}{4} \tag{12}$$

Substituting (12) into (11) shows that $p^T > p^O$ under the parameter values of the benchmark scenario of Table 1. Thus, the cross-market price-incidence result survives platform competition.

As to the ratio of the burden of the standard-good consumers to the additional tax revenue, $\frac{(p^T - p^O)q^T}{\tau p_a m_F^T}$ in (9), in our numerical analysis of the benchmark value in Table 1, under the platform competition, the increase in standard-good expenditure attributable to repricing exceeds the newly collected VAT revenue from foreign developers. This result is in Table 2:

Case	$\tau = 0.1$	$\tau = 1/6$	$\tau = 0.2$
benchmark	2.809	3.060	3.203

Table 2: **Tax Incidence with competing platforms**, $\frac{(p^T - p^O)q^T}{\tau p_a m_F^T}$. Parameters are $\nu = 2$, $c = 0$, $M = 1$, $\alpha = \phi = 0.25$, $\overline{f} = 0.33$, and $\tau = t$.

The key policy takeaways are as follows:

- VAT can function as a Pigouvian tax to mitigate congestion externalities on two-sided platforms, thereby supporting the tax-enforcement reform analyzed here.
- The price-incidence results discussed in Section 3.2 remain robust to multiple platforms.

7 Conclusion

Governments increasingly rely on digital platforms to close VAT-enforcement gaps involving foreign suppliers and small businesses. This paper shows that the consequences of such enforcement reforms extend beyond the market in which the tax obligation is imposed. In a two-sided market, a platform responds to the taxation of foreign developers by adjusting its prices on both sides of the market. As a result, the platform operator's per-unit tax burden remains unchanged. In contrast, even without any change in the statutory VAT rate on the standard good, consumers bear an additional tax burden through the platform's endogenous repricing. Platform-based VAT enforcement can therefore generate substantial cross-market tax incidence.

The welfare consequences of this incidence depend critically on network externalities and firm entry. Taxing foreign developers reduces their participation and contracts the network, while the platform's pricing response changes the entry incentives of domestic developers. Entry responsiveness determines the magnitude of these adjustments and therefore the welfare cost of enforcement. The reform can nevertheless increase tax revenue by narrowing the enforcement gap between domestic and foreign developers.

We quantify this trade-off using the Marginal Value of Public Funds (MVPF). When entry responsiveness is low, network contraction is limited and the MVPF can fall below unity, in which case the benefits of improved enforcement and revenue collection outweigh the welfare losses associated with network shrinkage. By contrast, high entry responsiveness amplifies the contraction of the platform and raises the welfare cost of enforcement. Because prices, quantities, firm entry, and network size are jointly determined, evaluating platform-based enforcement requires structural analysis rather than a reduced-form analysis.

We also apply the framework to platform-based VAT registration of small and medium-sized enterprises (SMEs). When network externalities and entry responsiveness are strong, extending VAT obligations to SMEs can induce substantial network contraction and SME exit and can eliminate the windfall gains otherwise enjoyed by firms that were already registered before the reform. Critics often express concern that the reform may induce SME exit and generate windfall gains for pre-reform registered firms. Our analysis shows, however, when entry responsiveness and network externalities are sufficiently strong, greater network contraction can induce an adverse environment for firm entry, eliminating the windfall gains of pre-reform registered firms.

The taxation of foreign digital suppliers has an interesting effect on the developers' congestion problem in two-sided markets. That is, it mitigates excessive entry when entry generates negative externalities. Also, the central incidence mechanism remains relevant under platform competition. Moreover, alternative assignments of statutory tax liability with respect to the new tax burden on foreign sellers are neutral with respect to economic incidence. Finally, the non-equivalence between ad valorem and the unit tax is unique in that the latter yields a lower commission fee but a higher standard-good price.

The welfare consequences therefore depend not only on how much additional revenue enforcement raises, but also on how platforms adjust prices, how firms enter and exit, and how these responses depend on network externalities. These interactions should be taken into account when governments use digital platforms as instruments of tax enforcement.

Appendix

A. Derivation of R^*

By differentiating $\pi_P^* = (p(1-t)-c)q^* + R(m_H^* + m_F^*)$ for $* = O$ and T with respect to R, $\frac{\partial q}{\partial R} = 2\alpha\frac{M}{\overline{f}}\frac{-1}{\gamma}$, $m = \frac{M}{\overline{f}}\Big[\{2-(1+\eta)\tau\}\phi q(p,R) - 2R\Big] = \frac{M}{\overline{f}}\frac{\{2-(1+\eta)\tau\}\phi\overline{f}(\nu-p)-2R\overline{f}}{\overline{f}-\alpha M\phi(2-(1+\eta)\tau)}$ and $\frac{\partial m}{\partial R} = -\frac{M(2-(1+\eta)\tau)\phi}{\overline{f}}\frac{2\alpha M}{\overline{f}-\alpha M\phi(2-(1+\eta)\tau)} + \frac{M(-2)}{\overline{f}} = -\frac{M}{\overline{f}}\frac{2\overline{f}}{\overline{f}-\alpha M\phi(2-(1+\eta)\tau)}$. Applying (6) and $p^*(1-t)-c =$

$\frac{\nu(1-t)-c}{2} - \{\alpha + (1-0.5(1+\eta)t)\widetilde{\phi}\}\frac{(1-t)M}{\overline{f}}R^*$ yields:[23]

$$\frac{\partial \pi_P}{\partial R}\left(-\frac{\partial q}{\partial p}\right)^{-1}\frac{\overline{f}}{M} = (2-(1+\eta)\tau)\widetilde{\phi}(1-t)(\nu-p) - 4R - 2\alpha(p(1-t)-c) = 0. \tag{A-1}$$

This yields the following expression, where $den^* = 2 - (\alpha + (1-0.5(1+\eta)\tau)\phi)^2\frac{(1-t)M}{\overline{f}} > 0$ ($den^T > den^O$) denotes the term appearing in the denominator of R^*.

$$R^O - R^T = \frac{1}{den^T}\{\frac{((1-t)\nu - c)}{4}\tau\widetilde{\phi} + R^O(den^T - den^O)\} \tag{A-2}$$

$R^T < R^O$ occurs when $R^O \propto (1-0.5\tau)\phi \geq (1-t)\alpha \geq 0$. See Appendix B for the second term of the above formula.

Substituting (6) and R^* into (1'), $m_H(p,R) = \frac{M[\{1-\tau\}\phi q(p,R)-R]}{\overline{f}}$ and $m_F(p,R) = \frac{M[\{1-\eta\tau\}\phi q(p,R)-R]}{\overline{f}}$, we have

$$q^* = \frac{\overline{f}(\nu - \frac{c}{1-t})}{2\overline{f} - (1-t)M\{\alpha + (1-0.5(1+\eta)\tau)\frac{\phi}{1-t}\}^2}, \quad m^* = \frac{\{(1-0.5(1+\eta)\tau)\widetilde{\phi} + \alpha\}(\nu - \frac{c}{1-t})(1-t)M}{2\overline{f} - (1-t)M\{\alpha + (1-0.5(1+\eta)\tau)\frac{\phi}{1-t}\}^2}. \tag{A-3}$$

The denominators are positive due to Assumption 1.

Ad valorem rate

Here, we discuss the equivalence in treating β and R ($R = \beta p_a = \beta\phi q$) in Section 2.3. $m_H(q, \beta\phi q)$ and $m_F(q, \beta\phi q)$ derived through (2) and (3) and $q = \nu - p + \alpha(m_H + m_F)$ derive a system of q, m_H and m_F as functions of p and β. Let the induced demand be denoted as $q \equiv Q(p,\beta)$. Alternatively, $Q(p,\beta)$ is a solution of $q = q(p, \beta\phi q)$ in (1') with respect to q.

Substituting them into (4) derives the profit-maximizing values of p and β, denoted as p^{**} and β^{**} for $* = O$ and T, where one can define $R^{**} \equiv \beta^{**}\phi q^*(p^{**}, \beta^{**}\phi q^{**}) = \beta^{**}\phi q^*(p^{**}, R^{**})$ uniquely with respect to (p^{**}, β^{**}), and $m_J = m_J^*(q^{**}, \beta^{**}\phi q^{**}) = m_J^*(q^{**}, R^{**})$ for $* = O$ and T and $J = H$ and F. That is, the choice of β and R has correspondence, so $p^{**} \neq p^*$ or $\beta^{**}\phi q^*(p^{**}, \beta^{**}\phi q^{**}) \neq R^*$ contradicts the uniqueness of the profit-maximizing pair (p^*, R^*) in (6) and (7).

[23] For the second-order conditions, we have $\frac{\partial^2 \pi_P}{\partial p \partial p}\gamma^{-1} = -2(1-t) < 0$, $\frac{\partial^2 \pi_P}{\partial R \partial R}\gamma^{-1} = -4\frac{M}{\overline{f}} < 0$, $\frac{\partial^2 \pi_P}{\partial p \partial R}\gamma^{-1} = -\frac{2\alpha(1-t)M}{\overline{f}} - \frac{(2-(1+\eta)\tau)\widetilde{\phi}(1-t)M}{\overline{f}}$. Within the range of Assumption 1, the following condition holds:

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

To reinforce, denote $\Pi_P(p,\beta) \equiv \pi_P(p,\beta\phi Q(p,\beta))$. Then $\partial R^{**}/\partial\beta = \phi q + \beta\phi\partial q/\partial R \cdot \partial R^{**}/\partial\beta = \frac{\phi q}{1-\beta\phi\partial q/\partial R}$ with $1-\beta\phi\partial q/\partial R > 0$ and $\phi q > 0$, so :

$$\frac{\partial \Pi_P}{\partial \beta} = \frac{\partial \pi_P}{\partial R}\frac{\phi q}{1-\beta\phi\partial q/\partial R} = 0 \quad \Longleftrightarrow \quad \frac{\partial \pi_P}{\partial R} = 0$$

Likewise, for the subscripts p and R to be partial derivatives, we have:

$$\frac{\partial \Pi_P}{\partial p} = \frac{\partial \pi_P}{\partial p} + \frac{\partial \pi_P}{\partial R}\frac{\beta\phi q_p}{1-\beta\phi q_R},$$

so, at the point of $\frac{\partial \pi_P}{\partial R} = 0$, $\frac{\partial \Pi_P}{\partial p} = 0$ if and only if $\frac{\partial \pi_P}{\partial p} = 0$. The global optimality of (p^*, R^*) is warranted by Assumption 1, and there is no (p,β) that yields higher profit than (p^{**},β^{**}).

On Equation (9)

From (6), (7), (A-2), and (A-3),

$$\frac{(p^T-p^O)q^T}{\tau p_a 0.5 m^T} \geq \frac{(R^O-R^T)(\phi+\alpha)\frac{M}{\bar{f}}q^T}{0.5\tau p_a m^T} \geq \frac{0.5\tau\phi\frac{1}{(1-\tau)(\phi-\alpha)}R^T}{0.5\tau p_a} = \frac{\frac{1}{(1-\tau)(\phi-\alpha)}R^T}{\frac{1}{\phi}p_a} \quad \text{when } R^O \geq 0 \tag{A-4}$$

The multiplication of 0.5 in the numerator and the denominator of (A-4) comes from the fact that the foreign-firm share is 50%, which is canceled out. In the Supplementary file for review only, we show that a generalized formula for $p^T - p^O \geq (R^O - R^T)(\phi+\alpha)\frac{M}{\bar{f}} \geq 0.5\tau\phi\frac{\alpha+\phi}{(1-\tau)(\phi-\alpha)}\frac{M}{\bar{f}}R^T$ can be obtained,[24] and we conjecture that the approximate offsetting relationship $\{\alpha+\phi\}\frac{(1-t)M}{\bar{f}}q^T \approx m^T$ continues to hold in the general model. That is, $\{\alpha+\phi\}\frac{(1-t)M}{\bar{f}}R^T q^T \approx R^T m^T$, so the price reduction associated with the second term on the RHS of (6) is approximately offset by commission-fee revenue in (8).

This suggests that the corresponding incidence bound may extend to more general specifications.

[24]For $\Phi \equiv \phi q$, $\frac{R^T}{(1-\tau)\{\phi(\frac{\partial m_H}{\partial \Phi}+\frac{\partial m_F}{\partial \Phi})\frac{-\partial q_1}{\partial p}-\alpha(\frac{-\partial m}{\partial R})\}}$ is well-defined in its continuous extension at $\phi(\frac{\partial m_H}{\partial \Phi}+\frac{\partial m_F}{\partial \Phi})\frac{-\partial q_1}{\partial p} = \alpha(\frac{-\partial m}{\partial R})$.

B. Proof of Lemma 1

The second term of (A-2) is:

$$\frac{((1-0.5\tau)\widetilde{\phi}-\alpha)((1-\tau)\nu-c)(den^T-den^O)}{2den^O}$$
$$=\frac{\tau\phi((1-\tau)\nu-c)}{2den^O}\frac{\left\{(2-\tau)\widetilde{\phi}-2\alpha\right\}\left\{4\alpha+(4-3\tau)\widetilde{\phi}\right\}(1-t)M}{8\overline{f}},$$

which relates to entry responsiveness $\frac{(1-t)M}{\overline{f}}$. From (7) and (A-2), the above value is positive when $(1-0.5\tau)\phi \geq (1-t)\alpha \propto R^O \geq 0$, and (A-2) is positive when $\frac{(1-t)M}{\overline{f}}$ satisfies the following (A-6).

With $den^* = 2-(\alpha+\phi-0.5(1+\eta)\tau\phi)^2\frac{M}{\overline{f}} > 0$ for $\eta = 0,\ 1$, we have:

$$p^T-p^O=\frac{(\alpha+\phi)((1-t)\nu-c)M}{4den^T\overline{f}}\tau\widetilde{\phi}\left\{1+\frac{((2-\tau)\widetilde{\phi}-2\alpha)(\alpha+(1-0.75\tau)\widetilde{\phi})(1-t)M}{den^O\overline{f}}\right\}$$
$$+0.5\tau\widetilde{\phi}\frac{((1-t)\nu-c)((1-0.5\tau)\widetilde{\phi}-\alpha)(1-t)M}{2den^O\overline{f}} \tag{A-5}$$

From (A-2) and (A-5), $(1-0.5\tau)\widetilde{\phi}-\alpha \geq 0$ or $p^T > p^O$ implies $R^O > R^T$.

When $(1-0.5\tau)\widetilde{\phi}-\alpha \leq 0$, $p^T > p^O$ if the following holds:

$$\frac{\overline{f}}{(1-t)M}\frac{den^O}{2} \geq \frac{(4\alpha+4\widetilde{\phi}-3\tau\widetilde{\phi})((2\alpha)^2-(2-\tau)^2(\widetilde{\phi})^2)}{8\{4-3\tau\}\widetilde{\phi}.} \tag{A-6}$$

Q.E.D.

C. Proof of Proposition 2

(i): Tax Revenue A comparison between TR^O and TR^T is made in the following way.

$$TR^T-TR^O=\tau\phi(2m_H^Tq^T-m_H^Oq^O)+tp^O(q^T-q^O)+t(p^T-p^O)q^T$$

When $R^O \geq 0$, a variant of (A-5) holds to induce $p^T > p^O$ and $R^T < R^O$. We decompose the change in VAT revenue from the standard good into two components. The last term is positive. Now we show that the sum of the first and second terms is positive.

We first notice from (A-3),

$$m_F^O \leq \frac{M}{\underline{h}} \Leftrightarrow \frac{\overline{f}}{M} \geq (1-t)\Big\{\frac{\big\{2\alpha+\frac{\phi}{1-t}(2-\tau)\big\}^2}{8}+\frac{\big(2\alpha+(2+\tau)\frac{\phi}{1-t}\big)(\nu-\frac{c}{1-t})\underline{h}}{8M}\Big\}, \quad \text{(A-7)}$$

$$m_H^* = \frac{M(\nu-\frac{c}{1-t})\left\{(1-t)\alpha+\{1-(1.5-0.5\eta)\tau\}\phi\right\}}{4\overline{f}-2(1-t)M\{\alpha+(1-0.5(1+\eta)\tau)\frac{\phi}{1-t}\}^2},$$

$$q^O-q^T = \frac{\tau\phi(\nu-\frac{c}{1-t})(\alpha+(1-0.75\tau)\frac{\phi}{1-t})(1-t)M/\overline{f}}{\left\{2-\{\alpha+\phi\}^2(1-t)M/\overline{f}\right\}\left\{2-\{\alpha+(1-0.5\tau)\frac{\phi}{1-t}\}^2(1-t)M/\overline{f}\right\}} \quad \text{(A-8)}$$

(A-7) follows from Assumption 1. From the above formula and $m_F^T = m_H^T$ we have:

$$(m_H^T+m_F^T)q^T - m_H^O q^O + p^O(q^T-q^O)/\phi \propto$$

$$\begin{aligned}
&(\alpha+\phi)\left(1.7[2-\{(1-0.5\tau)\frac{\phi}{1-t}+\alpha\}^2(1-t)\frac{M}{\overline{f}}]^2-[2-\{\phi+\alpha\}^2(1-t)\frac{M}{\overline{f}}]^2\right)\\
&+0.3(\alpha+\phi)\big[2-\{(1-0.5\tau)\frac{\phi}{1-t}+\alpha\}^2(1-t)\frac{M}{\overline{f}}\big]^2+0.5\tau\frac{\phi}{1-t}\big[2-\{\phi+\alpha\}^2(1-t)\frac{M}{\overline{f}}\big]^2\\
&-tp^O(\nu-\frac{c}{1-t})(\alpha+(1-0.75\tau)\frac{\phi}{1-t})\times\\
&\quad[2-\{\alpha+\phi\}^2(1-t)\frac{M}{\overline{f}}][2-\{\alpha+(1-0.5\tau)\frac{\phi}{1-t}\}^2(1-t)\frac{M}{\overline{f}}]/(\nu-\frac{c}{1-t})^2
\end{aligned}$$

The first term in the right-hand side (RHS) of the above formula is positive if $\sqrt{1.7}-1 \approx 0.30 > t$ and $\frac{\overline{f}}{M}$ or $\nu-\frac{c}{1-t}$ is sufficiently large ($2\frac{\overline{f}}{(1-t)M} - ((1-0.5\tau)\frac{\phi}{1-t}+\alpha)^2 \geq \frac{\phi}{1-t}\big(\alpha+(1-0.75\tau)\frac{\phi}{1-t}\big)$). For $b = q^T/q^O$ and $p^O \leq \frac{c}{1-t}+0.5(\nu-\frac{c}{1-t})$ under $R^O \geq 0$, the rest of the term is positive if the following expression is positive when $t=\tau$:

$$\begin{aligned}
&(\alpha+\phi)b^2+0.5\frac{\phi}{1-t}-p^O\left(\nu-\frac{c}{1-t}\right)^{-1}\left(\alpha+(1-0.75\tau)\frac{\phi}{1-t}\right)b\\
\geq&(\alpha+\phi)(b^2+0.25)+0.25\left(\frac{1+1.5\tau}{1-t}\phi-\alpha\right)-\left\{0.5+\frac{c}{1-t}\left(\nu-\frac{c}{1-t}\right)^{-1}\right\}b\,(\alpha+\phi) \quad \text{(A-9)}
\end{aligned}$$

Since $b^2+0.25 \geq b$, if $\frac{c}{1-t} < 0.5(\nu-\frac{c}{1-t})$, then (A-9) is positive. This also proves that the denominator of B is positive.

(ii): Domestic firms' behavior We have $m_H^* = (\alpha+\phi-(1.5-0.5\eta)\tau\frac{\phi}{1-t})\frac{(1-t)M}{2\overline{f}}q^*$, and entry responsiveness $\frac{(1-t)M}{\overline{f}}$ relates to the domestic entrants' profits π_{SH} in (2). Notice that $\frac{1}{q^T}(q^O-q^T) =$

$\frac{\tau\phi(\alpha+(1-0.75\tau)\frac{\phi}{1-t})(1-t)M/\overline{f}}{\left\{2-\{\alpha+(1-0.5\tau)\frac{\phi}{1-\tau}\}^2(1-t)M/\overline{f}\right\}}$. We have:

$$\pi_{SH}^{T}-\pi_{SH}^{O}\gtreqless 0 \Leftrightarrow \frac{1-t}{den^{O}}\left(\frac{0.5\tau\widetilde{\phi}}{2}q^{T}-\frac{(\alpha+\widetilde{\phi}-1.5\tau\widetilde{\phi})}{2}(q^{O}-q^{T})\right)\gtreqless 0 \tag{A-10}$$

$$\Leftrightarrow \frac{\overline{f}}{M}\gtreqless (1-t)\frac{\{2\alpha+(2-\tau)\widetilde{\phi}\}^2}{8}+(1-t)\frac{(2\alpha+2\widetilde{\phi}-3\tau\widetilde{\phi})(4\alpha+4\widetilde{\phi}-3\tau\widetilde{\phi})}{8},$$

with $t=\tau$ for the general consumption tax. The above formula consists of: (a) Replacement of developers in country F with domestic entrants (the first term of the first line). This effect is proportional to the price of the specific good p_a (Section 2.2) determined in the post-reform regime. (b) Reduction of consumption of the standard good (the second term of the first line). Thus, the enforcement reform has two opposing effects on domestic developers' profits: a gain from the reduction in the commission fee and a loss from the contraction of the user network.

For the producer surplus:

$$PS_H=\int_{h_S\geq h_{SH}}\{(1-\tau)\phi q-R-\frac{\overline{f}}{h_S}\}\frac{M}{(h_S)^2}dh_S=\frac{m_H^2\overline{f}}{2M}$$

Recall that $m_H=\frac{M\pi_{SH}}{\overline{f}}$.

(iii): The consumer surplus (fiscal externalities) The consumer surplus can be expressed as follows. (A-8) shows that $q^T-q^O<0$:

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

Therefore, the effect on consumer surplus is rewritten as:

$$\frac{(q^O)^2}{2}-\frac{(q^T)^2}{2}=(p^Tq^T-p^Oq^O)\frac{1}{2}+\{(\nu+\alpha m^O)q^O-(\nu+\alpha m^T)q^T\}\frac{1}{2}$$

When the denominator of A is negative, A is negative since $q^O>q^T$. When the denominator of A is positive, the first term of the above formula is greater than $t(p^Tq^T-p^Oq^O)$ when $t<0.5$, and the second term in the curly bracket is positive. Therefore, the fiscal externalities defined in the text is either negative or greater than 1. This proves Proposition 2.(iii). *Q.E.D.*

D. Proof of Proposition 3

In the regime with VAT threshold, the equilibrium number of specific good sold, $m_u^{Vt}(p,R)+m_r^{Vt}(p,R)=\frac{2M[\phi q-R]}{\overline{f}}$, is substituted into the platform's profit $((1-t)p-c)q+R(m_u^{Vt}+m_r^{Vt})$,

where $m_r^{Vt}(p^*,R^*)+m_u^{Vt}(p^*,R^*) = 2m_F^O(p^*,R^*) = \dfrac{M(\nu-\frac{c}{1-t})\{(1-t)\alpha+\phi\}}{2\overline{f}-(1-t)M\{\alpha+\frac{\phi}{1-t}\}^2}$ as discussed in the text and Appendix C. After eliminating the threshold, the number of units sold is equal to $2m_F^T(p,R) = m^T(p,R)$ of the basic model as well as q^T. As in the above analysis, the equilibrium number of network users becomes $q^{Vt} = \frac{\overline{f}(\nu-\frac{c}{1-t})}{2\overline{f}-(1-t)M\{\alpha+\frac{\phi}{1-t}\}^2} > q^T$ and the number of the specific good sold becomes $m_r^{Vt}+m_u^{Vt} > m^T$. As in (A-8), a proportional decline in network users is small (large) with lower (higher) entry responsiveness.

$R^{Vt} = \frac{(\nu(1-t)-c)\left(2\widetilde{\phi}-2\alpha\right)}{8-(2\alpha+2\widetilde{\phi})^2\frac{(1-t)M}{\overline{f}}}$, which follows that the enforcement reform decreases R under the conditions where Lemma 1 holds. For the gross profit $[\{1-\tau\}\phi\Delta q^* - \Delta R^*]h_S$ of pre-reform registered firms (group r) in the text, we obtain a formula similar to (A-10) for their entry and producer surplus. The profits of pre-reform registered firms increase (decrease) when entry responsiveness is low (high). *Q.E.D.*

E. Incidence neutrality of the post-reform regime

Consider the following scenario. Regime O is the same as in our benchmark case. In Regime T', the platform collects the *tax-inclusive commission fee from both domestic and foreign developers*.

$$\pi_{SH} = (\phi q - R)h_S - \overline{f} - (1-\lambda)\tau\phi q h_S,\ \lambda = 0 \text{ under Regime } O \text{ and } \lambda = 1 \text{ under Regime } T'$$
$$\pi_{SF} = (\phi q - R)h_S - \overline{f},$$
$$\pi_P^* = (p(1-t)-c)q^* + (R-\lambda\tau\phi q^*)(m_H^* + m_F^*) \text{ for } * = O,\ T'.$$

A calculation yields $R^{T'} - \tau\phi q^{T'} = R^T$, and all real variables in Regime T' are identical to those in Regime T. Thus, changing the statutory assignment of VAT liability from developers to the platform does not affect equilibrium allocations or the economic incidence of the tax. The tax-inclusive commission fee in Regime T' adjusts so that the effective commission fee coincides with that in Regime T.

F. Unit tax

Consider a unit tax $\hat{t}$ on q, with an equivalent scaling $\hat{t} = \widetilde{c} - c$ (and with an analogous scaling of τ if one also considers the unit tax on ϕq), we have:

$$\nu - p^* = \frac{\nu - \hat{t} - c}{2} + \frac{[\alpha + \{1 - 0.5(1+\eta)\tau\}\phi]M}{\overline{f}}R^*.$$

Under a unit tax, the tax burden is additive rather than proportional to the price so that the reduction in the tax burden under an ad valorem tax when $R^* > 0$, as reflected $\widetilde{\phi} > \phi$ in (6), has no counterpart under unit taxation. The first-order condition for R under unit taxation is equivalent to (A-1). Thus, when $R^* > 0$ under ad valorem taxation, the equilibrium commission fee is lower under unit taxation than under ad valorem taxation.

G. Competing platforms

Substituting the expressions for m_1 and m_2 in the demand function, we have a formula similar to (1′):

$$q_i[1-(2-(1+\eta)\tau)\tfrac{\alpha\phi}{z}\tfrac{M}{\overline{f}}] = 0.5 - \tfrac{1}{2z}p_i - \tfrac{1}{2z}\tfrac{2\alpha M}{\overline{f}}R_i - \tfrac{\alpha\{(2-(1+\eta)\tau)\phi - 2R_j\}M/\overline{f} - p_j}{2z},$$
$$i, j = 1, 2,\ j \neq i.$$

Platform $i = 1,\ 2$ maximizes $(p_i(1-t)-c)q_i + R_i m_i$. For $\gamma \equiv 1-(2-(1+\eta)\tau)\tfrac{\alpha\phi}{z}\tfrac{M}{\overline{f}}$, we have $\tfrac{\partial q_i}{\partial p_i} = -\tfrac{1}{2z\gamma} < 0$ and $\tfrac{\partial q_i}{\partial R_i} = -\tfrac{2\alpha}{2z\gamma}\tfrac{M}{\overline{f}}$. We also have $q = \tfrac{1}{2}$, and we have $m_i = \tfrac{M[(2-(1+\eta)\tau)\phi q_i - 2R_i]}{\overline{f}}$ and $\tfrac{\partial m_i}{\partial p_i} = \{1-0.5(1+\eta)\tau\}\phi\tfrac{-1}{z\gamma}\tfrac{M}{\overline{f}}$. Moreover, in the symmetric equilibrium in which p and R are identical across platforms. Therefore, we obtain the following first-order conditions:

$$\frac{\partial \pi_P}{\partial p_i} = -\big(p(1-t)-c\big)\frac{1}{2z\gamma} + (1-t)\frac{1}{2} - R\frac{[2-(1+\eta)\tau]\phi M}{2z\gamma\overline{f}} = 0,$$
$$\frac{\partial \pi_P}{\partial R_i} = -\big(p(1-t)-c\big)\frac{2\alpha M}{2z\gamma\overline{f}} + \frac{M}{\overline{f}}([2-(1+\eta)\tau]\phi\frac{1}{2} - 4R) - R\frac{[2-(1+\eta)\tau]\phi M}{\overline{f}}\frac{2\alpha M}{2z\gamma\overline{f}} = 0.$$

Solving these conditions yields the equilibrium price reported in the text.

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Supplementary file for review only for "Tax Incidence of VAT Enforcement Reform for Foreign Services and Small Businesses in Two-sided Markets"

For $\Phi \equiv \phi q$, denote the number of apps sold by the general function $m_J = m_J((1-\eta_J\tau)\Phi, R)$ $(J = H,\ F)$, with $\eta_J = 0$ only under Regime O with $J = F$ and $\eta_J = 1$ otherwise. Then, rewrite this function as $m_J = (1-\eta_J\tau)\phi q\frac{\partial m_J}{\partial \Phi} - m_{2,J}R$. $m_{2,J}$ is defined as the residual.

Substituting this relation into the demand function $q = q_1(p) + \alpha m = q_a + \frac{\partial q_1}{\partial p}p + \alpha m$ where q_a is the residual from the first-order approximation of $q_1(p)$, we obtain $q\{1-\alpha\sum_{J=H,F}(1-\eta_J\tau)\phi\frac{\partial m_J}{\partial \Phi}\} \equiv q\gamma = q_a + \frac{\partial q_1}{\partial p}p - \alpha m_2 R$ and $q\{1-\alpha\phi\frac{\partial m}{\partial \Phi}\} \equiv q\gamma = q_a + \frac{\partial q_1}{\partial p}p - \alpha m_2 R$ and $dq\gamma = \frac{\partial q_1}{\partial p}dp - \alpha\frac{\partial m}{\partial R}dR$ to obtain $\frac{\partial q}{\partial p}$ and $\frac{\partial q}{\partial R}$. As in our linear model, we define $\nu = \frac{q^a}{-\partial q_1/\partial p}$. The demand function $q(p, \alpha m)$ allows for a wide range of specifications, including the widely used logit model as a special case.

To maximize $\pi_P^* = ((1-t)p - c)q^* + Rm^*$, with $n(\tau,\eta) \equiv \frac{(1-\tau)\frac{\partial m_H}{\partial \Phi} + (1-\eta\tau)\frac{\partial m_F}{\partial \Phi}}{m_2}\frac{-\partial q_1}{\partial p}$ and, for $m_2 \equiv m_{2,H} + m_{2,F}$, $\epsilon_{m_2R} = \frac{\partial(\sum_{J=H,F}(1-\eta_J\tau)\phi q\frac{\partial m_J}{\partial \Phi})/\partial R}{m_2} - \frac{\partial m_2/\partial R}{m_2}R$ that incorporates the elasticity of m_2 with respect to R:[25]

$$\frac{\partial \pi_P^*}{\partial R}|_{\frac{\partial \pi_P^*}{\partial p}=0}\frac{\gamma}{m_2} = -R^*\left\{2 - \epsilon_{m_2R} - \left(\frac{(1-t)\alpha m_2/2}{-\partial q_1/\partial p} + \sum_{J=H,F}(1-\eta_J\tau)\phi\frac{\partial m_J/\partial\Phi}{2}\right)\left(\alpha\left(-\frac{\partial m/\partial R}{m_2}\right) + \widetilde{\phi}n(\tau,\eta)\right)\right\}$$
$$+ \left[\widetilde{\phi}n(\tau,\eta) - \alpha\left(-\frac{\partial m/\partial R}{m_2}\right)\right]\frac{\nu(1-t)-c}{2} = 0.$$

We denote the expression in curly brackets by den^*, which is assumed to be positive. In our model in the text, (A-2) decomposes $(R^T - R^O)\cdot den^T$ into $-(\nu - \widetilde{c})\frac{\tau\phi}{4} \equiv \Delta R_a \cdot den^T$ and $\Delta R_b \equiv (R^T - R^O) - \Delta R_a$. ΔR_b includes the terms that characterize entry responsiveness and network externalities, which are $\frac{(1-t)\alpha m_2/2}{-\partial q_1/\partial p}$ and $\sum_{J=H,F}(1-\eta_J\tau)\phi\frac{\partial m_J/\partial\Phi}{2}$. In the general model, we define $\Delta R_a = -\frac{\tau\phi\frac{\partial m_F}{\partial\Phi}}{m_2/(-\partial q_1/\partial p)}\frac{\nu-\widetilde{c}}{2}\cdot(den^T)^{-1}$ and define ΔR_b as above. If $-\Delta R_a$ is large, we have $R^T - R^O < 0$.

Hereafter, with a slight abuse of notation, we use a first-order approximation to decompose the discrete change in domestic developer entry into the effects of changes in the commission fee and network size: we have $m_H^T - m_H^O = -m_{2,H}(R^T - R^O) + \frac{\partial m_H}{\partial q}(q^T - q^O)$. $m_{2,H}$ is defined as the residual.

[25] We use the following two formulas:

$$\frac{\partial\Big((p(1-t)-c)q^* + Rm^*\Big)}{\partial p} = -(1-t)p(-2\frac{\partial q}{\partial p}) + c(-\frac{\partial q}{\partial p}) + (1-t)\frac{q_a}{\gamma} - R(\alpha\frac{(1-t)m_2}{\gamma} - \sum_{J=H,F}(1-\eta_J\tau)\phi\frac{\partial m_J}{\partial\Phi}\frac{\partial q}{\partial p}) = 0$$

$$\frac{\partial\Big(((1-t)p-c)q^* + Rm^*\Big)}{\partial R}\frac{\gamma}{m_2} = \phi(\nu - p)n(\tau,\eta) - 2R^* + \epsilon_{m_2R}R^* + \frac{\gamma}{m_2}\frac{\partial q}{\partial R}(p(1-t)-c) = 0$$

A similar derivation is conducted for $m^T - m^O$ below:

$$m_H^T - m_H^O = -m_{2,H}\Delta R_a - \{\frac{\partial m_H}{\partial q}(q^O - q^T) + m_{2,H}\Delta R_b\} \gtreqless 0 \quad \text{with weak/strong entry responsiveness.} \tag{B-1}$$

which is essentially equivalent to (A-10). For $m_H^T > m_H^O$, $R^T - R^O < 0$ is necessary.

For completeness, we demonstrate that q decreases after reform, and market contraction is more pronounced when entry responsiveness is higher. We have $m^T - m^O = (-\tau\phi q^T \frac{\partial m_F}{\partial \Phi} - m_2\Delta R_a)$ $-\{\phi((1-\tau)\frac{\partial m_H}{\partial \Phi} + \frac{\partial m_F}{\partial \Phi})(q^O - q^T) + m_2\Delta R_b\} \equiv \Delta m_a - \{\phi((1-\tau)\frac{\partial m_H}{\partial \Phi} + \frac{\partial m_F}{\partial \Phi})(q^O - q^T) + m_2\Delta R_b\}$.[26] For robustness, one can express $q = q_1(p) + \alpha m$ as:

$$(q^T - q^O)\{1 - \alpha \sum_{J=H,F}(1-\eta_J\tau)\phi\frac{\partial m_J}{\partial \Phi} + (1-t)\alpha m_2 \frac{\Delta R_b}{q^T - q^O}\} = \frac{\partial q_1}{\partial p}\Delta p + \alpha\Delta m_a.$$

$$(q^T - q^O)\{1 - \alpha \sum_{J=H,F}(1-\eta_J\tau)\phi\frac{\partial m_J}{\partial \Phi}\} = \frac{\partial q_1}{\partial p}\Delta p + \alpha\Delta m_a - (1-t)\alpha m_2\Delta R_b.$$

When ΔR_b is negative (positive), we apply the first (second) formula. When $p^T - p^O > 0$, the right-hand side of each formula is negative (for the RHS of the first line, we assume that the sign of Δm_a either follows that of footnote 26, or it does not dominate $\frac{\partial q_1}{\partial p}\Delta p < 0$) and decreasing in entry responsiveness, and the term in the curly brackets on the left-hand side of each formula is positive, decreases with entry responsiveness, and depends on $\phi\frac{\partial m_J}{\partial \Phi}$ and $-\alpha m_2$.

In conclusion, if the fair-market effect, expressed as $\frac{\tau\phi\frac{\partial m_F}{\partial \Phi}}{m_2/(-\partial q_1/\partial p)}\frac{\nu - \widetilde{c}}{2}$, which corresponds to the first term on the right-hand side of (A-10), is sufficiently large relative to other factors — including entry responsiveness given above — then the reform leads to increased entry by domestic firms. However, if the entry responsiveness is high, the resulting market shrinkage (i.e., the reduction in q) dominates, leading to the exit of domestic firms after the reform. We therefore establish an extension of Equation (7) and the property of $q^T < q^O$ in a general model. Furthermore, in Appendix A, we show that (9) holds under the assumption of $\{\alpha + \phi\}\frac{(1-t)M}{\overline{f}}q^T \approx m^T$.[27]

[26] In the linear model of the text, we have

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

$\Delta m_a = (-\tau\phi q^T\frac{\partial m_F}{\partial \Phi} - m_2\Delta R_a)$ corresponds to the first term of the above formula, which is negative in our basic model.

[27] The first line of the first-order conditions in footnote 25 leads to the optimal p^* as (6) of the basic model. That is, $\{\alpha + \phi\}\frac{(1-t)M}{\overline{f}}R^T q^T \approx R^T m^T$ if the price reduction associated with the second term on the RHS of (6) is approximately offset by commission-fee revenue in (8).