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Platform acquisitions, product imitation and openness

J. Manuel Sanchez-Cartas[1,2]

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Abstract
Public authorities have shown concern about the possible harmful effects of platforms acquiring or imitating complementary services sold on their platforms. The effect of these practices on the restrictions on participation, development, or use of platform services (platform openness) has started to attract the attention of policymakers and researchers alike, but the evidence is still limited. We build a model that considers the trade-off that a monopoly platform faces when deciding whether to acquire or imitate a complementor and how such a decision influences openness and welfare. We show that a platform always has an incentive to acquire or imitate complementors. Which one is preferred depends on whether the increase in platform value (acquisition) offsets the market expansion effect (imitation). We find that acquisitions reduce openness and welfare but may generate more valuable complements while imitation increases openness and welfare but may harm third-party developers.

Keywords Acquisitions · Mergers · Digital platforms · Openness

JEL Classification L41 · L12 · L13 · L86 · K21

1 Introduction

It is increasingly common to find digital services that are free for users (e.g., Facebook, Google Chrome, or Steam). At first glance, it would seem that a free product should not be of particular concern. However, the fact that a good is free does not imply that the company producing it does not have the ability to unilaterally affect

✉ J. Manuel Sanchez-Cartas
jmscartas@ucm.es

[1] Departamento de Análisis Económico y Economía Cuantitativa, Universidad Complutense de Madrid, Campus de Somosaguas, Madrid, Spain

[2] CAIT, Universidad Politécnica de Madrid, Campus de Montegancedo, Pozuelo de Alarcon, Madrid, Spain

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the terms of exchange. Digital platforms can unilaterally set restrictions on participation, development, or use across their distinct roles (e.g., users and developers). In other words, platforms can determine how "open" they are to users and developers (Eisenmann et al., 2009). In this sense, a platform is said to be more "open" to the extent that it places fewer of those restrictions.[1]

In recent years, some platform sponsors have been in the spotlight because they have facilitated the creation of new services by "opening up" and appropriating the innovations created on their platforms through acquisitions or imitations. For instance, only in 2011, Google acquired more than one company per week,[2] and some of these companies were services created on top of Android that did not compete with Google directly at the time, such as TalkBin, PittPatt or Pulse.io. Similarly, Meta has been accused of copying features from multiple developers including Snapchat, Foursquare, and Groupon,[3] a practice that Amazon is also accused of.[4] These practices have raised regulatory concerns over the lack of a level playing field, and the possibility that they lead to dominant positions (Eisenmann et al., 2011), which has led to specific regulations in some countries. In February 2019, India forced the separation of platforms and their own marketplaces.[5] In the US, the Ending Platforms Monopolies Act includes provisions with similar objectives.

Although acquisition and imitation of complementors have attracted significant attention from policymakers and researchers, the focus has been on investment or pricing but, to our knowledge, little attention has been paid to the impact on the set of usage restrictions that platforms implement on their products (i.e., openness). Since openness influences the quantity and quality of services offered to users and developers, its role is of utmost importance as it affects the very core of digital services. In fact, openness is a strategic variable that influences how platforms compete (see Huang et al., 2020), how the platform regulates its internal ecosystem (see Parker & Van Alstyne, 2018), or even how taxes are passed through (see Sanchez-Cartas, 2021). By opening a platform, its sponsor can spur growth by harnessing network effects or stimulating downstream production since third-party developers often have ideas that the sponsor has not considered, but it may increase competition and reduce the sponsor's ability to capture rents (Parker & Van Alstyne, 2018). Therefore, two questions of utmost relevance are: How do acquisitions and imitation affect platform openness, and what are the welfare implications?

To answer these questions, we propose a model based on Parker and Van Alstyne (2018). In this model, a monopoly platform makes a strategic decision regarding its level of openness, which refers to the extent to which the platform shares its core value with a third-party developer (complementor). The platform sponsor faces a

[1] Under this definition, a fully open standard corresponds to a completely open platform; in contrast, a software system where the sponsor has full control over the content and restricts access to unapproved applicants would be an example of a completely closed platform (e.g., early versions of Mac OS).

[2] https://dealbook.nytimes.com/2011/10/27/google-hits-new-ma-record/.

[3] https://slate.com/technology/2012/12/facebooks-poke-its-snapchat-clone-is-a-bad-sign.html.

[4] https://www.reuters.com/investigates/special-report/amazon-india-rigging/.

[5] https://tcrn.ch/2TaSWAA.

trade-off between allowing the developer to use the open portion of the platform for content creation (such as applications) and imposing a tax on that content, or alternatively, directly monetizing the platform by selling it to users.

We depart from Parker and Van Alstyne (2018) model by introducing an initial stage in which the platform chooses between acquiring, imitating, or remaining independent (status quo). We analyze the new equilibria under acquisition and imitation and compare them with the status quo case to shed light on the incentives to acquire or imitate.

We show that platforms always have an incentive to integrate third-party complements and reduce openness. However, we also find that the possibility of imitating complementors mitigates this incentive. If acquisition is costly or not possible, imitation is preferred to the status quo. Interestingly, the model suggests that imitation always leads to higher levels of openness, which is welfare-enhancing. However, it also increases competition, which can harm the incentives to innovate from third-party developers. Although acquisitions and imitation have generated significant concerns among policymakers, we find that prohibiting one or the other may exacerbate current problems. On the one hand, prohibiting imitation may increase the number of acquisitions, which reduces openness and welfare. On the other hand, prohibiting acquisitions may hurt third-party developers and discourage them from entering platforms, which harms innovation in complementary markets.

The paper is organized as follows. In Sect. 2, we introduce the Parker and Van Alstyne model. In Sect. 3, we analyze how acquisition and imitation influence openness, profits, and welfare, and the platform incentives to adopt one of these strategies. In Sect. 4, we conclude.

2 Acquisition model preliminaries

In contrast to price competition, non-price dimensions pose an additional challenge as their boundaries are less clear. The concept of openness serves a great example. For some readers "the set of restrictions on participation (or development)" may have physical connotations, such as the extent to which the platform is freely accessible and modifiable at a given moment (which we call "static openness" and is represented by $\alpha \in [0, 1]$ in this work), the period granted to developers to access some platform tools without restrictions (which we call "dynamic openness" and is represented by $\delta \in [0, 1]$ in this work), or even a combination of these two. Since openness can have different meanings depending on the context, we use these two definitions for the purpose of this paper.

Moreover, we adopt the Parker and Van Alstyne (2018) model and terminology to facilitate the reading of the results, as this model has recently become a standard in the analysis of openness in multi-sided markets and also uses these definitions. In the following subsections, we present the basic model and the simplifications made to address acquisition and imitation.

2.1 The Parker and Van Alstyne (2018) model

The model comprises two stages in which a developer, a user, and a platform interact. The model assumes that the user has a uniform value v for developer output (apps) and a uniform value V for the platform, which is also the value of the platform for the developer. In the first stage, the platform sponsor partially opens its technology and offers a take-it-or-leave-it contract to the developer, who can only choose to participate or not. Consequently, the developer can use a fraction (σV) of the total platform value (V) freely. In other words, the platform decides whether to sell the platform for V or share a proportion σV freely with the developer, in which case platform sales fall to $(1-\sigma)V$. The implicit assumption is that the sponsor forgoes sales of the "free" resource by choosing an open innovation scheme. For example, Microsoft Office has an API that is free for developers to create applications. This part of MS Office is given away for free, but there is an important part that is not open, and users have to pay to use it.

The developer produces output (apps or content) using platform open resources (σV). By extending these open resources, the developer produces more output, sells it to users, and shares revenues with the platform. Specifically, σV is used to produce output following a Cobb–Douglas production function, $y = k(\sigma V)^{\alpha}$, where k is the re-usability parameter, and α represents the diminishing returns of the technology. The output of the first stage is $y_1 = k(\sigma V)^{\alpha}$. At the end of this stage, the platform absorbs all output created by the developer and integrates it into the platform. In the second stage, the platform sponsor stimulates its ecosystem by giving away new resources based on what was absorbed in the previous stage. The developer again creates output using these new resources and shares revenues with the platform. The output of the second stage is $y_2 = k(y_1)^{\alpha}$. Innovations are recursive, they are generated on top of previous innovations. By contrast, if the sponsor chooses a closed platform, then the developer produces nothing.

Note that in the first stage, the user adopts the platform but has the option to purchase content from the developer either during the first stage or wait until the second stage. Although the user values each unit of the developer's output at v, the user can wait until the second stage, when the first-stage output is free (it is bundled with the open part of the platform). Therefore, the user is not willing to pay more than the difference between the output value in the first stage (v) and the discounted value of waiting for the second stage (δv, where δ is the discount parameter). The maximum price she is willing to pay is $p = (1-\delta)v$, which is the price set by the developer. Finally, the platform imposes a royalty on the developer's revenues. For simplicity, the model assumes the Nash bargaining solution, giving each party 50% as in Parker and Van Alstyne (2018).

Under these assumptions, the profits of the platform (Π) and the developer (π) are respectively

$$\Pi = V - \sigma V + \frac{1}{2}(vy_1 + \delta v y_2) \tag{1}$$

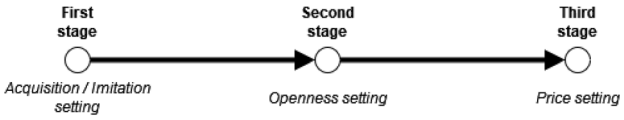

Fig. 1 Timing

$$\pi = \frac{1}{2}(vy_1 + \delta vy_2) \tag{2}$$

The platform faces a trade-off between foregoing sales and incentivizing third-party innovation on the platform or selling the platform as a stand-alone product. Examples of this duality can be found in many digital platforms where parts of the platform are freely accessible and others are only accessible by subscription, such as Google, Apple or Amazon. All of them offer services to developers that can be used to create content while selling services directly to users.

On the one hand, the platform must decide how many resources to give away. By giving away resources (higher σ), it increases the set of technologies on which the developer can innovate and, therefore, the more valuable the innovations in the second stage, the higher the royalties. However, not giving away resources allows the platform to monetize its technologies. On the other hand, it must set the length of the period to exploit the developer's innovations before they are integrated into the platform. The longer the developer maintains its innovations (lower δ), the more revenue the platform and the developer will earn in the first stage. In contrast, the sooner the technologies are absorbed, the sooner the developer can innovate upon the new set of tools, and the greater the value generated in the second stage.

2.2 Model extension. Acquisition and imitation

To address the role of acquisitions and imitation and keep the model simple, we adopt a "decaffeinated" version of it and make slight modifications to the timing. Unlike the original model where the platform sponsor simultaneously determines the optimal duration (δ) and extent of open resources (σ), we assume that the platform sponsor sets either one or the other. This assumption significantly simplifies our problem, enabling us to isolate and examine the individual effects of acquisitions and imitation on δ and σ. Regarding the new timing, it unfolds as follows: In the first stage, the platform has the option to either make an acquisition offer to the developer, imitate her, or maintain a neutral stance (status quo). In the second stage, the platform determines its degree of openness. Finally, in the third stage, the developer and/or the platform set the price for their respective outputs, see Fig. 1.

If the platform decides to make an acquisition offer, the developer can either reject it or accept it. If the developer rejects it, we converge to Parker and Van Alstyne's model. If the developer accepts the offer, the platform absorbs and integrates the developer. In the second stage, the platform sets the openness to maximize the profits of the merged entities and then sets the price p for the acquired content.

On the other hand, if the platform decides to imitate the developer, it will release a copycat of the developer's product. In this situation, platform payoffs are written as $\Pi^{cop} = V(1-\sigma) + \frac{1}{2}P_1Y_1 + P_2Y_2$, where $Y_1 = k_1(\sigma V)^{\alpha}$ and $Y_2 = k_2(\sigma V)^{\alpha}$ represent the developer output and the copycat output respectively and P_1 and P_2 represent the prices paid by the user. The developer faces the same production technology but now has a competitor. We maintain our previous assumption about the uniform value of the user for developer output (v_1) and now assume the user has a uniform value v_2 for copycat output. In the second stage, the platform sets openness to maximize the profits it earns from the platform and the copycat. In the third stage, the platform and the developer set prices for their products simultaneously. We assume both products are differentiated and such differentiation is represented by $d \in [0, 1]$, where $d = 0$ represents independent products and $d = 1$ perfect substitution. Finally, if the platform sponsor decides to keep the status quo, the model converges to the Parker and Van Alstyne model.

3 Equilibrium analysis

Consider the simplified version of Parker and Van Alstyne (2018) model in which the platform chooses the optimal duration (δ) or the level of open resources (σ).[6] Suppose the platform is interested in entering the developer market and is considering two options: either the platform acquires the developer or imitates it by launching a parallel service.

3.1 Equilibrium with static openness (σ)

As noted in the Introduction, both the acquisition and imitation of complementary products have raised significant concerns. However, it is not clear which outcome, if any, is better from a social point of view. It is convenient to see first what is the optimal level of static openness (σ) if the platform and the developer coexist (status quo). In this scenario, the platform faces the trade-off between profiting from selling the platform to the user, $(1-\sigma)V$, or opening it up to allow the developer to innovate, σV. Formally, the platform chooses the level of σ that maximizes Eq. (1).

Lemma 1 *If the developer and the platform coexist* (*status quo*), *the platform sets* $\sigma^* = \left[\frac{\frac{1}{2}vk\alpha}{V}\right]^{\frac{1}{1-\alpha}}$, *platform profits are* $\Pi^* = V - \left[\frac{1}{2}vk\alpha\right]^{\frac{1}{1-\alpha}} + \frac{1}{2}vk\left[\frac{1}{2}vk\alpha\right]^{\frac{\alpha}{1-\alpha}}$ *and developers profits are* $\pi^* = \frac{1}{2}vk\left[\frac{1}{2}vk\alpha\right]^{\frac{\alpha}{1-\alpha}}$.

Proof Beginning from Eq. (1), calculate first-order conditions on platform profit with respect to σ as follows: $\frac{\partial \Pi}{\partial \sigma} = -V + \frac{1}{2}vkV^{\alpha}\alpha\sigma^{\alpha-1} = 0$. To establish the results

[6] We address the case of optimal duration in the appendix, since its results show that the main ideas do not change when considering one variable or the other.

of Lemma 1, rearrange terms in the previous equation and substitute in Eqs. (1) and (2). Note that $\frac{\partial^2 \Pi}{\partial \sigma^2} < 0$. Thus, solving first-order conditions provides a global maximum. □

This case represents the status quo and is the same as in Parker and Van Alstyne (2018) when δ is fixed, and serves as a benchmark. Let us turn to the case in which the platform acquires the developer. In this situation, the platform pays a lump sum (L) to the developer and fully integrates the service. Thus, the platform can sell the platform and the new service to the user. Note that the platform has no interest in opening the platform, as it implies reducing its profits (there is no active developer selling to the user). Therefore, the equilibrium is $\sigma^{acq} = 0$, platform profits are $\Pi^{acq} = V + vkV^{\alpha} - L$ and the developer earns L.

Consider now that the acquisition and the status quo are possible. For the developer to be indifferent between the acquisition and the status quo scenario, the lump sum payment should be at least $L = \pi^*$. If we compare the profits of the platform in both scenarios, we see that $\Pi^* < \Pi^{acq}$ when $L = \pi^*$.

Proposition 1 *When considering static openness, platforms always have the incentive to integrate complementors*, $\Pi^* < \Pi^{acq}$.

Proposition 1 highlights that, when platforms set openness levels to orchestrate their ecosystems, there is always an incentive to integrate complementors. This result always holds due to the simplifying assumptions of this model (frictionless acquisition). However, if we assume that there may be other costs associated with integration, this result may not always hold. In other words, the platform prefers integration in the absence of friction. Intuitively, by acquiring the complementor, the platform removes the trade-off between forgoing sales and incentivizing third-party innovation. By integrating the developer's content with its own, the platform gains the ability to offer the platform and the developer's innovations as a bundled package, leading to increased profits.

Although acquisitions are commonplace in digital markets, imitation is also frequent. This is a common complaint from third-party developers about platform companies, who imitate what is successful on their platforms, often decimating third parties in the process.[7]

Suppose that the platform has the opportunity to launch a new service (a copycat) that makes use of the same open resources. In this situation, platform payoffs are written as $\Pi^{cop} = V(1-\sigma) + \frac{1}{2}P_1 Y_1 + P_2 Y_2$, and the developer faces a competitor. Starting from the third stage, if the platform sponsor and the complementor set prices simultaneously, the equilibrium price is

$$P(v_1, v_2) = \begin{cases} v_i - dv_{-i}, & \text{if } v_i - dv_{-i} > 0 \\ 0, & \text{otherwise} \end{cases} \tag{3}$$

[7] https://hbr.org/2019/06/when-tech-companies-compete-on-their-own-platforms.

If $d = 0$, products are independent; if $d > 0$, products are substitutes and, the higher the d, the stronger the competition.[8] Moving to the second stage and substituting in the profit function, the optimal static level of openness is given by the following lemma.

Lemma 2 *If the platform launches a complementary service to compete with the developer, the platform sets* $\sigma^{cop} = \frac{\left[\left(\frac{1}{2}P_1k_1+P_2k_2\right)\alpha\right]^{\frac{1}{1-\alpha}}}{V}$.

Proof In the same way as in Lemma 1, if we follow the same steps but using Π^{coop} instead of Π (Eq. 1), we arrive at the result expressed in Lemma 2. □

Lemma 2 shows that the platform faces a trade-off. The new complement (copycat) incentivizes a higher openness level because this product generates extra revenues, but there is a countervailing effect because competition reduces revenues. To determine whether openness increases or decreases, we need to compare when it is profitable to imitate the developer and how openness reacts. In Fig. 2, we show the conditions that makes imitation profitable for the platform in blue ($(\frac{1}{d} - \frac{v_1}{v_2}) > \frac{k_1}{k_2}$ and $\frac{1}{d} > \frac{v_1}{v_2} > d$), and the cases when openness is reduced in light brown, ($\frac{k_1}{k_2}\frac{d}{2} > 1 - d\frac{v_1}{v_2}$). As we observe, these two areas never overlap.[9] In other words, openness always increases after imitation ($\sigma^{cop} > \sigma^*$).

Lemma 3 *The platform increases openness if it imitates a complementor.*

A priori, it seems that more openness will always benefit the developer. However, it depends on the level of competition in the complementary market. If we compare developer profits with and without the platform complement, after some algebraic manipulations, we have a sufficient condition that guarantees the profitability of being imitated, $\frac{1}{d} > \frac{v_1}{v_2} > 2d$. This condition is met when differentiation is high enough (small d) and the platform's value proposition is not too high ($v_1/v_2 \leq 1$). Intuitively, developers can benefit from platforms launching their own complements when differentiation is high enough, as differentiation insulates the effects of competition and developers can benefit from greater openness.

In Fig. 3, we compare the cases with higher levels of openness (light brown), increases in developer profits (green) and platform incentives to imitate (blue). The overlap of these three areas highlights when imitation leads to greater openness and platform and developer profit from it. Interestingly, the degree of overlap depends on the ratio k_1/k_2, which represents how many extra units of output the developer can generate with respect to the platform using the same inputs. As the graphs suggest, when this ratio goes up, the platform prefers to avoid imitating. In other words, the incentive to imitate decreases with the developer's ability to produce more output.

[8] We assume that $\frac{1}{d} > \frac{v_1}{v_2} > d$, which guarantees that demands are well-behaved.

[9] More generally, these areas never overlap for all $\frac{k_1}{k_2}$. Graphs and code are available upon request.

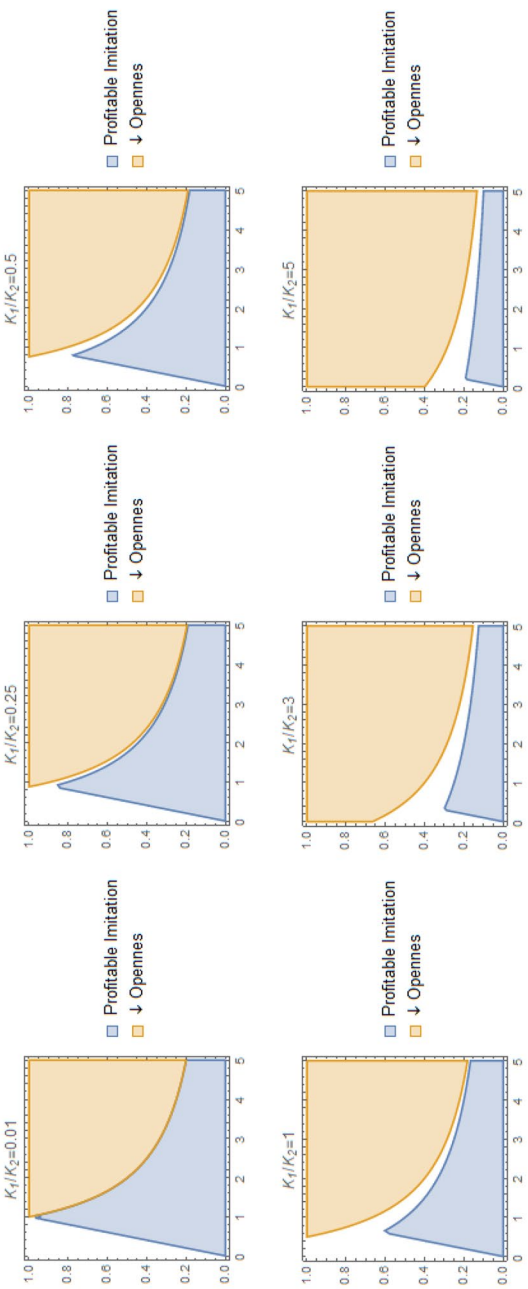

Fig. 2 Vertical axis: differentiation, d. Horizontal axis: ratio of intrinsic values, v_1/v_2. In blue, platform incentives to imitate. In light brown, cases with lower openness levels than status quo. Each graph represents different ratios of technologies, k_1/k_2

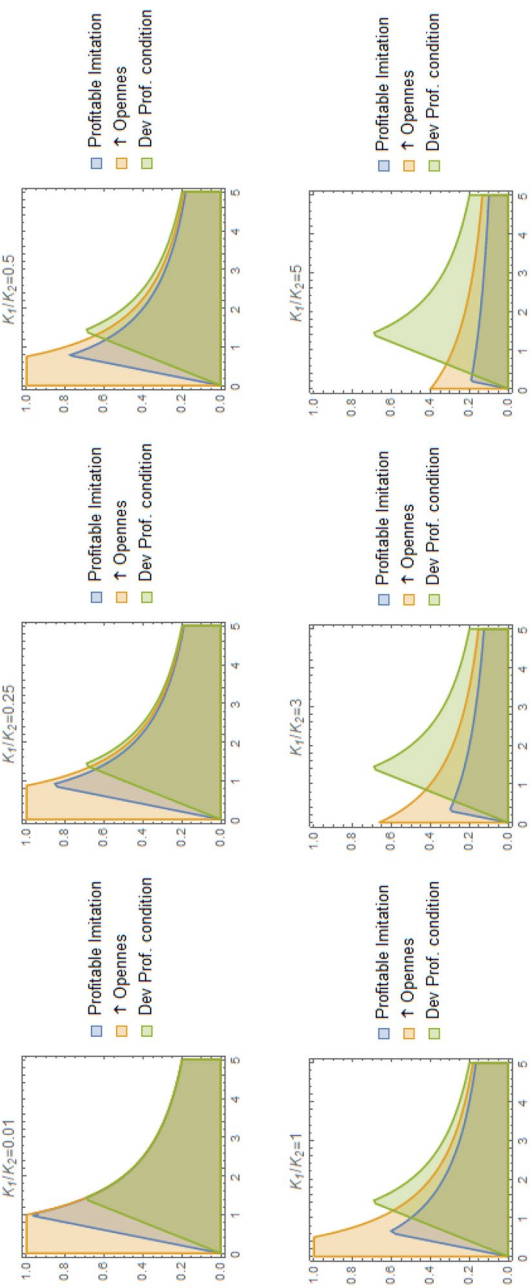

Fig. 3 Vertical axis: differentiation, d. Horizontal axis: ratio of intrinsic values, v_1/v_2. In blue, platform incentives to imitate. In light brown, cases with higher openness levels than status quo. In green, when imitation increases developer profits. Each graph represents different ratios of technologies, k_1/k_2

Table 1 Summary of cases when the platform launches a copycat

Comparison of cases	Openness is higher with competing complements ($\sigma^{cop} > \sigma^*$)	Openness is lower with competing complements ($\sigma^{cop} < \sigma^*$)
$\pi^{cop} > \pi^*$	Win–Win case	Not possible
$\pi^{cop} < \pi^*$	The developer is worse off	Not possible

Therefore, we can conclude that imitation generally results in increased levels of openness. However, the impact on developers is not always positive, as the net effect depends on factors such as the level of differentiation between the developer and the platform, as well as the platform's value. In fact, imitation can potentially decrease developer profits while increasing platform profits. Those are the cases where the blue area does not overlap with the green areas in Fig. 3.

As a summary, Table 1 highlights the possible scenarios and points out that imitation may lead to a win-win situation for all players. Prohibiting or limiting imitation may generate a loss of potential profits for third parties, as well as a change in the incentives that might lead platforms to acquire complementors, which may not always be desirable. In other words, a nuanced approach is needed.

Finally, let us move to the first stage. The platform can acquire the developer, release a complement, or maintain the status quo. We already know that acquisition always dominates the status quo and launching a complementary service dominates the status quo in the blue region of Fig 3. However, if we compare platform profits between acquiring or launching a complement, we observe that only if the intrinsic value of the platform is high enough (V), the acquisition could be dominant. In any other case, it depends on whether the higher value proposition of the integration dominates the expansion market effect of launching a complementary service.

Proposition 2 *Acquiring is always profitable for the platform. Imitation is not. However, when launching a complement in the developer's market is profitable, the acquisition incentive can be mitigated.*

This result provides an alternative explanation to the coexistence of acquisitions and imitations, and it could explain why some digital companies, such as Amazon, even when they have had sufficient resources to acquire complementors, have preferred to launch their own complements. In some cases, acquisitions do not increase the intrinsic value of the platform and make more sense to imitate, as with apparel. On the one hand, the model highlights that acquisitions are always better for the platform than maintaining the status quo. However, this model also assumes that there is no friction in acquisitions, but this may not always be true. For example, the platform may require specialized developer expertise, leading to higher acquisition costs and potentially hindering a merger, which, in turn, may encourage the emergence of imitations.

On the other hand, launching an additional complementary product is not always profitable and some conditions must be met. As discussed previously, the release of

these complements may have adverse effects on developers (or third-party companies). However, if imitation increases openness, it can generate a win-win situation for all players. This is probably what we have observed on digital platforms such as Steam or Epic Games Store, where platforms have published their own titles while releasing tools that have favored the ecosystem. Another reading of these results is that prohibiting or limiting the ability to copy these complementary products could hurt third-parties. This harm may have repercussions beyond what this model shows. For instance, if developers expect platforms to imitate them, they may refrain from entering the market, which can limit innovation and harm consumers. In this regard, prohibitions such as those imposed in India in 2019 could have mixed effects. Therefore, a nuanced approach is needed to regulate these practices, as a one-size-fits-all policy seems implausible.

3.2 Welfare analysis

So far, we have addressed the optimal platform decision and how that affects the developer and market outcome. However, we did not mention how those changes in the market translate into changes in welfare. Depending on whether we assume the platform launches its complement, we have

$$W(\sigma) = \begin{cases} V + (v_1 - dv_2)k_1(\sigma V)^{\alpha} + (v_2 - dv_1)k_2(\sigma V)^{\alpha}, & \text{with platform complement} \\ V + v_1 k_1(\sigma V)^{\alpha}, & \text{otherwise} \end{cases} \tag{4}$$

If we solve for the level of openness that maximizes welfare (σ^w), it is direct that $\sigma^w = 1 > \sigma^{cop} > \sigma^* > \sigma^{acq}$. Therefore, acquiring the complement may help to integrate the product and increase the value for consumers, but it may mean that openness is reduced, which reduces welfare. In contrast, the coexistence of platform and developer generates welfare levels closer to the social optimum. In this sense, it seems that imitation may be socially preferred to the status quo, even though some third parties may be harmed. From this perspective, it seems that imitation should be less of a concern than acquisition. As the previous section pointed out, it is possible that the launch of a new complement increases openness and, at the same time, increases developer profits. This is a situation that is welfare-enhancing and a Pareto improvement. However, a nuanced approach is needed because excessive imitation can harm third parties beyond what is shown in this model (it can reduce innovation, for example).

Proposition 3 *Imitation is preferred to acquisition from a social point of view and, in some cases, may be a Pareto improvement.*

In line with Furman et al. (2019), non-price variables influence welfare and the incentives to acquire or compete. These results call for stricter oversight of acquisitions as they reduce welfare, while a more lenient approach is recommended for cases of imitation. However, a *laissez faire* approach to imitation is also not recommended because it may reduce developers' incentives to innovate.

4 Discussion and conclusions

What are the consequences of acquisition/imitation for the openness of digital platforms? If society strives for more open platforms, should it allow acquisitions or imitations of small developers by large platforms? Although the debate on whether or not greater openness is desired is far from closed, some players have positioned themselves in favor of open digital platforms, such as the European Union.[10] In this regard, it is important to understand how competition policy can influence the achievement of this objective. A strict merger policy may limit the acquisition of small developers and encourage imitation, while a lenient merger policy may lead to excessive levels of acquisitions. It is crucial to recognize that competition policies in digital markets can have an influence beyond prices and investment. In this sense, these policies can contribute to other societal goals, such as privacy or openness. However, the role and impact of those non-price variables are less understood.

This work studies the impact of acquiring or imitating a complementary service on platform openness. We consider a simplified version of Parker and Van Alstyne (2018), in which a platform decides the extent to which it allows a developer access to the platforms' core technologies (openness), the developer uses those technologies to create content, and the user consumes the output created by the developer and the platform.

We find that the platform always has an incentive to integrate third-party complements but the possibility of imitating complementors and competing with them mitigates this incentive. We also show that acquisitions lead to lower than optimal levels of openness and imitation favors higher levels. However, although imitation appears to be socially desirable, it can be detrimental to third-party developers, which may discourage innovation. Thus, prohibiting or limiting acquisitions may improve welfare in some circumstances, but risks harming third-party developers. On the other hand, prohibiting or limiting imitation may exacerbate the acquisition problem, leading to lower levels of openness and welfare.

This work offers an initial exploration of acquisitions and imitation from a non-price perspective but does not fully address the complexity of the problem, including competition among platforms. One of the next steps will be to address how competition between and within platforms influences openness and welfare. In addition, we do not address how bargaining between developers and platforms may influence openness, which has also recently become a key point of concern. In our model, we assume a Nash bargaining solution in which each party shares 50% of the outcome. At the time of writing, Amazon, Apple, Steam and other major platforms charge around 30%. However, there is evidence of platform fees ranging from 2% to 70%, suggesting that the 50% split is a reasonable approximation.[11] Nonetheless, it would be interesting to introduce another stage for bargaining to understand how it may affect these results. Similarly, another limitation of the model is that the output value of the developer and the platform are

[10] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52016DC0288 &from=EN.

[11] https://abovethecrowd.com/2013/04/18/a-rake-too-far-optimal-platformpricing-strategy/.

independent, but it is likely that the better the platform, the better the applications on it. This approach leads to a different (but more complete) model in which platform quality plays a key role, which also raises an interesting line for future work.

5 Appendix: Equilibrium with dynamic openness (δ)

Consider now the alternative case in which the platform establishes the period that developers are entitled to retain their intellectual property (IP) when they have created content with the platform's tools (which we call "dynamic openness" and is represented by δ). As we did in Sect. 3, it is convenient to see first what is the optimal level of dynamic openness if platform and developer coexist. In this scenario, the platform faces the trade-off between profiting from first-period output or second-period output. Formally, the platform chooses the level of δ that maximizes Eq. (1).

Lemma 4 *If developer and platform coexist, the platform sets* $\delta^* = \frac{1}{2}\left(1 - \frac{Y_1}{Y_2}\right)$, *platform and developer profits are* $\Pi^* = \pi^* = \frac{Y_1}{2Y_2}\left[\frac{Y_2+Y_1}{2}\right]^2$

Proof Beginning from Eq. (1), calculate first-order conditions on platform profit with respect to δ as follows: $\frac{\partial \Pi}{\partial \delta} - \frac{vk(\sigma V)^{\alpha}}{2} + \frac{vk^{1+\alpha}(\sigma V)^{\alpha^2}}{2} - vk^{1+\alpha}(\sigma V)^{\alpha^2}\delta = 0$. To establish the results of Lemma 4, rearrange terms in the previous equation. Note that $\frac{\partial^2 \Pi}{\partial \delta^2} < 0$. Thus, solving first-order conditions provides a global maximum, δ^*. If we substitute δ^* in Eq. (2), we have Π^* □

Interestingly, when considering dynamic openness, the interest of the platform and the developer are aligned. Both are interested in keeping a balance between current and future profits. Let us turn to the case in which the platform integrates or acquires the developer. As in the previous case, the platform pays a lump sum (L) to the developer and fully integrates it. In this situation, there is no need to establish a period of IP protection, as the platform controls the core and the complement in both periods. Thus, the platform sets $\delta = 1$, it pays L to the developer, and platform profits are $\Pi^{acq} = v(Y_1 + Y_2)$. It is direct to show that, to leave the developer indifferent, $L = \pi^*$ and, if acquisition is possible, it is always profitable for the platform to acquire the developer ($\Pi^{acq} - L > \Pi^*$).

Lemma 5 *Platforms always have an incentive to integrate complementors in this framework.*

Let us turn to the case in which the platform can launch its own complement. In this case, we assume the platform launches its complement in the second period; thus $P_1 = v(1 - \delta)$ but, in the second period, we maintain the same assumptions regarding the equilibrium price as in Eq. (3). Formally:

$$P(v_1, v_2) = \begin{cases} (v_i - dv_{-i})(1-\delta), & \text{if } v_i - dv_{-i} > 0 \\ 0, & \text{otherwise} \end{cases} \tag{5}$$

Therefore, platform payoffs are written as $\Pi^{cop} = V(1-\sigma) + \frac{1}{2}P_1Y_1 + \delta\frac{1}{2}P_1Y_{1,2} + \delta P_2Y_2$, where $Y_1 = k_1(\sigma V)^{\alpha}$, $Y_{1,2} = k_1(Y_1)^{\alpha}$, and $Y_2 = k_2(\sigma V)^{\alpha}$. In this scenario, the optimal dynamic level of openness is given by the following lemma.

Lemma 6 *If the platform can launch a complementary service to compete with the developer, the platform sets* $\delta^{cop} = \frac{\delta^* + \theta}{1+2\theta}$, *where* $\theta = -\frac{dv_2}{2v} + \frac{(v_2 - vd)Y_2}{vY_{1,2}}$.

Proof In the same way as in Lemma 4, if we follow the same steps but using Π^{coop} instead of Π (Eq. 1), we arrive at the result expressed in Lemma 6. □

After some tedious algebraic manipulations, it is straightforward to show that releasing a competing complement increases the period of protection granted to developers ($\delta^* > \delta^{cop}$). Interestingly, this may not always benefit the developer. On the one hand, a longer protection period increases prices in period one, but delays the second period and its potential revenues.

We can turn to the case in which the platform can acquire or launch its own complement. As was the case with static openness, it is direct to show that the platform always prefers to acquire rather than maintain the status quo ($\Pi^{acq} - L \geq \Pi^*$). However, imitation is only profitable under specific parameters. If we consider the option of acquiring or launching a complement ($\Pi^{acq} - L \geq \Pi^{cop}$), we observe that it is possible to find values for which this condition can be fulfilled or violated. Therefore, we find a conclusion similar to that of Proposition 2. In this sense, it seems that our previous insights hold regardless of whether we consider openness as a static or dynamic phenomenon. In summary, there is an incentive to acquire the complementor, imitation leads to greater openness and may be more profitable depending on the characteristics of the market, but it does not imply that developers are better off. Similar insights as those of Sect. 3. If we now turn back to welfare, we have that

$$W(\delta) = \begin{cases} V + v_1(1-\delta)Y_1 + \delta(1-\delta)[(v_1 - dv_2)Y_{1,2} + (v_2 - dv_1)Y_2], & \text{with platform complement} \\ V + v_1(1-\delta)[Y_1 + \delta Y_{1,2}], & \text{otherwise} \end{cases} \tag{6}$$

Solving for the welfare-maximizing level of dynamic openness (δ^w) shows that the social level of welfare is the same as that chosen by the platform when coexisting with the developer or launching its own complement ($\delta^* = \delta^w$ and $\delta^{cop} = \delta^w$). This result highlights that, from a dynamic point of view, the platform and the social planner share the same interest; therefore, it is the static openness that should raise more concerns.

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