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Platform Liability and Innovation*

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We study a platformâs incentives to delist IP-infringing products and the effects of holding the platform liable for the presence of such products on innovation and consumer welfare. For a given number of buyers, platform liability increases innovation by reducing the competitive pressure faced by innovative products. However, there can be a misalignment of interests between innovators and buyers. Furthermore, platform liability can have unintended consequences, which overturn the intended effect on innovation. Platform liability tends to increase (decrease) innovation and consumer welfare when the elasticity of participation of innovators is high (low) and that of buyers is low (high).

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1 Introduction

In recent years, online misconduct emerged as a fundamental problem of the Web. A common activity is the sale of items infringing intellectual property (IP) rights, such as trademarks, designs, and copyright. According to the OECD (2018), counterfeits account for 3% of global trade and "e-commerce platforms represent ideal storefronts for counterfeits". Similar concerns were also raised by popular brand owners like Nike and Birkenstock that decided to pull their products from Amazon due to the proliferation of counterfeits, claiming that the "open business model" adopted by the platform was prone to third parties' misconduct.[1]

As part of the governance of its marketplace ecosystem, a platform's owner can take (costly) measures to screen out illicit players. However, this involves a trade-off: whereas allowing low-quality merchants, possibly including IP infringers, on the platform might lower the incentives for innovative sellers to develop new products, it might increase the platform's market reach and sales. Therefore, it is *a priori* unclear whether a platform has an incentive to delist IP-infringing sellers, especially when their products do not entail direct damage to consumers. Moreover, the enforcement of primary liability, that is the possibility to directly sue and get compensation from wrongdoers, is oftentimes remote in online markets because illicit players may be hard to identify, may belong to a different jurisdiction, or may be judgment proof.[2] This could motivate the introduction of a liability rule that increases the platform's incentives to screen and delist illegal products.[3]

We provide a theoretical framework to understand an online platform's incentives to delist IP-infringing products and study the impact of holding platforms liable for third parties' IP-infringements on innovators and consumers. In our framework, platform liability takes the form of a negligence-based liability rule under which platforms need to comply with two requirements to benefit from liability exemption: a minimum screening requirement and the obligation to delist any identified IP infringer. We focus on the case in which the platform finds it optimal to comply with these (binding) requirements and, therefore, platform liability leads to an increase in the screening level.[4]

To this end, we develop a tractable model in which all transactions between buyers and sellers

[1] See https://www.cnbc.com/2016/07/20/birkenstock-quits-amazon-in-us-after-counterfeit-surge.html. Amazon implemented Project Zero - Amazon Brand Registry and blocked more than 10 billion suspected listings (Amazon, 2021).

[2] For example, vendors might not have enough assets to compensate harmed parties for the damage they have suffered. In our case, IP-infringing vendors might not have the ability to compensate innovators.

[3] This is akin to the "gatekeeper liability" discussed by Kraakman (1986) who argues that it might be optimal to make liable intermediaries that are in the condition to prevent misconduct or withhold support to wrongdoers.

[4] For example, under the EU Electronic Commerce Directive 2000, online intermediaries benefit from liability exemption provided that they act expeditiously to remove any illegal activity or information they become aware of (artt. 13-14). The Digital Services Act complements the Directive by adding a list of additional requirements for 'very large online platforms'.

occur on a monopoly platform.[5] There are two types of sellers: the innovators, who incur innovation costs to develop a new product that gives rise to a new product category; and their imitators (i.e., copycats) who sell a low-quality version of the innovative product. An imitator can only exist if an innovator has developed an innovative product. With a certain probability, the copycat is legitimate and with the complementary probability, it infringes IP. We consider a setting in which an IP-infringing product does not create any direct harm to buyers, who make their purchasing decision knowing whether the product they buy is an original product or its imitation.[6] This captures the evidence that many counterfeits are neither deceptive nor harmful and can be beneficial to consumers while harming innovators.[7]

The platform makes profits by charging sellers an ad valorem commission,[8] and commits to a (costly) screening level, that is, the probability that an IP infringer is identified.[9] If an IP infringer is identified, it is delisted by the platform, whereas legitimate imitators cannot be delisted (e.g., because of the Platform-to-Business regulation in the EU).[10] Therefore, the screening level determines the degree of competition that each innovative product faces and, as a result, it affects innovators' incentives to develop new products. In this framework, the introduction of platform liability that induces a higher screening level leads to an increase in the probability that an IP-infringing product is identified and delisted, thereby reducing the expected competitive pressure that each innovator faces from an imitator. This intended effect of platform liability, which we call the IP-protection effect, gives innovators more incentives to

[5]For illustrative purposes, we will refer to an e-commerce platform. However, the model we propose also applies to an app store (e.g., Apple's App Store) that decides an ad-valorem commission and its screening policy (e.g., Apple's App Review).

[6]For example, a T-shirt branded *Love* that looks similar to the branded *Levi's* might attract buyer demand and not deceive consumers as the difference between the original and its copycat product is obvious. Moreover, the fact that some consumers might discover a taste for low-quality imitations, somewhat infringing IP, can also be motivated by the growing success of the ultra-fast fashion industry and of platforms like Shein, which became in 2021 the *tech industry's most valuable private startup*. See https://www.theguardian.com/fashion/2021/dec/21/how-shein-beat-amazon-at-its-own-game-and-reinvented-fast-fashion

[7]If the IP-infringing product was deceptive, thus pretending to be the original one, in most cases consumers would still have the possibility to return it and obtain a refund either because platforms provide such a possibility or because of consumer protection policy. Moreover, we assume that products are not harmful.

[8]Ad valorem fees are widely adopted by online marketplaces (e.g., Amazon, eBay) and app stores (e.g., Apple Store, Google Play). The economic rationale for their use is studied by Wang and Wright (2017, 2018).

[9]In reality, a platform has repeated interactions with a large number of sellers, who can share information about the platform's behavior. This induces the platform to build a reputation. Commitment to a screening level in our static model can be a good approximation of what a platform with reputational concerns does in situations of repeated interactions. By contrast, if we assume no commitment in our static model, it induces the platform to hold up innovators (see Section 6.4), which corresponds to a platform with no reputation concerns stemming from repeated interactions. Furthermore, if the platform is subject to transparency obligations regarding its screening policy, then the latter should be observable to third parties, which corresponds to the commitment scenario that we consider in our main model.

[10]Note that in our model a platform always has an incentive to delist any identified IP infringer. Absent a liability regime, if the platform has invested in filtering technology to reach a certain screening level, by a revealed preference argument, it clearly has no incentive to keep any identified IP infringer in its ecosystem. In the presence of a liability regime, instead, the platform is required to delist any identified IP infringer in order to benefit from liability exemption. We assume that the platform finds it optimal to comply.

innovate, *all other things being equal*. However, we show that platform liability can also have unintended consequences on innovation, which can be either positive or negative.

Our first result concerns the platform's incentive to screen and delist IP-infringing products by acting as a private regulator of its ecosystem. For a given commission rate, a higher screening level has two effects on the platform's expected profit gross of the screening cost. First, a higher screening level induces more innovators to develop new products by relaxing ex post competition from imitators and, therefore, it increases the number of product categories. Second, it leads to either more or less total profit per product category. This is because a monopolistic industry structure in which the innovative product faces no competition may generate either more or less total profit than a duopolistic industry structure in which the innovator competes with a copycat.[11] If total profit is greater under the monopolistic industry structure, then the platform's optimal screening level is always positive. Otherwise, the platform faces a trade-off between inducing more innovation and increasing total profit per category. As a result, the platform's optimal screening level may be zero.

The second result concerns the direct and indirect effects of introducing platform liability. In the baseline model with inelastic buyer participation and exogenous commission rate, the positive effect of platform liability on innovators' incentives to develop new products — the IP-protection effect — might not suffice to make platform liability desirable for consumers. Specifically, platform liability has two opposite effects on consumer surplus: whereas it increases innovation and hence the number of product categories, it reduces consumer surplus per category by making each category more likely to be monopolistic rather than duopolistic. The net effect depends on the relative magnitude of the two effects and is negative (respectively, positive) if the elasticity of buyer surplus per category with respect to the screening level is larger (resp. smaller) in absolute value than that of the amount of innovation. This implies that platform liability benefits consumers only if its impact on innovation is sufficiently strong. Otherwise, platform liability harms consumers.

In Section 4, we extend the baseline model by introducing elastic buyer participation. We do it by considering two different cases, the case of one-way network effects and that of two-way network effects. Network effects are one-way (i.e., from buyers to innovators) when buyer decision to join the platform is made for each product category and hence depends only on the expected surplus in each product category. In this case, the introduction of platform liability always reduces buyer participation as raising the screening level makes the monopolistic structure more likely. By contrast, network effects are two-way (i.e., being also present from innovators to buyers) when buyer decision to join the platform depends on the total expected surplus from the platform and thereby on the number of product categories. Then platform liability can increase or reduce buyer participation depending on the elasticity of participation of innovators. Even if the two cases are very different in terms of the nature of network effects,

[11] This result can be microfounded in a model of both vertical and horizontal differentiation.

we find that the effects of platform liability on innovation and consumer surplus are remarkably similar. In both cases, platform liability is likely to increase both the amount of innovation and consumer surplus when the elasticity of participation of innovators is high and that of buyers is low. By contrast, when the elasticity of participation of innovators is low and that of buyers is high, platform liability reduces buyer participation and thereby reduces the amount of innovation as this negative effect on buyer participation outweighs the positive IP-protection effect. Then, platform liability harms those innovators that it is supposed to safeguard.

In Section 5, we identify another channel through which platform liability may generate unintended effects on innovation. Specifically, we study how changes in the commission rate induced by platform liability affect innovation in the baseline model with inelastic buyer participation. We find that platform liability can lead to either an increase or decrease in the commission rate. If the commission rate decreases, then the positive effect of platform liability identified in the baseline model with inelastic buyer participation is strengthened. On the contrary, if the commission rate increases, the overall effect of platform liability on innovation is the combination of the positive IP-protection effect and the negative effect stemming from an increase in the commission rate. We find, however, that the former dominates the latter, leading to a positive overall impact of platform liability on innovation.

In a battery of extensions and robustness checks (Section 6), we relax some of our assumptions and identify additional effects that the introduction of platform liability can generate. First, platform liability can change imitators' incentive to infringe IP and thereby reduce innovation through a composition effect: it changes the composition of imitators by raising the share of legitimate imitators, which can strengthen the competition faced by innovators. Second, platform liability can induce the platform to imitate innovative products with its own imitations (i.e., can induce the platform to adopt a hybrid business model). Third, we show that our finding that the effect of platform liability on the commission rate may be either positive or negative carries over to the scenario in which the platform charges sellers a fixed membership fee. Fourth, we provide an extension to the no commitment case and show that platform liability can mitigate hold-up and thereby increase the platform's profit. Finally, we generalize our analysis to the case in which there is an infinite number of periods and delisting of an imitator triggers a subsequent entry of another imitator.

Related literature. This article contributes to two strands of the literature.

Platform governance. We contribute to the literature on online platforms (Caillaud and Jullien, 2003; Rochet and Tirole, 2003) and, more specifically, to the literature on platform governance as we study a platform's policy to screen out IP-infringing sellers. Recent papers on platform governance have studied the incentives of digital platforms to choose the intensity of seller competition (Teh, 2022), to bias their innovations by trading off one side's surplus against that of the other side (Choi and Jeon, 2022), to introduce deceptive features (Johnen and Somogyi, 2021), to moderate content (Liu et al., 2022; Madio and Quinn, 2021), to delist low-quality sellers (Casner, 2020), and to ensure privacy protection (Etro, 2021a).[12] In addition, this paper is related to the literature on how platforms can influence seller innovation (Belleflamme and Peitz, 2010; Jeon and Rey, 2022) and seller competition (Karle et al., 2020). More specifically, Karle et al. (2020) shows that the degree of competition in a product category impacts the pricing strategies of competing platforms. In our paper, the platform's screening policy affects the degree of competition an innovator faces and thereby its incentive to innovate.[13]

Law & economics. This article contributes to the law & economics literature on liability, which has mostly dealt with product liability in contexts where a firm sells its products to consumers directly and there is harm caused by an insufficient level of care. This literature has identified conditions for the introduction of liability to be socially desirable or undesirable (Daughety and Reinganum, 1995, 1997, 2006, 2008; Ganuza et al., 2016; Hua and Spier, 2020; Iossa and Palumbo, 2010; Polinsky and Shavell, 2010). We contribute to this literature by formally investigating the economic effects of holding online intermediaries liable, which have been discussed in non-formalized studies (Buiten et al., 2020; Lefouili and Madio, 2022).

We present a formal analysis of some possible intended and unintended effects of holding e-commerce platforms (and app stores) liable on innovation and consumer welfare. To the best of our knowledge, this is the first paper that studies the effect of platform liability on innovation and the key role played by cross-group network effects in determining the desirability of platform liability. Two other papers study economic effects of platform liability. De Chiara et al. (2021) studies the incentives of a hosting platform like Youtube to ex ante filter copyright infringing material and the incentives of right holders to send take-down notices to the platform. They investigate the socially optimal public intervention and find it to be a dual system combining ex ante regulation and ex post liability. There are two key differences between this paper and ours, besides the fact that De Chiara et al. (2021) does not investigate the impact of platform liability on innovation. First, they focus on different types of platforms and users. Second, they give a prominent role to right-holders in the enforcement of copyright protection. Hua and Spier (2022) study the optimal liability regime for online intermediaries when some firms are harmful. They show that it is optimal to hold platforms liable when harmful firms are judgment proof, but that the optimal liability regime may be partial. Our setting differs from theirs in three main respects. First, unlike us, they do not investigate the effect of platform liability on innovation. Second, they focus on harmful firms that impose costs on users, who are on the other side of the market, whereas in our model IP-infringing imitators only cause

[12] Other papers have studied quality certification and threshold in online platforms (Elfenbein et al., 2015; Hui et al., 2021, 2022) and role of certification intermediaries (Lizzeri, 1999).

[13] Our paper also shares some commonalities with recent work on platform business models (e.g., Anderson and Bedre-Defolie 2021; Etro 2021b; Hagiu et al. 2022; Zennyo 2022; Shelegia and Hervas-Drane 2022), and on the platform's incentives to produce imitations (Jiang et al., 2011; Madsen and Vellodi, 2022). Our analysis sheds light on the incentives of platforms to copy innovative products in response to the introduction of platform liability.

direct harm to innovators, who are on the same side of the market. Third, they consider strict liability, whereas we consider negligence-based liability.

Our paper also relates to the literature on indirect liability and, more specifically, to Lichtman and Landes (2003) and Hay and Spier (2005). The former identifies conditions for holding a manufacturer liable for consumers intentionally causing harm to other consumers. The latter discusses the pros and cons of making parties that are not direct wrongdoers (e.g., manufacturers) accountable for other parties' conduct (e.g., buyers). We focus instead on the economic effects of holding a platform liable for IP-infringing sellers active on the platform.

Finally, we contribute to the literature on the economics of digital piracy (e.g., for a critical review, see Peitz and Waelbroeck 2006a; Belleflamme and Peitz 2012), and the positive externalities that pirated content may have on the original one, e.g., through sampling (Peitz and Waelbroeck, 2006b). In our model, the availability of an IP-infringing product is mediated by a platform and might generate a positive effect on innovators if their availability increases buyer participation on the platform.

Outline. The rest of the article is organized as follows. In Section 2, we present the model. In Section 3, we study the platform's private incentives to screen and the effect of platform liability on innovation and consumer welfare under the assumption of inelastic buyer participation and exogenous commission rate. In Section 4, we study how the effects of platform liability depend on the existence and nature of cross-group network effects. In Section 5, we study how the introduction of platform liability impacts the commission rate and thereby innovation incentives. In Section 6, we provide several extensions. Finally, in Section 7, we gather concluding remarks and policy implications.

2 The model

Consider an economy in which all transactions between sellers and buyers take place on an e-commerce monopoly platform. Sellers can be of two types: innovators and imitators.

Innovators. There is a mass one of innovators, who can develop an innovative product that gives rise to a new product category. We assume that innovators are heterogenous in their cost of innovation, k, which is distributed according to a cdf $F(.)$ with density $f(.) > 0$ over the interval $[0, \overline{k}]$. We assume that $f(.)$ is continuously differentiable. Once an innovative product is developed, the innovator sells it via the platform. For simplicity, we assume that the marginal production cost is zero.

Imitators. An innovative product can face competition from an imitation. An imitation is legitimate with probability equal to $\nu \in (0, 1)$ and infringes IP with probability equal to

$1-\nu$. In the baseline model, we assume that ν is exogenous and the imitation cost is equal to zero.[14] We assume that there is perfect information so that consumers buying an imitation are not deceived. Moreover, two imitations of different legal status in a given category (i.e., one that infringes IP and the other that does not) are perceived by consumers as homogeneous. We assume that only a single imitator joins the platform in each realized product category.[15] Finally, we assume that primary liability is not enforceable, i.e., an innovator cannot obtain damages from an IP infringer (e.g., because it is located in another jurisdiction or is judgment proof).

The platform. The platform does not charge any price on the buyer side. But on the seller side, it charges an ad valorem commission rate $\tau \in (0,1]$ per transaction and commits to a screening level $\phi \in [0,1]$, that is, the probability that an IP infringer is identified as such. We assume that there are no type-I errors, i.e., a legitimate imitator cannot be flagged as infringing IP. If an IP infringer is identified, it can be delisted by the platform, whereas a legitimate imitator cannot be delisted.[16] We assume that screening is costly and we let $\Omega(\phi)$ denote the fixed screening cost incurred by the platform associated with a level of screening ϕ. For example, a screening activity might require sunk investments in artificial intelligence to train an algorithm that filters IP-infringing products. Alternatively, the platform can buy a filtering technology whose cost is increasing in its accuracy rate. Finally, we make the following assumption regarding the screening cost incurred by the platform.

Assumption 1. $\Omega(0) = 0 = \Omega'(0)$, $\Omega'(\phi) > 0$, $\Omega(\phi) \underset{\phi \to 1}{\to} +\infty$.

This assumption implies that the cost of achieving a very low screening level is very small, whereas perfect screening is prohibitively costly. Moreover, by revealed preferences, this assumption also implies that any IP infringer that is identified as such is delisted. We assume that ϕ is observable by all agents, which is consistent, for instance, with the transparency obligations imposed by the EU Digital Services Act. We focus on the case in which the platform can commit to ϕ although we also analyze the case of no commitment in Section 6.

Consumers. There is a mass 1 of consumers. To disentangle different forces at stake, in the baseline model we assume that all buyers join the platform, i.e., buyer participation is inelastic. In Section 4, we relax this assumption by introducing elastic buyer participation driven by

[14] In Section 6, we relax this assumption by allowing for endogenous infringement.

[15] The assumption that only one imitator enters can be justified as the presence of a second imitator, entering subsequently, would drive prices to zero and thus render the second entry unprofitable. In Section 6 we generalize our analysis to the case in which there is an infinite number of periods and delisting of an imitator triggers a subsequent entry of another imitator. We show that our main results carry out qualitatively.

[16] This assumption is consistent with regulations existing in the European Union. Under the P2B (platform-to-business) regulation, for example, online intermediaries should ensure fair treatment to business users and contractual relations are required to be conducted in good faith and based on fair dealing (see Regulation (EU) 2019/1150). Thus, arbitrary screening of sellers can be considered a remote possibility.

cross-group network effects. We assume that consumers are ex ante homogeneous but ex post heterogeneous in the sense that it is only after joining the platform that they discover their valuations for the innovators' and the imitators' products.

Market structure in each category. Market structure in each product category is either duopolistic or monopolistic. It is monopolistic if, and only if, the imitator infringes IP and is identified and delisted by the platform. In each category, let π_I^m (resp. π_I^d) represent the corresponding expected profit, gross of the commission paid to the platform and the fixed innovation cost, of an innovator when it faces no competition (resp., faces competition from an imitator). Let π_C^d represent an imitator's expected profit when competing with an innovator; the subscript 'C' stands for copycats. We assume the following.

Assumption 2. $\pi_I^m > \pi_I^d > \pi_C^d > 0$.

The first part of the assumption means that an innovator's profit is higher when it faces no competition than when it faces competition from an imitator. The second part means that when there is competition between an innovator and an imitator, the former obtains a higher profit than the latter. For a given screening level ϕ, an innovator's expected profit, gross of the commission paid to the platform and the fixed innovation cost, is given by:

$$\pi_I(\phi) \equiv (1-\nu)\phi\pi_I^m + [1-(1-\nu)\phi]\,\pi_I^d. \quad (1)$$

With probability $(1-\nu)\phi$, the innovator is the only seller in its respective product category and earns monopoly profit π^m. With the remaining probability, the innovator competes with an imitator and earns a duopoly profit π_I^d. Given the screening level ϕ, the expected gross profit of an imitator is

$$\pi_C(\phi) \equiv [1-(1-\nu)\phi]\,\pi_C^d. \quad (2)$$

For a given number n_I of innovators who developed an innovative product, the expected consumer surplus is equal to $u(\phi)n_I$, with

$$u(\phi) \equiv (1-\nu)\phi u^m + (1-(1-\nu)\phi)u^d, \quad (3)$$

where u^m (resp. u^d) represents the expected buyer surplus per category, net of price, when the product market structure is monopolistic (resp. duopolistic). Because we focus on imitations that are neither malicious nor harmful, we assume that buyer surplus per category is higher in a duopolistic market structure than in a monopolistic one. Formally, we assume the following.

Assumption 3. $u^d > u^m > 0$.

Timing. We consider the following timing:

- Stage 1: The platform decides its screening level ϕ and the commission rate τ.
- Stage 2: Innovators make their innovation decisions and join the marketplace if they innovate. In each product category, an imitator joins the marketplace and is delisted with probability ϕ if it infringes IP.
- Stage 3: Buyers decide whether to join the marketplace. Upon joining it, they discover their valuations for the products and make their purchasing decisions: for each product category, they decide whether to buy and which product to buy if there is more than one product.

The model is solved backward and the equilibrium concept is subgame perfect Nash equilibrium. In *the baseline model* analyzed in Section 3, we assume that all buyers join the marketplace and the commission rate is exogenously given. In Section 4 we allow for elastic buyer participation, whereas in Section 5 we relax the assumption of exogenous commission rate.

3 Analysis of the baseline model

In this section, we analyze the baseline model with inelastic buyer participation and an exogenously-given commission rate.[17]

In Stage 2, an innovator develops a new product if, and only if, her innovation cost is lower than the expected profit she makes on the platform, net of the commission, i.e., $(1-\tau)\pi_I(\phi)$. Therefore, the number of innovators that develop an innovative product and join the marketplace is

$$n_I(\tau,\phi) = F((1-\tau)\pi_I(\phi)).$$

Throughout the analysis, we refer to $n_I(\tau,\phi)$ as the *amount of innovation*.

In Stage 1, the platform acts as a private regulator of its innovation ecosystem by choosing the screening level ϕ in order to maximize the following expected profit, which we assume to be quasi-concave in ϕ:

$$\Pi(\tau,\phi) = \tau F((1-\tau)\pi_I(\phi))\Big[\pi_I(\phi) + \pi_C(\phi)\Big] - \Omega(\phi). \tag{4}$$

[17] We endogenize the commission rate in Section 5. Note that there are circumstances under which the commission rate can be considered exogenous. First, the commission rate can be a long-run decision and there is indeed little evidence of frequent adjustments by existing online marketplaces and app stores. Second, the commission rate can be regulated by the government or capped to avoid 'excessive pricing'. Unfair or excessive pricing by dominant firms is forbidden by Article 102 TFEU as it may constitute an abuse of dominance. Third, the platform can be constrained in its choice of the commission rate by the possibility for innovators to sell through direct channels if the profit from this outside option is sufficiently large (e.g., Hagiu et al. 2022).

The first-order condition of the platform's expected profit with respect to ϕ can be written as

$$\frac{\partial \Pi(\tau,\phi)}{\partial \phi} = \tau\left\{\frac{\partial n_I(\tau,\phi)}{\partial \phi}\Big[\pi_I(\phi)+\pi_C(\phi)\Big] + F((1-\tau)\pi_I(\phi))\Big[\pi_I'(\phi)+\pi_C'(\phi)\Big]\right\} - \Omega'(\phi) = 0, \quad (5)$$

with $\pi_I'(\phi)+\pi_C'(\phi) = (1-\nu)[\pi_I^m - \pi_I^d - \pi_C^d]$. Therefore, $\pi_I'(\phi)+\pi_C'(\phi)$ is positive (resp. negative) if the monopoly profit π_I^m is greater (resp. smaller) than the total duopoly profits $\pi_I^d + \pi_C^d$. Both scenarios may arise depending on the relative magnitudes of a business-stealing effect and a market-expansion effect that an imitator creates (see e.g., Chen and Riordan 2008). The two scenarios can be microfounded in a model with both vertical and horizontal product differentiation. Let $\phi^\star$ denote the screening level chosen by the platform in the absence of platform liability. The following proposition is about the platform's private incentive to screen and delist IP infringers.[18]

Proposition 1. *Suppose that buyer participation is inelastic. For a given commission rate, the platform's private incentive to screen is as follows:*

(i) If $\pi_I^m \geq \pi_I^d + \pi_C^d$ then the platform chooses a positive screening level, i.e. $\phi^\star \in (0,1)$.

(ii) If $\pi_I^m < \pi_I^d + \pi_C^d$ then the platform does not engage in any screening, i.e. $\phi^\star = 0$, if the L.H.S. of (5) is weakly negative at $\phi = 0$, and chooses a positive screening level i.e. $\phi^\star \in (0,1)$, otherwise.

Note first that an increase in the level of screening raises the expected profit of innovators and thereby leads to the development of a larger number of innovative products on the platform.[19] More precisely, a higher screening level reduces the competitive pressure faced by an innovator as each product category becomes more likely to be monopolistic, which increases the innovator's expected profit:

$$\pi_I'(\phi) = (1-\nu)(\pi_I^m - \pi_I^d) > 0. \quad (6)$$

We call this the *IP-protection effect.* This positive effect leads to an increase in the amount of innovation.

In addition, the above proposition identifies the key role played by total profit per category in shaping the platform's incentive to screen. If $\pi_I^m \geq \pi_I^d + \pi_C^d$, then an increase in the level of screening raises not only the amount of innovation but also the platform's profit per product category, which implies that the marginal private benefit of screening (gross of screening costs)

[18]Note that our assumption $\Omega(\phi) \underset{\phi\to 1}{\to} +\infty$ precludes the possibility that the platform chooses full screening of IP-infringing products, i.e. $\phi^\star = 1$. This could however happen in a setting in which the cost of full screening is not prohibitively high.

[19]This is the standard rationale for IP protection.

is always positive. This, combined with the fact that the marginal cost of screening is zero at $\phi = 0$, makes the platform always choose a positive level of screening. However, if $\pi_I^m < \pi_I^d + \pi_C^d$, then the marginal benefit of screening (gross of screening cost) is negative if the positive impact on the amount of innovation is outweighed by the negative effect on the profit per category. In that case, the platform finds it optimal to let all imitators be active in the marketplace.

The impact of platform liability. We now study the impact of introducing a negligence-based liability rule under which a platform benefits from liability exemption if and only if it complies with two requirements: (i) the screening level should be (weakly) above a certain threshold, denoted by ϕ^L; (ii) the platform delists any identified IP infringer. We focus on the case in which the minimum screening requirement is binding, i.e., $\phi^L > \phi^\star$ and we assume that liability costs from losing the liability exemption are so large that the platform always finds it optimal to comply with the two requirements. As a consequence, platform liability leads to an increase in the screening level.

We have seen previously that an increase in the screening level raises the amount of innovation through the IP-protection effect for a given commission rate. Therefore, an immediate effect of introducing platform liability is that it raises the amount of innovation.

However, the fact that platform liability leads to a larger amount of innovation does not necessarily make it desirable for policymakers if they also care about consumer welfare. As imitations benefit consumers for a given amount of innovation but exert competitive pressure on innovators, there is a potential misalignment of interests between consumers and innovators. To investigate this, we now assess the effect of platform liability on consumer surplus, which is given by $CS(\tau, \phi) \equiv u(\phi) n_I(\tau, \phi)$, with $u(\phi)$ defined in (3). Differentiating this with respect to ϕ, we obtain

$$\frac{\partial CS(\tau,\phi)}{\partial \phi} = \underbrace{\frac{\partial n_I(\tau,\phi)}{\partial \phi} u(\phi)}_{\text{variety effect}} + \underbrace{n_I(\tau,\phi) u'(\phi)}_{\text{effect on per-category buyer surplus}} . \tag{7}$$

Two opposite effects are present. As the amount of innovation increases as a consequence of the introduction of platform liability, consumers benefit from a larger variety, holding fixed the buyer surplus per category. Yet, given an amount of innovation (and hence given a number of product categories), raising the screening level lowers buyer surplus per category as the industry structure is more likely to be monopolistic. As the two effects move in opposite directions, the introduction of platform liability benefits (resp. harms) consumers only if the gains from a larger amount of innovation more than offset (resp. are dominated by) losses from the reduction in consumer surplus per category.

Denoting $\varepsilon_{n_I}(\tau, \phi) \equiv \frac{\frac{\partial n_I(\tau,\phi)}{\partial \phi}}{n_I(\tau,\phi)} \phi$ the elasticity of the amount of innovation with respect to ϕ and $\varepsilon_u(\phi) \equiv \frac{u'(\phi)}{u(\phi)} \phi$ the elasticity of buyer surplus with respect to ϕ, we get the following result.

Proposition 2. *Suppose that buyer participation is inelastic. For a given commission rate, a liability rule that induces a higher level of screening always has a positive effect on innovation, and has a positive (resp. negative) effect on consumer surplus if*

$$\varepsilon_{n_I}(\tau, \phi) > (<) - \varepsilon_u(\phi).$$

for any $\phi \in \left(\phi^\star, \phi^L\right)$.

This result suggests that if the loss in buyer surplus per category increases with the screening level at a faster rate than the increase in the amount of innovation does, there is an important trade-off that policymakers should take into account: benefits for innovators do not translate into benefits for final consumers. Proposition 2 implies that platform liability benefits consumers only if its impact on innovation is strong enough.

Finally, we study the impact of platform liability on the surplus of imitators. First, the aggregate surplus of legitimate imitators is given by

$$n_I(\tau, \phi)(1 - \tau)\nu\pi_C^d.$$

As legitimate imitators cannot be delisted, platform liability only impacts their surplus via the (positive) change in the number of product categories on the marketplace. Therefore, platform liability positively affects the surplus of legitimate imitators.

Second, the aggregate surplus of IP-infringing imitators is given by

$$n_I(\tau, \phi)(1 - \tau)(1 - \nu)(1 - \phi)\pi_C^d.$$

There are two opposite effects stemming from the introduction of platform liability. On the one hand, for a given number of product categories, platform liability leads to more IP infringers being identified and delisted. On the other hand, for a given expected profit per category, platform liability leads to more innovation and thus more product categories. The net effect is positive (resp. negative) if the benefit from a larger number of product categories is larger (resp. smaller) than the loss from a higher screening and delisting activity. The formal conditions are provided in the following proposition.

Proposition 3. *Suppose that buyer participation is inelastic. For a given commission rate, a liability rule that induces a higher level of screening always has a positive effect on the aggregate surplus of legitimate imitators and has a positive (resp. negative) effect on the aggregate surplus of IP-infringing imitators if*

$$\varepsilon_{n_I}(\tau, \phi) > (<) \frac{\phi}{(1 - \phi)}$$

for any $\phi \in \left(\phi^\star, \phi^L\right)$.

Finally, after defining social welfare as the sum of consumer surplus, innovators' profit, imitators' profit, and the platform's profit, we get the following corollary.

Corollary 1. *A liability rule that induces a higher level of screening benefits consumers, innovators, and imitators if*

$$\varepsilon_{n_I}(\tau,\phi) > \max\left\{\frac{\phi}{(1-\phi)}, -\varepsilon_u(\phi)\right\} \text{ for any } \phi \in \left(\phi^\star, \phi^L\right). \tag{8}$$

Moreover, if (8) *is satisfied, a negligence-based liability rule that leads to a marginal increase in the screening level above the privately optimal one ($\phi^\star$) strictly raises social welfare as long as $\phi^\star$>0.*

The above corollary identifies a sufficient condition for platform liability to benefit all different groups of users of the platform.[20] If an increase in the screening level has a sufficiently strong positive effect on innovation, platform liability benefits every group of users, including consumers and IP-infringers. On the contrary, platform liability harms the platform as it is constrained to behave sub-optimally. However, given that the negative effect on the platform's profit is second order in the neighborhood of the privately optimal screening level $\phi^\star$ for an interior $\phi^\star$, whereas the effects on consumers, innovators, and imitators are first order, there exists scope for welfare-improving platform liability if (8) is satisfied.

4 Elastic buyer participation and network effects

In this section, we consider the scenario in which buyer participation is elastic while the commission rate is exogenously given. We consider two different kinds of cross-group network effects to generate elastic buyer participation. In the first case, network effects are *one-way* in the sense that they run from buyers to innovators but not from innovators to buyers. In the second case, network effects are *two-way* in the sense that they run from buyers to innovators and from innovators to buyers.[21]

In order to microfound these two cases, we define the (ex ante) utility of a buyer as follows

$$un_I - \gamma n_I - \xi \tag{9}$$

[20] The condition can be relaxed if we consider the aggregate surplus of all imitators. Then $\frac{\phi}{(1-\phi)}$ needs to be replaced by $\frac{(1-\nu)\phi}{\nu+(1-\nu)(1-\phi)}$.

[21] These are *membership* externalities, as discussed by Rochet and Tirole (2006): participation of end users on one side affects the participation of end users on the other side and vice versa. In our setting, the participation of buyers on the platform affects the decision of innovators to develop a new product and sell it via the platform. This is the participation externality from buyers to innovators. The participation externality from innovators to buyers arises when the number of innovators on the platform affects buyer decisions to join the platform.

with γ representing a per-category opportunity cost, and ξ a platform-related opportunity cost. We assume that γ is distributed according to a cdf $G(.)$ and pdf $g(.)$ over a support $[0, \overline{\gamma}]$, whereas ξ is distributed according to a cdf $H(.)$ and pdf $h(.)$ over a support $[0, \overline{\xi}]$. For ease of exposition, we assume in this section that the elasticities of $F(.)$, $G(.)$, and $H(.)$, respectively $\varepsilon_F \equiv \frac{f(k)}{F(k)}k$, $\varepsilon_G \equiv \frac{g(\gamma)\gamma}{G(\gamma)}$, and $\varepsilon_H \equiv \frac{h(\xi)}{H(\xi)}\xi$, are constant.[22]

Expression (9) enables us to capture different scenarios of elastic buyer participation. If $\xi = 0$ and $\gamma > 0$, a consumer incurs an opportunity cost to join each product category but it does not incur a platform-related opportunity cost. A buyer's decision whether to join the platform is driven by (the sign of) $u - \gamma$, which is independent of the number of categories on the platform. This setting is akin to that of Hagiu et al. (2022) for which what matters for buyer decisions to join the platform is the utility obtained in a given product category. This setting generates cross-group network effects from buyers to innovators but no participation externality from innovators to buyers.

If $\xi > 0$ and $\gamma = 0$, then buyers incur an opportunity cost of joining the platform only once, but they do not incur any per-category opportunity cost. In this case, the decision to join the platform for a buyer depends on the number of realized product categories. Therefore, there are cross-group network effects from buyers to innovators and vice versa.

Recall that buyer taste for products is assumed to be drawn upon joining the platform. We also assume that buyer valuations and their opportunity costs are independent. The gross expected profit of an innovator is given by $\pi_I(\phi)n_B(\tau, \phi)$, where $n_B(\tau, \phi)$ denotes the number of buyers who join the platform (without deriving its expression for now). Therefore, in Stage 2, the number of innovators that develop an innovative product is

$$n_I(\tau, \phi) = F((1 - \tau)\pi_I(\phi)n_B(\tau, \phi)).$$

Differently from the baseline model, for a given commission rate, the introduction of platform liability has now the following impact on the amount of innovation

$$\frac{\partial n_I(\tau, \phi)}{\partial \phi} = (1 - \tau)f((1 - \tau)\pi_I(\phi)n_B(\tau, \phi))\Big[\underbrace{\pi_I'(\phi)}_{\text{IP-protection effect}} n_B(\tau, \phi) + \pi_I(\phi) \underbrace{\frac{\partial n_B(\tau, \phi)}{\partial \phi}}_{\text{market size effect}} \Big]. \tag{10}$$

Two effects coexist. First, there is a positive IP-protection effect that is similar to the one identified in the baseline model. Second, there is a new indirect effect that is channeled by the change in buyer participation in the platform. This effect, which we refer to as the *market size effect*, can be either positive or negative depending on whether the number of buyers in the marketplace increases or decreases in response to a higher screening level. If the number of

[22]This assumption is mainly for expositional simplicity as we use only once the constant elasticity of $G(.)$ for computation: see the footnote just before Proposition 6.

buyers increases, then both effects are positive and, therefore, platform liability has a positive effect on innovation. However, if the number of buyer decreases, then the two effects have opposite signs and the net effect depends on their relative magnitudes.

To understand further the role of networks effects in the impact of platform liability on innovation, we define $\varepsilon_{\pi_I}(\phi) \equiv \frac{\frac{\partial \pi_I(\phi)}{\partial \phi}}{\pi_I(\phi)}\phi$ the elasticity of the gross (per-buyer) profit of an innovator with respect to ϕ and $\varepsilon_{n_B}(\tau, \phi) \equiv \frac{\frac{\partial n_B(\tau,\phi)}{\partial \phi}}{n_B(\tau,\phi)}\phi$ the elasticity of the number of buyers on the platform with respect to ϕ. From (10), we find that the elasticity of the amount of innovation with respect to ϕ can be written as

$$\varepsilon_{n_I}(\tau, \phi) = \varepsilon_F[\varepsilon_{\pi_I}(\phi) + \varepsilon_{n_B}(\tau, \phi)]. \tag{11}$$

The elasticity $\varepsilon_{n_I}(\tau, \phi)$ can be interpreted as the impact (in relative terms) of a marginal increase in the level of screening on the amount of innovation.[23] Three observations can be made at this point. First, the (magnitude of the) impact on the amount of innovation of an increase in the screening level critically depends on ε_F, which has two interpretations. The first one, which applies when considering the term $\varepsilon_F\varepsilon_{\pi_I}(\phi)$ in (11), is that ε_F captures the elasticity of the amount of innovation with respect to per-category innovator profit.[24] The second one, which applies when considering the term $\varepsilon_F\varepsilon_{n_B}(\phi)$ in (11), is that ε_F captures the intensity of the network effects from buyers to innovators.[25] The larger ε_F, the larger the magnitude of the impact on innovation of a liability rule that induces a higher screening level, regardless of the sign of that impact. Second, if buyer participation is elastic, the impact of such a liability rule on innovation is greater (resp. less) than its impact in the baseline model with inelastic buyer participation whenever it leads to an increase (resp. decrease) in buyer participation, i.e. if $\varepsilon_{n_B} > (<) 0$.[26] Third, the sign of the impact on innovation is determined by the sign of $\varepsilon_{\pi_I}(\phi) + \varepsilon_{n_B}(\tau, \phi)$. More specifically, we have the following result.

Proposition 4. *Suppose that buyer participation is elastic. For a given commission rate, a liability rule that induces a higher level of screening has a positive (resp. negative) effect on*

[23]We can write the impact (in relative terms) of a liability rule that induces an increase in the level of screening from $\phi^\star$ to ϕ^L as

$$\frac{n_I(\tau, \phi^L) - n_I(\tau, \phi^\star)}{n_I(\tau, \phi^\star)} = \exp\left(\int_{\phi^\star}^{\phi^L} \varepsilon_{n_I}(\tau, \phi)\frac{d\phi}{\phi}\right) - 1 = \exp\left(\varepsilon_F \int_{\phi^\star}^{\phi^L} [\varepsilon_{\pi_I}(\phi) + \varepsilon_{n_B}(\tau, \phi)]\frac{d\phi}{\phi}\right) - 1.$$

[24]For a given per-category innovator profit π_I, the number of innovators is $n_I = F((1-\tau)\pi_I n_B(\phi))$. Hence, the elasticity of the number of innovators with respect to the innovator per-category profit is: $\frac{\pi_I \partial n_I}{n_I \partial \pi_I} = \frac{(1-\tau)\pi_I n_B f((1-\tau)\pi_I n_B(\phi))}{F((1-\tau)\pi_I n_B(\phi))} = \varepsilon_F$.

[25]For a given number of buyers on the platform n_B, the number of innovators is $n_I = F((1-\tau)\pi_I(\phi)n_B)$. Hence, the elasticity of the number of innovators with respect to the number of buyers –which we can interpret as a measure of the network effects from buyers to innovators– is: $\frac{n_B \partial n_I}{n_I \partial n_B} = \frac{(1-\tau)\pi_I(\phi)n_B f((1-\tau)\pi_I(\phi)n_B)}{F((1-\tau)\pi_I(\phi)n_B)} = \varepsilon_F$.

[26]This follows immediately from (11) and the fact that the baseline model corresponds to the special case in which $\varepsilon_{n_B} = 0$.

innovation if

$$\varepsilon_{\pi_I}(\phi) > (<) \; -\varepsilon_{n_B}(\tau, \phi)$$

for any $\phi \in \left(\phi^\star, \phi^L\right)$.

In the next subsections, we study how the introduction of liability affects buyer participation, innovation and consumer surplus both when there is only a per-category opportunity cost and when there is only a platform-related opportunity cost.[27]

4.1 One-way network effects

Let us first consider the scenario in which each buyer only incurs a per-category opportunity cost, i.e., $\gamma > 0$ and $\xi = 0$. In this case, we have one-way network effects (from buyers to innovators) because the decision of buyers to join the platform does not depend on the number of product categories (while the latter depends on the number of buyers). All buyers have the same expected utility per product category gross of the opportunity cost, and this is given by $u(\phi)$, as previously defined.[28] This implies that the number of buyers on the platform is given by $n_B(\phi) = G(u(\phi))$. We assume that $\overline{\gamma} > u^d$, which ensures that $\overline{\gamma} > u(\phi)$ for any ϕ and, therefore, $n_B(\phi) < 1$ for any ϕ.[29] The impact of a marginal increase in the screening level on the number of buyers on the platform is given by

$$n_B'(\phi) = u'(\phi)g(u(\phi)) < 0, \tag{12}$$

which means that the *market size effect* is always negative in this case. This result is stated in the following lemma.

Lemma 1. *Suppose that buyer participation is elastic such that each buyer incurs only a per-category opportunity cost. A liability rule that induces a higher level of screening always has a negative effect on buyer participation in the marketplace.*

Together with Proposition 4, the above lemma implies that the effect on innovation can be either positive or negative. Because $\varepsilon_{n_B}(\phi) = \varepsilon_G \varepsilon_u(\phi)$, we get the next result which follows from Proposition 4.

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[27]The general case where both opportunity costs are present is essentially a convex combination of the two scenarios in which one of the opportunity costs is zero.

[28]The decision of a buyer to join a product category of the platform only depends on the comparison between the gross expected utility per category $u(\phi)$ and the opportunity cost γ, which can be interpreted as the cost of discovering the number and the characteristics (including prices) of the products in the category by conducting search.

[29]The baseline model can be obtained by assuming that $\overline{\gamma} < u^m$, which ensures that $\overline{\gamma} < u(\phi)$ for any ϕ and, therefore, $n_B(\phi) = 1$ for any ϕ.

Proposition 5. *Suppose that buyer participation is elastic such that each buyer incurs only a per-category opportunity cost. A liability rule that induces a higher level of screening has a positive (resp. negative) effect on innovation if*

$$\varepsilon_{\pi_I}(\phi) > (<) \ -\varepsilon_G \varepsilon_u(\phi)$$

for any $\phi \in \left(\phi^\star, \phi^L\right)$.

This proposition shows that there are indeed conditions under which the *market size effect* dominates the *IP-protection effect*. In that case, platform liability leads to less innovation and harms the innovators that it intends to protect. Such a scenario occurs if the elasticity of the number of buyers with respect to per-category buyer surplus ε_G is relatively large because in this case platform liability leads to a substantial decrease in buyer participation. However, if ε_G is relatively small, the net effect of platform liability on innovation remains positive as in the baseline model.

We now investigate the effect of platform liability on consumer surplus. The latter is given by

$$CS(\tau,\phi) = n_I(\tau,\phi) \int_0^{u(\phi)} (u(\phi) - \gamma) g(\gamma) d\gamma.$$

Differentiating it with respect to ϕ, we find that an increase in the level of screening has a positive (resp. negative) impact on consumer surplus if

$$\frac{\frac{\partial n_I(\tau,\phi)}{\partial \phi}}{n_I(\tau,\phi)} > (<) - \frac{u'(\phi)}{u(\phi) - \gamma^e(\phi)}, \tag{13}$$

where $\gamma^e(\phi) \equiv \frac{\int_0^{u(\phi)} \gamma g(\gamma) d\gamma}{G(u(\phi))}$ is the average per-category opportunity cost of the buyers on the platform. Therefore, an increase in the level of screening has a positive (resp. negative) effect on consumer surplus if

$$\varepsilon_{n_I}(\phi) > (<) - \varepsilon_u(\phi) \frac{u(\phi)}{u(\phi) - \gamma^e(\phi)}.$$

Straightforward computations show that $\gamma^e(\phi) = \frac{\varepsilon_G}{1+\varepsilon_G} u(\phi)$,[30] which implies that the above inequality can be rewritten as

$$\varepsilon_{n_I}(\phi) > (<) - \varepsilon_u(\phi)(\varepsilon_G + 1).$$

Using the fact that $\varepsilon_{n_I}(\phi) = \varepsilon_F[\varepsilon_{\pi_I}(\phi) + \varepsilon_{n_B}(\phi)] = \varepsilon_F[\varepsilon_{\pi_I}(\phi) + \varepsilon_G \varepsilon_u(\phi)]$, we get the following result.

[30] The assumption that ε_G is constant implies that $G(\gamma) = M\gamma^{\varepsilon_G}$ where $M = 1/(\overline{\gamma})^{\varepsilon_G}$ to ensure that $G(\overline{\gamma}) = 1$. This implies that $g(\gamma) = M\varepsilon_G \gamma^{\varepsilon_G - 1}$, and leads to $\frac{\int_0^{u(\phi)} \gamma g(\gamma) d\gamma}{G(u(\phi))} = \frac{\varepsilon_G}{\varepsilon_G + 1} u(\phi)$.

Proposition 6. *Suppose that buyer participation is elastic such that each buyer incurs only a per-category opportunity cost. A liability rule that induces a higher level of screening has a positive (resp. negative) effect on consumer surplus if*

$$\varepsilon_F[\varepsilon_{\pi_I}(\phi) + \varepsilon_G\varepsilon_u(\phi)] > (<) - (\varepsilon_G + 1)\varepsilon_u(\phi).$$

for any $\phi \in \left(\phi^\star, \phi^L\right)$.

A key implication of the above proposition is that an increase in ε_G, and therefore in the elasticity of buyer participation, makes it less likely that platform liability benefits consumers.[31] To derive further insights from Proposition 6, it is useful to distinguish between two scenarios. If $\varepsilon_{\pi_I}(\phi) < -\varepsilon_G\varepsilon_u(\phi)$, platform liability leads to a decrease in innovation (by Proposition 5) and a decrease in consumer surplus (because the R.H.S. in Proposition 6 is positive). However, if $\varepsilon_{\pi_I}(\phi) > -\varepsilon_G\varepsilon_u(\phi)$, platform liability leads to an increase in innovation, and can either benefit or harm consumers depending on the magnitude of ε_F. If the latter is sufficiently large (resp. small), then platform liability leads to an increase (resp. decrease) in consumer surplus. Figure 1 summarizes these results.

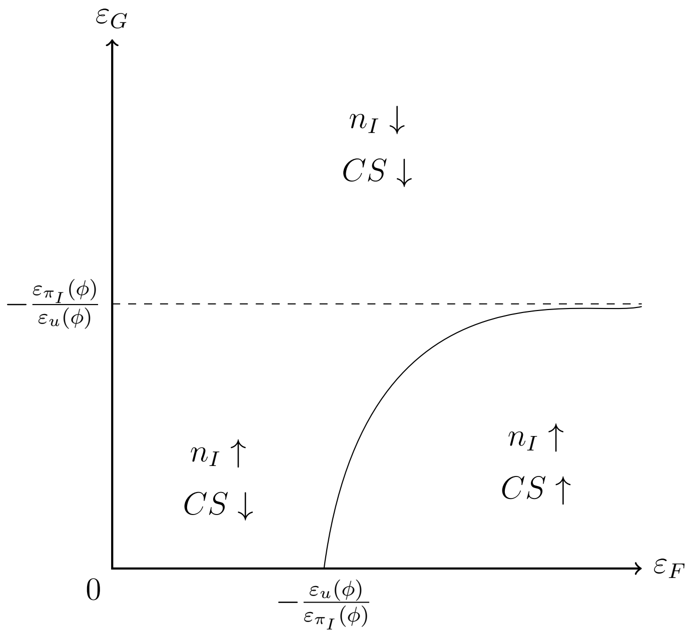

Figure 1: Impact of platform liability on innovation and consumer surplus (one-way network effects)

[31] To see why, recall that $\varepsilon_u(\phi)$ is negative. Furthermore, note that the baseline model with inelastic buyer participation corresponds to the special case $\varepsilon_G = 0$.

4.2 Two-way network effects

We now consider the scenario in which each buyer incurs a platform-related opportunity cost but no per-category opportunity costs ($\gamma = 0$ and $\xi > 0$).[32] This implies that buyers decide to join the platform taking into account the number of product categories present in the marketplace. As there are two-way network effects, determining the equilibrium number of buyers on the platform requires solving for a fixed point. The number of innovators and that of buyers are, respectively, given by

$$n_I(\tau,\phi) = F((1-\tau)\pi_I(\phi)n_B(\tau,\phi)); \qquad n_B(\tau,\phi) = H(u(\phi)n_I(\tau,\phi)).$$

Hence,

$$n_I(\tau,\phi) = F((1-\tau)\pi_I(\phi)H(u(\phi)n_I(\tau,\phi))); \qquad n_B(\tau,\phi) = H(u(\phi)F((1-\tau)\pi_I(\phi)n_B(\tau,\phi))).$$

A sufficient condition for the existence and uniqueness of an interior and stable equilibrium is that the slopes of the functions $n_I \to F((1-\tau)\pi_I(\phi)H(u(\phi)n_I))$ and $n_B \to H(u(\phi)F((1-\tau)\pi_I(\phi)n_B))$ are less than 1. Simple algebraic manipulations show that this is satisfied if

$$\varepsilon_H \; \varepsilon_F < 1. \tag{14}$$

which we assume in this subsection.[33] This condition means that the intensity of total network effects is not too large. Indeed, ε_H is the elasticity of the number of buyers with respect to the number of innovators, which can be interpreted as a measure of the network effects from innovators to buyers. However, note that, similar to ε_F, the parameter ε_H has an alternative interpretation: it is the elasticity of the number of buyers with respect to per-product buyer surplus.

From $n_B(\tau,\phi) = H(u(\phi)F((1-\tau)\pi_I(\phi)n_B(\tau,\phi)))$ and $n_I(\tau,\phi) = F((1-\tau)\pi_I(\phi)H(u(\phi)n_I(\tau,\phi)))$,

[32] We assume $\overline{\xi}$ is sufficiently large that $n_B(\tau,\phi) < 1$ holds for any ϕ.

[33] To see why, note that

$$\begin{aligned}\frac{\partial F((1-\tau)\pi_I(\phi)H(u(\phi)n_I))}{\partial n_I} &= f((1-\tau)\pi_I(\phi)H(u(\phi)n_I))(1-\tau)\pi_I(\phi)u(\phi)h(u(\phi)n_I) \\ &= \frac{f((1-\tau)\pi_I(\phi)H(u(\phi)n_I))(1-\tau)\pi_I(\phi)H(u(\phi)n_I)}{n_I}\frac{u(\phi)n_I h(u(\phi)n_I)}{H(u(\phi)n_I)} \\ &= \frac{f((1-\tau)\pi_I(\phi)H(u(\phi)n_I))(1-\tau)\pi_I(\phi)H(u(\phi)n_I)}{F((1-\tau)\pi_I(\phi)H(u(\phi)n_I))}\frac{u(\phi)n_I h(u(\phi)n_I)}{H(u(\phi)n_I)} \\ &= \varepsilon_F\varepsilon_G.\end{aligned}$$

Similarly

$$\frac{\partial H(u(\phi)F((1-\tau)\pi_I(\phi)n_B))}{\partial n_B} = \varepsilon_G\varepsilon_F.$$

it follows that

$$\varepsilon_{n_B}(\tau,\phi) = \varepsilon_H[\varepsilon_{n_I}(\tau,\phi) + \varepsilon_u(\phi)], \qquad \varepsilon_{n_I}(\tau,\phi) = \varepsilon_F[\varepsilon_{\pi_I}(\phi) + \varepsilon_{n_B}(\tau,\phi)].$$

Solving for $\varepsilon_{n_B}(\tau,\phi)$ and $\varepsilon_{n_I}(\tau,\phi)$, we obtain

$$\varepsilon_{n_B}(\tau,\phi) = \frac{\varepsilon_H[\varepsilon_F\varepsilon_{\pi_I}(\phi) + \varepsilon_u(\phi)]}{1-\varepsilon_H\varepsilon_F}, \qquad \varepsilon_{n_I}(\tau,\phi) = \frac{\varepsilon_F[\varepsilon_{\pi_I}(\phi) + \varepsilon_H\varepsilon_u(\phi)]}{1-\varepsilon_H\varepsilon_F}. \tag{15}$$

The above conditions show how the effects (in relative terms) of a marginal increase in the level of screening on buyer participation and the amount of innovation depend on the magnitude of the cross-group network effects. Two-way network effects have an amplifying effect captured by the multiplicative term $\frac{1}{1-\varepsilon_H\varepsilon_F}$, which is larger than 1. The term can be considered a multiplier in a two-sided market and increases with the intensity of the network effects. Using (15), the next lemma provides a sufficient condition for platform liability to have a positive (resp. negative) effect on buyer participation.

Lemma 2. *Suppose that buyer participation is elastic such that each buyer incurs a platform-related opportunity cost. A liability rule that induces a higher level of screening has a positive (resp. negative) effect on buyer participation in the marketplace if*

$$\varepsilon_F \ \varepsilon_{\pi_I}(\phi) > (<) \ -\varepsilon_u(\phi)$$

for any $\phi \in \left(\phi^\star, \phi^L\right)$.

Interestingly and contrary to our previous results, platform liability can now lead to an increase in buyer participation, i.e. the *market size effect* can be positive. This occurs if ε_F is relatively large. In this case, the increase in the number of product categories induced by an increase in the level of screening is relatively large and buyers benefit more from such an increase in the number of product categories than they are harmed by the decrease in the surplus they derive in each product category. On the contrary, if ε_F is relatively small, buyer participation is negatively affected by platform liability.

Using again the condition in (15) and Proposition 4, we also get the following result regarding the amount of innovation.

Proposition 7. *Suppose that buyer participation is elastic such that each buyer incurs a platform-related opportunity cost. A liability rule that induces a higher level of screening has a positive (resp. negative) effect on the amount of innovation if*

$$\varepsilon_{\pi_I}(\phi) > (<) \ -\varepsilon_H \ \varepsilon_u(\phi)$$

for any $\phi \in \left(\phi^\star, \phi^L\right)$.

Note that the sufficient condition for platform liability to increase innovation provided in Proposition 7 always holds if the sufficient condition for platform liability to increase buyer participation provided in Lemma 2 holds.[34] In other words, if ε_F is relatively large (i.e., $\varepsilon_F > -\varepsilon_u(\phi)/\varepsilon_{\pi_I}(\phi)$), then platform liability leads to an increase in both buyer participation and the amount of innovation. However, if ε_F is relatively small (i.e., $\varepsilon_F < -\varepsilon_u(\phi)/\varepsilon_{\pi_I}(\phi)$), then platform liability lowers buyer participation and the sign of its impact on innovation depends on the magnitude of ε_H. If the latter is relatively small (i.e., $\varepsilon_H < -\varepsilon_{\pi_I}(\phi)/\varepsilon_u(\phi)$), then platform liability leads to an increase in the amount of innovation. However, if it is relatively large (i.e., $\varepsilon_H > -\varepsilon_{\pi_I}(\phi)/\varepsilon_u(\phi)$), then platform liability leads to a decrease in the amount of innovation.

We now investigate the effect of platform liability on consumer surplus. The latter is given by

$$CS(\tau,\phi) = \int_0^{n_I(\tau,\phi))u(\phi)} (n_I(\tau,\phi)u(\phi) - \xi)h(\xi)d\xi.$$

The derivative of $CS(\tau,\phi)$ with respect to ϕ is

$$\frac{\partial CS(\tau,\phi)}{\partial \phi} = H(n_I(\tau,\phi)u(\phi)) \left(u(\phi)\frac{\partial n_I(\tau,\phi)}{\partial \phi} + n_I(\tau,\phi)u'(\phi) \right),$$

and has the same sign as $u(\phi)\frac{\partial n_I(\tau,\phi)}{\partial \phi} + n_I(\tau,\phi)u'(\phi)$. The following proposition states that when there are two-way network effects, the effect of platform liability on consumer surplus has the same sign as the effect of platform liability on buyer participation.

Proposition 8. *Suppose that buyer participation is elastic such that each buyer incurs a platform-related opportunity cost. A liability rule that induces a higher level of screening leads to a positive (resp. negative) effect on consumer surplus if it leads to an increase (resp. decrease) in buyer participation, which is the case if*

$$\varepsilon_F \ \varepsilon_{\pi_I}(\phi) > (<) \ -\varepsilon_u(\phi).$$

Figure 2 summarizes the effect of platform liability on innovation and consumer surplus in the case of two-way network effects. If ε_F is larger than the threshold $-\varepsilon_u(\phi)/\varepsilon_{\pi_I}(\phi)$, then from the stability assumption $\varepsilon_F\varepsilon_H < 1$, ε_H is smaller than the other threshold $-\varepsilon_{\pi_I}(\phi)/\varepsilon_u(\phi)$. Therefore, platform liability raises both the amount of innovation and consumer surplus. If ε_F is smaller than the threshold $-\varepsilon_u(\phi)/\varepsilon_{\pi_I}(\phi)$, platform liability always reduces consumer surplus and it increases the amount of innovation only if ε_H is smaller than $-\varepsilon_{\pi_I}(\phi)/\varepsilon_u(\phi)$.

Let us now compare the case of one-way network effects with the case of two-way network effects. Figures 1 and 2 reveal that the conditions for platform liability to increase innovation

[34] To see why, suppose that $\varepsilon_{\pi_I}(\phi) > -\frac{\varepsilon_u(\phi)}{\varepsilon_F}$ so that buyer participation increases (see Lemma 2). The latter condition implies the condition in Proposition 7, $\varepsilon_{\pi_I}(\phi) > -\varepsilon_H \ \varepsilon_u(\phi)$, because $\frac{1}{\varepsilon_F} > \varepsilon_H$ (by equation (14))

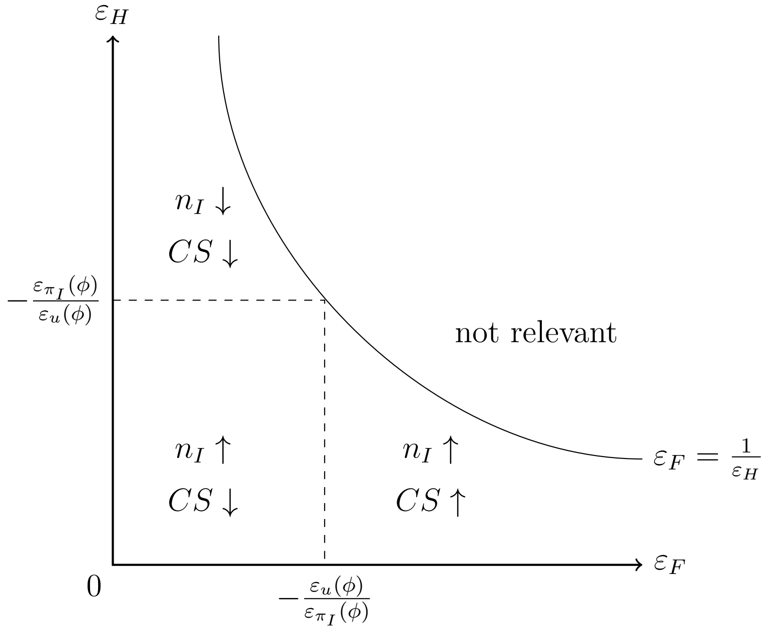

Figure 2: Impact of platform liability on innovation and consumer surplus (two-way network effects)

or consumer surplus are remarkably similar even if the two cases exhibit very different network effects. First, the condition for platform liability to increase (or reduce) the amount of innovation is exactly the same across both cases as long as we apply the relevant elasticity on the buyer side, i.e., ε_G or ε_H. Second, the condition for the platform liability to increase consumer surplus is similar and requires ε_F to be large and ε_G (or ε_H) to be small. One notable difference arises in terms of buyer participation. The effect of platform liability on buyer participation is always negative in the case of one-way network effects whereas in the case of two-way network effects, the effect can be either positive or negative depending on the value of ε_F. Another difference is the existence of a multiplier effect in the case of two-way network effects. Even when the sign of the effect on innovation or buyer participation is the same, the magnitude of the effect is larger in the case of two-way network effects than in the case of one-way network effects because the former involves the multiplier effect $\frac{1}{1-\varepsilon_H\varepsilon_F}$.

Finally, the analysis carried out in this section also identifies a sufficient condition for platform liability to be certainly socially undesirable. To see why, suppose platform liability reduces innovation. Then, it obviously harms innovators. It also harms buyers because of a reduction in the number of product categories and a lower surplus per category. The surplus of legitimate imitators decreases too because of the demand contraction and a reduction in the number of product categories. The surplus of IP infringers decreases as well because of the higher probability of being identified and delisted, the reduced buyer participation and the reduction in the number of product categories. Finally, the platform is harmed because of the binding requirements to obtain liability exemption. This discussion is summarized in the following corollary that applies to the two scenarios with elastic buyer participation.

Corollary 2. *Suppose buyer participation is elastic. If platform liability reduces innovation, then it harms the platform, consumers, innovators, and imitators and, therefore, reduces social welfare.*

5 Platform liability and endogenous commission rate

In this section, we consider that buyer participation is inelastic as in the baseline model but we assume that the platform endogenously decides the commission rate. We assume that the commission rate is non-discriminatory, such that all sellers are subject to the same commission rate τ, regardless of their legal status and their quality level.[35]

Consider the pricing problem of the platform for a given screening level. The expected profit of the platform, which we assume to be quasi-concave in τ, is given by

$$\Pi(\tau, \phi) = \tau n_I(\tau, \phi)[\pi_I(\phi) + \pi_C(\phi)] - \Omega(\phi).$$

Differentiating it with respect to τ, we obtain the following first-order condition:

$$n_I(\tau, \phi)[\pi_I(\phi) + \pi_C(\phi)] + \tau \frac{\partial n_I(\tau, \phi)}{\partial \tau}[\pi_I(\phi) + \pi_C(\phi)] = 0. \tag{16}$$

There are two (standard) opposite effects. The first term represents how much the platform gains from raising τ from the inframarginal innovators and imitators, whereas the second term captures the platform's loss from having less product categories as the marginal innovators decide not to develop new products. Simplifying we obtain

$$n_I(\tau, \phi) + \tau \frac{\partial n_I(\tau, \phi)}{\partial \tau} = 0. \tag{17}$$

In order to understand the impact of platform liability on the optimal commission rate, which we denote by $\tau^\star(\phi)$, we need to understand how ϕ affects the terms in (17). The term $n_I(\tau, \phi)$ is increasing in ϕ, whereas the term $\tau \frac{\partial n_I(\tau,\phi)}{\partial \tau}$ can be be either increasing or decreasing in ϕ. Differentiating (17) with respect to ϕ yields

$$\frac{\partial n_I(\tau, \phi)}{\partial \phi} + \tau \frac{\partial^2 n_I(\tau, \phi)}{\partial \phi \partial \tau},$$

which is positive (resp. negative) if the elasticity of $\frac{\partial n_I(\tau,\phi)}{\partial \phi}$ with respect to τ is greater (resp.

[35] Note that our results hold qualitatively if the platform were allowed to discriminate against vendors on the basis of their 'innovativeness'. This would imply a commission rate equal to $\tau_C^\star = 1$ for the imitators and $\tau_I^\star \in [0, 1)$ for the innovators. However, fee discrimination by platforms is mostly based on broad product categories (e.g., books, computer items, on Amazon) and it does not occur within product categories. For an analysis of the platform's incentive to discriminate across categories, see Tremblay (2021).

smaller) than -1, i.e.,

$$\frac{\tau\frac{\partial^2 n_I(\tau,\phi)}{\partial\phi\partial\tau}}{\frac{\partial n_I(\tau,\phi)}{\partial\phi}} > (<) - 1$$

In the next proposition, we rewrite these conditions in terms of primitives of the model. Denoting $\varepsilon_F(.)$ the elasticity of $F(.)$ and $\varepsilon_f(.)$ the elasticity of $f(.)$, we get the following result.

Proposition 9. *Suppose that buyer participation is inelastic. A liability rule that induces a higher level of screening leads to a lower (resp. higher) commission rate if*

$$\varepsilon_F(k) - \varepsilon_f(k) < (>) 1$$

for any $k \in [0, \overline{k}]$.

Interestingly, there are circumstances in which the platform responds to the introduction of a liability rule by reducing its commission rate. Note also that in the case of a uniform distribution, $\varepsilon_F(k) - \varepsilon_f(k) = 1$, which implies that the optimal commission rate does not depend on ϕ and the results from the baseline model apply in full.

The above analysis identifies a new channel through which the introduction of platform liability that raises the screening level impacts the amount of innovation. Specifically, the impact of a higher screening level on the amount of innovation can be decomposed as follows

$$\frac{dn_I(\tau^\star(\phi), \phi)}{d\phi} = f((1-\tau^\star(\phi))\pi_I(\phi))\Big\{\underbrace{(1-\tau^\star(\phi))\pi_I'(\phi)}_{\text{IP-protection effect}} \quad \underbrace{-\frac{d\tau^\star(\phi)}{d\phi}}_{\text{margin effect}}\Big\}.$$

If a higher level of screening leads to a lower commission rate, the margin effect is positive. Therefore, the overall effect on the amount of innovation is positive and greater than in the baseline model. On the contrary, if a higher level of screening leads to a higher commission rate, the margin effect goes in the opposite direction of the IP-protection effect. In principle, any of the two effects could outweigh the other. However, in our model, it turns out that the IP-protection effect always dominates the margin effect. Therefore, the overall effect on the amount of innovation is still positive although it is smaller than in the baseline model. The following proposition formalizes this finding.

Proposition 10. *Suppose that buyer participation is inelastic. A liability rule that induces a higher level of screening leads to a higher amount of innovation, regardless of whether it leads to a higher or lower commission rate.*

6 Extensions and discussions

In this section, we first endogenize imitators' decisions to infringe IP or not. Second, we discuss the incentives of the platform to change its business model from a pure marketplace to a hybrid one in response to the introduction of platform liability. Third, we study the effect of platform liability on the platform's choice of a fixed membership fee. Fourth, we discuss the impact of platform liability when the platform lacks commitment power. Finally, we generalize our analysis to the case in which there is an infinite number of periods and delisting of an imitator triggers a subsequent entry of another imitator.

6.1 Endogenous infringement

In this subsection, we consider the baseline model and relax the assumption that the decision to infringe IP is exogenous: instead imitators endogenously decide whether to infringe IP. We continue to assume that in each product category there is space for exactly one imitator. If the imitator is legitimate, it obtains $\pi_C^d - \rho$, where ρ represents the cost of being legitimate and is distributed according to cdf $L(\cdot)$ and pdf $l(\cdot)$. If the imitator infringes IP, it obtains π_C^d conditional on not being delisted by the platform. Thus, an imitator prefers to infringe IP if, and only if,

$$(1-\phi)\pi_C^d \geq \pi_C^d - \rho, \tag{18}$$

which can be rewritten as

$$\rho \geq \pi_C^d \phi.$$

Hence, the probability that a legitimate imitator is present in a given product category is $\nu(\phi) = L(\pi_C^d \phi)$, which increases with ϕ, and the probability that an IP-infringing product is present in a given product category is $1 - \nu(\phi)$.

The endogenous infringement adds a new effect when the introduction of platform liability leads to a higher level of screening: it changes the *composition* of imitators by increasing the share of legitimate imitators. As a result, it is possible that the introduction of platform liability increases the probability that innovators face a competitor, which occurs if the composition effect dominates the direct effect of raising the level of screening. In this case, platform liability leads to a reduction (instead of an increase) in the amount of innovation.

More precisely, the expected gross profit of an innovator before paying the commission rate is

$$\pi_I(\phi) = \pi_I^m \Big(1 - \nu(\phi)\Big)\phi + \pi_I^d \Big(1 - (1 - \nu(\phi))\phi\Big).$$

The mass of innovators in the marketplace is $F((1-\tau)\pi_I(\phi))$. For a given commission rate τ, a higher screening level implies the following effect on an innovator's profit

$$\pi_I'(\phi) = (\pi_I^m - \pi_I^d)\Big(1 - \nu(\phi) - \phi\nu'(\phi)\Big),$$

where $1 - \nu(\phi) - \phi\nu'(\phi)$ represents the change in the probability for an innovator to be a monopolist. If this term is negative, the introduction of a liability rule that induces a higher level of screening reduces the amount of innovation.

6.2 Hybrid business model

Most platforms (e.g., Amazon, Apple, Google) use a hybrid business model in that they not only enable interactions between sellers and buyers on their marketplace or app store but are also active as sellers. Imposing platform liability may induce a platform to adopt a hybrid business model instead of a pure marketplace one. We here illustrate this idea in a simple way.

We consider a variation of the baseline model in which the platform can preempt the entry of an imitator by producing its own copycat version. Differently from third-party imitators, the platform's version does not infringe IP (for example, thanks to a first-rate legal team that the platform can afford to have or simply because it collects data and information from innovators). Assume that apart from not infringing IP, the platform's imitation is homogeneous to the one produced by a third-party imitator and can be produced at a fixed cost κ. Let β represent the fraction of product categories into which the platform introduces its own imitations.

We assume that the commission rate is exogenously determined and buyer participation is inelastic. We consider the following (modified) timing.

- Stage 1: The platform announces (ϕ, β) for a given τ.
- Stage 2: Innovators make innovation decisions and join the platform if they develop a new product.
- Stage 3: The platform incurs the imitation cost κ for a fraction β of product categories.
- Stage 4: Independent imitators enter the remaining product categories.
- Stage 5: The platform screens third-party imitators according to the screening level ϕ.

For the sake of illustration, we focus on the special case in which $\kappa = (1-\tau)\pi_C^d$. The platform's expected total profit from a category in which its imitation is present is then equal to

$$\tau\pi_I^d + \pi_C^d - \kappa = \tau(\pi_I^d + \pi_C^d),$$

which makes the platform indifferent between selling its own copycat product and letting a third party sell an imitation. This implies that the platform is indifferent between a hybrid business model and a pure marketplace business model in the absence of platform liability. Let $\phi^\star$ be the screening level chosen by the platform absent platform liability, leading to a probability of duopolistic market structure per category equal to $1-(1-\nu)\phi^\star$.

Suppose now that platform liability induces the platform to raise ϕ to the minimum level $\phi^L(>\phi^\star)$ that ensures liability exemption. This clearly reduces the platform's profit conditional on the platform maintaining the pure marketplace business model. However, under a hybrid business model, the platform can restore the probability of a duopolistic market structure absent liability, i.e. $1-(1-\nu)\phi^\star$, by choosing β such that

$$\beta+(1-\beta)\left[1-(1-\mu)\phi^L\right]=1-(1-\mu)\phi^\star,$$

which leads to

$$\beta=\frac{\phi^L-\phi^\star}{\phi^L}\ (<1).$$

By entering the above fraction of product categories, the platform can make higher profits than under a pure marketplace business model. The reason is that, under our assumption of $\kappa=(1-\tau)\pi_C^d$, what matters for the platform's profit is the probability of a duopolistic market structure per category. Under the pure marketplace business model, platform liability lowers this probability below the privately optimal probability. Yet, under the hybrid business model, the platform can restore this privately optimal probability by introducing its own imitation in some product categories.

6.3 Fixed membership fee

Platforms might adopt alternative pricing schemes to capture value from their ecosystem. They can charge, for instance, fixed membership fees instead of (or in addition to) ad valorem commissions. In this extension, we show that platform liability might lead to an increase or reduction of the membership fee charged by the platform.

Let m denote the membership fee and ϕ the screening level. We need to distinguish four cases:

(i) If $m>\pi_I^m$, then the number of product categories is zero and, therefore, the platform's profit gross of screening cost is zero too.

(ii) If $\pi_C^d<m\leq\pi_I^m$, then imitators do not join the platform (regardless of their nature) and all innovators whose innovation costs are lower than π_I^m-m join the platform, which implies that the number of product categories is $F(\pi_I^m-m)$ and the platform's expected profit gross of screening cost is $mF(\pi_I^m-m)$.

(iii) If $(1-\phi)\,\pi_C^d<m\leq\pi_C^d$, then legitimate imitators are willing to pay the membership fee whereas IP-infringing imitators are not. Therefore, innovators whose innovation costs

are lower than $\nu\pi_I^d + (1-\nu)\pi_I^m - m$ join the platform, which implies that the number of product categories is $F(\nu\pi_I^d + (1-\nu)\pi_I^m - m)$ and that the platform's expected profit per category is $m(1+\nu)$. Thus, the platform's expected profit gross of screening cost is $m(1+\nu)F(\nu\pi_I^d + (1-\nu)\pi_I^m - m)$.

(iv) If $m \leq (1-\phi)\,\pi_C^d$, then both types of imitators are willing to pay the membership fee but a fraction ϕ of IP-infringing imitators is screened out. Therefore, innovators whose innovation costs are lower than $\pi_I(\phi) - m$ join the platform. This implies that the number of product categories is $F(\pi_I(\phi) - m)$ and the platform's expected profit per category is $m[2-\phi(1-\nu)]$. Hence, the platform's expected profit gross of screening cost is $m[2-\phi(1-\nu)]F(\pi_I(\phi) - m)$.

Thus, the platform's expected profit net of screening cost is given by

$$\Pi\left(m,\phi\right) = \begin{cases} m[2-\phi(1-\nu)]F(\pi_I(\phi)-m) - C(\phi) & \text{if} \quad m \leq (1-\phi)\,\pi_C^d \\ m(1+\nu)F(\nu\pi_I^d + (1-\nu)\pi_I^m - m) - C(\phi) & \text{if} \quad (1-\phi)\,\pi_C^d < m \leq \pi_C^d \\ mF(\pi_I^m - m) - C(\phi) & \text{if} \quad \pi_C^d < m \leq \pi_I^m \\ -C(\phi) & \text{if} \quad m > \pi_I^m. \end{cases}$$

Assume that $mF(\pi_I(\phi) - m)$ is quasi-concave in m and denote

$$\tilde{m}(\phi) \equiv \arg\max_m m[2-\phi(1-\nu)]F(\pi_I(\phi)-m) - C(\phi),$$

and

$$m^\star(\phi) \equiv \arg\max_m \Pi\left(m,\phi\right).$$

If the maximum of $\Pi\left(m,\phi\right)$ is reached over the interval $\left[0,(1-\phi)\,\pi_C^d\right]$, i.e. $m^\star(\phi) \in \left[0,(1-\phi)\,\pi_C^d\right]$, then $m^\star(\phi) \in \left\{\tilde{m}(\phi),(1-\phi)\,\pi_C^d\right\}$; otherwise, $m^\star(\phi)$ does not depend on ϕ. This implies that a marginal increase in ϕ can either lead to an increase in $m^\star(\phi)$, lead to a decrease in $m^\star(\phi)$, or have no effect on ϕ. To see why, note that $(1-\phi)\,\pi_C^d$ decreases with ϕ and $\tilde{m}(\phi)$ can either increase or decrease in ϕ depending on the shape of $F(\cdot)$.

The analysis above shows that the impact of a higher level of screening on the membership fee can be either positive or negative. This shows that our finding (in Section 5) that the effect of platform liability on the commission rate may be either positive or negative carries over to the scenario in which the platform charges sellers a fixed membership fee rather than a commission.

6.4 Inability to commit

One of the assumptions in our analysis is that the platform can commit to its screening policy. However, this may not necessarily be the case in reality. If it lacks commitment power, it will choose its screening policy to maximize its profit after innovators have taken decisions to innovate and join the platform. This resembles the setting of Hua and Spier (2022) in which the platform chooses its screening policy after firms join the platform.

Suppose that the platform cannot commit to its screening policy while it can commit to an ad valorem commission rate. The latter is necessarily part of the Terms & Conditions the platform sets upfront. For the sake of simplicity, let us consider the case in which buyer participation is inelastic and the commission rate is exogenously given. The lack of commitment creates a hold-up problem on the part of the platform and, therefore, the introduction of a liability rule that allows the platform to commit may raise the platform's profit.

Specifically, absent platform liability, given a number $n_I(\tau)$ of innovators who have joined the platform marketplace, the platform maximizes the following expected profit

$$\tau n_I(\tau)[\pi_I(\phi) + \pi_C(\phi)] - \Omega(\phi).$$

The first-order condition with respect to ϕ is given by

$$\tau n_I(\tau)[\pi_I'(\phi) + \pi_C'(\phi)] = \Omega'(\phi),$$

with $\pi_I'(\phi) + \pi_C'(\phi) = (1-\nu)(\pi_I^m - \pi_I^d - \pi_C^d) \lesseqgtr 0$. It is straightforward that the platform will choose $\phi = 0$ if $\pi_I^m < \pi_I^d + \pi_C^d$. Even if $\pi_I^m > \pi_I^d + \pi_C^d$ holds, it does not internalize the benefit that a higher screening level can generate by increasing the amount of innovation and hence tends to choose a lower screening level than in the baseline model with commitment.

Suppose now a liability rule is introduced such that it induces the platform to achieve ϕ^L (the minimum imposed by the liability regime) in order to benefit from liability exemption. Let us focus on the case in which $\pi_I^m < \pi_I^d + \pi_C^d$ holds such that the platform chooses zero screening in the no liability benchmark. In this case, the platform may want to commit to a positive screening level. Then, a liability regime that imposes a positive level of screening can increase the platform's profit. For instance, if $\phi^L = \phi^\star$ where $\phi^\star$ is the screening policy that would be chosen by the platform if it were able to commit, then platform liability restores the commitment power of the platform and raises its profit. The same kind of reasoning carries out to the case in which $\pi_I^m > \pi_I^d + \pi_C^d$ holds.

6.5 Infinite rounds of screening

One of the assumptions in our analysis is that once an IP infringer is identified and delisted, the product category remains monopolistic and no further entry occurs. In this subsection, we relax this assumption by allowing for subsequent entry after delisting in a setting with an infinite number of periods, $t = 1, 2, ...$ and show that all results from Section 3 to Section 5 carry out.

Let $y(\phi) \equiv (1-\upsilon)\phi$ denote the probability that an IP infringer is identified and delisted. Let s_t denote the market structure of a given product category at time t with $s_t \in \{m, d\}$ and $t = 1, 2, ...$ We assume that if at $t = 1$ the entrant is identified as an IP infringer and hence delisted (i.e., $s_1 = m$), which occurs with probability $y(\phi)$, this triggers the entry of another imitator at $t = 2$. By contrast, if at $t = 1$ no IP infringement is identified and hence $s_1 = d$, which occurs with probability $1-y(\phi)$, the market structure remains duopolistic forever thereafter. In other words, $s_t = d$ implies $s_{t+1} = d$, whereas $s_t = m$ triggers entry at $t + 1$ so that $s_{t+1} = m$ with probability $y(\phi)$ and $s_{t+1} = d$ with probability $1 - y(\phi)$. Therefore, the unconditional probability that $s_t = m$ is $(y(\phi))^t$.

Let $\delta \in (0, 1)$ be the discount factor (which we assume to be common to all economic agents) and let $\nu^m(\phi)$ denote the "aggregate" probability that a given category is monopolistic. In order to obtain $\nu^m(\phi)$, we sum up the probabilities that $s_t = m$ after discounting them (i.e., $(y(\phi))^1 + \delta(y(\phi))^2 + \delta^2(y(\phi))^3 + ...$) and normalize the sum by multiplying it with $1-\delta$, which gives rise to $\nu^m(\phi) \equiv \frac{(1-\delta)(1-\nu)\phi}{1-\delta(1-\nu)\phi}$. As expected, $\nu^m(\phi)$ increases in ϕ. The expected profit of an innovator is

$$\pi_I(\phi) = \nu^m(\phi)\pi_I^m + (1-\nu^m(\phi))\pi_I^d \tag{19}$$

which increases in ϕ, as in the baseline model. The expected profit of a whole sequence of imitators in a given category is

$$\pi_C(\phi) = (1-\nu^m(\phi))\pi_C^d$$

which decreases in ϕ. The expected surplus of a buyer in a given product category is now equal to

$$u(\phi) = \nu^m(\phi)u^m + (1-\nu^m(\phi))u^d$$

which decreases in ϕ as in the baseline model. The expression for the profit of the platform remains the same as it is expressed in terms of $\pi_I(\phi)$ and $\pi_C(\phi)$.

In the Appendix, we show that the results from Section 3 to Section 5 do not change qualitatively.

7 Concluding remarks and policy implications

Our paper is motivated by the growing concern about the diffusion of illicit products in online markets and the mounting demands that platforms should take more responsibility in limiting (or hindering) misconduct by third parties.

From a policy standpoint, we contribute to the discussion on whether platforms should be held liable for third parties' misconduct. Under the current regimes (e.g., Section 230 of the Communication Decency Act in the US; E-commerce Directive in the EU), online platforms are granted a liability exemption under a very wide range of circumstances. Proposals have been made in the US and in the EU to introduce more stringent liability rules.

Our paper shows that policymakers should pay close attention to the impact of platform liability on key strategic variables of platforms as the unintended effects of platform liability substantially affect its desirability. More specifically, our analysis generates the following policy implications. First, policymakers should be aware that even when platform liability fulfills the goal of protecting IP and stimulating innovation, there might be a negative effect on consumers. Second, policymakers should account for the elasticity of participation of both innovators and buyers, which depends in particular on the strength of cross-group network effects. Platform liability is likely to increase both the amount of innovation and consumer surplus when the elasticity of participation of innovators is high and that of buyers is low. However, if the elasticity of participation of innovators is low then platform liability is likely to reduce consumer surplus and may even lead to a reduction in innovation if the elasticity of buyer participation is high. Third, the introduction of platform liability may lead to either an increase or a decrease in the commission charged by a platform, which contrasts with the intuition that platform liability is likely to lead to an increase in the commission (because of an increase in marginal screening costs). This is policy-relevant because the decrease in the commission rate creates a new channel through which the imposition of platform liability spurs innovation. Finally, policymakers should foresee strategic reactions not only by the platform but also by imitators who might react by choosing to sell products that do not infringe IP. We find that such a strategic response can lead to a reduction in innovation incentives and, therefore, to a possible undesirable outcome.

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Appendix

Proof of Proposition 1

Evaluating the first-order condition of the platform's profit with respect to ϕ in (5) at $\phi = 0$, we obtain

$$\frac{\partial \Pi(\tau,\phi)}{\partial \phi}\Big|_{\phi=0} =\tau\Big\{\frac{\partial n_I(\tau,0)}{\partial \phi}\Big|_{\phi=0}\Big[\pi_I(0)+\pi_C(0)\Big]+F((1-\tau)\pi_I(0))\Big[\pi_I'(0)+\pi_C'(0)\Big]\Big\}$$

As $\left.\frac{\partial n_I(\tau,0)}{\partial\phi}\right|_{\phi=0} > 0$, the sign of $\left.\frac{\partial\Pi(\tau,\phi)}{\partial\phi}\right|_{\phi=0}$ depends on the sign of $\pi_I'(0) + \pi_C'(0) = (1-\nu)[\pi_I^m - \pi_I^d - \pi_C^d]$. Two cases can arise:

(i) if $\pi_I^m > \pi_I^d + \pi_C^d$, then $\left.\frac{\partial\Pi(\tau,\phi)}{\partial\phi}\right|_{\phi=0} > 0$. Therefore, $\phi^\star > 0$. Moreover, $\phi^\star < 1$ because $\Omega(\phi) \underset{\phi\to1}{\to} +\infty$.

(ii) if $\pi_I^m < \pi_I^d + \pi_C^d$, then $\left.\frac{\partial\Pi(\tau,\phi)}{\partial\phi}\right|_{\phi=0}$ can be either positive or negative. If it positive, then $\phi^\star \in (0,1)$. Otherwise, $\phi^\star = 0$ (because $\Pi(\tau,\phi)$ is quasi-concave in ϕ).

This concludes the proof.

Proof of Proposition 2

The proof for the effect on innovation follows immediately from (6). The proof for the effect on consumer surplus follows from (7), i.e.,

$$\frac{\partial CS(\tau,\phi)}{\partial\phi} = \frac{\partial n_I(\tau,\phi)}{\partial\phi}u(\phi) + n_I(\tau,\phi)u'(\phi),$$

which can be rewritten as

$$\frac{\partial CS(\tau,\phi)}{\partial\phi} = n_I(\tau,\phi)u(\phi)[\varepsilon_{n_I}(\tau,\phi) + \varepsilon_u(\phi)].$$

Thus, $\frac{\partial CS(\tau,\phi)}{\partial\phi}$ has the same sign as $\varepsilon_{n_I}(\tau,\phi) + \varepsilon_u(\phi)$.

Proof of Proposition 3

The surplus of IP-infringing imitators is

$$n_I(\tau,\phi)(1-\tau)(1-\nu)(1-\phi)\pi_C^d.$$

Differentiating it with respect to ϕ yields

$$(1-\tau)(1-\nu)\pi_C^d\Big[(1-\phi)\frac{\partial n_I(\tau,\phi)}{\partial\phi} - n_I(\tau,\phi)\Big]$$

Therefore, raising ϕ has a positive (resp. negative) effect on IP-infringing imitators if

$$\frac{\frac{\partial n_I(\tau,\phi)}{\partial\phi}}{n_I(\tau,\phi)} > (<)\frac{1}{(1-\phi)}.$$

Multiplying both sides by ϕ, we can rewrite the above expression as

$$\varepsilon_{n_I}(\tau,\phi) > (<) \frac{\phi}{(1-\phi)}.$$

Proof of Corollary 1

The proof for the first part of the corollary follows immediately from Propositions 2 and 3.

The proof for the second part of the corollary is as follows. Denote $W(\tau,\phi)$ social welfare. Under condition (8) the aggregate surplus of consumers, innovators and imitators increases with ϕ. In other words,

$$\frac{\partial W}{\partial \phi} - \frac{\partial \Pi}{\partial \phi} > 0.$$

As $\frac{\partial \Pi}{\partial \phi}\Big|_{\phi=\phi^\star} = 0$, the above inequality implies that $\frac{\partial W}{\partial \phi}\Big|_{\phi=\phi^\star} = 0$, which implies that a negligence-based liability rule that leads to marginal increase in the screening level above the privately optimal one raises social welfare. This concludes the proof.

Proof of Proposition 4

The proof immediately follows from the discussion in the main text.

Proof of Lemma 1

The proof immediately follows from (12).

Proof of Proposition 5

The proof follows immediately from the result established in Proposition 4 and the fact that

$$\varepsilon_{n_B}(\phi) = \phi \frac{\frac{\partial n_B(\phi)}{\partial \phi}}{n_B(\phi)} = \phi \frac{u'(\phi) g(u(\phi))}{G(u(\phi))} = \phi \frac{u'(\phi)}{u(\phi)} \frac{u(\phi) g(u(\phi))}{G(u(\phi))} = \varepsilon_u(\phi)\varepsilon_G.$$

Proof of Proposition 6

The proof follows immediately from the discussion in the main text.

Proof of Lemma 2

The proof follows immediately from (15) in the main text.

Proof of Proposition 7

The proof follows immediately from (15) in the main text.

Proof of Proposition 8

As shown in the main text, the derivative of $CS(\tau,\phi)$ with respect to ϕ has the same sign as $u(\phi)\frac{\partial n_I(\tau,\phi)}{\partial \phi}+n_I(\tau,\phi)u'(\phi)$. Therefore, it has the same sign as $\varepsilon_{n_I}(\tau,\phi)+\varepsilon_u(\phi)$. This, combined with the fact that $\varepsilon_{n_B}(\tau,\phi)=\varepsilon_H[\varepsilon_{n_I}(\tau,\phi)+\varepsilon_u(\phi)]$ implies that $\frac{\partial CS(\tau,\phi)}{\partial \phi}$ has the same sign as that of ε_{n_B}, which has the same sign as that of $\frac{\partial n_B(\tau,\phi)}{\partial \phi}$.

Proof of Corollary 2

The proof follows immediately from the main text.

Proof of Proposition 9

Consider the problem of the platform for a given screening level. The expected profit of the platform is provided by (4). Differentiating it with respect to τ and dividing by $[\pi_I(\phi)+\pi_C(\phi)]$ yields

$$F((1-\tau^\star(\phi))\pi_I(\phi))-\tau^\star(\phi)\pi_I(\phi)f((1-\tau)^\star(\phi)\pi_I(\phi))=0. \tag{A-1}$$

Differentiating the above expression with respect to ϕ, we get

$$\frac{d\tau^\star(\phi)}{d\phi}=\frac{(2\tau^\star(\phi)-1)f((1-\tau^\star(\phi))\pi_I(\phi))+\tau^\star(1-\tau^\star(\phi))\pi_I(\phi)f'((1-\tau^\star(\phi))\pi_I(\phi)}{-2\pi_I(\phi)f((1-\tau^\star(\phi))\pi_I(\phi))+\tau^\star(\phi)\pi_I(\phi)^2f'((1-\tau^\star(\phi))\pi_I(\phi))}\pi_I'(\phi). \tag{A-2}$$

The denominator is negative under our assumption that the platform's expected profit is quasi-concave with respect to τ. Therefore, the sign of $\frac{d\tau^\star(\phi)}{d\phi}$ is the opposite of the sign of the numerator. It follows that $\frac{d\tau^\star(\phi)}{d\phi}$ has the same sign as

$$-2+\frac{1}{\tau^\star(\phi)}-\frac{(1-\tau^\star(\phi))\pi_I(\phi)f'((1-\tau^\star(\phi))\pi_I(\phi))}{f((1-\tau^\star(\phi))\pi_I(\phi))}.$$

Moreover, (A-1) implies

$$\frac{\tau^\star(\phi)}{1-\tau^\star(\phi)}=\frac{F((1-\tau^\star(\phi))\pi_I(\phi))}{(1-\tau^\star(\phi))\,\pi_I(\phi)f((1-\tau^\star(\phi))\pi_I(\phi))},$$

which is equivalent to

$$\frac{1}{\tau^\star(\phi)} = 1 + \frac{(1-\tau^\star(\phi))\,\pi_I(\phi) f((1-\tau^\star(\phi))\pi_I(\phi))}{F((1-\tau^\star(\phi))\pi_I(\phi))}.$$

Therefore, $\frac{d\tau^\star(\phi)}{d\phi}$ has the same sign as

$$-1 + \frac{(1-\tau^\star(\phi))\,\pi_I(\phi) f((1-\tau^\star(\phi))\pi_I(\phi))}{F((1-\tau^\star(\phi))\pi_I(\phi))} - \frac{(1-\tau^\star(\phi))\pi_I(\phi) f'((1-\tau^\star)\pi_I(\phi))}{f((1-\tau^\star(\phi))\pi_I(\phi))}.$$

Denoting $\varepsilon_F(k) = k\frac{f(k)}{F(k)}$ and $\varepsilon_f(k) = k\frac{f'(k)}{f(k)}$, the sign of $\frac{d\tau^\star(\phi)}{d\phi}$ is the same as the sign of

$$-1 + \varepsilon_F((1-\tau^\star(\phi))\,\pi_I(\phi) - \varepsilon_f((1-\tau^\star(\phi))\,\pi_I(\phi)).$$

Thus, a sufficient condition for $\frac{d\tau^\star(\phi)}{d\phi}$ to be negative (resp. positive) is that $\varepsilon_F(k) - \varepsilon_f(k)$ is smaller (resp. greater) than 1 for any k.

Proof of Proposition 10

Totally differentiating $n_I(\tau^\star(\phi), \phi)$ with respect to ϕ, we obtain

$$\frac{dn_I(\tau^\star(\phi), \phi)}{d\phi} = f((1-\tau^\star(\phi))\Big\{(1-\tau^\star(\phi))\pi_I'(\phi) - \frac{d\tau^\star(\phi)}{d\phi}\pi_I(\phi)\Big\} \tag{A-3}$$

Using (A-2), it follows that $\frac{dn_I(\tau^\star(\phi),\phi)}{d\phi}$ has the same sign as

$$(1-\tau^\star(\phi)) - \frac{(2\tau^\star(\phi)-1) f((1-\tau^\star(\phi))\pi_I(\phi)) + \tau^\star(\phi)(1-\tau^\star(\phi))\pi_I(\phi) f'((1-\tau^\star(\phi))\pi_I(\phi)}{-2\pi_I(\phi) f((1-\tau^\star(\phi))\pi_I(\phi)) + \tau^\star(\phi)\,(\pi_I(\phi))^2\, f'((1-\tau^\star(\phi))\pi_I(\phi))}\pi_I(\phi) \tag{A-4}$$

As the denominator of the second term because of the second-order condition, $\frac{dn_I(\tau^\star(\phi),\phi)}{d\phi}$ has the opposite sign of the following expression

$$\begin{aligned}
&(1-\tau^\star(\phi))\Big(-2\pi_I(\phi) f((1-\tau^\star(\phi))\pi_I(\phi)) + \tau^\star(\phi)\,(\pi_I(\phi))^2\, f'((1-\tau^\star(\phi))\pi_I(\phi))\Big) - \\
&\pi_I(\phi)\Big((2\tau^\star(\phi)-1) f((1-\tau^\star(\phi))\pi_I(\phi)) + \tau^\star(1-\tau^\star(\phi))\pi_I(\phi) f'((1-\tau^\star(\phi))\pi_I(\phi)\Big) \\
=& -\pi_I(\phi) f((1-\tau^\star(\phi))\pi_I(\phi)) < 0.
\end{aligned}$$

Therefore, $\frac{dn_I(\tau^\star(\phi),\phi)}{d\phi} > 0$.

Infinite rounds of screening

In what follows, we provide details regarding the claims made in Section 6.5.

First, consider the private incentives of the platform. As $\pi_I'(\phi) > 0$ and

$$\frac{d(\pi_I(\phi) + \pi_C(\phi))}{d\phi} = \frac{d\nu^m(\phi)}{d\phi}(\pi_I^m - \pi_I^d - \pi_C^d)$$

is positive (resp. negative) if $\pi_I^m > (<)\pi_I^d - \pi_C^d$, Proposition 1 fully applies. Moreover, as the expression for consumer surplus does not change, Proposition 2 fully applies as well.

What changes, however, is the analysis related to Proposition 3. After some straightforward computations, we find that the aggregate surplus of legitimate imitators is now given by

$$n_I(\tau, \phi)(1 - \tau)\frac{\nu}{1 - \delta(1 - \nu)\phi}\pi_C^d.$$

As both the first term and the third term increase with ϕ, a higher screening level increases the surplus of legitimate imitators as is stated in Proposition 3. The third term captures a new effect: more delisting of IP infringers increases the chance for legitimate imitators to sell their products. The aggregate surplus of IP infringers is now given by

$$n_I(\tau, \phi)(1 - \tau)\frac{(1 - \nu)(1 - \phi)}{1 - \delta(1 - \nu)\phi}\pi_C^d.$$

As the first term increases with ϕ but the third term decreases with it, there is a trade-off. Differentiating the above surplus with respect to ϕ yields a derivative, which has the same sign as that of

$$\frac{\partial n_I(\tau, \phi)}{\partial \phi}\nu^{d,I}(\phi) + n_I(\phi)\frac{\partial \nu^{d,I}(\phi)}{\partial \phi},$$

where $\nu^{d,I}(\phi) = \frac{(1-\nu)(1-\phi)}{1-\delta(1-\nu)\phi}$ represents the aggregate probability that an IP-infringing imitation is sold in a given category. The above expression is positive (resp. negative) if

$$\varepsilon_{n_I}(\tau, \phi) > (<) - \varepsilon_{\nu^{d,I}}(\phi)$$

Putting all conditions together, we can rewrite (8) as follows

$$\varepsilon_{n_I}(\tau, \phi) > \max\left\{\frac{\phi}{1 - \phi}, -\varepsilon_{\nu^{d,I}}(\phi)\right\} \text{ for any } \phi \in \left(\phi^\star, \phi^L\right).$$

which represents a sufficient condition for a liability rule that induces a higher level of screening to benefit innovators, consumers, and imitators.

The same kind of reasoning applies to Section 4 and Section 5: since we never rely on the specific form of $\nu^m(\phi)$, the analysis literally carries over in those sections.