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Denial of interoperability and future first-party entry [☆]

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ABSTRACT

Motivated by a recent antitrust case involving Google, we develop a rationale for foreclosure when the owner of an essential input is not yet integrated downstream. Our theory rests on data-enabled network effects across periods. If a platform considers offering a first-party app in the future, by not allowing a third-party app to be hosted on its platform, it ensures that the third-party app would be a weaker competitor to its own app in the future. This makes denial of access attractive as a full or partial foreclosure strategy, which is costly in the short term but may be beneficial in the long term. We also study the effects of policies such as compulsory access or data-sharing, showing under which conditions they might be beneficial to consumers or backfire.

1. Introduction

In 2021, the Italian Competition Authority (ICA) found that Google had behaved anti-competitively because it had denied Enel X's app JuicePass – an app providing functionalities for recharging electric vehicles – access to Android Auto.[2] What is striking in this antitrust case (which is described in more detail in Section 2) is that Google itself at the time did not offer the same functionalities – although Google Maps has allegedly planned to incorporate some of them. This is therefore a very unusual case in which vertical foreclosure takes place without the owner of the input being integrated.

In this paper, we propose a theory of foreclosure that is motivated by this case. The main idea is that a platform that is considering future first-party entry in a downstream market may refuse interoperability to a third-party app in order to prevent the latter from acquiring data which would confer it a competitive advantage over the former. In particular, consistent with our motivating case –

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[2] The ICA's decision, dating from 13 May 2021, imposed a 102 million euro fine and an order to allow access. It was fully upheld by the TAR, Italy's court of first instance, in its Judgment n. 10147 of 18 July 2022. When quoting the Decision and the Judgment, the translations from Italian are ours.

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where usage data determine the future quality of the app – we assume that more users of an app today will imply higher utility for future users of that same app.

Our economic mechanism relies on data-enabled network effects and captures that the interaction with clients and users may allow a firm to be able to better interpret their needs and hence improve the quality of its products.[3] The same mechanism applies to standard network effects according to which future consumers benefit from current consumers' participation; see the discussion in Section 3. A similar mechanism may work on the supply side through learning by doing, whereby production costs fall with cumulative output. In the concluding section, we discuss related mechanisms based on consumer switching costs and a competitor's degradation of quality. The general idea that a firm may sacrifice profits in the present to gain a strategic advantage in the future is well known among IO economists; however, we look at the specifics of intertemporal demand-side linkages and the role of interoperability, which has not received much attention.

We show that the denial of interoperability involves a trade-off for the platform. On the one hand, it improves the (future) competitive condition of its first-party app, and hence it increases future profits. On the other, since the platform appropriates a share of the third party's profits, the denial reduces current profits. At equilibrium, denial of interoperability is more likely to occur, ceteris paribus, the lower the platform's share of third-party profits, the higher the mass of future consumers, and the stronger the network effect that early consumers exert on later ones.

We also investigate how the platform might react – and more generally how the equilibrium outcome changes – under different regulatory policies concerning interoperability and access to data. In our deliberately simple base model, where the platform's entry costs are assumed to be so small that first-party entry always occurs in the second period, denial of interoperability can take place only in the first period (because regulation rules out self-preferencing or because denial after entry with its own service increases the risk that the conduct is judged anticompetitive)[4] and all period-1 data are possessed by the third-party app, we show that a compulsory period-1 access policy is unambiguously beneficial to consumers.

Moving beyond the base model, when interoperability can be decided in any period or when first-party entry is costly, we find particular circumstances in which compulsory access policies might backfire. For instance, antitrust agencies and courts typically accept that a dominant firm may not grant access at all, but they prohibit denying access once it has been given. We show that this policy may backfire, leading the dominant firm to not give access from the beginning. When first-party entry is costly, denial of interoperability in period 1 may increase expected first-party profits, thereby facilitating the entry of the platform's first-party app. Under some conditions, the availability of the first-party app may be more beneficial to consumers than the non-availability of the third-party app in the first period.

Regarding the effects of compulsory data sharing with competitors, we find that if users' data are possessed by the platform, a data-sharing policy is beneficial: it makes third-party app entry more likely (because its expected profits increase with shared data) without triggering a denial of interoperability. If instead users' data are possessed by the third-party app, a data-sharing policy gives rise to a trade-off: on the positive side, if third-party entry occurs, the app will be given access (whereas without the policy it might be denied); on the negative side, third-party entry is less likely to occur, since the complementor's expected profits are lower because in period 2 it will have to compete equally with the platform's app.

Our proposed mechanism (and variants thereof) has applications beyond the Google v. Enel X case, as we discuss at various instances in the paper including Section 6.

Related literature Our paper contributes to the literature that studies incumbent firms' exclusionary strategies, and more particularly vertical foreclosure – see Fumagalli et al. (2018) for a discussion of this literature. Our main contribution in this context is twofold. First, we show that a firm which owns a necessary input (in our case, access to a platform) may deny access even when it is not yet vertically integrated, as a way to improve the *future* competitive position of its subsidiary (in our case, a first-party app). Our theory is based on intertemporal demand linkages arising from data-enabled intertemporal network effects.

Second, while in many vertical foreclosure models (think, e.g., of Ordover et al., 1990) the incumbent needs to commit to a particular action, for example, refusal to supply, to deter or marginalize entry – and if entry did take place, the incumbent would have the incentive to rescind its choice — here the denial of interoperability can be an equilibrium decision even when the entrant is already in the market. Other papers where an ex-post incentive to deny or degrade the input, or its interoperability, are Allain et al. (2016) and the network-effect model (but not the fixed-cost one) in Fumagalli and Motta (2020).

We provide a mechanism in which market structure can change over time and thus speak to the dynamic foreclosure theory of harm first proposed by Carlton and Waldman (2002) in the shape of tying of complementary products and then applied by Fumagalli and Motta (2020) in a vertical setting. In those papers the incumbent is integrated, and its objective when foreclosing is to preserve its monopolistic position in the primary (or upstream) market.[5] Here instead, the objective is to improve its competitive position in a market which it has not yet entered. Since this objective is achieved by refusing interoperability to the third-party app and thereby

[3] For instance, in the *General Electric/Alstom* merger case, a key ingredient for innovation appears to be the number of servicing contracts, as the interaction with customers provides opportunities and ideas for improving the quality and performance of gas turbines. As a result, the EC imposed a remedy whereby the buyer of the turbines, divested from the merging parties, should also have a sufficient number of servicing contracts, without which it would not have had the ability to compete.

[4] The Digital Markets Act in the European Union contains various provisions against self-preferencing. Also, in the EU General Court's decision on Google Shopping (Case T-612/17), the Court finds that a change of conduct after the platform's entry with its own service is relevant to establish that the practice is anticompetitive. Also, the U.S. Supreme Court used a "change of conduct" criterion in its reasoning in Trinko (540 U.S. 398 (2004)).

[5] In a similar vein, Motta (2023) proposes a simple model inspired by the Facebook v. FTC case where the upstream monopolist is not integrated and it also excludes a complementor in order to preserve its upstream position.

denying it data-enabled network effects, our mechanism might be interpreted as "raising rivals' costs" (or "reducing rivals' scale"), in the spirit of Salop and Scheffman (1983), Ordover et al. (1990) and the following vast literature.[6] Our mechanism is related to, but different from the predation mechanism formalized by Cabral and Riordan (1997) in a two-period model.[7] They call the incumbent's action predatory "if (1) a different action would increase the likelihood that rivals remain viable, and (2) the different action would be more profitable under the counterfactual hypothesis that the rival's viability were unaffected. In other words, a predatory action is unprofitable but for its effect on a rival's exit decision." (Cabral and Riordan, 1997, p. 160) By contrast, in our base model, the rival's viability is not at stake, but the competitive constraint faced by the integrated firm depends on its initial action.

Our paper also contributes to the literature on network effects and incumbency advantage. Biglaiser et al. (2019) review this literature and indicate reasons as to why an installed firm (in our analysis the complementor when the platform does not deny access) enjoys an incumbency advantage, which they define as "the fact that an incumbent, that is, a firm already with an installed base, will be able to generate higher profits than a new firm (an entrant) even if the entrant offers identical terms to consumers..." (p. 41) More specifically on data network effects, de Cornière and Taylor (2020) explain how the use of data can improve product quality from which future consumers will benefit and thus create an incumbency advantage. Data-enabled network effects also arise when more user data reduce the marginal cost of quality improvements, as postulated and analyzed by Prüfer and Schottmüller (2021). Hagiu and Wright (2023) address "data-enabled learning", which encompasses data-enabled network effects, and analyze dynamic competition when superior access to data gives an incumbency advantage. Data can also operate on the supply side. Learning by doing through data can make a firm more competitive when data enables firms to make a better choice between alternative production techniques (Farboodi et al., 2019); for earlier work on dynamic competition according to which learning-by-doing can reduce a firm's production cost, see, e.g. Cabral and Riordan (1994). Different from all these works, in our model, the platform can deny the complementor early market access and thereby deprive it of the subsequent quality increase that would stem from data-enabled network effects.

More generally, our paper connects to the work on platform governance (Belleflamme and Peitz, 2021, Chapter 6; Teh, 2022) and a platform's decision to add first-party offers. In terms of timing, this is the reverse strategy of a firm that becomes a platform by hosting third-party offers (see Hagiu et al., 2020). Prominent empirical work on subsequent first-party entry is provided by Wen and Zhu (2019) and Zhu and Liu (2018). Of particular concern have been imitation strategies by platforms that may marginalize existing third-party offers and may gain competitive advantages from being partially vertically integrated. In response, third-party sellers may adjust their offerings to inhibit platform learning (Jiang et al., 2011) or reduce the likelihood of first-party entry (Lam and Liu, 2020) or they may reduce investments in the case of lower expected profits. This issue has gained prominence around the economics of hybrid platforms and self-preferencing; in particular, Madsen and Vellodi (2023) analyze the potential of data-usage regulation in this context.

Plan of the paper The paper continues as follows. In Section 2 we describe in some detail the Google v. Enel X case that inspired this paper. Section 3 presents the base model. In Section 4 we study when denial of interoperability may occur in equilibrium and analyze the effects of a compulsory access policy. In Section 5, we consider a few model extensions and, in Section 6, we discuss the broader applicability of our analysis and conclude.

2. The Google v. Enel X case

On 13 May 2021, the Italian Competition Authority (ICA) found that Google had abused a dominant position because it had denied Enel X (a subsidiary of Enel, the main energy company in Italy) the possibility of developing a version of its JuicePass app to be compatible with Android Auto, a feature of the Android OS that allows apps to be used safely while driving. JuicePass offered a series of functionalities for recharging electric vehicles, including searching for charging stations, reserving a place at them, managing and monitoring the recharge, as well as paying for it. At the time this took place, Google Maps was not offering any of these functionalities, with the exception of locating charging stations.

Google repeatedly denied Enel X the necessary tools for programming a version of JuicePass compatible with Android Auto, arguing among other things that templates for developing compatible apps were available only for media and messaging apps. The ICA notes that not only did Google's own apps, Google Maps and Waze, have a compatible version but also that Google had allowed certain developers to have "custom apps" (apps which could be developed without a template). It also notes that Google had offered Enel X to include some of its functionalities directly in Google Maps, an offer Enel X did not accept because the user would have interacted with Google Maps rather than with JuicePass, with the former thus appropriating crucial data, and because the user could not have access to the booking functionalities of JuicePass (ICA, 2021: para.169-170). Enel had also offered to carry out all the necessary investments for the development of a compatible app but Google replied that it was not possible to provide any further information in this regard and that, ultimately, the product managers were against expanding the types of apps present on Android Auto (TAR, 2022: p.11). Google also explained the denial with limited resources which would prevent it from developing templates

[6] In a sense, our paper is also related to those works which justify vertical foreclosure with imperfect rent extraction; this includes work on self-preferencing. If the platform was able to set contract terms able to extract (most of the) rents of the complementor, then it would likely not want to exclude it. But of course it is quite difficult to think of terms of access that allow the platform to absorb all future rents.

[7] For a model of predation in a context in which there may be not only supply-side, but also demand-side (network-driven) scale economies, see Fumagalli and Motta (2013).

for apps which are not considered a priority. However, the ICA and the TAR countered that Google could have asked Enel X to contribute to the development both financially and with technical resources, but never did so.[8]

Relevant to our discussion, the ICA found that between JuicePass and Google Maps, there was not only (limited) effective competition in that both apps allowed users to find charging stations, and more generally, competition for users' data, but also potential competition because of "Google's intention, highlighted in some documents acquired during the proceedings, to integrate into Google Maps the other functionalities currently covered by JuicePass".[9]

It is also worth noting that both the ICA and the Tribunal found that access to Android Auto is indispensable because it is essential for drivers to use the app without having to stop the car, as also confirmed by the full integration of the first-party apps Google Maps and Waze into Android Auto (TAR, 2022: p. 12).

Finally, the ICA and Tribunal stress that the refusal of interoperability has long-term consequences for the market: "Due to Google's rejection, the app JuicePass was excluded from the Android Auto platform throughout 2020 and early 2021 and, thus, at the beginning of the 2020-2025 period, in which significant growth was expected of sales of electric vehicles, which significantly limited the chances of market success of the product. In the context under consideration, in fact, the existence of network effects and winner-takes-all phenomena imply that the deferment of the availability of the JuicePass app on Android Auto was apt to prevent it from gaining an adequate user base to establish itself." (TAR, 2022: 13; see also ICA, 2021, e.g. at paragraphs 275 and 383).

In particular, the ICA emphasizes the importance of data as a necessary input for the improvement of the quality of the services offered and for the profiling of users and of their needs: "Since users are a source of data and data on searches for charging stations are of particular relevance for the analysis of the demand for charging services, Google's conduct has deprived and may deprive in the future Enel X Italia of the possibility of acquiring a valuable data flow to define its operations in the field of electric mobility and to improve the quality of its services." (ICA, 2021: 389; see also paragraphs 306-308).

3. A model with data-enabled network effects

Our analysis is motivated by the Google v. Enel X case at the Italian competition authority. We develop a theory of harm for Google's denial of access of Enel X's app to Google's app store when Enel X's app offered a functionality not offered by other apps, and identify the market environments in which there is consumer harm. Our reduced-form model is applicable to any situation in which a firm that has not yet integrated downstream may refuse access to an essential input to facilitate its own downstream entry in the future.

A firm P (Platform) operates a platform, which consumers can use to access the listed apps. Consumers do not intrinsically value the platform and can use an app only if they have access to the platform.

A firm C (Complementor) may enter with a new (third-party) app in one of two periods. In period $t = 1$, there is no other app with the same functionality. In period $t = 2$, the platform may enter its own version of the app (first-party app). Two groups of consumers (one in each period) who have so far not used the platform and would not derive any utility from any other apps are potentially interested in downloading C's app, or P's app if and when it is available.

In our analysis with reduced-form profit functions, we express equilibrium profits in the product market depending on the availability of apps in the two periods *gross of any payment from the complementor to the platform*. In period 1, only C may be active in the app market and we write its profit π_C^1 as a function of its app being available on the platform in this period. An app is only available on the platform in a given period if it has been developed *and* if it is admitted. The complementor makes monopoly profit $\pi_C^1(1) > 0$ if its app is available in period 1 ($x = 1$), while it makes zero profit otherwise ($\pi_C^1(0) = 0$ if $x = 0$).[10] We denote period-2 profits as $\pi_j^2(x, y_C, y_P)$, $j \in \{C, P\}$, where again $x = 1$ means that the third-party app was available on the platform in period 1 and $x = 0$ that it was not available; $y_C = 1$ means that the third-party app is available on the platform in period 2 and $y_C = 0$ that it is not; $y_P = 1$ means that the first-party app is available in period 2 and $y_P = 0$ that it is not. Thus, second-period profits depend on which apps are available on the platform and on the availability of the entrant's app in the first period. The availability of a competing app clearly affects the profits made from an app in the second period, but so may the availability of the third-party app in the first period. This is motivated by data-enabled network effects exerted from period-1 participation on period-2 attractiveness of the app, which can be seen as learning by doing that positively affects the inclination of consumers to use the app. Developing an app is costly; we denote the entrant's cost by F_C and the incumbent's cost by F_P.

Period-2 profits in the app market (gross of any payment from C to P) are assumed to satisfy the following properties: (i) $\pi_C^2(1, 1, y_P) > \pi_C^2(0, 1, y_P)$ because data collected from usage in period 1 positively affects the performance of the third-party app in period 2; (ii) $\pi_P^2(1, 1, 1) < \pi_P^2(0, 1, 1)$ because the third-party app's superior performance harms the platform's profits made from its

[8] At a later stage and with the investigation well under way, Google developed a beta version of a template for electric recharge, but Enel X chose not to enter the beta-testing process because of the lack of visibility of the app to users and because of uncertainty about the timing of the development of a standard version (ICA, 2021: para. 179).

[9] See TAR (2022: p. 9), and ICA (2021: e.g. at paragraphs 111-119 and 334-341).

[10] Since data collected in period 1 may be valuable in period 2, in general, C may set a period-1 price lower than the single-period monopoly price, as a lower price induces more consumers to buy the product and, thus, generates more data. However, C continues to set the monopoly price if either data-enabled network effects have faded out at the monopoly quantity or if there is full consumer participation. The latter holds in the two microfoundations developed below.

first-party app when the third-party app remains available in period 2[11]; (iii) $\pi_C^2(x,1,1) < \pi_C^2(x,1,0)$ and $\pi_P^2(x,1,1) < \pi_P^2(x,0,1)$ as competition from the competing app reduces profit.

Property (i) is a shortcut for network effects that period-1 consumers exert on period-2 consumers. Our two-period model can be interpreted as a model with two markets, one for period-1 consumers and one for period-2 consumers. These markets are linked through cross-market network effects as data collected from period-1 consumers affect the period-2 consumers benefit of the complementor's product. In this sense, our model fits within the broad framework of de Cornière and Taylor (2020). Under imperfect competition, property (ii) is a consequence of these network effects making the complementor stronger in period 2 and thereby reducing the profits of the platform when it enters with its own app in period 2. Absent the intertemporal link through data-enabled network effects, in our model, the platform would not have any incentive to deny access in period 1.

Network effects capture the idea that when using the app, individuals' attention and usage are converted into data which can improve the experience of future app users: think for instance of a searchable GIF app which can better predict which GIFs users prefer, or a marketplace which learns from richer consumer data accumulated over time leading to a better consumer experience, or a navigation app which can offer better solutions as it gathers information about how users move and how traffic is likely to develop.[12]

We assume that the platform has two sources of profits: profits from the first-party app and a fraction $\beta \in [0,1)$ of third-party profit. In the extreme case of $\beta = 0$, the platform provides free access to the third-party app. If we had $\beta = 1$, the platform would not leave any profit to the third-party app developer net of the payment. Given the advantage of the third-party developer, the platform would not have any incentive to enter with a first-party app since it extracts the full monopoly profit of the firm that makes use of data-enabled network effects. Thus, for foreclosure incentive to arise, it is essential that such full rent extraction is not possible and assume that $\beta < 1$ is given. The exogenous profit sharing is a shortcut for a revenue share (say 30%) to be extracted from the third-party app developer and negligible variable costs. We develop a simple analysis of the platform's incentives to deny third-party interoperability with its platform.

In the real world, platforms such as Amazon (on its market place) or Google and Apple (on the app stores of their respective mobile operating systems) set these shares to be uniform across a broad range of products or services. To the extent that the platform considers first-party entry in only a small subset of them, we can approximate this by considering the share to be exogenous (and be driven by considerations for products and services for which first-party entry is not a consideration).[13]

The game is as follows.

(1.1) Firm C decides whether to develop in period 1 at cost F_C. It will then ask for interoperability with the platform.[14]
(1.2) Firm P decides whether to allow period-1 interoperability between its platform and the third-party app, or deny it.
(1.3) Period-1 profits are realized.
(2.1) Firm P decides whether to spend F_P to create its first-party app.
(2.2) Firm P decides whether to allow period-2 interoperability between its platform and the third-party app, or deny it.
(2.3) Period-2 profits are realized.

We solve for the subgame perfect Nash equilibrium in the following section. For simplicity, in period 1, firms maximize the undiscounted sum of period-1 and period-2 profits. We note that the third-party app developed in period 1 can become available to consumers in period 2 only (after period-1 access has been denied).[15]

In the base model, we assume that the platform has to provide interoperability to the third-party app if it offers a competing first-party app. This is clearly the case if discriminating against the third-party app (which can be seen as an act of self-preferencing) is not permitted due to regulation or intervention by an antitrust authority.[16] We analyze the issue of period-2 interoperability in Section 5.1. In the base model, we also take platform entry with its first-party app in period 2 for granted. In other words, F_P and

[11] If the third-party app is not available in period 2, then period-1 entry does not harm the platform's profits made from its first-party app, $\pi_P^2(1,0,1) \geq \pi_P^2(0,0,1)$ where this holds with equality if the platform does not obtain access to the data generated by the first-party app.

[12] Alternatively, one may have traditional network effects where the utility of users increases directly with the number of users joining in the other period, provided that period-1 users stay around for two periods, do not care about period 2-users, and do not reconsider their period-1 decision in period 2; for example, period-1 users are experts who improve the experience of period-2 consumers who lack expertise. Ad revenues collected from users who make the app installation decision encompass ad revenues in both periods from these consumers.

[13] For a number of reasons, a platform may set β such that first-party app developers earn positive profits in equilibrium. For example, if fixed costs are private information of the developer, the platform will have to set a uniform fee within a category of apps and leave some rents to developers in order to attract a sufficient number of apps. If an app turns out to be particularly profitable, it may then have an incentive to develop a first-party app. Similarly, even if the information on fixed costs were publicly available after entry, the platform may prefer to commit to a uniform fee to avoid a hold up-problem that would arise if the platform adjusted its fee after first-party entry. Finally, a platform with discriminatory access fee may be in violation of competition law. Parameter β may also simply be seen as reflecting the bargaining power of the platform vis-à-vis the firm offering the third-party app.

[14] Firm C might enter in period 1 but the platform may make the app available to consumers only in period 2.

[15] In reality, the third-party app may attract a number of consumers even if the platform denies access and thus the effect of denial of first-period access may be less drastic – our analysis could easily accommodate such a situation.

[16] A related setting is one in which the platform cannot give access in period 1 and then deny it in period 2. This is in line with current case law in most jurisdictions, where *withdrawing* access is likely to be considered a violation of the law even if denying access may otherwise not be unlawful. The difference between the two settings is that a rule against self-preferencing or discrimination implies that the third-party app would make a profit $(1-\beta)[\pi_C^1(1) + \pi_C^2(1,1,1)]$ if admitted in period 1, but profit $(1-\beta)\pi_C^2(0,1,y^P)$ if denied access. If $F_C < (1-\beta)\pi_C^2(0,1,1)$ the complementor will enter in our setting, whereas the platform can deny access in period 2, conditional on doing so in period 1 and may therefore avoid third-party entry even if $F_C < (1-\beta)\pi_C^2(0,1,1)$ in the related setting.

β are sufficiently small that it always enters in period 2.[17] Taking first-party entry in period 2 for granted, the platform does not make any effective decision at stage (2.1) – we analyze the case of F_P taking any positive value and the platform's entry decision in Section 5.2.

To evaluate consumer harm, we assume a partial ordering of consumer surplus. Consumer surplus in period 1 depends on x, consumer surplus in period 2 depends on (x, y_C, y_P). As long as consumer surplus is not fully extracted in the first period, one has $CS^1(1) > CS^1(0)$, which is what we assume. For period-2 consumer surplus we assume that $CS^2(1,1,1) > CS^2(0,1,1) > CS^2(0,0,1)$; that is, given that the first-party app is available in period 2, consumers prefer the third-party app to be available in both periods to it being available in period 2 only, which in turn is preferred to it not being available at all. In our two examples below, we confirm this consumer surplus ranking.

Example 1. Horizontally differentiated apps and monetization through advertising To provide a concrete setting, we derive reduced profit as a function of users in a simple differentiated product model in which apps compete for consumer attention and monetize through advertising. The number of consumers (to be endogenously determined) who will download the apps in period 1 and period 2, respectively, are denoted by N_C^1, N_C^2, and N_P^2. For simplicity, we assume that the N_1^C consumers use the app only in period 1 and then disappear (or base their decision on whether to download only on the utility derived in period 1). Downloading an app has a positive but arbitrarily small cost, ϵ, which can be thought of as the opportunity cost of time for installing the app or the opportunity cost of storage space. The utility of one consumer (directly or indirectly) increases with the number of all other individuals who have used the app in the past: $U_j^t = v - \tau \mid \omega - l_j \mid + \gamma N_j^{t-1}$, with $t = 1, 2$, and $j \in \{C, P\}$. N_j^t represents the number of users of app j at time t; $N_j^0 = 0$ because any app cannot be available before time $t = 1$; $N_P^1 = 0$ because the first-party app can only be introduced in $t = 2$. Note that at time $t = 2$ consumers may use the app from either C or P if both are made available; v is the stand-alone utility of the app (that consumers experience under zero participation in the previous period), τ is a disutility parameter that measures how much consumers suffer from a mismatch (also called the transport cost parameter). The consumer type ω represents the preferred specification of the app for a consumer, $l_C = 0$ and $l_P = 1$ are respectively the "product specification" of the complementor's and the platform's version of the app, and γ is a parameter which measures the strength of network effects (for simplicity, we assume linear network effects). We assume that consumer preferences ω are uniformly distributed on the unit interval; there is mass $M^1 = 1$ of period-1 consumers and mass M^2 of period-2 consumers. Regarding the parameter values, we assume (in this and the following example) that $v \geq 2$ and $\gamma < \tau \leq 1$.

All firms monetize through advertising; thus, both apps are available for free and so is the use of the platform. Each user brings an advertising revenue of a. Platform and apps have zero variable costs (zero marginal cost for operations and maintenance). At the end of each period, advertiser revenues are realized. The complementor has to pay a fraction β of its ad revenue to the platform. Alternatively, when thinking about an ad-funded website being accessed through a search engine, the search engine may be able to directly monetize through advertising such that total ad spending is split between the search engine and the website.

This simple specification allows us to express profits as a function of primitives of the model (reported here gross of any payment from third-party developer to platform). Let us start with $\pi_C^1(1)$. In this case, C serves all period-1 consumers since $v - \tau > 0$ and its (gross) profit is $\pi_C^1(1) = a$. In period 2, if C entered and interoperability was denied in period 1, profits are $\pi_C^2(0,1,1) = \pi_P^2(0,1,1) = M^2 a/2$; if C did not enter, C makes zero profit and P makes $\pi_P^2(0,0,1) = M^2 a$. The remaining case is that C has entered and interoperability was allowed in period 1. In this case, C's app was installed by all period-1 consumers. Thus, in period 2, the indifferent consumer satisfies $\gamma - \tau\hat{\omega} = -\tau(1 - \hat{\omega})$ and, thus, $\hat{\omega} = (\tau + \gamma)/(2\tau) \in (1/2, 1)$ under our assumption that $\gamma < \tau$. Hence, $\pi_C^2(1,1,1) = M^2 a(1/2 + \gamma/(2\tau))$ and $\pi_P^2(1,1,1) = M^2 a(1/2 - \gamma/(2\tau))$.

Consumer surplus is expressed as follows. If all consumers use the same app, the average mismatch generated disutility $\tau/2$. Thus, $CS^1(1) = v - \tau/2$ and $CS^2(0,0,1) = M^2(v - \tau/2)$. If half of all consumers choose either app in the second period (apps are symmetric because the third-party app was not available on the platform in period 1), we have $CS^2(0,1,1) = M^2(v - \tau/4)$. In the situation in which the first-party app was available on the platform in period 1 and both apps are available in period 2, the fraction $\hat{\omega}$ of consumers benefits from data-enabled network benefits and obtains a surplus of $v + \gamma$ gross of the disutility from mismatch. The average disutility from mismatch across all consumers is $\hat{\omega}\tau\hat{\omega}/2 + (1-\hat{\omega})\tau(1-\hat{\omega})/2 = (\tau/2)(\hat{\omega}^2 + (1-\hat{\omega})^2) = (1/(8\tau))((\tau+\gamma)^2 + (\tau-\gamma)^2) = (\tau^2+\gamma^2)/(4\tau)$. Thus, $CS^2(1,1,1) = M^2[v + \gamma\hat{\omega} - (\tau^2+\gamma^2)/(4\tau)] = M^2[v + \gamma(\tau+\gamma)/(2\tau) - (\tau^2+\gamma^2)/(4\tau)] = M^2[v - (\tau^2 - \gamma^2 - 2\gamma\tau)/(4\tau)]$.

The assumed partial orderings of profits and consumer surplus are all satisfied. In particular, we have $CS^2(1,1,1) > CS^2(0,1,1)$. In the example this means that we must have $v - (\tau^2 - \gamma^2 - 2\gamma\tau)/(4\tau) > v - \tau/2$, which is equivalent to $\tau^2 - \gamma^2 - 2\gamma\tau < 2\tau^2$, which is clearly satisfied. The reason is that one of the apps is of higher quality (thanks to data-enabled network effects) and nothing else has changed; therefore, consumer surplus must be higher.

Example 2. Horizontally differentiated apps and subscription pricing. We use the same setting as in Example 1 with the only difference that apps do not make revenues from advertising but charge users a subscription price. In this case, the timing of the game with reduced profit function is augmented by a price-setting stage in each period that is introduced after entry and interoperability decisions have been made. The app market then becomes a (possibly asymmetric) Hotelling model with linear transport costs in

[17] In the base model, we set $F_P = 0$. Even with $F_P = 0$, if β is sufficiently high, P prefers to make profit from the commission fee rather than entering with its own app. In the next section, we provide the exact condition that rules this out and, thus, focus on the case of interest in which the platform does have the incentive to enter with its first-party app.

which users have to pay prices p^t_C and p^t_P to use the apps offered by C and P, respectively, in period t. The utility is written as $U^t_j = v - \tau \mid \omega - l_j \mid + \gamma N^{t-1}_j - p^t_j$, $j \in \{C, P\}$. App profit is thus $p^t_j N^t_j(p^t_C, p^t_P)$.

Equilibrium profits are as follows: If only one app is available in a given period t, under our parameter assumption, the app will be sold to all period-t consumers. The price will be set to make the consumer whose preferred specification is furthest away from the available specification just indifferent between buying and not buying. If the third-party app developer enters and the app is made available on the platform, it will thus sell at price $v - \tau$ and make a profit of $v - \tau$ in the first period (before sharing those profits with the platform). This means that $\pi^1_C(1) = v - \tau$. If the third-party app is not available, then the first-party app generates profit in the second period of $\pi^2_P(0,0,1) = M^2(v - \tau)$. If instead the third-party app is available but does not enjoy an advantage from data-enabled network effects (because interoperability was denied in period 1), this boils down to the symmetric Hotelling model with equilibrium prices equal to τ. Thus, profits are $\pi^2_C(0,1,1) = \pi^2_P(0,1,1) = M^2\tau/2$, as demand for each app is $M^2/2$. If first-party and third-party apps are available in period 2 and the platform allowed interoperability in period 1, the third-party app gives stand-alone utility $v + \gamma$ in period 2 (since all consumers in period 1 used the app), while the first-party app gives only v. Equilibrium prices are easily calculated as $p^2_C(1,1,1) = \tau + \gamma/3$ and $p^2_P(1,1,1) = \tau - \gamma/3$. In equilibrium, the fraction $\lambda^2_C = (\tau + \gamma/3)/(2\tau)$ of consumers subscribe to C's app and $\lambda^2_P = (\tau - \gamma/3)/(2\tau)$ of consumers to P's app. Equilibrium profits are $\pi^2_C(1,1,1) = M^2(\tau + \gamma/3)^2/(2\tau)$ and $\pi^2_P(1,1,1) = M^2(\tau - \gamma/3)^2/(2\tau)$. We note that the third-party app developer obtains a higher profit in period 2 if the platform granted period-1 interoperability, $\pi^2_C(1,1,1) > \pi^2_C(0,1,1)$ (since $(\tau + \gamma/3)^2/(2\tau) > (\tau + \gamma/3)/2 > \tau/2$). The assumption on the profit ranking in the model with reduced-form profits is satisfied.

We now report consumer surplus in this example and show that the partial ordering assumed in the model with reduced-form profits is also satisfied. We have $CS^1(1) = \tau/2$ and $CS^2(0,0,1) = M^2\tau/2$. Under symmetric competition, each app is made available at price τ and, on average, consumers incur a disutility from the mismatch of $\tau/4$. Thus, $CS^2(0,1,1) = M^2(v - (5/4)\tau)$, which is larger than $CS^2(0,0,1)$. Under asymmetric competition in period 2, $CS^2(1,1,1) = M^2(v + \lambda^2_C\gamma - \lambda^2_C(\tau\lambda^2_C)/2 - \lambda^2_P(\tau\lambda^2_P)/2) - (\pi^2_C(1,1,1) + \pi^2_P(1,1,1))$, where the first term is total surplus (gross of fixed costs). Substituting for the equilibrium values, we obtain $CS^2(1,1,1) = M^2(v - 5\tau/4 + \gamma/2 + (13\gamma^2)/(18\tau))$. We see that $CS^2(1,1,1) > CS^2(0,1,1)$. The surplus ordering also follows from the observation that with interoperability in period 1, each app offers a higher net surplus to every period-2 consumers than without interoperability in period 1: Consumer ω obtains $v - (\tau - \gamma/3) - \tau(1 - \omega) > v - \tau - \tau(1 - \omega)$ when choosing P's app and $v + \gamma - (\tau + \gamma/3) - \tau\omega > v - \tau - \tau\omega$ when choosing C's app.

4. Denial of interoperability as raising-the-rival's-cost strategy

If the platform can deny interoperability only in the first period, the following outcomes are possible: (i) the third-party developer invests, the platform approves the request for interoperability and develops its own app, which it introduces in period 2; (ii) the third-party developer invests, the platform denies the request for interoperability and develops its own app, which it introduces in period 2; (iii) the third-party developer does not invest and the platform introduces its own app in period 2; (iv) the third-party developer invests, the platform approves the request for interoperability and does not develop its own app; (v) neither the third-party developer nor the platform invests. All other possible outcomes are dominated. To reduce the number of possible outcomes, we assume in this section that F_P is sufficiently small that the platform will always develop the first-party app in period 2. Thus, we can focus on outcomes (i)-(iii).

Outcome (i) implies profits for the third-party developer of $(1-\beta)(\pi^1_C(1)+\pi^2_C(1,1,1)) - F_C$ and for the partially integrated platform of $\pi^2_P(1,1,1) + \beta(\pi^1_C(1) + \pi^2_C(1,1,1)) - F_P$. Outcome (ii) implies profits for the third-party developer of $(1-\beta)\pi^2_C(0,1,1) - F_C$ and for the platform of $\pi^2_P(0,1,1) + \beta\pi^2_C(0,1,1)) - F_P$. Outcome (iii) implies profits for the third-party developer of 0 and for the platform of $\pi^2_P(0,0,1) - F_P$.

Suppose that the third-party developer invested. The platform then decides whether to deny interoperability. Denial is preferred by the platform if

$$\pi^2_P(0,1,1)) + \beta\pi^2_C(0,1,1)) > \pi^2_P(1,1,1) + \beta(\pi^1_C(1) + \pi^2_C(1,1.1)),$$

which is equivalent to

$$\pi^2_P(0,1,1) - \pi^2_P(1,1,1) > \beta[\pi^1_C(1) + \pi^2_C(1,1,1) - \pi^2_C(0,1,1)]. \tag{1}$$

The advantage of denial for the platform is that it faces a weaker competitor in period 2 and will thereby obtain a higher profit with its first-party app; this is the term on the left-hand side of the inequality. The countervailing effect is that it makes a lower profit from its share in the third-party developer's gross profit: the platform's share in the third-party developer's gross profits amounts to zero in period 1 since the third-party developer will not make profits in the first period and it also receives a lower payment in the second period since the third-party developer does not benefit from network effects from first-period usage; this is the term on the right-hand side of the inequality. If β is sufficiently small, the platform denies interoperability in the first period.

What will the third-party developer do? If inequality (1) holds, it will invest provided that $(1-\beta)\pi^2_C(0,1,1) > F_C$. If inequality (1) does not hold, it will invest if $(1-\beta)(\pi^1_C(1) + \pi^2_C(1,1,1)) > F_C$. Recall that we presumed that P will always enter in period 2. When inequality (1) does not hold, first-party entry in period 2 takes place if $\pi^2_2(1,1,1) + \beta\pi^2_C(1,1,1) - F_P \geq \beta\pi^2_C(1,1,0)$. To be satisfied at $F_P = 0$, we must have

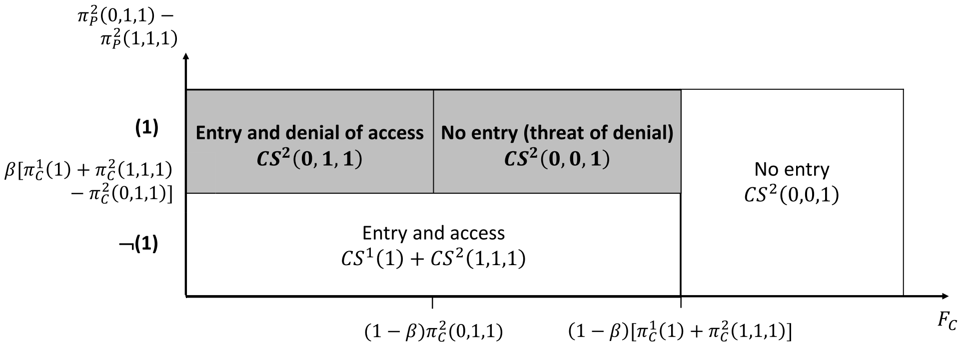

Fig. 1. Outcomes and consumer surplus in the base model.

$$\beta \leq \frac{\pi_P^2(1,1,1)}{\pi_C^2(1,1,0) - \pi_C^2(1,1,1)} \equiv \hat{\beta}.$$

If inequality (1) does not hold, β must be at or above the critical $\tilde{\beta}$ given by $[\pi_P^2(0,1,1) - \pi_P^2(1,1,1)]/[\pi_C^1(1) + \pi_C^2(1,1,1) - \pi_C^2(0,1,1)]$. Period-1 entry and access of the third-party app and period-2 entry of the first-party app require that $\hat{\beta} > \tilde{\beta}$. Otherwise (i.e. $\hat{\beta} \leq \tilde{\beta}$), with first-party entry in period 2, inequality (1) always holds.

Fig. 1 illustrates the equilibrium outcomes under laissez-faire according to the different parameter regions. The following proposition characterizes them:

Proposition 1. *When the platform has to provide compulsory period-2 access, the following holds:*

- *If $\pi_P^2(0,1,1) - \pi_P^2(1,1,1) \leq \beta(\pi_C^1 + \pi_C^2(1,1,1) - \pi_C^2(0,1,1))$ and $(1-\beta)(\pi_C^1(1) + \pi_C^2(1,1,1)) \geq F_C$, in equilibrium, the third-party app enters and the platform approves the request for period-1 interoperability.*
- *If $\pi_P^2(0,1,1) - \pi_P^2(1,1,1) > \beta(\pi_C^1(1) + \pi_C^2(1,1,1) - \pi_C^2(0,1,1))$ and $(1-\beta)\pi_C^2(0,1,1) \geq F_C$, in equilibrium, the third-party app enters and the platform denies the request for period-1 interoperability (but it has to allow access in period 2).*
- *If either $\pi_P^2(0,1,1) - \pi_P^2(1,1,1) \leq \beta(\pi_C^1 + \pi_C^2(1,1,1) - \pi_C^2(0,1,1))$ and $(1-\beta)(\pi_C^1(1) + \pi_C^2(1,1,1)) < F_C$ or $\pi_P^2(0,1,1) - \pi_P^2(1,1,1) > \beta(\pi_C^1(1) + \pi_C^2(1,1,1) - \pi_C^2(0,1,1))$ and $(1-\beta)\pi_C^2(0,1,1) < F_C$, in equilibrium, the third-party app does not enter and the platform's own app has a monopoly position in period 2.*

Under inequality (1), the platform will always deny interoperability. This reduces the third-party developer's profit and either deters entry (region where $(1-\beta)\pi_C^2(0,1,1) < F_C < \beta(\pi_C^1(1) + \pi_C^2(1,1,1))$) or it makes the developer a weaker competitor in the case it entered (region where $F_C \leq (1-\beta)\pi_C^2(0,1,1)$). Denial thus is a way for the platform to make the first-party app relatively more attractive compared to the third-party app (because it deprives the third-party app of increased attractiveness thanks to data-enabled network effects); since the complementor's profit decreases, the parameter range for which the third-party app will not be developed becomes larger.

Compulsory access What happens if the antitrust authority intervenes and forces the platform to allow interoperability in period 1 (compulsory period-1 access)? Then, the third-party developer knows that, with entry, it will make a profit of $(1-\beta)(\pi_C^1(1) + \pi_C^2(1,1,1))$. The third-party developer thus enters if this profit is larger than the entry cost.

Lemma 1. *Consider compulsory period-1 access. If $(1-\beta)(\pi_C^1(1) + \pi_C^2(1,1,1)) \geq F_C$, the platform makes equilibrium profit $\pi_P^2(1,1,1) + \beta(\pi_C^1(1) + \pi_C^2(1,1,1))$ and the complementor $(1-\beta)(\pi_C^1(1) + \pi_C^2(1,1,1))$, and consumer surplus is $CS^1(1) + CS^2(1,1,1)$. By contrast, if $(1-\beta)(\pi_C^1(1) + \pi_C^2(1,1,1)) < F_C$, the platform makes equilibrium profit $\pi_P^2(0,0,1)$ and the complementor zero, and consumer surplus is $CS^2(0,0,1)$.*

The comparison between laissez-faire and policy intervention then plays out as follows:

Proposition 2. *The introduction of compulsory period-1 access can change the market outcome in either one of two ways:*

- *If $\pi_P^2(0,1,1) - \pi_P^2(1,1,1) > \beta(\pi_C^1(1) + \pi_C^2(1,1,1) - \pi_C^2(0,1,1))$ and $(1-\beta)\pi_C^2(0,1,1) > F_C$, the third-party app will be available on the platform not only in period 2 but also in period 1. Consumer surplus increases as a result of this policy as $CS^1(1) + CS^2(1,1,1) > CS^2(0,1,1)$.*
- *If $\pi_P^2(0,1,1) - \pi_P^2(1,1,1) > \beta(\pi_C^1(1) + \pi_C^2(1,1,1) - \pi_C^2(0,1,1))$ and $(1-\beta)\pi_C^2(0,1,1) < F_C < (1-\beta)(\pi_C^1(1) + \pi_C^2(1,1,1))$, the third-party app will be available in both periods instead of not being developed. Consumer surplus increases as a result of this policy as $CS^1(1) + CS^2(1,1,1) > CS^2(0,0,1)$.*

In all other cases, the policy is neutral.

In terms of Fig. 1, in the region where inequality (1) holds and hence the platform denies access in period 1, with a policy of compulsory access, the equilibrium outcomes are replaced by entry if $F_C \leq (1-\beta)(\pi_C^1(1)+\pi_C^2(1,1,1))$, thereby increasing consumer surplus.

Regarding total surplus we note the potential downside of third-party entry because this leads to additional costs. For $F_C < (1-\beta)\pi_C^2(0,1,1)$, total surplus necessarily increases with a policy of compulsory access, as denial of interoperability does not reduce costs. For $(1-\beta)\pi_C^2(0,1,1) < F_C < (1-\beta)(\pi_C^1(1)+\pi_C^2(1,1,1))$, denial of period-1 access saves the entry cost F_C. However, a policy of compulsory access continues to increase total surplus provided that $F_C < CS^1(1)+\pi_C^1(1)+[CS^2(1,1,1)+\pi_C^2(1,1,1)+\pi_P^2(1,1,1)-(CS^2(0,0,1)+\pi_P^2(0,0,1))]$.

We illustrate the findings of Proposition 2 with our two examples.

Example 1 continued. In this example, the inequality $\pi_P^2(0,1,1)-\pi_P^2(1,1,1) > \beta(\pi_C^1(1)+\pi_C^2(1,1,1)-\pi_C^2(0,1,1))$ becomes $M^2 a\gamma/(2\tau) > \beta a(1+M^2\gamma/(2\tau))$ or, equivalently,

$$\beta < \frac{\gamma}{\gamma 2\tau/M^2}. \tag{2}$$

If inequality (2) is satisfied and $(1-\beta)M^2 a/2 > F_C$, the prohibition of denying interoperability implies that the complementor's app is available in both periods and not only in period 2. For consumers, this has two benefits: benefits in period 1 and an improved app by the complementor thanks to data-enabled network effects in period 2.

If inequality (2) is satisfied and $(1-\beta)M^2a/2 < F_C < (1-\beta)(a+M^2a/2+M^2a\gamma/(2\tau))$, the prohibition of denying interoperability implies that the complementor's app is available in both periods instead of not being developed at all. For consumers, this has two benefits: benefits in period 1 and the availability of both apps and not just the platform's own app in period 2 (where the complementor's app is improved thanks to data-enabled network effects).

Note that the inequality is more likely to be satisfied, with all else being equal, the lower β (that is, the lower the appropriability of rents by the platform), the higher M^2 (that is, the more weight for period-2 demand), the lower τ (that is, the lower the transport cost, namely the more competitive the app market), and the higher γ (that is, the more important the network effect).

Example 2 continued. The inequality $\pi_P^2(0,1,1)-\pi_P^2(1,1,1) > \beta(\pi_C^1(1)+\pi_C^2(1,1,1)-\pi_C^2(0,1,1))$ becomes

$$\beta < \frac{2\tau-\frac{\gamma}{3}}{2\tau-\frac{\gamma}{3}+\frac{6\tau}{M^2\gamma}(v-\tau)}. \tag{3}$$

If inequality (3) is satisfied and $(1-\beta)M^2\tau/2 > F_C$, the prohibition of denying interoperability implies that the complementor's app is available in both periods and not only in period 2. For consumers, this has two benefits: benefits in period 1 and an improved app by the complementor thanks to data-enabled network effects in period 2.

If inequality (3) is satisfied and $(1-\beta)M^2\tau/2 < F_C < (1-\beta)((v-\tau)+M^2(\tau+\gamma/3)^2/(2\tau))$, the prohibition of denying interoperability implies that the complementor's app is available in both periods instead of not being developed at all. Consumers benefit from the availability of the third-party app in period 1 and the availability of both apps in period 2 (where the complementor's app is improved thanks to data-enabled network effects) and not just the platform's own app in period 2.

As in Example 1, the inequality is more likely to be satisfied, with all else being equal, the lower β (that is, the lower the appropriability of rents by the platform), the higher M^2 (that is, the more weight for period-2 demand). The additional parameter v plays the opposite role of M^2 as a higher stand-alone value leads to a higher price in period 1 and does not affect the price in period 2 and, thus, makes period 1 a relatively more important source of profits.

As a side remark, note that the platform may not be satisfied with the outcome under laissez-faire because the third-party developer does not invest fearing that it will be denied interoperability. If the platform denies interoperability and this triggers no entry, it will make profit $\pi_P^2(0,0,1)$. Suppose that the platform is better off under compulsory period-1 access. This requires that the following inequality holds: $\pi_P^2(1,1,1)+\beta(\pi_C^1(1)+\pi_C^2(1,1,1)) > \pi_P^2(0,0,1)$ or, equivalently, $\pi_P^2(0,0,1)-\pi_P^2(1,1,1) < \beta(\pi_C^1(1)+\pi_C^2(1,1,1))$. The condition that the platform denies interoperability after C's entry is $\pi_P^2(0,1,1)-\pi_P^2(1,1,1) > \beta(\pi_C^1(1)+\pi_C^2(1,1,1)-\pi_C^2(0,1,1)$. Thus, a necessary condition for both inequalities to be simultaneously satisfied is $\pi_P^2(0,0,1) < \pi_P^2(0,1,1)+\beta\pi_C^2(0,1,1)$. In principle, this is possible as duopoly industry profits may exceed monopoly profits under sufficient differentiation and then the inequality holds for sufficiently large β. In addition, it must hold that complementor entry is not profitable when interoperability is denied, but profitable when allowed – that is, $(1-\beta)\pi_C^2(0,1,1) < F_C < (1-\beta)(\pi_C^1(1)+\pi_C^2(1,1,1))$.[18] Under these conditions, compulsory period-1 access leads to a Pareto improvement: the partially integrated platform, the third-party developer, and consumers are better off after the intervention.

[18] Here we do not return to our examples because in our examples product differentiation is insufficient to generate this outcome. However, if we were to allow for lower v in Example 2, the inequality can be satisfied.

5. Extensions

5.1. Denial of interoperability in both periods

In the main model, we did not allow for denial of interoperability in period 2. In this subsection, we do so and show that it may be the preferred strategy by the platform, and then argue that given the legal risks this involves, the platform may find it a better option to deny interoperability in the first period. Denial of interoperability concurrent with first-party entry is a potentially anticompetitive practice that can be achieved through software updates by the platform.[19]

In the extended setting in which the platform can allow interoperability in period 1, but deny it in period 2, we have the following.

Lemma 2. *If the platform can deny interoperability in any period, then:*

i It always offers interoperability in period 1.
ii It denies interoperability in period 2 if and only if

$$\pi_P^2(1,0,1) = \pi_P^2(0,0,1) > \pi_P^2(1,1,1) + \beta\pi_C^2(1,1,1). \quad (4)$$

Proof. (i) The platform has no reason to deny interoperability in period 1 if it has the option to deny it in period 2 since this generates an additional profit of $\beta\pi_C^1(1)$.

(ii) Suppose that the third-party app has entered in period 1. If the platform denies interoperability in period 2 it will make a period-2 profit of $\pi_P^2(1,0,1)$, which is equal to $\pi_P^2(0,0,1)$ under the assumption that the platform cannot make use of the data acquired by the third-party app. If it allows interoperability it will make a period-2 duopoly profit of $\pi_P^2(1,1,1) + \beta\pi_C^2(1,1,1)$. □

Note also that as long as monopoly profits without data-enabled network effects, $\pi_P^2(0,0,1)$, are larger than industry duopoly profits with data-enabled network effects, $\pi_P^2(1,1,1) + \pi_C^2(1,1,1)$ (and thus larger than $\pi_P^2(1,1,1) + \beta\pi_C^2(1,1,1)$), condition (4) holds. Thus, the platform will deny period-2 interoperability if it can do so.

Building on this lemma, the following result holds:

Proposition 3. *If inequality (4) holds (i.e., $\pi_P^2(x,0,1) > \pi_P^2(1,1,1) + \beta\pi_C^2(1,1,1)$), then*

- *for $F_C \leq (1-\beta)\pi_C^1(1)$, the third-party app enters and it is given access in period 1 but not in period 2;*
- *for $F_C > (1-\beta)\pi_C^1(1)$, the third-party app does not enter.*

If instead inequality (4) does not hold (i.e., $\pi_P^2(x,0,1) \leq \pi_P^2(1,1,1) + \beta\pi_C^2(1,1,1)$), then

- *for $F_C \leq (1-\beta)(\pi_C^1(1) + \pi_C^2(1,1,1)$, the third-party app enters and it is given access in both periods;*
- *for $F_C > (1-\beta)(\pi_C^1(1) + \pi_C^2(1,1,1)$, the third-party app does not enter.*

Proof. If $\pi_P^2(x,0,1) > \pi_P^2(1,1,1) + \beta\pi_C^2(1,1,1)$ we know from Lemma 2 that, under complementor entry, the platform gives access in period 1 but denies it in period 2. Anticipating this, if the complementor's period-1 profits are sufficient to cover its entry cost, that is, $(1-\beta)\pi_C^1(1) \geq F_C$, then the complementor enters with a third-party app. If period-1 profits are insufficient to cover development costs, entry will not take place. If $\pi_P^2(x,0,1) \leq \pi_P^2(1,1,1) + \beta\pi_C^2(1,1,1)$ the complementor anticipates that entry will always be accompanied by access, so as long as $F_C \leq (1-\beta)(\pi_C^1(1) + \pi_C^2(1,1,1)$, it will enter. □

Fig. 2 illustrates the equilibrium outcomes when the platform can decide on interoperability in any period. It also indicates the consumer surplus associated with each outcome (recall that we are assuming that the platform always enters the first-party app in period 2).

Compulsory access Next, we want to investigate the effects of compulsory access. A natural policy to investigate is compulsory period-2 access; this reflects real-world policies, such as the prohibition of self-preferencing (which would reduce the visibility of the third-party app in period 2) or the obligation to continue to provide access if it has been given in the past. We shall also look at the effects of a stricter policy, consisting of the obligation to provide access whenever requested.

[19] For example, in the class action suit filed against Apple in the early 2000's, plaintiffs claimed that Apple repeatedly updated its software with the aim of denying interoperability. According to the amended complaint of the plaintiffs, "True to its threats, beginning in October 2004, Apple 'updated' its iPod and iTunes software to prevent songs downloaded from RealNetworks' music store from being played on iPods" (Amended Complaint, The Apple iPod iTunes Antitrust Litigation, C 07-6507 JW (N.D. Cal. July 9, 2010): note 93). Cite taken from Newman (2012) who provides more details on the case.

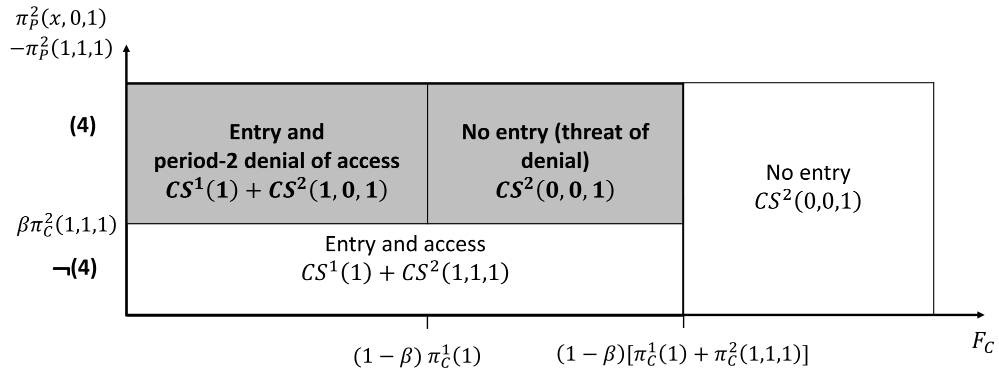

Fig. 2. Outcomes and consumer surplus when access can be denied in any period.

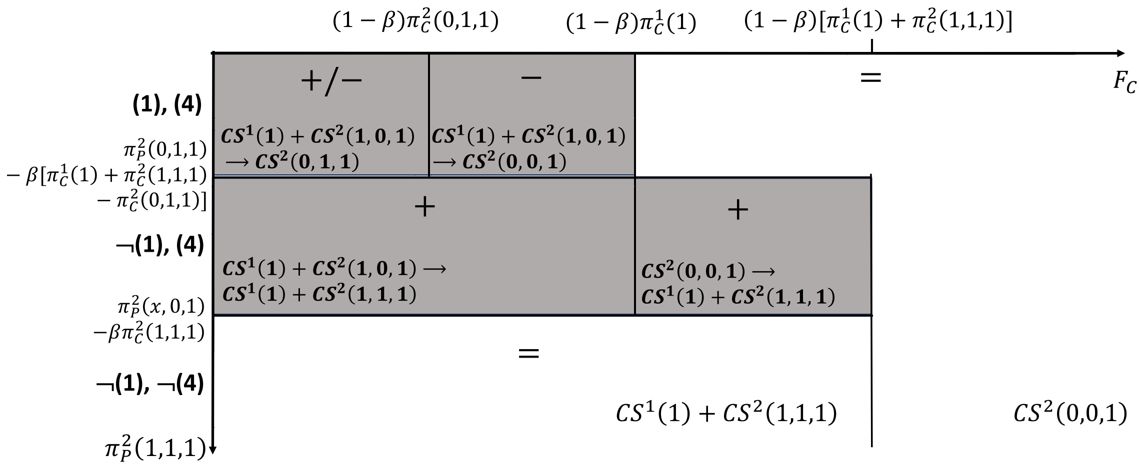

Fig. 3. Effects of compulsory period-2 access.

Let us study the effects of compulsory period-2 access when the platform can deny it in any period. To do so, we can build upon the results in Proposition 1 and Proposition 3. These are illustrated in Fig. 3, which is a combination of Figs. 1 and 2,[20] for the case in which $\pi_C^1(1) > \pi_C^2(0,1,1)$. The opposite case of $\pi_C^1(1) \leq \pi_C^2(0,1,1)$, which may hold true when demand in period 2 is much higher than in period 1, can easily be obtained by combining the two previous figures.

We obtain the following proposition.

Proposition 4. *Suppose that industry profits are (weakly) higher under monopoly than under duopoly: $\pi_P^2(x,0,1) \geq \pi_P^2(0,1,1) + \pi_C^2(0,1,1)$. Compulsory period-2 access (but no restriction in period 1) affects consumers as follows:*

- *If $\pi_P^2(0,1,1) - \pi_P^2(1,1,1) \leq \beta(\pi_C^1 + \pi_C^2(1,1,1) - \pi_C^2(0,1,1))$ and $(1-\beta)(\pi_C^1(1) + \pi_C^2(1,1,1)) \geq F_C$, compulsory period-2 access leads to an increase of consumer surplus.*
- *If $\pi_P^2(0,1,1) - \pi_P^2(1,1,1) > \beta(\pi_C^1(1) + \pi_C^2(1,1,1) - \pi_C^2(0,1,1))$ and*
    - *if $(1-\beta)\min\{\pi_C^2(0,1,1), \pi_C^1(1)\} > F_C$, compulsory period-2 access leads to an increase of consumer surplus if and only if $CS^1(1) + CS^2(1,0,1) < CS(0,1,1)$.*
    - *if $\pi_C^2(0,1,1) > \pi_C^1(1)$ and $(1-\beta)\pi_C^1(1) < F_C \leq (1-\beta)\pi_C^2(0,1,1)$, compulsory period-2 access leads to an increase of consumer surplus.*
    - *if $\pi_C^2(0,1,1) < \pi_C^1(1)$ and $(1-\beta)\pi_C^1(1) \geq F_C > (1-\beta)\pi_C^2(0,1,1)$, compulsory period-2 access leads to a decrease of consumer surplus.*
- *In all other cases, the policy is neutral.*

[20] To combine the two figures, we rearranged along the y-axis.

Proof. Since by assumption industry profits are weakly higher under monopoly, condition (4) is satisfied; that is, the platform has the incentive to deny interoperability. If this were not the case, policy intervention would not affect market outcomes. Note that we can rearrange condition (1) as follows: $\pi_P^2(1,1,1) + \beta\pi_C^2(1,1,1) < \pi_P^2(0,1,1) - \beta(\pi_C^1(1) - \pi_C^2(0,1,1))$. Given the assumption in the proposition that $\pi_P^2(x,0,1) \geq \pi_P^2(0,1,1) + \pi_C^2(0,1,1)$ (which is not necessary, but done for simplification), we have that $\pi_P^2(x,0,1) > \pi_P^2(0,1,1) + \beta\pi_C^2(0,1,1) - \beta\pi_C^1(1)$. In other words, when condition (4) holds, condition (1) may hold or not, as shown in Fig. 3.

First, consider the case in which condition (1) is not satisfied; that is, $\pi_P^2(1,1,1) + \beta\pi_C^2(1,1,1) > \pi_P^2(0,1,1) - \beta(\pi_C^1(1) - \pi_C^2(0,1,1))$. This implies that the platform offers access in both periods when the compulsory period-2 policy exists and leads to entry whenever $F_C \leq \pi_C^1(1) + \pi_C^2(1,1,1)$. The resulting total consumer surplus $CS^1(1) + CS^2(1,1,1)$ is higher than the surplus arising under laissez-faire (and hence no access in period 2), $CS^1(1) + CS^2(1,0,1)$ when period-1 profits are sufficient for the third-party app to enter, and $CS^2(0,0,1)$ when they are not.

Second, consider the case in which both conditions are satisfied ($\pi_P^2(1,1,1) + \beta\pi_C^2(1,1,1) < \pi_P^2(0,1,1) - \beta(\pi_C^1(1) - \pi_C^2(0,1,1))$), that is, the bottom region in Fig. 3. We know from Proposition 1 that under the period-2 compulsory access policy, entry takes place if $F_C \leq (1-\beta)\pi_C^2(0,1,1)$, giving rise to a surplus equal to $CS^2(0,1,1)$.

Entry under laissez-faire takes place for $F_C \leq (1-\beta)\pi_C^1(1)$. The comparison with the laissez-faire case depends then on whether $\pi_C^2(0,1,1)$ is smaller or greater than $\pi_C^1(1)$. Suppose that $\pi_C^1(1) > \pi_C^2(0,1,1)$. Then for $F_C < (1-\beta)\pi_C^2(0,1,1)$, the period-2 compulsory policy changes the outcome from $CS^1(1) + CS^2(1,0,1)$ to $CS^2(0,1,1)$. For $(1-\beta)\pi_C^2(0,1,1) < F_C < (1-\beta)\pi_C^1(1)$, it changes it from $CS^1(1) + CS^2(1,0,1)$ to $CS^2(0,0,1)$, which is detrimental to consumers.

Suppose instead that $\pi_C^1(1) < \pi_C^2(0,1,1)$. Then for $F_C < (1-\beta)\pi_C^1(1)$, the period-2 compulsory policy changes the outcome from $CS^1(1) + CS^2(1,0,1)$ to $CS^2(0,1,1)$. For $(1-\beta)\pi_C^1(1) < F_C < (1-\beta)\pi_C^2(0,1,1)$, it changes it from $CS^2(0,0,1)$ to $CS^2(0,1,1)$, which is beneficial to consumers. □

The proposition points to an undesired effect of the period-2 compulsory policy. Knowing that it cannot deny interoperability in period 2, the platform will deny it in period 1. This leads the third-party app to earn profits only in period 2. If such profits are sufficient to cover the costs of development, the resulting outcome will be superior for consumers relative to the one arising without compulsory period-2 access when C enters in period 1 and P enters in period 2 (and it is the only available app because it would deny interoperability) as long as competition in period 2 gives consumers more surplus than two successive monopolies. But when the period-2 profits are insufficient to cover costs, the third-party app does not enter at all, and consumers will certainly be harmed since they would prefer to use a app under monopoly in each period, rather than using the first-party app under monopoly in period 2 only.

These considerations have some policy relevance. A prohibition of self-preferencing (rather than of straight compulsory access) amounts in our context to the period-2 compulsory access policy.[21] Similarly, antitrust authorities and courts may allow a dominant firm to generally deny access, but prohibit it from withdrawing access if has been given in the past. Such policy rules might lead an incumbent that is considering future downstream entry to deny access in the first place, as a way to protect its future downstream affiliate, and this may, in turn, be – under some conditions – detrimental to consumers.

In our examples, the relevant inequalities in Proposition 4 take the following form:

Example 1 continued. As shown above, the condition $\pi_P^2(0,1,1) - \pi_P^2(1,1,1) > \beta(\pi_C^1(1) + \pi_C^2(1,1,1) - \pi_C^2(0,1,1))$ becomes inequality (2) in the example. For $\min\{M^2a/2, a\} > F_C$, compulsory period-2 access leads to an increase of consumer surplus if and only if $v - \tau/2 + M^2(v - \tau/2) < M^2(v - \tau/4)$, which is equivalent to $v - \tau/2 < M^2\tau/4$. The condition $\pi_C^2(0,1,1) > \pi_C^1(1)$ becomes $M^2a/2 > a$ or, equivalently, $M^2 > 2$.

Hence, if the number of period-2 consumers is relatively large compared to the number of period-1 consumers, compulsory period-2 access always leads to an increase of consumer surplus whenever the policy has any impact. Only in the opposite case can the policy decrease consumer surplus.

Example 2 continued. As shown above, the condition $\pi_P^2(0,1,1) - \pi_P^2(1,1,1) > \beta(\pi_C^1(1) + \pi_C^2(1,1,1) - \pi_C^2(0,1,1))$ becomes inequality (3). For $\min\{M^2\tau/2, v - \tau\} > F_C$, compulsory period-2 access leads to an increase of consumer surplus if and only if $\tau/2 + M^2\tau/2 < M^2(v - (5/4)\tau)$, which is equivalent to $\tau/(2M^2) + (7/4)\tau < v$. The condition $\pi_C^2(0,1,1) > \pi_C^1(1)$ becomes $M^2\tau/2 > v - \tau$. As in Example 1, if the number of period-2 consumers is relatively large compared to the number of period-1 consumers, compulsory period-2 access leads to an increase of consumer surplus whenever the policy has any impact.

Compulsory period-2 access (without any restriction in period 1) thus gives a somewhat ambiguous result. However, if the platform has to offer interoperability in both periods, such compulsory full access necessarily increases consumer surplus. To see this, we compare the outcome of Lemma with that of Lemma 1. We immediately obtain the following result:

Proposition 5. *Compulsory full access (compared to the laissez-faire in which the platform is not restricted at all) never decreases consumer surplus:*

[21] Article 6(5) of the Digital Markets Act prohibits self-preferencing of designated gatekeeper platforms. Peitz (2023) discusses how this prohibition may be applied.

- *If* $(1-\beta)\pi_C^1(1) \geq F_C$, *consumer surplus increases from* $CS^1(1) + CS^2(0,0,1)$ *to* $CS^1(1) + CS^2(1,1,1)$.
- *If* $(1-\beta)\pi_C^1(1) < F_C < (1-\beta)(\pi_C^1(1) + \pi_C^2(1,1,1))$, *consumer surplus increases from* $CS^2(0,0,1)$ *to* $CS^1(1) + CS^2(1,1,1)$.

Otherwise, the policy is neutral.

Proof. Under compulsory access, interoperability must be given in either period. Therefore, the third-party app will always be there in both periods whenever $F_C \leq (1-\beta)(\pi_C^1(1) + \pi_C^2(1,1,1)$, and under our maintained assumptions the first-party app will be there in period 2 too. Hence, consumer surplus will be $CS^1(1) + CS^2(1,1,1)$ – which is the highest achievable level in the model – whenever $F_C \leq (1-\beta)(\pi_C^1(1) + \pi_C^2(1,1,1)$ and $CS^2(0,0,1)$ otherwise. The proposition follows from the comparison with the laissez-faire case, studied above. □

Under full compulsory access, the third-party app enters whenever the costs of development are not too high ($F_C \leq (1-\beta)(\pi_C^1(1) + \pi_C^2(1,1,1))$. As a result, the highest possible outcome, with the third-party app being available in both periods, and the first-party app being available in the second one, is attained. The policy can only improve consumer welfare: either by allowing third-party entry in both periods rather than in period 1 alone, or by allowing it in both periods rather than never.

5.2. Costly entry of the first-party app

In the main model, we assumed that the entry cost for the first-party app was sufficiently low that entry definitely occurred in the second period. In this extension, we assume that entry costs can be substantial, so we have to analyze when the first-party app will be made available in period 2. We will analyze the implications for the platform's decision regarding interoperability and show that the policy that prohibits the denial of interoperability in period 1 may backfire.

To limit the number of comparisons, we follow the base model and we assume that the platform cannot deny interoperability in period 2. Consider, for simplicity, the limit case in which $\beta = 0$.[22] The strategic game boils down to the two-stage game in which, at the first stage, the complementor decides whether to enter and, at the second stage, the platform decides whether or not to allow for interoperability and whether or not to enter with a first-party app in period 2.[23]

Proposition 6. *Suppose that* $F_P > 0$ *period-2 access is compulsory.*

(i.) *If* $F_P \leq \pi_P^2(0,1,1)$, *P expects to enter and denies interoperability if C has developed the third-party app.*
(ii.) *If* $F_P \leq \pi_P^2(0,1,1)$ *and* $F_C \leq \pi_C^2(0,1,1)$, *both apps are developed (but C sells only in period 2). If* $F_C > \pi_C^2(0,1,1)$, *only the first-party app enters.*
(iii.) *If* $F_P > \pi_P^2(0,1,1)$ *and* $F_C \leq \pi_C^1(1) + \pi_C^2(0,1,1)$, *C enters and is given access. Otherwise, no app is developed.*

Proof. We move backwards and start with the first-party app entry decision. If the platform enters with its first-party app, its period-2 profit is $\pi_P^2(x,1,1) - F_P$ (recall that $\beta = 0$, so wholesale activities give no revenue), provided that the third-party app has been developed. Given $x = 1$, the platform develops the first-party app if $\pi_P^2(1,1,1) \geq F_P$. Given $x = 0$ and the development of the third-party app, the platform develops the first-party app if $\pi_P^2(0,1,1) \geq F_P$. If the third-party app is not developed, P enters with its app if $\pi_P^2(0,0,1) \geq F_P$.

Let us now look at period-1 decisions: first C decides on whether to develop the third-party app and then P decides whether to allow for interoperability.

(i.) Consider first the case where P can deny interoperability in period 1. If C has developed its app, P will always deny interoperability in period 1 whenever its first-party app can enter, because $\pi_P^2(0,1,1) > \pi_P^2(1,1,1)$. If $F_P > \pi_P^2(0,1,1)$ the platform will not deny interoperability, because it will not manage to enter even when facing a weak third-party app.

Consider C's entry decisions. (ii.) If $F_P \leq \pi_2^P(0,1,1)$, it knows that if it enters it will not preempt the first-party app entry and hence will not obtain access in period 1. So, it can make profits only in period 2, and it will enter if and only if $F_C \leq \pi_2^C(0,1,1)$. (iii.) If instead $F_P > \pi_2^P(0,1,1)$, then it knows that if it enters, the first-party app will not be developed even if the platform denies interoperability. Hence, it enters and will be offered access. □

Fig. 4 illustrates the equilibrium outcomes. Note that the third-party app has the first-mover advantage and the platform cannot pre-commit to denying interoperability before the complementor makes its decision. As a result, C may pre-empt first-party entry when the platform's costs of developing the app are large enough. Hence, when $F_P > \pi_2^P(0,1,1)$, C enters because it knows that duopoly profits are not sufficient for P to cover costs, even if P does not award access in period 1. As a result, the third-party app will be available in both periods. (For any $\beta > 0$, P will always make higher profits by giving access. In the limit case, $\beta = 0$ it is

[22] All the qualitative results in this Section are similar when β is positive but low enough for the platform to deny interoperability; i.e., condition (1) holds. If β is high enough for (1) not to hold, then access will always be given at equilibrium and a compulsory access policy is immaterial.

[23] Relative to the base model, the game is augmented by the decision of the platform on whether to develop its own app at cost F_P at the beginning of period 2 (that is, we account for the decision at stage 2.1 in the timing presented in Section 3).

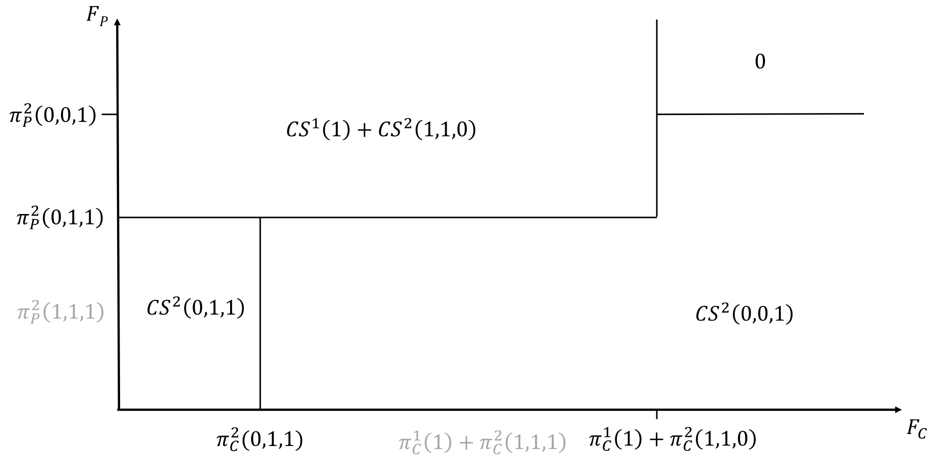

Fig. 4. Equilibrium outcomes and consumer surplus when $F_P > 0$.

indifferent as it will make zero profits anyway, but if there is a small cost for refusing interoperability – e.g., the risk of litigation or regulatory inquiries – access will be given). When instead $F_P \leq \pi_2^P(0,1,1)$ the complementor anticipates that (symmetric) duopoly profits will allow P to recoup its development costs, and hence P will always deny interoperability. Hence, C enters only if the symmetric duopoly profits are sufficient to cover its entry costs, $F_C \leq \pi_2^C(0,1,1)$.

The effects of compulsory access Consider now a period-1 compulsory access policy, which amounts to a straight compulsory access policy since we are assuming that P cannot deny access in period 2.

Proposition 7. *Equilibrium outcomes with $F_P > 0$ and compulsory access.*

- *Whenever $F_P \leq \pi_P^2(1,1,1)$, the first-party app will be developed. If $F_C \leq \pi_C^1(1) + \pi_C^2(1,1,1)$, the third-party app will be developed (and be available in both periods). Otherwise, C will not develop its app.*
- *If $F_P > \pi_P^2(1,1,1)$, the first-party app will never be developed unless C stays out. If $F_C \leq \pi_C^1(1) + \pi_C^2(1,1,0)$, the third-party app will be developed (and be available in both periods). If $F_C > \pi_C^1(1) + \pi_C^2(1,1,0)$, C will not develop its app. P will enter iff $F_P \leq \pi_P^2(0,0,1)$.*

Proof. By backward induction. By the policy assumption, C knows it will always be given access. Hence, it will never enter if $F_C > \pi_C^1(1) + \pi_C^2(1,1,0)$, because in that case not even monopoly profits in both periods would cover costs. In this case, the first-party app will be developed only if $F_P \leq \pi_P^2(0,0,1)$.

Consider now the remaining values of F_C. If $F_P \leq \pi_P^2(1,1,1)$, the first-party app enters even if it faces a third-party app with the advantage of having sold in period 1. Anticipating this, C will enter only if $F_C \leq \pi_C^1(1) + \pi_C^2(1,1,1)$. Otherwise, it will prefer to stay out, and there will be a period-2 monopoly by the first-party app. □

This Proposition shows that, as expected, compulsory access promotes entry of the third-party app. C will not develop its app only when either (a.) monopoly profits in both periods are insufficient to cover costs ($F_C > \pi_C^1(1) + \pi_C^2(1,1,0)$), or (b.) the first-party app costs are so low that it will enter even when facing a 'superior' third-party app ($F_P \leq \pi_P^2(1,1,1)$), and the sum of period-1 monopoly profits and period-2 duopoly profits are insufficient to cover its costs ($F_C > \pi_C^1(1) + \pi_C^2(1,1,0)$).

We turn to the effects of the compulsory access policy, which are illustrated in Fig. 5. The Figure combines the equilibrium outcomes obtained in the two previous propositions. In each region, when access can be denied, consumer surplus and the associated availability of apps is given in the first expression, whereas, when imposing compulsory access, it must be replaced by the second expression. The arrow indicates the replacement thanks to the policy intervention. In the figure, we indicate four regions, named from (A) to (D), in which the intervention affects the outcome. In the other regions the compulsory access policy is neutral to the outcome and consumer surplus is unchanged.

In regions [B], [C], and [D] the policy intervention is unambiguously beneficial. In [B] and [D], instead of no app in period 1 and the monopoly by the first-party app in period 2, compulsory access leads to the third-party app being available in both periods (in region [D] without crowding out first-party entry). In region [C], instead of no app in period 1 and a duopoly in period 2, the third-party app is already available in period 1 (which also increases the value of the app in period 2).

However, in region [A] the policy intervention may negatively affect consumers. By denying access in period 1, P allows the first-party app's profits to increase and cover entry cost: if C is available in period 1, P's profits are $\pi_P^2(1,1,1) < F_P$, whereas by denying access in period 1, profits are $\pi_P^2(0,1,1) \geq F_P$. When instead there is compulsory access, first-party entry is crowded out.

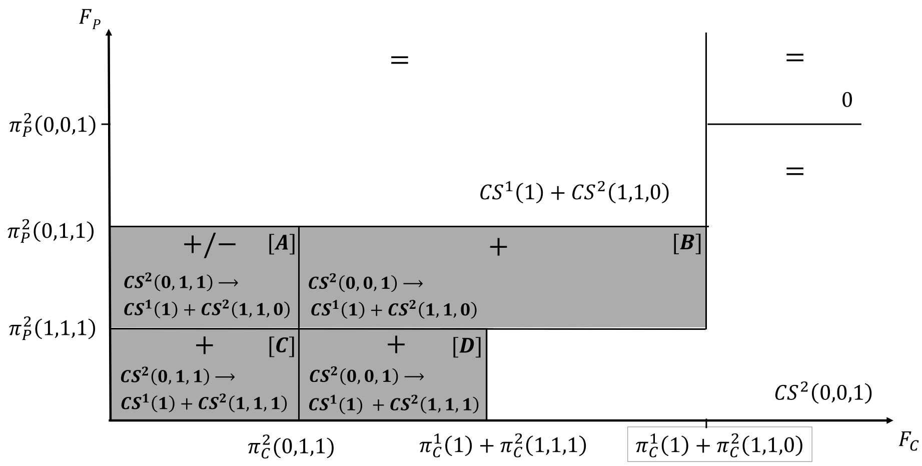

Fig. 5. The introduction of compulsory access when $F_P > 0$.

The following states the conditions under which the policy intervention may harm consumers. In short, the policy allows the third-party app to be available in period 1, which in turn puts it in a better competitive position vis-à-vis the first-party app in period 2. This may discourage the first-party app from entering. If consumers have a higher surplus under a period-2 duopoly than when facing the third-party monopolist in both periods, then the policy is detrimental to them.

Corollary 1. *Provided that* $CS^2(0,1,1) > CS^1(1) + CS^2(1,1,0)$*, compulsory period-1 access reduces consumer surplus if and only if* $\pi_P^2(1,1,1) < F_P \le \pi_P^2(0,1,1)$.

We note that this result is robust to the platform obtaining as share $\beta > 0$ of third-party app revenues as long as β is not too large. The condition $CS^2(0,1,1) > CS^1(1) + CS^2(1,1,0)$ says that consumer surplus under monopoly over both periods is less than consumer surplus under symmetric competition in period 2 only. We illustrate that this condition can hold by taking a look at Example 2.

Example 2 continued. In the example, the condition $\pi_P^2(1,1,1) < F_P \le \pi_P^2(0,1,1)$ is $M^2(\tau - \gamma/3)^2/(2\tau) < F_P \le M^2\tau/2$. Under this condition, when does the prohibition decrease consumer surplus (for F_C small enough that third-party entry always takes place)? As explained above, we have that $CS^2(0,1,1) = M^2(\upsilon - (5/4)\tau)$ and $CS^1(1) + CS^2(1,1,0) = (1 + M^2)\tau/2$ (noting that $CS^2(1,1,0) = M^2\tau/2$ because the utility increment γ due to data-enabled network effects is fully extracted through the subscription price). Hence, the prohibition reduces consumer surplus if $\upsilon > \frac{7M^2+2}{4M^2}\tau$.

The message from this extension is that there is a possible downside of compulsory period-1 access if the platform's first-party entry is at stake. Here the tradeoff is between early availability of an app and competition between apps at a later point in time. Looking beyond our duopoly model, our results suggest that caution is warranted when considering compulsory period-1 access if a platform's costs to enter the app market at a later stage are substantial and if there are no other important competitive constraints on the complementor's pricing in period 2 when the first-party app is absent from the market.

5.3. Effects of data-sharing and different ownership of data

In our main model, we assumed that network effects are *app-specific*. However, the platform may have full or partial access to the data generated by the third-party app in the first period and use it for its own purposes. In an e-commerce context, this would be the case if the complementor's experimentation efforts in period 1 enable the platform to introduce a more successful product in period 2.[24]

Further, in some situations, it might be the platform itself that interacts with the users of the app or with the purchaser of a third-party product and hence owns the data. For instance, the European Commission in *Apple Music* and the Netherlands' Competition Agency (ACM) in *Dating apps* argue that Apple's anti-steering policy has the effect of depriving software developers of their customer data. In the *Google v. Enel X* case itself, Enel X refused Google's offer to integrate JuicePass's services into Google Maps because this would have shifted user data from the former to the latter. To reflect such situations, we allow that it is the first-party app, rather than the third-party's, which benefits from data-enabled network effects.

[24] Recent work on the dynamics of hybrid platforms has provided models in this vein (Hervas-Drane and Shelegia, 2022; Madsen and Vellodi, 2023). An empirical finding that is in line with an e-commerce platform benefitting from spillovers is that Amazon is more likely to target its first-party entry toward successful product categories (Zhu and Liu, 2018).

In this extension, we assume as in the base model (Section 3) that first-party entry will always take place in period 2 and that period-2 access is compulsory. Here we allow for different ownership of data and for possible spillovers or data-sharing rules, in order to explore their implications on the platform's strategy regarding interoperability. To this end, we capture the share of data possessed by the third-party and the first-party app, respectively, by introducing the pair x_C, x_P as arguments in the period-2 profit functions (since data are non-rival, the sum may be larger than 1). We now write $\pi_j^2(x_C, x_P, y_C, y_P)$ and assume that $\frac{\partial \pi_P^2(x_C,x_P,y_C,y_P)}{\partial x_P} > 0$, $\frac{\partial \pi_P^2(x_C,x_P,y_C,y_P)}{\partial x_C} < 0$, and that $\frac{\partial \pi_C^2(x_C,x_P,y_C,y_P)}{\partial x_C} > 0$, $\frac{\partial \pi_C^2(x_C,x_P,y_C,y_P)}{\partial x_P} < 0$: an app's profits increase with the data it can access and decrease with the data accessed by the rival app. Note that this generalizes our base model, where the notation $\pi_j^2(x, y_C, y_P)$ corresponds to the special case where data were possessed by the third-party app and the platform did not have access to them: $\pi_j^2(x_C = 1, x_P = 0, y_C, y_P)$ using the notation of this section.

We also assume that if $x_C = x_P = \bar{x}$, then $\frac{\partial \pi_P^2(\bar{x},\bar{x},y_C,y_P)}{\partial \bar{x}} \geq 0$ and $\frac{\partial \pi_C^2(\bar{x},\bar{x},y_C,y_P)}{\partial \bar{x}} \geq 0$, because stronger data-enabled network effects lead to a higher quality of the app, and hence weakly higher total demand and, all else being equal, weakly higher profits for the apps.

We can now solve for the equilibrium of this extended game with various scenarios on data possession. Suppose that, if the third party enters, it will always enter in period 1. In the base model, the complementor does not have an incentive to postpone the release of its app to the second period. In the extended setting it might want to do so if it is the platform that benefits from period-1 data. This is ruled out by the condition that $\pi_C^1(1) + \pi_C^2(x_C, x_P, 1, 1) - \pi_C^2(0, 0, 1, 1) > 0$. If the third-party app has entered, the platform will deny interoperability if the following condition, adapted from expression (1), holds:

$$\pi_P^2(0, 0; 1, 1) - \pi_P^2(x_C, x_P; 1, 1) > \beta \left(\pi_C^1(1) + \pi_C^2(x_C, x_P; 1, 1) - \pi_C^2(0, 0; 1, 1)\right). \tag{5}$$

Our next result immediately follows.

Proposition 8. *Suppose that $x_P \geq x_C$ and $\pi_C^1(1) > \pi_C^2(0, 0, 1, 1) - \pi_C^2(x_C, x_P, 1, 1)$. Then, the platform will always provide interoperability to the third-party app.*

Proof. First, the right-hand side of condition (5) must be positive since $\pi_C^1(1) + \pi_C^2(x_C, x_P, 1, 1) - \pi_C^2(0, 0, 1, 1) > 0$. Second, for $x_P \geq x_C$, the left-hand side is non-positive under our assumptions. It follows that the condition never holds. □

Two corollaries of this result are interesting for policy purposes.

Corollary 2. *Under the conditions given in Proposition 8, if the data of the users of the third-party app are possessed by the platform, the platform will always have the incentive to provide interoperability.*

Corollary 3. *Under the conditions given in Proposition 8, if there exists a policy which commits to sharing the users' data between the app and the platform, independently of who possesses such data, the platform will always have the incentive to provide interoperability.*

The intuition behind these results is straightforward. In the base model, the platform may deny interoperability because it protects its future first-entry app by denying a competitive advantage to the complementor's app. But if it is the main beneficiary of data, or if there is a policy in place which effectively guarantees a level-playing field with respect to data-enabled network effects, then the incentive to deny interoperability disappears.

To find the subgame perfect Nash equilibrium of the whole game, we move backwards and analyze the complementor's entry decision. The third-party app will enter the market if

$$(1 - \beta)\left(\pi_C^1(1) + \pi_C^2(x_C, x_P, 1, 1)\right) \geq F_C.$$

This leads to the following:

Proposition 9. *Suppose that the data of period-1 users of the third-party app are either possessed by the platform or by the complementor (i.e., $x_P = 1$ or $x_C = 1$).*

- *If they are possessed by the platform and $\pi_C^1(1) > \pi_C^2(0, 0, 1, 1) - \pi_C^2(x_C, 1, 1, 1)$, a data-sharing policy is beneficial to consumers. It will make third-party entry more likely without triggering a denial of interoperability.*
- *If they are possessed by the third-party app, a data-sharing policy will give rise to a trade-off. On the one hand, if third-party entry takes place, the app will always be given access (whereas absent the policy, access may be denied); on the other hand, the condition for entry will be less likely to be satisfied.*

Proof. First, note that we know from Corollary 3 that the platform has the incentive to provide interoperability under data-sharing. (i) If the platform possesses the data of the third-party app, the entry condition $(1 - \beta)\left(\pi_C^1(1) + \pi_C^2(x_C, 1; 1, 1)\right) \geq F_C$ will be more likely to be satisfied under data-sharing, given that $\frac{\partial\left(\pi_C^2(x_C,1,1,1)\right)}{\partial x_C} > 0$. (ii) If instead the complementor possesses the data, the entry condition is $(1-\beta)\left(\pi_C^1(1)+\pi_C^2(1,x_P,1,1)\right) \geq F_C$ and it will be *less* likely to be satisfied under data-sharing, given that $\frac{\partial\left(\pi_C^2(1,x_P,1,1)\right)}{\partial x_P} < 0$. □

This shows that a policy of compulsory data-sharing is unambiguously beneficial when the platform otherwise can keep the user data of the third-party app for itself – a situation in which software developers are prevented from interacting directly with their customers. The consequences are instead a priori unclear when it is the third party that possesses the users' data, since the anticipation of lower profits – due to the absence of a competitive advantage over the future first-party app – decreases its incentive to launch the app in the first place.

We derived our result under the condition that the third-party app does not have an incentive to postpone the release of its app to period 2. When this condition does not hold, in the case that the platform possesses the data, the complementor would not make the app available in period 1 but wait until period 2 because it would obtain $(1-\beta)[\pi_C^1(1)+\pi_C^2(x_C,1,1,1)]$ if it made the app available in period 1 and $(1-\beta)\pi_C^2(0,0,1,1)$ if it did so in period 2. Thus, the platform would earn $\pi_C^2(0,0,1,1)+\beta\pi_C^2(0,0,1,1)$ absent data sharing, while it would earn $\pi_P^2(1,1,1,1)+\beta[\pi_C^1(1)+\pi_C^2(0,0,1,1)]$ with data-sharing. Thus, the platform has an incentive to commit to data-sharing at the beginning. When such commitment is not feasible, it has an incentive not to honor such a promise in period 2 because then it would choose between making a profit of $\pi_P^2(1,1,1,1)+\beta\pi_C^2(1,1,1,1)$ with data-sharing and a profit of $\pi_P^2(x_C,1,1,1)+\beta\pi_C^2(x_C,1,1,1)$ without data-sharing. As a result, in this situation, compulsory data-sharing is also beneficial for the platform when it is not able to commit to data-sharing at the beginning.

Finally, a word of caution: in this section, we have assumed that $F_P = 0$ (and β sufficiently small), so that the first-party app will always enter. If instead F_P is positive, then first-party entry will be affected by the data-sharing policy in the opposite direction. Entry is hindered by data-sharing when the platform possesses the third-party app data; when the complementor possesses them, it is facilitated.

6. Discussion and conclusion

Dynamic competition within a platform ecosystem may feature first-party and third-party offers. As we argue in this paper, the platform operator may sacrifice current profits in order to be in a more favorable position in the future regarding the prospects of first-party entry. To do so, the platform operator may deny access to third-party providers or downgrade the user experience with third-party content. Our motivating case is the recent decision by the Italian competition authority in Google vs. Enel X.

From a managerial perspective, our analysis provides insights into the optimal strategic behavior of firms operating in a dynamic platform ecosystem. In particular, third-party developers need to foresee strategic responses by forward-looking platform operators. While certain investments may look profitable in an environment that is friendly to the third-party provider, the risk of access denial or downgrading may make such investments unprofitable. This may also lead to a loss for the platform operator because, deprived of third-party entry, the whole ecosystem may become less attractive to the users of the ecosystem. In response, the platform may want to commit to open access policies to solve the hold-up problem.[25]

The platform may however not have the incentive to avoid hold-up or may lack the necessary commitment power. Then, regulatory intervention may make a difference and market outcomes depend on the regulatory environment the firms operate in. A compulsory access regime removes (or, in the case of only partial compliance, reduces) the foreclosure risk and, therefore, tends to encourage third-party entry. Relatedly, if third-party data can also be processed by the platform, then such data access tends to reduce the platform's incentive to foreclose its future third-party competitor. Both strategies may thereby effectively remedy the foreclosure risk.

Our simple theory has applications other than the case of Google vs. Enel X. For instance, Spotify's complaints about Apple included not only the payment of a 30% fee on App Store payments by Premium subscribers but also various ways in which Apple allegedly hindered access to its App Store for Spotify's apps.[26] While it is conceivable that Apple's behavior was part of a strategy to force Spotify to pay more fees, Apple may have intended to reduce Spotify's incumbency advantage after the decision to launch Apple Music.[27]

The platform's rationale to deny early third-party access may not be data-driven. Instead, such a rationale may exist because of a related mechanism. When consumers are subject to switching costs, the complementor may build up an installed base with a significant fraction of locked-in consumers and this may reduce the profits the platform can make with its first-party app later on – this notably holds if consumers are myopic and the complementor can price discriminate between early and late adopters.

[25] Commitment may be gained through reputation mechanisms in an environment in which third-party providers appear over time and decide whether to enter in different categories.

[26] See Spotify's allegations at www.timetoplayfair.com; last accessed 20 June 2023.

[27] Particularly relevant seems to be the fact that Spotify could not have access to data about its iOS clients. On 28 February 2023, the European Commission announced a revised Statement of Objections which focuses on Apple's "anti-steering obligations". On 4 March 2024, the European Commission has fined Apple over 1.8 billion Euro for its anti-steering provisions that, according to the European Commission amount to unfair trading conditions are in breach of Article 102(a) TFEU. In addition, Apple has to remove its anti-steering provisions. As Apple has to let Spotify inform its iOS users of alternative means to pay the subscription and redirect them to its website, Spotify will also have access to information about them.

CRediT authorship contribution statement

Massimo Motta: Conceptualization, Formal analysis, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing. **Martin Peitz:** Conceptualization, Formal analysis, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing.

Data availability

No data was used for the research described in the article.

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