Platform Liability and Innovation*

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We study a platform's 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. The impact of platform liability on innovation can be either positive or negative and critically depends on the existence and nature of cross-group network effects. A necessary but not sufficient condition for platform liability to benefit consumers is that it leads to more innovation. We consider various extensions that allow us to identify additional forces that strengthen or weaken the desirability of liability for innovators and consumers.

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1. Introduction

In recent years, online misconduct emerged as a fundamental problem of the free Web. A common activity is the sale of items infringing intellectual property rights (IPRs). According to the OECD (2018), counterfeits account for 3% of global trade and, for their large customer reach, "e-commerce platforms represent ideal storefronts for counterfeits" and, because "online marketplace gains commissions from every selling transaction from third parties [..] this creates an incitement for the marketplace not to take serious action against sellers of counterfeit goods".[1] 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.[2]

As part of the governance of its marketplace ecosystem, a platform's owner can design its policy to screen out illicit players. However, this involves a trade-off: whereas allowing low-quality merchants (possibly including IP-infringers) might lower the incentives for innovative sellers to develop new products, their presence 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, as illicit players may not be directly identified, may belong to a different jurisdiction, or be judgment proof.[3] In the case of innovative products the lack of enforcement of primary liability against IP-infringers could motivate the introduction of a platform liability that creates incentives for more screening.[4]

We provide a theoretical framework to understand an online platform's incentives to delist IP-infringing products and the economic effects of a liability regime that makes platforms liable unless they satisfy a minimum screening requirement.[5] We first analyze how the platform chooses its screening policy and its ad valorem commission rate in a *laissez-faire* regime.[6] We then study the impact of a liability regime that induces the platform to engage in more screening

[1] This citation is from an anonymous feedback received by the EU Commission on the Digital Services Act. (Feedback F355679, June 30, 2021).

[2] See https://www.cnbc.com/2016/07/20/birkenstock-quits-amazon-in-us-after-counterfeit-surge.html. Since then, Amazon started tackling the problem (i.e., Project Zero and collaboration with the International Anti-Counterfeiting Coalition (IACC)) and blocked more than 10 billion suspected listings (Amazon, 2021).

[3] 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.

[4] 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.

[5] For example, online intermediaries might be subject to a set of costly screening obligations in order to benefit from liability exemption for third parties' misconduct in their marketplace. This is similar to a negligence-based liability regime in which a party is exempted from liability if it fulfills its duty of care, i.e., a minimum effort.

[6] 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).

on the commission rate, innovators' incentive to innovate, and consumer welfare.

To this end, we develop a tractable yet general model in which an online platform mediates interactions between sellers and buyers. For illustrative purposes, we will refer to an e-commerce platform. However, the model we propose can also be applied to an app store (e.g., Apple's App Store), which decides an ad-valorem commission and its screening policy (e.g., Apple App review). In our model, there are two types of sellers, the innovative ones, who incur innovation costs to develop new products, and their imitators (i.e., copycats), who sell a low-quality version of the innovative product. Imitators can only exist if an innovator has developed an innovative product, which creates a respective product category. With a certain probability, an imitation violates IPRs (e.g., trademarks) while with the remaining probability it is legitimate. We consider a setting in which an IP-infringing product does not create any direct harm to buyers, who make their purchase decision knowing whether the product they buy is an original product or its imitation. This captures the evidence that some counterfeits are neither deceptive nor harmful and can attract buyers' demand even if they generate negative externalities to innovators in terms of reduced profits.[7][8]

The platform makes profits by charging sellers an ad valorem commission and can delist IP-infringing products at some cost. However, even if it wishes, the platform cannot remove legitimate imitators who compete with innovators (e.g., Platform-to-Business regulation in the EU). Indeed, by removing IP-infringing products, the screening policy determines the degree of competition that each innovative product faces and thereby affects innovators' incentives to develop new products. Precisely, an introduction of platform liability which raises the screening intensity reduces the likelihood that each innovator faces competition from an imitator and thereby increases its incentive to innovate, *all other things being equal*. However, there can be unintended consequences such that platform liability ends up reducing innovation instead of increasing it. In this paper, we identify various intended and unintended consequences of introducing platform liability.

Our first result concerns the platform's incentive to screen IP-infringing products by acting as a private regulator of IPRs. First, for a given commission rate, a higher screening intensity reduces the probability that an innovative product faces competition and thereby induces more

[7]For example, a T-shirt branded *Love* that looks similar to the branded *Levi's* might attract buyers' 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 IPRs, 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 startups*. See https://www.theguardian.com/fashion/2021/dec/21/how-shein-beat-amazon-at-its-own-game-and-reinvented-fast-fashion

[8]In our framework, platform liability is not a substitute for product liability. Product liability is the set of legal rules that allocates responsibility for a product that is defective or dangerous and causes injury. We consider a setting in which there is no asymmetric information or moral hazard by sellers. Note also that if copycats were deceptive, thus pretending to be the original one, consumers would still have the possibility to return them and obtain a refund. Moreover, we do not consider reputational concern of the platform.

innovators to develop new products, which we call the IP-protection effect. Second, after an innovative product is developed, the platform may prefer either a monopolistic structure in which the innovative product faces no competition or a duopolistic structure in which the innovative product faces competition from an imitator. Its incentive to screen is the highest when it prefers the monopolistic market structure: in this case, raising the screening intensity generates both a gain in terms of more innovation and a gain in terms of a higher per-category profit. By contrast, when the platform prefers the duopolistic market structure, it faces a trade-off between inducing more innovation and increasing per-category profit. Hence, the platform tends to choose a lower (or even zero) screening intensity.

The second result concerns the direct and indirect effects of introducing a platform liability that imposes a higher screening intensity. In the baseline model with inelastic buyer participation, we find that, for a given commission rate, the introduction of platform liability always induces more innovators to develop new products because of the IP-protection effect. Yet, this might not suffice to ensure the social desirability of platform liability as platform liability can lower consumer surplus. This is because buyer surplus per product category is larger under a duopolistic market structure than under a monopolistic one. More precisely, if the semi-elasticity of buyer surplus per category with respect to the screening intensity is larger than that of the amount of innovation, then the introduction of platform liability has the unintended negative effect of reducing consumer surplus. This result identifies a potential misalignment of interests between innovators and consumers.

We then characterize the conditions under which raising the screening intensity increases (resp. lowers) the platform's commission depending on whether the platform makes more profits by exploiting its intensive (resp. extensive) margin. When a higher screening intensity leads to a lower commission, the introduction of platform liability has an additional force that raises innovators' incentive to innovate. This case arises when the platform earns more by increasing the number of product categories available on its platform. There are, however, cases in which platform liability leads to an increase in the commission rate as the platform earns more by extracting a higher surplus in per product category rather than by increasing the number of product categories. This generates a force that lowers brand owners' innovation incentives. We find, however, that this unintended negative consequence does not fully offset the positive IP-protection effect.

Platforms are often considered as managers of cross-group network effects, orchestrating interactions between buyers and sellers to maximize profits. We do find that the nature of cross-group network effects and the presence of elastic buyer participation entail new channels through which platform liability can impact innovation and consumer surplus. When buyers face only category-related opportunity costs, the introduction of platform liability reduces buyer participation as raising the screening intensity makes the monopolistic structure more likely and thereby reduces buyer surplus per category. If the negative effect on buyer participation outweighs the positive IP-protection effect, platform liability has an unintended negative effect of reducing innovators' innovation. In this case, platform liability harms those innovators that it is supposed to safeguard and it is certainly socially undesirable. On the contrary, when buyers decide to join the platform bearing a platform-related opportunity cost and thus accounting for the number of product categories available on the platform, there exist two-sided cross-group network effects. In this platform liability is more likely to benefit consumers compared to when they incur category-related opportunity costs. As buyer participation increases with the number of product categories, platform liability can boost buyers' demand even when it lowers buyer surplus per category.

In a series of extensions (Section 6), we relax some of the assumptions made throughout and identify additional forces that the introduction of platform liability can generate, for example by changing imitators' incentive to infringe IPRs or inducing the platform to imitate innovative products with its own copycats (i.e., adoption of a hybrid business model). In the former case, we show that the introduction of platform liability can reduce innovators' incentive to innovate through a composition effect: platform liability changes the composition of imitators by raising the share of legitimate imitators, which can strengthen the competition faced by innovators. We also provide an extension to the no commitment case and another to an imperfect screening technology.

Related literature. This article contributes to the literature on online platforms and their governance and the law & economics literature on liability.

Platform governance. This article contributes to the literature on online platforms (Caillaud and Jullien, 2003; Rochet and Tirole, 2003) and, more specifically, to the literature on platform governance. Recent papers on platform governance have studied the incentives of digital platforms to choose the intensity of seller competition (Teh, 2021), to bias its innovation 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 engage in curation, e.g., delisting low-quality sellers (Casner, 2020), to ensure privacy protection (Etro, 2021a).[9] In addition, this paper is related to the literature on how platforms can influence seller innovation (Belleflamme and Peitz, 2010; Jeon and Rey, 2021) 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 intensity of competition between sellers in a given product category has a critical role in screening IP-infringers. The platform has incentives to screen out IP-infringing products as a part of its governance of the platform ecosystem of innovations.

We also share some commonalities with recent words on platform business models, such as the

[9]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).

adoption of hybrid business models (e.g., Anderson and Bedre-Defolie 2021; Etro 2021b; Hagiu et al. 2022; Zennyo 2022; Shelegia and Hervas-Drane 2022), and to produce copycats (Jiang et al., 2011; Madsen and Vellodi, 2022). Our analysis identifies the incentives of the platform to copy innovative products in response to the introduction of platform liability.

Law & economics. This article contributes to the law & economics literature on liability, which has mostly dealt with product liability in contexts wherein a firm sells its products to consumers directly and there is harm caused by a limited 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 liability of online intermediaries, which has been discussed in non-formalized studies (Buiten et al., 2020; Lefouili and Madio, 2022).

We present a formal analysis of the possible intended and unintended effects of liability for e-commerce platforms (and app stores) on innovation and consumer welfare. Two (complementary) studies are closer to ours. 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 the optimal liability regime is partial. Our paper differs from theirs in scope and multiple dimensions. First, we focus on a different type of harm (i.e., IP-infringement) that impacts a different type of agents, i.e., the innovators, and platform liability has a different connotation, requiring, therefore, platforms to increase their screening intensity. Second, we focus on the interplay between innovators' incentive to develop new products and buyers' participation in determining the desirability of platform liability.

The second work we complement is by De Chiara et al. (2021) on the design of a liability system for online hosting platforms dealing with violation of copyright by content creators. Our paper differs from theirs in that we do not identify the optimal liability regime in a second-best environment. Rather we focus on the direct and indirect effects of introducing a liability regime that leads to a higher screening intensity on key economic variables such as the commission rate charged by the platform and brand owner's innovation and the surplus of market participants. 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.

Outline. The rest of the article is organized as follows. Section 2 presents the baseline model, which is analyzed in Section 3 where we study the privately optimal screening and the effect of a more stringent liability regime on innovators' innovation and consumer welfare. In Section 4, we study how the introduction of platform liability impacts the commission rate and thereby innovators' innovation. In Section 5, we study how the effects of platform liability critically depend on the existence and nature of cross-group network effects. Section 6 provides extensions and discussions of new forces that may change the incentives of the platform. Finally, Section 7 gathers concluding remarks and policy implications.

2. The baseline 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, $\widetilde{k}$, 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 online marketplace and pays the commission fee to the platform. Throughout the analysis, we refer to the number of innovators in the economy as the *amount of innovation*. For simplicity, we assume that the marginal cost is zero for all sellers.

Imitators. In each realized product category, imitators can produce a copycat product. A fraction $\nu \in (0, 1)$ of imitators is legitimate whereas the remaining fraction, $1 - \nu$, infringes IPRs. In the baseline model, we assume that ν is exogenous and the imitation cost is equal to zero.[10] We assume that the IP-infringing products do not cause any direct harm to buyers. We capture this aspect in a stark way by assuming that consumers perceive all imitations as homogeneous.[11] We assume that, in each realized product category, there is a single imitation.[12] Finally, we assume that primary liability is not enforceable, i.e., an innovator cannot obtain damages from an IP-infringer.[13]

The platform. The platform charges an ad valorem commission rate $\tau \in (0, 1]$ to sellers for any transaction on the marketplace. We assume that the platform can identify IP infringers

[10] In Section 6 we relax this assumption.

[11] In other words, there is perfect information and buyers are aware that buying a copycat means that the product is not the branded one. This implies that buyers do not care about whether a product infringes IPRs but they consider all imitators' products as low-quality versions of the branded ones.

[12] The assumption that there is one imitator can be justified as the presence of a second imitator, entering subsequently, would drive prices to zero and thus render entry unprofitable. Moreover, we assume that a legitimate imitator is given the opportunity to enter first with probability ν.

[13] For example, the IP-infringer is located in another jurisdiction or is judgement-proof.

perfectly, but that this is a costly action. Let ϕ denote the screening intensity, i.e., the probability that an IP-infringing imitator is delisted by the platform and $\Omega(\phi)$ denote the fixed screening cost incurred by the platform. For example, a screening activity might require sunk investments in artificial intelligence to train an algorithm that filters (some) IP-infringing products. We assume that the platform cannot delist legitimate sellers for legal reasons.[14] Finally, we make the following assumption regarding the screening cost incurred by the platform.

Assumption 1. $\Omega(0) = 0 = \Omega'(0)$, *$\Omega(\phi)$ is strictly convex,* $\Omega(\phi) \underset{\phi \to 1}{\to} +\infty$.

This assumption implies that small intensity of screening costs little whereas full screening is prohibitively costly. Moreover, this assumption allows us to rule out the case in which all IP-infringers are removed and focus on the most interesting scenario in which there is a positive fraction of IP-infringing products on the platform. We also assume that ϕ is perfectly observable by all agents, which is consistent with the transparency obligations imposed by the EU Digital Services Act, i.e., algorithmic accountability and the assessment and mitigation of systemic risks to 'very large platforms'.

Consumers. There is a mass 1 of consumers. To highlight the main forces at stake, in the baseline model we assume all buyers join the platform, i.e., buyer participation is inelastic. In Section 5 we relax this assumption by assuming that buyers incur opportunity costs when joining the platform. We assume that consumers are ex ante homogeneous but ex post heterogeneous in the sense that, after joining the platform, they discover their valuations for the innovators' and the imitators' products, which are independently and identically distributed across different product categories. We denote by u the ex ante per category utility of each consumer.

Industry Structure. Each product category is either duopolistic or monopolistic. It is monopolistic if, and only if, the imitator infringes IPRs and is delisted by the platform. In each category, let π_I^m (respectively, π_I^d) represent the corresponding expected profit of an innovator when it faces no competition (respectively, 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. $\pi_I^m > \pi_I^d > \pi_C^d$

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 than

[14] 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, which can ideally be part of platform governance, can be considered a remote possibility.

when there is competition between an innovator and an imitator, the former obtains a higher profit than the latter. For a given screening intensity ϕ, an innovator's expected profit, gross of the commission paid to the platform and the fixed innovation cost, is given by:

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

With probability equal to $(1-\nu)\phi$, 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 intensity ϕ, the expected per-category profit of the imitators is

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

Given $n_I(\phi)$ innovators, the utility of buyers is equal to $u(\phi)n_I(\phi)$, with

$$u(\phi) \equiv (1-\nu)\phi u^m + (1-(1-\nu)\phi)u^d \tag{3}$$

with u^m (resp. u^d) the utility if the product is sold in a monopolistic setting (resp. duopolistic setting). We assume that, for a given product, consumers gain more utility from having a duopolistic market structure than a monopolistic one. This is because IP-infringing products are not malicious and do not cause harm to consumers, which makes it reasonable to assume that per category buyer surplus is higher in a duopolistic market structure. Formally, we assume

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

Timing. We consider the following timing:

- Stage 1: The platform decides its screening intensity 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.
- 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.[15]

The model is solved backward and the equilibrium concept is subgame perfect Nash equilibrium.

[15] In the baseline model, all buyers join the marketplace by assumption. In Section 5, however, we relax this assumption.

3. Analysis of the baseline model with exogenous commission rate

In this section, we present the analysis of the baseline. In stage 2, innovators make their innovation decisions upon observing the screening intensity. Therefore, the number of innovators that develop an innovative product and join the marketplace is $n_I(\tau, \phi) = F((1-\tau)\pi_I(\phi))$.

In stage 1, the platform maximizes the following expected profit

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

We first focus on the case in which the commission rate τ is exogenously given. There are circumstances under which the commission rate can be considered as 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'.[16] We relax the assumptions of exogenous commission rate in Section 5, respectively.

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

$$\begin{aligned}\frac{\partial \mathbb{E}\Pi(\tau, \phi)}{\partial \phi} =& \tau f((1-\tau)\pi_I(\phi))(1-\tau)\pi_I'(\phi)\Big[\pi_I(\phi) + \pi_C(\phi)\Big] + \\ & \tau F((1-\tau)\pi_I(\phi)\Big[\pi_I'(\phi) + \pi_C'(\phi)\Big] - \Omega'(\phi) = 0,\end{aligned} \tag{4}$$

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 (respectively, negative) if the monopoly profit π_I^m is greater (respectively, 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. The following proposition shows when the platform has an incentive to delist IP-infringers.[17]

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

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

[16] Moreover, the commission rate can be constrained 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).

[17] 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.

(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 (4) *is weakly negative at $\phi = 0$, and chooses a positive screening intensity, i.e. $\phi^\star \in (0, 1)$, otherwise.*

Note first that an increase in the intensity of screening leads to the development of a larger number of innovative products on the platform, which is the standard reason for IP protection. More precisely, a higher screening intensity implies a reduction in the competitive pressure from imitators, which we label *IP-protection effect*, i.e.,

$$\frac{\partial n_I(\tau, \phi)}{\partial \phi} = f((1-\tau)\pi_I(\phi))\pi_I'(\phi) = f((1-\tau)\pi_I(\phi))(1-\nu)(\pi_I^m - \pi_I^d) > 0. \tag{5}$$

In addition, the above proposition identifies the key role played by per-category total profit in shaping the platform's incentive to screen. If $\pi_I^m \geq \pi_I^d + \pi_C^d$, then an increase in the intensity of screening raises the amount of innovation as well as the platform's profit per product category, which implies that the marginal benefit of screening (gross of screening costs) is always positive. This, combined with the fact that the marginal cost of screening is small for low levels of screening, makes the platform always choose a positive screening intensity. 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 per-category profit. In that case, the platform finds it optimal to let all imitators be active in the marketplace, regardless of whether or not they infringe IPRs.

The impact of platform liability. We now study the impact of introducing platform liability. We suppose that the regulator imposes a minimum screening intensity, ϕ, that platforms should ensure in order to benefit from liability exemption. We assume that liability costs are so large that the platform always finds it optimal to comply with the minimum screening requirement.

We have seen previously in (5) that an increase in screening intensity raises the amount of innovation for a given commission rate. Therefore, introducing platform liability which induces the platform to raise its screening intensity will raise the amount of innovation.

Proposition 2. *Suppose buyers' participation is inelastic. For a given commission rate, platform liability always has a positive effect on innovation.*

The fact that liability leads to a higher innovation level by innovators may not necessarily make it desirable for policymakers if they also care about consumer welfare. As imitations do not harm consumers but exert a competitive pressure on innovators, a potential misalignment between consumers and innovators can emerge.

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 it with respect to ϕ, we obtain

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

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 consumer surplus per category. Yet, given an amount of innovation (and hence given a number of product categories), raising the screening intensity lowers buyer surplus per category as the market structure becomes more monopolistic. As the two effects move in the opposite direction, the introduction of platform liability benefits (resp. harms) consumers only if the gains from a larger amount of innovation offset (resp. are more than compensated by) losses from the reduction in consumer surplus per category. The following proposition summarizes this result.

Proposition 3. *Suppose buyers' participation is inelastic. For a given commission rate, platform liability has a positive (resp. negative) effect on consumer surplus if*

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

This result suggests that if the loss in buyer surplus per category increases at a faster rate than the amount of innovation, there is an important trade-off that policymakers should take into account: benefits for innovators do not necessarily translate into benefits for final consumers.

4. Platform liability and endogenous commission rate

In this section, we consider now the case in which the platform also endogenously decide the commission rate. We assume that the commission rate is non-discriminatory, such that all sellers, regardless of their legal status and their quality level, are subject to the same commission rate τ.[18] In this case, the platform faces a trade-off between increasing the amount of innovation and extracting more surplus per product category. Specifically, raising the commission implies a larger profit from existing product categories and a loss from a reduction in the amount of innovation (i.e., a reduction in the number of categories).

[18]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 categories of products (e.g., books, computer items, on Amazon) and it does not occur within categories of products. For an analysis of the platform's incentive to discriminate across categories, see Tremblay (2021).

Let $\tau^\star$ be the solution of the following first-order condition from the maximization of the platform profit

$$F((1-\tau^\star)\pi_I(\phi)) - \tau^\star\pi_I(\phi)f((1-\tau^\star)\pi_I(\phi)) = 0, \tag{6}$$

which then implies that

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

The L.H.S. of the above equality can be interpreted as the elasticity of innovation supply with respect to the ad valorem commission charged by the platform.

Therefore, to understand the impact of a higher screening intensity ϕ on the commission rate τ, we first differentiate (6) with respect to ϕ, which leads to

$$\frac{d\tau^\star(\phi)}{d\phi} = \frac{(2\tau^\star(\phi)-1)f((1-\tau^\star(\phi))\pi_I(\phi)) + \tau^\star(\phi)(1-\tau^\star(\phi))\pi_I(\phi)f'((1-\tau^\star(\phi))\pi_I(\phi)}{-2\pi_I(\phi)f((1-\tau^\star(\phi))\pi_I(\phi)) + \tau^\star(\phi)\left(\pi_I(\phi)\right)^2 f'((1-\tau^\star(\phi))\pi_I(\phi))}\pi_I'(\phi). \tag{7}$$

The denominator is negative under the assumption that the platform's expected profit is 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, or, as we formally show in the Appendix, the same sign as

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

Denoting $\varepsilon_F(.)$ the elasticity of $F(.)$ and $\varepsilon_f(.)$ the elasticity of $f(.)$, the above equality shows that 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 (positive) is that $\varepsilon_F(y) - \varepsilon_f(y)$ is smaller (greater) than 1 for any y. Specifically, since an increase in ϕ raises both the gain and the loss from an increase in the commission, there are two opposite effects. If the former dominates the latter, the platform raises its commission rate whereas the opposite holds if the latter dominates the former. As the loss from an increase in the commission rate is proportional to $\tau^\star(\phi)$ and $\tau^\star(\phi)$ is small if $\varepsilon_F(.)$ is large, the former dominates the latter if $\varepsilon_F(.)$ is large. The intuition, in this case, is that the platform operates more by trying to stimulate innovation by brand owners (thus lowering the commission rate) when $\varepsilon_F(y) - \varepsilon_f(y) < 1$ whereas it operates more extracting surplus in the existing product categories when $\varepsilon_F(y) - \varepsilon_f(y) > 1$ (thus raising the commission rate). Note that it is possible that $\varepsilon_F(y) - \varepsilon_f(y) = 1$ holds such that the commission rate becomes independent of the screening intensity.[19] The following proposition summarizes how the commission rate is affected by the introduction of platform liability.

[19]For example, when the distribution of the innovation cost is uniform.

Proposition 4. *Suppose buyers' participation is inelastic. A platform liability regime that induces a higher screening intensity leads to a lower (resp. higher) commission rate if* $\varepsilon_F(y) - \varepsilon_f(y) < (>) 1$.

Proof. See Appendix A.1 □

The above analysis identifies a new channel through which the introduction of platform liability that raises the screening intensity impacts the amount of innovation. Interestingly, there are circumstances in which the platform responds to the introduction of platform liability by reducing the commission rate. This certainly amplifies any positive effect that platform liability has on the amount of innovation.

There are also circumstances in which the platform might react to the introduction of platform liability by raising this commission rate. To understand whether this strategic effect on the margin (i.e., margin effect) outweighs any positive direct benefit (i.e., IP-protection effect) of platform liability, we (totally) differentiate $n_I(\tau^\star(\phi), \phi)$ with respect to ϕ and observe the following

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

In the Appendix, we show that the IP-protection effect always outweighs the margin effect. Therefore, platform liability always leads to more innovation but this effect can be amplified or mitigated depending on whether the platform's reaction via a change in the commission rate leads to a lower or a higher commission rate.

Proposition 5. *Suppose buyers' participation is inelastic. Platform liability raises the amount of innovation even if it induces the platform to increase its commission rate.*

Proof. See Appendix A.2 □

5. Elastic demand participation and network effects

In this section, we introduce elastic buyer participation. We consider two different scenarios of buyer participation. To this end, we define the (ex ante) utility of a buyer as follows

$$un_I - \gamma n_I - \xi \tag{8}$$

with γ representing a category-related opportunity cost, and ξ a platform-related opportunity cost. We assume that γ is distributed according to a cdf $G(.)$ and pdf $g(.)$, whereas ξ is distributed according to a cdf $H(.)$ and pdf $h(.)$. Expression (8) enables us to capture different scenarios of elastic buyer participation. For example, if $\xi = 0$ and $\gamma > 0$, then buyers' decisions 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 buyers' decisions to join the marketplace is the utility obtained in a given product category. On the contrary, if $\xi > 0$ and $\gamma = 0$, then buyers incur an opportunity cost of joining the platform only once. In this case, the decision to join the marketplace for a buyer depends on the number of realized product categories.[20]

We assume that buyers' taste is drawn upon joining the marketplace, as in the baseline model, and we assume that buyers' valuations and their opportunity costs are independent. Let us denote $D(\phi)$ the mass of consumers who join the platform (without deriving its expression for now). Under this assumption, the gross expected profit of an innovator is given by $\pi_I(\phi)D(\phi)$. Therefore, in stage 2, the number of innovators that develop an innovative product is

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

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

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

Two effects can be identified. First, there is the direct positive direct effect that we have already observed in the baseline model, i.e., the *IP-protection effect*. Second, there is a new indirect effect that is channeled by the change in the buyer's participation to the platform. This effect, which we refer to this effect as the *market size effect*, can be either positive or negative depending on whether the number of buyers on the marketplace increases or decreases in response to a higher screening intensity. If $\frac{\partial D(\phi)}{\partial \phi} > 0$ is positive, then both effects are positive and, therefore, platform liability has a positive effect on innovation. However, if $\frac{\partial D(\phi)}{\partial \phi} < 0$, then the two effects have opposite signs and the net effect depends on their relative magnitude. Specifically, raising the screening intensity induces more innovators to develop new products if their expected gross profit increases at a faster rate than the change in the buyers' participation to the platform. The following proposition formalizes this discussion.

Proposition 6. *Suppose buyers' participation is elastic. For a given commission rate, platform*

[20]Note that the limit case, which we used in the baseline model, is when both opportunity costs are equal to zero and, therefore, buyers' demand is inelastic. Note also that 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.

liability has a positive (resp. negative) effect on innovation if

$$\frac{\pi_I'(\phi)}{\pi_I(\phi)} > (<) - \frac{\frac{\partial D(\phi)}{\partial \phi}}{D(\phi)}.$$

In the next subsection, we identify how buyer participation is impacted by the introduction of liability both when there is only a category-related opportunity cost and when there is only a platform-related opportunity cost. For the sake of exposition, we abstract away from the effect that ϕ has on the commission rate τ, which is equivalent to assuming it as exogenous. The main insights, however, carry over to when we allow for a change in the commission rate, as shown in Appendix A.7.

5.1. One-sided cross-group network effects

Let us first consider a scenario in which each buyer only incurs an opportunity cost for each category, i.e, $\xi = 0$. In this case, we have one-sided cross-group network effects (from buyers to innovators) because buyers' decision 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 of joining the platform gross of the opportunity cost, and this is given by $u(\phi)$, as previously defined. This implies that the demand for a given product is $D(\phi) = G(u(\phi))$. Under Assumption 3, we have

$$\frac{\partial D(\phi)}{\partial \phi} = u'(\phi) g(u(\phi)) < 0, \tag{9}$$

which implies the presence of a negative *market size effect*. This result is summarized in the following lemma.

Lemma 1. *Suppose that buyer participation is elastic such that each buyer incurs category-related opportunity costs. Platform liability always has a negative effect on buyer participation to the marketplace.*

Together with Proposition 6, the above lemma implies that the effect on innovation can be either positive or negative. In the following corollary, we identify conditions under which each case arises.

Corollary 1. *Suppose that buyer participation is elastic such that each buyer incurs category-related opportunity costs. Platform liability has a positive (negative) effect on innovation if*

$$\frac{\pi_I^m - \pi_I^d}{(1-\nu)\phi\pi_I^m + [1-(1-\nu)\phi]\pi_I^d} > (<) - \frac{g(u(\phi))(u^m - u^d)}{G(u(\phi))}.$$

In this case the *market size effect* is negative and can offset the (positive) *IP-protection effect*, thereby reducing innovation.[21]

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

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

Differentiating it with respect to ϕ, we observe that platform liability has a positive impact on consumer surplus if

$$\frac{\frac{\partial n_I(\tau,\phi)}{\partial\phi}}{n_I(\tau,\phi)} > -\frac{u'(\phi)}{u(\phi)-\gamma^e}, \tag{10}$$

with $\gamma^e \equiv \frac{\int_0^{u(\phi)}\gamma g(\gamma)d\gamma}{G(u(\phi))}$ is the average category-related opportunity cost and $\frac{\partial n_I(\tau,\phi)}{\partial\phi} = (1-\tau)f(\cdot)\left[\pi_I'(\phi)D(\phi)+\pi_I(\phi)\frac{\partial D(\phi)}{\partial\phi}\right]$. Otherwise, raising the screening intensity has a negative effect on consumer surplus. We note that the L.H.S. is negative when $\frac{\partial n_I(\tau,\phi)}{\partial\phi} < 0$, therefore a sufficient condition for platform liability to reduce consumer surplus is that it decreases the amount of innovation. This result is summarized in the following proposition.

Proposition 7. *Suppose that buyer participation is elastic such that each buyer incurs category-related opportunity costs. Platform liability has a positive (negative) effect on consumer surplus if*

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

In particular, a sufficient condition for platform liability to reduce consumer surplus is that the amount of innovation decreases in ϕ.

Proof. See Appendix A.3. □

This result highlights that unintended negative effects of platform liability may emerge when buyers incur category-related opportunity costs as a consequence of the contraction in buyer participation to the platform. If platform liability reduces innovation, it also reduces social welfare. The profit of the platform decreases because of the binding screening obligations; buyer surplus decreases because of a reduction in the number of product categories and a lower per-category surplus; the surplus of legitimate low-quality sellers decreases because of the demand contraction effect and a reduction in the number of product categories. This suggests that buyer elasticity resulting from the existence of category-related opportunity cost creates a force that tends to make platform liability less socially desirable relative to the baseline model.

[21] To ease exposition, we have focused on the case in which the commission rate is unresponsive to a change in the screening intensity. In Appendix (A.7), we show that the negative effect can prevail over the positive effect even when the platform strategically responds to platform liability by reducing the commission rate and, therefore, generating a higher margin for the innovators.

In the next section, we establish that this finding may not carry over to a different type of buyer opportunity cost.

5.2. Two-sided cross-group network effects

We now consider the second scenario in which each buyer incurs a per-platform opportunity cost but no per-category opportunity costs ($\gamma = 0$ and $\xi > 0$). This implies that buyers decide to join the platform taking into account the number of product categories present on the marketplace. As elastic buyer participation in this case generates two-sided cross-group effects, determining the equilibrium number of buyers (i.e. the demand) requires solving for a fixed point. The number of innovators and that of buyers are, respectively, given by

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

Hence

$$D(\tau,\phi) = H(u(\phi)F((1-\tau)\pi_I(\phi)D(\tau,\phi)))).$$

We assume that network effects, captured by the interaction between buyers' and innovators' per-category surplus — $u\pi_I$ —, are not 'too' strong, so that $1 - h(n_I(\tau,\phi)u(\phi))f((1-\tau)\pi_I(\phi)D(\tau,\phi))(1-\tau)\pi_I(\phi)u(\phi) > 0$. This assumption ensures there is a unique interior solution $D(\tau,\phi)$. Differentiating $D(\tau,\phi)$ with respect to ϕ, and solving for $\frac{\partial D(\tau,\phi)}{\partial \phi}$, we obtain

$$\frac{\partial D(\tau,\phi)}{\partial \phi} = \frac{h(n_I(\phi)u(\phi))\Big[(1-\tau)f((1-\tau)\pi_I(\phi)D(\tau,\phi))\pi_I'(\phi)D(\tau,\phi)u(\phi) + u'(\phi)n_I(\tau,\phi)\Big]}{1 - h(n_I(\tau,\phi)u(\phi))f((1-\tau)\pi_I(\phi)D(\tau,\phi))(1-\tau)\pi_I(\phi)u(\phi)}$$

Then raising the screening intensity has a positive effect on the demand if

$$\frac{\partial D(\tau,\phi)}{\partial \phi} > 0 \Longleftrightarrow \frac{\frac{\partial n_I(\tau,\phi)}{\partial \phi}}{n_I(\tau,\phi)} > -\frac{u'(\phi)}{u(\phi)} \tag{11}$$

with $\frac{\partial n_I(\tau,\phi)}{\partial \phi} = f((1-\tau)\pi_I(\phi)D(\tau,\phi))D(\tau,\phi)(1-\tau)\pi_I'(\phi)$. The following can be concluded.

Lemma 2. *Suppose that buyer participation is elastic such that each buyer incurs a platform-related opportunity cost. Platform liability has a positive (negative) effect on buyer participation to the marketplace if*

$$\frac{\frac{\partial n_I(\tau,\phi)}{\partial \phi}}{n_I(\tau,\phi)} > (<) - \frac{u'(\phi)}{u(\phi)}$$

Proof. See Appendix A.4 □

Interestingly and contrary to previous results, platform liability can lead to a demand expansion. This occurs if the increased number of categories from the IP protection effect is more important than the reduction in consumer surplus per category. On the contrary, there is a demand contraction and, therefore, a negative market size effect if buyers are more responsive to changes in competition in given categories than to changes in overall variety.

Proposition 8. *Suppose that buyer participation is elastic such that each buyer incurs a platform-related opportunity cost. A sufficient condition for platform liability to increase innovation is that buyer participation to the marketplace increases. If buyer participation decreases, platform liability has a positive (resp. negative) effect on innovation if*

$$\frac{\pi_I'(\phi)}{\pi_I(\phi)} > (<) - \frac{h(n_I(\phi)u(\phi))u'(\phi)n_I(\tau,\phi)}{H(n_I(\tau,\phi)u(\phi))}.$$

Proof. See Appendix A.5. □

Again it is sufficient that platform liability expands buyers' participation in the marketplace in order to generate a positive effect on innovation. On the contrary, when buyers' participation decreases, innovators face a trade-off between the *market size effect* and the *IP-protection effect*, which is similar to what happens in the presence of one-sided network effects.

As for consumer surplus, per-product consumer surplus has the same sign as $D(\phi)$. Total consumer surplus is given by

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

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

$$\begin{aligned}\frac{\partial CS(\tau,\phi)}{\partial\phi} =& \int_0^{n_I(\tau,\phi)u(\phi)} h(\xi)d\xi \left(u(\phi)\frac{\partial n_I(\tau,\phi)}{\partial\phi} + n_I(\tau,\phi)u'(\phi)\right)\\ =& H(n_I(\tau,\phi)u(\phi))\left(u(\phi)\frac{\partial n_I(\tau,\phi)}{\partial\phi} + n_I(\tau,\phi)u'(\phi)\right)\end{aligned}$$

which has the same sign as $u(\phi)\frac{\partial n_I(\tau,\phi)}{\partial\phi} + n_I(\tau,\phi)u'(\phi)$.

Proposition 9. *Suppose that buyer participation is elastic such that each buyer incurs a platform-related opportunity cost. Platform liability has a positive (resp. negative) effect on consumer surplus if*

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

A sufficient condition for platform liability to be undesirable for consumers is that it leads to less innovation, whereas platform liability is desirable for consumers if it expands buyers' participation.

The above proposition implies that the effect of platform liability on consumer surplus has the same sign as that of the effect on buyer participation. If platform liability raises buyer participation, it implies that platform liability increases consumer surplus. By contrast, if buyers' participation shrinks, there might be a misalignment of interest between consumers and innovators.

6. Extensions and discussions

In this section, we first endogenize imitators' decision to infringe IPRs or not. Then, we study 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. Finally, we discuss new forces that might change the incentives of the platform and the impact of platform liability when the platform lacks commitment power, or it adopts an imperfect screening technology.

6.1. Endogenous infringement

In this subsection, we relax the assumption that the decision to infringe IPRs is exogenous for all product categories. To help understand the mechanisms at stake when there is an endogenous decision to infringe IPRs by imitators, we consider the polar case in which all imitators have the possibility to decide whether to infringe IPRs. We continue to assume that in each product category there is space for at most one imitator. If the imitator is legitimate, it obtains $\pi_C^d - \rho$, where ρ represents the cost of being legitimate/compliant and is distributed according to cdf $L(\cdot)$ and pdf $l(\cdot)$. If the imitator infringes IPRs, it obtains π_C^d conditional on not being delisted by the platform. Thus, an imitator prefers to infringe IPRs if

$$(1-\phi)\pi_C^d \geq \pi_C^d - \rho \Longleftrightarrow \rho \geq \pi_C^d \phi. \tag{12}$$

Hence, the probability that a legitimate imitator is present on the platform is equal to $L(\pi_C^d \phi) \equiv \nu$ and the probability that an IP-infringing product is on the platform is equal to $1-\nu$.

Therefore, the endogenous infringement adds a new effect when the introduction of platform liability leads to a higher screening intensity: 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 screening intensity. In this case, platform liability reduces (instead of increasing) the amount of innovation.

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

$$\pi_I^m\Big(1 - L(\pi_C^d\phi)\Big)\phi + \pi_I^d\Big(1 - (1 - L(\pi_C^d\phi))\phi\Big) \equiv \pi_I(\phi). \quad (13)$$

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

$$\pi_I'(\phi) = (\pi_I^m - \pi_I^d)\Big(1 - L(\pi_C^d\phi) - \pi_C^d\phi l(\pi_C^d\phi)\Big),$$

where $\Big(1 - L(\pi_C^d\phi) - \pi_C^d\phi l(\pi_C^d\phi)\Big)$ represents the change in the probability for an innovator to remain monopoly. If this change is negative, an introduction of platform liability reduces the amount of innovation.

Proposition 10. *Suppose infringement is endogenous. For a given commission rate τ, a higher screening intensity leads to more (less) innovation if $L(\pi_C^d\phi) + \pi_C^d\phi l(\pi_C^d\phi) < (>)1$.*

Proof. See Appendix A.6 □

Proposition 10 identifies a condition — $L(\pi_C^d\phi) + \pi_C^d\phi l(\pi_C^d\phi) > 1$ — under which the amount of innovation decreases in the screening intensity. In this case, the reduction in innovation is caused by the increase in the probability for an innovator to face an imitator. Therefore, the impact of platform liability on consumer surplus is positive if the increase in consumer surplus from more competition is larger than the loss from reduced 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. To this end, we consider a variation of the baseline model in which the platform can *replace* an imitator by producing its own copycat version. Differently from independent imitators, the platform's version does not infringe IPRs (for example, for the superior legal team that the platform has or simply because it collects data and information from innovators). Assume that apart from not infringing IPRs, the platform's imitation is homogeneous to the one produced by an independent imitator and can be produced at a fixed cost k. Let β represent the probability of entry of an imitation of the platform.

Consider the baseline model in which the commission rate is exogenously determined and consumers have inelastic participation (i.e., $\gamma = 0$ and $\xi = 0$). In the absence of platform liability, let $\phi^\star$ be the screening intensity chosen, leading to a probability of duopoly market structure per category equal to $1-(1-\nu)\phi^\star$. Then, we consider the following (modified) timing.

- Stage 1: The platform announces (ϕ, β) for a given τ.
- Stage 2: Innovators make innovation decisions and decide to join the platform.
- Stage 3: The platform incurs the entry cost for β fraction of categories.
- Stage 4: Independent imitators join $(1-\beta)$ fraction of categories.
- Stage 5: The platform screens independent imitators with the screening intensity ϕ.

In addition, we assume $k = (1-\tau)\pi_C^d$. Thus, the platform's total profit from a category in which its imitation is present is

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

which makes the platform indifferent between selling its own copycat and letting let an independent imitator sell a copycat. This implies that the platform is indifferent between a hybrid business model and a pure marketplace business model in the absence of platform liability.

Suppose now that platform liability forces the platform to raise ϕ to ϕ' $(> \phi^\star)$. This clearly reduces the platform's profit conditional on that the platform maintains the pure marketplace business model. However, under a hybrid business model, the platform can restore its desired probability of a duopoly market structure $1-(1-\nu)\phi^\star$ by choosing β: namely,

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

which leads to

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

By entering $\beta'(< 1)$ fraction of product categories, it can realize its desired probability of a duopoly market structure, which induces the platform to prefer the hybrid business model. The reason is that what matters for the platform's profit is the probability of duopoly market structure per category. Platform liability lowers this probability under the pure marketplace business model. Yet, under the hybrid business model, the platform can increase the probability by introducing its own imitation.

6.3. Inability to commit

A critical assumption 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 the 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's screening policy is chosen after their entry into the platform marketplace (and is not observable to sellers). Suppose that the platform cannot commit to its screening policy while it can commit to an ad valorem commission rate, the latter being 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. We find that lack of commitment creates a hold-up problem on the part of the platform and therefore an introduction of platform liability can raise the platform's profit by mitigating the hold-up problem.

Absent platform liability, given a number n_I of brand owners who innovated and joined the platform marketplace, the platform maximizes the following expected profit

$$\tau n_I(\tau, \phi)\Big(\pi_I(\phi) + \pi_C(\phi)\Big) - \Omega(\phi).$$

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

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

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 can generate by increasing the amount of innovation and hence tends to choose lower screening than in the baseline model with commitment.

Suppose now liability is introduced such that it forces the platform to achieve a screening intensity greater or equal to $\underline{\phi}$ (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 intensity. Then, a liability regime that imposes a positive level of screening can increase the platform's profit. For instance, if $\underline{\phi} = \phi^\star$ where $\phi^\star$ is the screening policy that would be chosen by the platform under commitment power, then the 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.

6.4. Imperfect screening

We below show that our results continue to be valid in the presence of an imperfect screening technology that leads to type-I (false positives) and type-II errors (false negatives). Suppose that the platform technology leads to an imperfect detection of IP-infringing products. Let $\omega^+ \in [0,1]$ denote the probability of making type-I errors and $\omega^- \in [0,1]$ denote the probability of making type-II errors: a legitimate imitation is delisted with probability ω^+ and is listed with the remaining probability $(1-\omega^+)$ whereas an IP-infringing imitation is delisted with probability $(1-\omega^-)$ and remains listed with probability ω^-.

Then, conditional on screening being applied to a product caterogy, the innovator faces competition from an imitator with the following probability $\nu(1-\omega^+) + (1-\nu)\omega^- \equiv \tilde{\nu}$. Therefore, for a given screening intensity ϕ, the expected profit of the innovator, gross of the commission paid to the platform and the fixed innovation cost, is given by:

$$\pi_I(\phi) \equiv (1-\tilde{\nu})\phi\pi_I^m + [1-(1-\tilde{\nu})\phi]\,\pi_I^d;$$

the expected total per-category profit of the imitators is given by

$$\pi_C(\phi) \equiv [1-(1-\tilde{\nu})\phi]\,\pi_C^d;$$

The platform's expected profit is as in the baseline model. Therefore, all the previous analysis remains valid as long as we replace ν with $\tilde{\nu}$ because what matters for the platform's private incentive and the innovation incentive of the innovators is only the probability of having a monopolistic or a duopolistic market structure.

For simplicity, suppose now that the prediction accuracy is such that type-I and type-II errors occur with the same probability equal to $\omega = \omega^+ = \omega^- < 1/2$. Conditional on screening being applied to a product category, the innovator faces competition from an imitator with probability $\nu(1-\omega)+(1-\nu)\omega$, which decreases (increases) in ω if $\nu > (<)1/2$. Then, increasing prediction error ω will have the following effects. If $\nu > \frac{1}{2}$, a higher probability of making errors makes brand owners face less competition ex post in a given product category. Thus, all other things being equal, a larger prediction error makes them better off compared to the case in which there is a perfect screening technology. Indeed, there are conditions under which poorer screening technology can induce more innovation. In contrast, if $\nu < \frac{1}{2}$, competitive pressure on innovators becomes stronger the larger the prediction error.

7. Concluding remarks and 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.[22] We analyze the intended and unintended effects of a liability regime that increases online intermediaries' screening efforts. To the best of our knowledge, our paper offers the first formal analysis of the effects that imposing liability on e-commerce platforms has on innovation and the key role played by cross-group network effects in amplifying or mitigating the effects of platform liability.

[22]For example, major brand owners supported the introduction of a more stringent liability of online intermediaries in the US (i.e., the INFORM Consumers Act). See e.g., https://www.toyassociation.org/PressRoom2/News/2021-news/toy-assoc-applauds-intro-legislation-to-protect-consumers-from-counterfeits-online.aspx

We show that, in the absence of liability, the platform's incentives to screen out IP infringers depend on its preferences about the ex post market structure in each given category, and that there is a scenario in which it prefers not to engage in any screening activity. When a liability rule is introduced to induce the platform to raise its screening intensity, there are direct and indirect effects. Our analysis of these effects shows that even if innovation by brand owners increases, the introduction of platform liability might not necessarily be desirable for consumers.

We identify conditions under which the introduction of platform liability stimulates innovation incentives by brand owners. This effect is stronger if more intense screening induces the platform to lower its commission rate or if it leads to an increase in demand participation in the platform (due to two-sided cross-group network effects).

In this respect, the impact of platform liability on innovation and consumer surplus is affected by the elasticity of buyer participation with respect to screening. Interestingly, a higher elasticity of buyer participation can make platform liability either more or less desirable, depending on the source of buyer participation elasticity, that is, the nature of the opportunity costs that generate that elasticity. Specifically, our analysis suggests that category-related opportunity costs create a force that tends to make platform liability less likely to be desirable for consumers. In contrast, the presence of a platform-related opportunity costs creates a force that tends to make platform liability more likely to be beneficial to consumers because of a potential demand expansion. Identifying these forces is paramount to understanding the potentially negative or positive impact of platform liability on innovation channeled by the reduction or increase in buyer participation in the platform. Interestingly, there might be cases — identified in our analysis — in which the contraction in buyer participation offsets any gain from platform liability even when the platform responds to its introduction by reducing the commission rate.

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 generally granted a liability exemption. Proposals have been made in the US and in the European Union to stimulate pro-active measures. For example, the European Union Digital Services Act presents additional obligations for very large platforms in the presence of third parties' misconduct. Yet as discussed in policy-oriented non-formalized studies (Buiten et al., 2020; Lefouili and Madio, 2022), imposing liability on platforms might generate unintended effects or reinforce the intended ones.

Our paper shows that policymakers should pay close attention to the impact of platform liability on key (unregulated) 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 IPRs and stimulating innovation, there might be a negative effect on consumers. Indeed, there might be a misalignment between innovators and consumers. Second, 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 change in the commission rate might reinforce the positive benefits that imposing platform liability generates to innovators. Third, policymakers should foresee strategic reactions not only by the platform but also by imitators who, in response to the introduction of platform liability, might respond by becoming legitimate and therefore not infringing IPRs. We identify conditions under which such a strategic response can lead to a reduction of innovation by brand owners and, therefore, to a possible undesirable outcome. Finally, policymakers should assess whether there exist cross-group network effects from innovators to buyers. Our results suggest that platform liability is more likely to be desirable for consumers if such cross-group network effects exist.

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A. Appendix

A.1. Proof of Proposition 4

Consider the problem of the platform for a given screening intensity. The expected profit of the platform is

$$\mathbb{E}\Pi(\tau, \phi) = \tau F((1-\tau)\pi_I(\phi))[\pi_I(\phi) + \pi_C(\phi)]$$

From the first order condition with respect to τ, we obtain

$$\frac{\partial \mathbb{E}\Pi(\tau, \phi)}{\partial \tau} = F((1-\tau)\pi_I(\phi))[\pi_I(\phi)) + \pi_C(\phi)] - \tau\pi_I(\phi)f((1-\tau)\pi_I(\phi))[\pi_I(\phi) + \pi_C(\phi)] = 0.$$

In this case, $\tau^\star$ the optimal commission rate is such that

$$F((1-\tau^\star)\pi_I(\phi)) - \tau^\star\pi_I(\phi)f((1-\tau^\star)\pi_I(\phi)) = 0,$$

which implies that

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

In this case, the platform obtains

$$\Pi(\tau^\star, \phi) = \tau^\star F((1-\tau^\star)\pi_I(\phi))[\pi_I(\phi) + \pi_C(\phi)] = \frac{F((1-\tau^\star)\pi_I(\phi))^2}{\pi_I(\phi)f((1-\tau^\star)\pi_I(\phi))}\Big[\pi_I(\phi) + \pi_C(\phi)\Big].$$

To identify the effect of ϕ on the optimal commission rate, let us differentiate (6) with respect to ϕ, so as to obtain

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

The denominator is negative under our assumption that the platform's expected profit is 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.

Therefore, $\frac{d\tau^\star(\phi)}{d\phi}$ 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, (6) 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

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

Since the second term on the R.H.S. of the above equality is the elasticity of innovators' participation $F(.)$, denoted by $\varepsilon_F(.)$, the equation shows that the equilibrium commission decreases with the elasticity, which is intuitive.

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 $\varepsilon_f(.)$ the elasticity of $f(.)$, 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 (positive) is that $\varepsilon_F(y)-\varepsilon_f(y)$ is smaller (greater) than 1 for any y. This concludes the proof.

A.2. Proof of Proposition 5

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

$$\begin{aligned}\frac{dn_I(\tau^\star(\phi),\phi)}{d\phi}&=f(\cdot)\Big\{(1-\tau^\star(\phi))\pi_I'(\phi)-\frac{d\tau^\star(\phi)}{d\phi}\pi_I(\phi)\Big\}\\&=f(\cdot)\pi_I'(\phi)\Big\{(1-\tau^\star(\phi))-\frac{\partial\tau^\star(\phi)}{\partial\pi_I}\pi_I(\phi)\Big\}\end{aligned}\tag{A-1}$$

Using (7) we can write the term within the brackets as follows

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

As the numerator of the second term is negative, it follows that the term within the brackets in (A-1) has the opposite sign of the following expression

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

Therefore, as the term within the bracket is positive, we can conclude that

$$
sign\Big(\frac{dn_I(\tau^\star(\phi),\phi)}{d\phi}\Big)=sign\Big(\frac{\pi_I'(\phi)}{\partial\phi}\Big)>0.
$$

This concludes the proof.

A.3. Proof of Proposition 7

Suppose there is a one-sided network externality. Consumer surplus is

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

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

$$
\begin{aligned}
\frac{\partial CS(\tau,\phi)}{\partial\phi}=&\frac{\partial n_I(\tau,\phi)}{\partial\phi}\int_0^{u(\phi)}(u(\phi)-\gamma)g(u(\phi))d\gamma+n_I(\tau,\phi)u'(\phi)\int_0^{u(\phi)}g(\gamma)d\gamma\\
=&\frac{\partial n_I(\tau,\phi)}{\partial\phi}\int_0^{u(\phi)}(u(\phi)-\gamma)g(u(\phi))d\gamma+n_I(\tau,\phi)u'(\phi)G(u(\phi)).
\end{aligned}
$$

with $\frac{\partial n_I(\tau,\phi)}{\partial\phi}=(1-\tau)f(\cdot)\Big[\pi_I'(\phi)D(\phi)+\pi_I(\phi)D'(\phi)\Big]$. This implies that platform liability has a positive effect on consumer surplus if

$$
\frac{\frac{\partial n_I(\tau,\phi)}{\partial\phi}}{n_I(\tau,\phi)}>-\frac{u'(\phi)G(u(\phi))}{\int_0^{u(\phi)}(u(\phi)-\gamma)g(u(\phi))d\gamma},
$$

and a negative effect otherwise. Denote

$$
\gamma^e\equiv\frac{\int_0^{u(\phi)}\gamma g(\gamma)d\gamma}{G(u(\phi))}.
$$

Therefore, platform liability has a positive impact on consumer surplus if

$$
\frac{\frac{\partial n_I(\tau,\phi)}{\partial\phi}}{n_I(\tau,\phi)}>-\frac{u'(\phi)}{u(\phi)-\gamma^e}. \tag{A-3}
$$

Otherwise, platform liability has a negative effect on consumer surplus. Note that a sufficient condition for platform liability to have a negative effect on consumer surplus is that $\frac{\partial n_I(\tau,\phi)}{\partial \phi} < 0$. In such a case, the L.H.S. is negative and the R.H.S. is positive, therefore consumer surplus decreases. This concludes the proof.

A.4. Proof of Lemma 2

Suppose there are two-sided network effects. Recall that

$$D(\tau,\phi) = H(n_I(\tau,\phi)u(\phi)),$$

where $n_I(\phi) = F((1-\tau)\pi_I(\phi)D(\phi))$. For brevity, we suppress the arguments of F and H. Moreover,

$$\frac{\partial n_I(\tau,\phi)}{\partial \phi} = (1-\tau)f(\cdot)\Big[\pi_I'(\phi)D(\tau,\phi) + \pi_I(\phi)\frac{\partial D(\tau,\phi)}{\partial \phi}\Big],$$

Differentiating $D(\phi)$ with respect to ϕ

$$\begin{aligned}\frac{\partial D(\tau,\phi)}{\partial \phi} =& h(\cdot)\Big[\frac{\partial n_I(\tau,\phi)}{\partial \phi}u(\phi) + u'(\phi)n_I(\tau,\phi)\Big]\\ & h(\cdot)\Big[\Big((1-\tau)f(\cdot)\Big[\pi_I'(\phi)D(\phi) + \pi_I(\phi)\frac{\partial D(\tau,\phi)}{\partial \phi}\Big]\Big)u(\phi) + u'(\phi)n_I(\tau,\phi)\Big],\end{aligned}$$

Solving for $\frac{\partial D(\tau,\phi)}{\partial \phi}$, then

$$\frac{\partial D(\tau,\phi)}{\partial \phi} = \frac{h(\cdot)\Big[(1-\tau)f(\cdot)\pi_I'(\phi)D(\tau,\phi)u(\phi) + u'(\phi)n_I(\tau,\phi)\Big]}{1 - h(\cdot)f(\cdot)(1-\tau)\pi_I(\phi)u(\phi)}.$$

We assume $1 - h(\cdot)f(\cdot)(1-\tau)\pi_I(\phi)u(\phi) > 0$ so as to ensure interior solution of $D(\phi)$. As the denominator is positive, $\frac{\partial D(\tau,\phi)}{\partial \phi}$ has the same sign of the following expression

$$(1-\tau)f(\cdot)\pi_I'(\phi)D(\tau,\phi)u(\phi) + u'(\phi)n_I(\tau,\phi)$$

which means

$$\frac{\partial D(\tau,\phi)}{\partial \phi} > 0 \Longleftrightarrow \frac{(1-\tau)f(\cdot)\pi_I'(\phi)D(\tau,\phi)}{n_I(\tau,\phi)} > -\frac{u'(\phi)}{u(\phi)},$$

and negative otherwise. Alternatively,

$$\frac{\partial D(\tau,\phi)}{\partial \phi} > 0 \Longleftrightarrow \frac{\frac{\partial n_I(\tau,\phi)}{\partial \phi}}{n_I(\tau,\phi)} > -\frac{u'(\phi)}{u(\phi)},$$

This concludes the proof.

A.5. Proof of Proposition 8

Recall that for given τ, platform liability has a positive (negative) effect on innovation if

$$\frac{\pi_I'(\phi)}{\pi_I(\phi)} \geq (<) - \frac{\frac{\partial D(\tau,\phi)}{\partial \phi}}{D(\tau,\phi)}.$$

A sufficient condition for innovation to increase is that $\frac{\partial D(\tau,\phi)}{\partial \phi} > 0$.

Platform liability increases innovation if

$$\frac{\pi_I'(\phi)}{\pi_I(\phi)} > - \frac{\frac{h(\cdot)\Big[(1-\tau)f(\cdot)\pi_I'(\phi)D(\tau,\phi)u(\phi)+u'(\phi)n_I(\tau,\phi)\Big]}{1-h(\cdot)f(\cdot)(1-\tau)\pi_I(\phi)u(\phi)}}{D(\phi)},$$

which is the case if

$$\pi_I'(\phi)D(\tau,\phi)\Big[1-h(\cdot)f(\cdot)(1-\tau)\pi_I(\phi)u(\phi)\Big] >$$
$$-\pi_I(\phi)h(\cdot)\Big[(1-\tau)f(\cdot)\pi_I'(\phi)D(\tau,\phi)u(\phi)+u'(\phi)n_I(\tau,\phi)\Big]$$

that is

$$\pi_I'(\phi)D(\tau,\phi) - \pi_I'(\phi)D(\tau,\phi)h(\cdot)f(\cdot)(1-\tau)\pi_I(\phi)u(\phi) >$$
$$-\pi_I(\phi)h(\cdot)\Big[(1-\tau)f(\cdot)\pi_I'(\phi)D(\tau,\phi)u(\phi)+u'(\phi)n_I(\phi)\Big]$$

Simplifying, we obtain

$$\pi_I'(\phi)D(\tau,\phi) > -\pi_I(\phi)h(\cdot)u'(\phi)n_I(\tau,\phi),$$

with $D(\phi) = H(\cdot)$. Therefore, platform liability increases innovation if

$$\frac{\pi_I'(\phi)}{\pi_I(\phi)} > -\frac{h(\cdot)u'(\phi)n_I(\tau,\phi)}{H(\cdot)}.$$

Otherwise, when

$$\frac{\pi_I'(\phi)}{\pi_I(\phi)} < -\frac{h(\cdot)u'(\phi)n_I(\tau,\phi)}{H(\cdot)}$$

the effect of platform liability on innovation is negative. This concludes the proof.

A.6. Proof of Proposition 10

Recall that the mass of innovators in the marketplace is $F((1-\tau)\pi_I(\phi))$. For a given commission rate τ,

$$\pi_I'(\phi) = (\pi_I^m - \pi_I^d)\Big(1 - L(\pi_C^d\phi) - \pi_C^d\phi l(\pi_C^d\phi)\Big)$$

Moreover, the expected gross profit of an imitator is now determined as follows

$$[1 - (1 - L(\pi_C^d\phi))\phi]\pi_C^d \equiv \pi_C(\phi),$$

which implies that

$$\pi_C'(\phi) = -(1 - L(\pi_C^d\phi))\pi_C^d + (\pi_C^d)^2\phi l(\pi^e\phi).$$

Therefore, $\pi_C'(\phi)$ is positive (negative) if

$$\pi_C^d\phi l(\pi_C^d\phi) + L(\pi_C^d\phi) > (<) 1.$$

This concludes the proof.

A.7. Elastic demand participation and the endogenous commission rate

Consider the case in which the commission rate, τ, is determined endogenously by the platform. To ease notation, we denote as $\tilde{\pi}_I(\phi) = D(\phi)\pi_I(\phi)$ the expected profit of an innovator (gross of the commission charged by the platform) and $\tilde{\pi}_C(\phi) = D(\phi)\pi_C(\phi)$ the expected profit of an imitator (gross of the commission charged by the platform). The expected profit of the platform is therefore equal to

$$\Pi(\tau, \phi) = \tau F((1-\tau)\tilde{\pi}_I(\phi))[\tilde{\pi}_I(\phi) + \tilde{\pi}_C(\phi)] - C(\phi).$$

From the first order condition with respect to τ we obtain

$$\frac{\partial \Pi(\tau, \phi)}{\partial \tau} = F((1-\tau)\tilde{\pi}_I(\phi))[\tilde{\pi}_I(\phi)) + \tilde{\pi}_C(\phi)] - \tau\tilde{\pi}_I(\phi)f((1-\tau)\tilde{\pi}_I(\phi))[\tilde{\pi}_I(\phi) + \tilde{\pi}_C(\phi)] = 0$$

Denote $\tau^\star$ the optimal commission rate such that

$$F((1-\tau^\star)\tilde{\pi}_I(\phi)) - \tau^\star\tilde{\pi}_I(\phi)f((1-\tau^\star)\tilde{\pi}_I(\phi)) = 0 \tag{A-4}$$

Before proceeding with the analysis, recall the relationship between the screening intensity and the gross profit of innovators, as established in Corollary 1, which is equivalent to say that innovation increases (decreases) with a higher screening intensity if

$$\tilde{\pi}'_I(\phi) > 0 \Longleftrightarrow \frac{\pi'_I(\phi)}{\pi_I(\phi)} > (<) - \frac{\frac{\partial D(\phi)}{\partial \phi}}{D_I(\phi)} \tag{A-5}$$

Note that the screening intensity ϕ affects (A-4) only through $\tilde{\pi}_I(\phi)$, with this effect being positive or negative depending on whether (A-5) is satisfied. Thus, the effect of a higher screening intensity on the commission rate entirely depends on the sign of the following term

$$\frac{d\tau^\star(\phi)}{d\phi} = \frac{\partial \tau^\star(\phi)}{\partial \tilde{\pi}_I}\tilde{\pi}'_I(\phi). \tag{A-6}$$

Differentiating (A-4) with respect to $\tilde{\pi}_I$, we obtain

$$\frac{\partial \tau^\star(\phi)}{\partial \tilde{\pi}_I} = \frac{(2\tau^\star(\phi) - 1)f((1-\tau^\star(\phi))\tilde{\pi}_I(\phi)) + \tau^\star(\phi)(1-\tau^\star(\phi))\tilde{\pi}_I(\phi)f'((1-\tau^\star(\phi))\tilde{\pi}_I(\phi)}{-2\tilde{\pi}_I(\phi)f((1-\tau^\star(\phi))\tilde{\pi}_I(\phi)) + \tau^\star(\phi)\left(\tilde{\pi}_I(\phi)\right)^2 f'((1-\tau^\star(\phi))\tilde{\pi}_I(\phi))} \tag{A-7}$$

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

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

Following the same steps outlined in the proof of Proposition 4, one can verify that $\frac{\partial \tau^\star(\phi)}{\partial \tilde{\pi}_I}$ has the same sign as

$$-1 + \frac{(1-\tau^\star(\phi)(\phi))\,\tilde{\pi}_I(\phi)f((1-\tau^\star(\phi))\tilde{\pi}_I(\phi))}{F((1-\tau^\star(\phi))\tilde{\pi}_I(\phi))} - \frac{(1-\tau^\star(\phi))\tilde{\pi}_I(\phi)f'((1-\tau^\star(\phi))\tilde{\pi}_I(\phi))}{f((1-\tau^\star(\phi))\tilde{\pi}_I(\phi))}$$

Denoting $\varepsilon_f(.)$ the elasticity of $f(.)$, the sign of $\frac{\partial \tau^\star(\phi)}{\partial \tilde{\pi}_I}$ is the same as the sign of

$$-1 + \varepsilon_F((1-\tau^\star(\phi))\,\tilde{\pi}_I(\phi) - \varepsilon_f((1-\tau^\star(\phi))\,\tilde{\pi}_I(\phi)).$$

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

Summarizing the above discussion, we conclude the following

(i) If $\left|\frac{\frac{\partial D(\phi)}{\partial \phi}}{D(\phi)}\right| < \frac{\pi'_I(\phi)}{\pi_I(\phi)}$, the commission rate increases (decreases) with the screening intensity if $\varepsilon_F(y) - \varepsilon_f(y) > (<)1$.

(ii) If $\left|\frac{\frac{\partial D(\phi)}{\partial \phi}}{D(\phi)}\right| > \frac{\pi'_I(\phi)}{\pi_I(\phi)}$, the commission rate increases (decreases) with the screening intensity if $\varepsilon_F(y) - \varepsilon_f(y) < (>)1$.

To understand the effect of raising ϕ on innovation when the commission rate is endogenous and buyers' participation is elastic, we totally differentiate $n_I(\tau^\star(\phi), \phi)$ with respect to ϕ

$$\begin{aligned}\frac{dn_I(\tau^\star(\phi),\phi)}{d\phi} =& f(\cdot)\Big\{(1-\tau^\star(\phi))\tilde{\pi}_I'(\phi) - \frac{d\tau^\star(\phi)}{d\phi}\tilde{\pi}_I(\phi)\Big\} \\ =& f(\cdot)\tilde{\pi}_I'(\phi)\Big\{(1-\tau^\star(\phi)) - \frac{\partial\tau^\star(\phi)}{\partial\tilde{\pi}}\tilde{\pi}_I(\phi)\Big\}\end{aligned}$$

The term in the brackets can be writtenas

$$(1-\tau^\star(\phi)) - \frac{(2\tau^\star(\phi)-1)f((1-\tau^\star(\phi))\tilde{\pi}_I(\phi)) + \tau^\star(\phi)(1-\tau^\star(\phi))\tilde{\pi}_I(\phi)f'((1-\tau^\star(\phi))\tilde{\pi}_I(\phi)}{-2\tilde{\pi}_I(\phi)f((1-\tau^\star(\phi))\tilde{\pi}_I(\phi)) + \tau^\star(\phi)\left(\tilde{\pi}_I(\phi)\right)^2 f'((1-\tau^\star(\phi))\tilde{\pi}_I(\phi))}\tilde{\pi}_I(\phi) \tag{A-8}$$

Rearranging it, (A-8) has the opposite sign of the following term

$$\begin{aligned}=&(1-\tau^\star(\phi))\Big(-2\tilde{\pi}_I(\phi)f((1-\tau^\star(\phi))\tilde{\pi}_I(\phi)) + \tau^\star(\phi)\left(\tilde{\pi}_I(\phi)\right)^2 f'((1-\tau^\star(\phi))\tilde{\pi}_I(\phi))\Big) - \\ &\tilde{\pi}_I(\phi)\Big((2\tau^\star(\phi)-1)f((1-\tau^\star(\phi))\tilde{\pi}_I(\phi)) + \tau^\star(\phi)(1-\tau^\star(\phi))\tilde{\pi}_I(\phi)f'((1-\tau^\star(\phi))\tilde{\pi}_I(\phi)\Big) \\ =& -\tilde{\pi}_I(\phi)f((1-\tau^\star(\phi))\tilde{\pi}_I(\phi)) < 0\end{aligned}$$

In turn, the term within the bracket is positive and we can conclude that

$$sign\Big(\frac{dn_I(\tau^\star(\phi),\phi)}{d\phi}\Big) = sign\Big(\tilde{\pi}_I'(\phi)\Big).$$

This concludes the proof.