The Exclusionary Effects of Addictive Platforms

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Abstract

We study the incentives of an incumbent social media platform to be addictive depending on whether it expects to face future competition. In our model, consumers have different levels of vulnerability to becoming addicted to an addictive platform and are ex ante rational and fully aware of the risks of addiction. The paper will show that although the incumbent platform prefers to be non-addictive when not facing the threat of entry, the entry threat can make choosing to be an addictive platform more profitable due to its ability to deter entry. This can occur even when social welfare is higher with a non-addictive monopoly.

1 Introduction

There has been growing concern that social media platforms such as Facebook, Instagram and TikTok are addictive and that this harms consumers. These addictive attributes are alleged to be caused or exacerbated by the platforms themselves, by adding features such as infinite scrolling, pull to refresh buttons allegedly designed to resemble slot machines, likes, alerts, notifications, using artificial intelligence to route content that induces compulsive use and exploitation of human vulnerabilities of needing to reciprocate social gestures (Neyman (2017); Turel and Osatuyi (2017)). A parallel concern is that such platforms can gain market dominance.[1] This raises the question whether competition from a non-addictive social media

[1] See, e.g., Federal Trade Commission v. Facebook, Inc. (Case No.: 1:20-cv-03590), complaint; https://www.bundeskartellamt.de/SharedDocs/Meldung/EN/Pressemitteilungen/2019/07_02_2019_Facebook.html (documenting the German Competition Authority's proceeding against Facebook).

platform can alleviate the social harm from addiction. We show the contrary: the threat of entry may induce the incumbent to become addictive, in order to either block entry of a non-addictive platform or partially exclude it if it enters. Importantly, this can occur even when consumers are ex ante fully rational. Without the threat of entry, consumers vulnerable to addiction will prefer a non-addictive platform if the harm from addiction is sufficiently large, so that a monopolistic platform prefers to be non-addictive. With the threat of entry, however, the incumbent may prefer to make its platform addictive, because this can exclude or disrupt entry, by increasing the number of consumers who are not contestable by a non-addictive entrant.

In particular, if an addictive platform aggressively recruits consumers when it is a monopoly, then some of these consumers will become addicted. When a non-addictive platform tries to enter, those consumers who are already addicted join the less vulnerable consumers who prefer the addictive platform to create a large group of consumers that are not contestable. This can induce even consumers vulnerable to addiction to join the addictive platform when it is a monopoly rather than wait for a non-addictive entrant. First, since entry of a non-addictive platform can be blocked by the incumbent expanding its first period customer-base, vulnerable consumers understand the non-addictive entrant may not be viable. Second, even when consumers expect a non-addictive platform to enter, the negative externality the incumbent addictive platform imposes on the non-addictive entrant allows it to court consumers aggressively in the first period so as to recruit even vulnerable consumers. Here, vulnerable consumers share the profits made at the expense of the non-addictive entrant, by enjoying attractive first-period terms granted by the addictive incumbent. Hence exclusion, or partial exclusion, of the non-addictive entrant is achieved even though social welfare would be higher with a non-addictive monopoly platform or with a large non-addictive incumbent and a small addictive entrant. There are two externalities that drive this result. The first is a collective action problem among consumers with different levels of vulnerability to addiction, in a similar spirit to the naked exclusion literature of exclusive dealing (e.g., Rasmusen et al (1991); Segal and Whinston (2000)). The second externality is extraction of profits from the non-addictive entrant, bearing some resemblance to Aghion and Bolton (1986).

In the current preliminary version of the paper, we show that the non-addictive entrant's profit is decreasing in the addictive incumbent's first period market share when network effects are not too intense. This implies that the addictive incumbent can (partly or fully) exclude a non-addictive entrant by aggressively courting consumers when it is a monopoly. We also show that, with sufficiently small network effects, in the event of non-addictive entry, the addictive platform maximizes its second period profit by recruiting all consumers in the first period whenever its quality advantage is not too large. We then study when the threat of entry induces an addictive incumbent to more aggressively recruit consumers when it is a monopoly and show that this is more likely the lower is the addictive platform's quality relative to the harm from addiction. We also show how, absent the threat of entry, the first mover would have preferred to be non-addictive. Accordingly, if the incumbent decided to be addictive, this must be due to an exclusionary strategy. Finally, we show that even when the addictive platform's quality advantage is significantly lower than the cost of addiction, if the incumbent chooses to be addictive, it has better prospects of blocking entry and remaining a monopoly. Moreover, even if entry is not blocked, an addictive incumbent earns higher second-period profits than a non-addictive one.

In our base model, platforms charge subscription fees. This implies that it is not the lack of subscription fees and the fact that social media platforms' profits are based on ad revenue that drives exclusionary behavior by an addictive platform. In future drafts, we will extend the model to platforms not charging subscription fees and making their revenue from advertisers. We expect our main results to carry over to this case. If ad revenue is larger for addictive platforms, even a monopoly platform that does not face the threat of entry may prefer to be addictive, in order to gain more ad revenue. We expect it still to be the case, however, that the parameter space in which the platform prefers becoming addictive expands once the platform faces the risk of entry.

Our results have antitrust implications, because in our framework there is a parameter range in which a social media platform chooses to be addictive in order to exclude entry even though it would not do so without this threat. Under current antitrust doctrine, with such a non-price exclusionary strategy (namely, making the platform addictive) this can constitute a violation even if marginal profits are positive.[2] Such an antitrust prohibition is less intrusive than a ban on addictiveness. It condemns only using addictiveness as an exclusionary tool. For example, under such a regime, if the first mover is non-addictive, the second mover may be addictive, serving a niche of relatively invulnerable consumers.

To the best of our knowledge, ours is the first paper to model addictiveness of a platform as an exclusionary tool and the consequent choice of the first mover to be addictive. There is an extensive literature on platform competition unrelated to addiction. We contribute especially to the strand of this literature studying different types of networks competing over heterogeneous consumers, such as Fudenberg and Tirole (2000); Chen and Tse (2008); Jullien (2011); Hosain and Morgan (2013); Halaburda and Yehezkel (2016); Markovich and Yehezkel (2023) and Akerlof et al (2023).

A line of the platform literature related to the latter strand we contribute to is that which studies heterogeneous consumers possibly splitting among different platforms at the expense of network effects (e.g., Chen and Tse (2008); Hosain and Morgan (2013); Halaburda and Yehezkel (2016) and Biglaiser and Crémer (2020)). In our framework, however, the addictive platform can exclude the non-addictive one even from serving vulnerable consumers. Also, in our paper, the threat of competition can harm social welfare because it induces the incumbent to be addictive. This is while, for example, in Biglaiser and Crémer (2020), competition may harm social welfare by causing fragmentation of consumers, thereby sacrificing network effects.

Other papers study the advantages of an incumbent platform. We abstract in our paper from incumbency advantages stemming from consumers' expectations that an incumbent

[2] See, e.g., Brooke Grp. Ltd. v. Brown & Williamson Tobacco Corp., 509 U.S. 209 (1993); ZF Meritor v. Eaton Corp (3d. Cir.) 696 F.3d 254 (2012).

platform will be joined by other consumers and thus entrench its position. Instead, in our paper a first mover gains an advantage if it chooses to be addictive, not because of consumers' expectations, but due to the captive characteristic of addiction. In this sense, our paper is related to literature studying incumbency advantages stemming from switching costs of consumers who have joined the incumbent, such as Farrell and Saloner (1986) and Fudenberg and Tirole (2000) (who assume switching costs due to an installed base) and Cabral (2011) (who assumes consumers that join a platform do not leave it) . The mechanism excluding the new entrant in our framework is not switching costs: addicted consumers do not have a cost of switching but rather changed preferences and unaddicted consumers actually face an expected cost from joining the addictive incumbent. Another key difference between our model and the switching cost literature is that we study heterogeneous consumers affected by addiction in different ways. In particular, in our second period, addicted consumers, who are hooked to the incumbent due to changed preferences, are intermingled with unaddicted consumers facing the risk of addiction.

While all consumers are fully rational ex ante in our model, some of them may lose self-control after joining an addictive platform. In this sense we also contribute to literature studying platform behavior *vis a vis* boundedly rational consumers. Hosain and Morgan (2013) study competition between two-sided platforms matching between the two sides and characterize equilibria in which more rational consumers herd with less rational consumers. Liu et al (2021) study a platform's data sharing decisions when some consumers lack self-control when facing targeted ads by temptation goods, which may be addictive, such as online gambling. These papers do not study addictive use of the social media platform. Ichihashi and Kim (2023) study platform competition over the time-allocation of a single consumer, who loses self-control once she joins a platform. The competing platforms choose how addictive to be. Bhargava (2023) studies competition between an ad-revenue based addictive platform and a subscription-fee based non-addictive platform over a continuum of heterogeneous consumers where some lack self-control. He studies how such competition affects the level of addictiveness. Unlike our paper, these papers do not discuss using addictiveness of the platform as an exclusionary strategy. Our paper further contributes to Bhargava (2023)'s work in that he studies simultaneous competition while we study a sequential game, where one platform is a first mover. This framework enables us to draw policy implications regarding the use of addictiveness of the platform as an exclusionary device and the question how the threat of entry affects a platform's decision whether to become addictive. Indeed, the results of this framework are different. For instance, in his paper, network effects exacerbate the addictive platform's advantage while in our framework, exclusion of the non-addictive platform by the addictive one occurs especially with small network effects. Also, in his framework, a platform loses vulnerable consumers when it becomes more addictive while in ours, making the platform addictive can enable the addictive platform to monopolize the market.

2 Model

When a firm enters with an online platform, it chooses between two types of platforms $\{A, NA\}$. Platform A is (potentially) addictive. Platform NA is not addictive. There are a continuum of consumers, $\theta \in [0, 1]$ ($\theta \sim U[0, 1]$), which represents the risk of addiction for a consumer on an addictive platform.[3] There is no such risk on the non-addictive platform. Consumers' gross individual utility from using a platform of type i is v_i $i \in \{A, NA\}$. We assume that factors that make a platform addictive also weakly increase its value to consumers, so $v_A \geq v_{NA}$. This utility is reduced by k if a consumer becomes addicted.[4] We assume that addiction is sufficiently harmful such that at least some consumers prefer

[3] Such differences among consumers are consistent with Allcott et al (2022)'s randomized experiment showing that self-control problems explain 31% of social media use and that consumers are heterogeneous with regard to the degree of their self-control problems. For psychological literature on addiction to social media platforms see, e.g., Pontes et al (2018); Liu and Ma (2018); McCrory et al (2022).

[4] For psychological studies documenting the harm from addiction to social media platforms see, e.g., Wilksch et al (2020); Brailovskaia et al (2020); Yurdagül et al (2021) and Santini et al (2024) and for economic literature documenting the harm see, e.g., Allcott et al (2020); Braghieri et al (2022) and Bursztyn et al (2023).

the non-addictive platform absent network effects, $v_A - k < v_{NA}$. Consumers also receive a network utility of γz, where z is the fraction of consumers on the platform. Assume for now that a platform charges a subscription fee to consumers.[5]

3 Threat of entry

We now consider how the threat of entry affects the incentive to choose the addictive or non-addictive technology. There are two periods: Period 1, where platform 1 is a monopolistic first mover, and period 2, where platform 2 may enter and duopolistic competition evolves. Period 1 has two stages. In stage A, platform 1 enters and decides whether to be addictive or non-addictive and sets its price. In stage B, consumers decide whether to join this monopoly.

Period 2 has three stages. In stage A, platform 2 decides whether to enter, where entry involves a fixed and sunk stochastic entry cost with a cumulative distribution function G and density g; in stage B, if platform 2 enters, it decides whether to be addictive or non-addictive and sets its price under duopoly competition with platform 1 while platform 1 simultaneously sets its own price. In stage C, consumers decide whether to join a platform, and if so, if platform 2 entered, which of the two platforms to join.

3.1 Second period with threat of entry

Pursuant to the literature on addiction (e.g., Fudenberg and Levine (2006)), once a consumer loses self-control and becomes addicted, she considers only the benefit rather than the harm from addiction, so she has no reason to prefer a non-addictive platform. Hence the marginal baseline utility (not including network effects) of an already addicted consumer from platform i is v_i.

[5] We shall extend to zero subscription fees and ad revenue in future drafts. We expect our qualitative results to carry over. To illustrate, with subscription fees, revenue per consumer is the subscription fee p. If instead platforms earn ad revenue of r per consumer and charge zero subscription fees, while competing by offering better privacy settings, retrieving less data from consumers, or exposing them to fewer ads, their revenue per consumer is $r - p$, where p is the ad revenue the platform sacrifices to benefit the consumer.

If the first mover, platform 1, chose to be addictive in period 1 and all consumers with $\theta < \theta^*$ joined the platform, then some of those consumers will become addicted. There will be a mass of ${\theta^*}^2/2$ consumers with $\theta < \theta^*$ who are addicted in period 2, while there is a mass of $\theta^* - {\theta^*}^2/2$ unaddicted consumers with $\theta < \theta^*$, and a mass of $1 - \theta^*$ consumers with $\theta \geq \theta^*$ who are also unaddicted. If the period 1 incumbent was non-addictive, there will be no addicted consumers. This implies that the fraction of the period 2 market that is addicted is greater the more consumers joined an addictive platform in period 1.

If indeed the first mover, platform 1, chose to be addictive in period 1, then in period 2, platform 2 can make positive profits, if at all, only if it chooses to be non-addictive, since otherwise Bertrand competition would erode all profits. Accordingly, consider the case where the second mover is non-addictive. The addictive incumbent will have a comparative advantage with low-θ consumers and consumers who are already addicted, while the non-addictive platform will have a comparative advantage with unaddicted consumers having a larger θ. Because an addicted consumer has the same relative preferences between the two platforms as the $\theta = 0$ consumer, this suggests that if network effects are not too large, there will exist a $\tilde{\theta}$ such that the addictive platform will serve all addicted consumers and unaddicted consumers with $\theta < \tilde{\theta}$, and the non-addictive platform will serve unaddicted consumers with $\theta \geq \tilde{\theta}$.

The $\tilde{\theta}$ consumer's utility from the addictive platform is $v_A - k\tilde{\theta} + \gamma[\tilde{\theta} + (\theta^* - \tilde{\theta})(\theta^* + \tilde{\theta})/2] - p_A$. The term multiplying γ is the fraction of consumers that will choose the addictive platform: all consumers below $\tilde{\theta}$ and the addicted ones above $\tilde{\theta}$. If all unaddicted consumers above $\tilde{\theta}$ join the non-addictive platform, then the $\tilde{\theta}$ consumer's utility from this platform is $v_{NA} + \gamma[(1 - \tilde{\theta}) - (\theta^{*2} - \tilde{\theta}^2)/2] - p_{NA}$. Setting the $\tilde{\theta}$ consumer's utility from each platform equal to each other, we can solve for the indifferent consumer, $\tilde{\theta}$. Doing so gives:

$$\tilde{\theta} = 1 - \frac{k - \sqrt{(k - 2\gamma)^2 + 4\gamma[v_A - p_A - (v_{NA} - p_{NA}) - \gamma(1 - \theta^{*2})]}}{2\gamma} \tag{1}$$

The next result shows the addictive platform can reduce the non-addictive platform's profit by expanding its market share during its monopoly period.

Lemma 1. *The non-addictive platform's profit in period 2 is decreasing in θ^* for any $v_A \geq v_{NA}$* and any $\gamma \leq \frac{k}{3}$.

Proof. By the envelope theorem, we can find the effect of θ^* on the non-addictive platform's profit by holding p_{NA} constant (but allowing both $\tilde{\theta}$ and p_A to vary). Thus, the profit effect is the same as the market share effect holding p_{NA} constant. The derivative of the non-addictive platform's market share with respect to θ^* is:

$$\frac{-k\theta^* + (1-\tilde{\theta})\frac{dp_A}{d\theta^*}}{k - 2\gamma(1-\tilde{\theta})}$$

(Note, we obtain this expression by substituting for $\tilde{\theta}$ using (1) to find the effect of $\tilde{\theta}$ and then using (1) to convert back to $\tilde{\theta}$ for ease of presentation.) This is negative if and only if $\frac{dp_A}{d\theta^*} < \frac{k\theta^*}{(1-\tilde{\theta})}$. We examine $\frac{dp_A}{d\theta^*}$ by finding the first order conditions for both firms' profit functions and then totally differentiating them with respect to θ^* and solving for both $\frac{dp_A}{d\theta^*}$ and $\frac{dp_{NA}}{d\theta^*}$. First, let $\Delta u = v_A - p_A - (v_{NA} - p_{NA})$ be the difference in net utility gross of addiction and network effects. The first order conditions are:

$$\frac{(1-\tilde{\theta})[k-2\gamma(1-\tilde{\theta})]^2 - 2\gamma(1-\tilde{\theta})p_A + [\Delta u - k + \gamma(1+2\theta^{*2})](k-2\gamma(1-\tilde{\theta}))}{2\gamma[k-2\gamma(1-\tilde{\theta})]} \tag{2}$$

$$\frac{-(1-\tilde{\theta})[k-2\gamma(1-\tilde{\theta})]^2 - 2\gamma(1-\tilde{\theta})p_{NA} - [\Delta u - k - \gamma(1-2\theta^{*2})](k-2\gamma(1-\tilde{\theta}))}{2\gamma[k-2\gamma(1-\tilde{\theta})]}$$

We then differentiate these first order conditions with respect to θ^* (recognizing that $\tilde{\theta}$ depends on both θ^* and the prices, while Δu depends only on the prices) to find $\frac{dp_A}{d\theta^*}$. Doing so gives:

$$\frac{k\theta^*\{-(p_A+p_{NA})(k-2\gamma(1-\tilde{\theta})) + 2p_A\gamma(1-\tilde{\theta}) + (1-\tilde{\theta})(k-2\gamma(1-\tilde{\theta}))^2\}}{(1-\tilde{\theta})\{3(1-\tilde{\theta})(k-2\gamma(1-\tilde{\theta}))^2 + k(p_A-p_{NA})\}} \tag{3}$$

If the ratio of the terms in curly braces is less than one, then the non-addictive platform's market share is decreasing in θ^*. Using the first order conditions to substitute for the prices (we aren't solving for the prices because the terms in (3) include $\tilde{\theta}$ which is a function of prices), the ratio of the curly braces terms is:

$$\frac{\gamma(1-\tilde{\theta})^2(v_A - v_{NA} - \gamma(3-2\theta^{*2})) - k^2\tilde{\theta}(2-\tilde{\theta}) + k\gamma(1+4\tilde{\theta}-7\tilde{\theta}^2+2\tilde{\theta}^3)}{(1-\tilde{\theta})\{k(v_A - v_{NA} - \gamma(11(1-\tilde{\theta})^2 - 2\theta^{*2})) + 6\gamma^2(1-\tilde{\theta})^3 + k^2(3-4\tilde{\theta})\}} \tag{4}$$

Subtracting the numerator from the denominator gives:

$$(k-\gamma(1-\tilde{\theta}))[k(3-5\tilde{\theta}+3\tilde{\theta}^2) + (1-\tilde{\theta})(v_A - v_{NA} - \gamma(9-12\tilde{\theta}+6\tilde{\theta}^2-2\theta^{*2}))] \tag{5}$$

This has the sign of the term in square brackets. Because $v_A > v_{NA}$ and for any $\theta^* > \tilde{\theta}$, this term is strictly greater than:

$$k(3-5\tilde{\theta}+3\tilde{\theta}^2) - \gamma(1-\tilde{\theta})(3-2\tilde{\theta})^2) \tag{6}$$

This is positive for any $\tilde{\theta}$ if $k > 3\gamma$. □

Raising θ^* has two opposing effects on the non-addictive platform's profits. On one hand, there is a "price effect": The addictive platform wants to exploit its market power over addicted consumers in period 2 so it raises prices and this facilitates entry. On the other hand, there is a "market share effect": The addicted consumers are not contestable and this hinders entry. Lemma 1 shows that, if network effects are not too large (such that we are not in a corner solution), the market share effect dominates, so the non-addictive platform's profit is decreasing in θ^*.

The fact that the non-addictive entrant's profits are decreasing in the addictive incumbent's market share implies that the incumbent can exclude the entrant (fully or partly) by expanding its first-period market share. We further study platform 1's optimal first period strategy in the next sub-section.

Consider now how the addictive incumbent platform's second period profit varies with its first-period market share, θ^*, given entry. We focus here on small network effects and leave the case of larger network effects for future drafts. If $\gamma \to 0$, then the cutoff for unaddicted consumers to choose the addictive platform is $\theta \leq \tilde{\theta}_0 \equiv \frac{v_A - v_{NA} - (p_A - p_{NA})}{k}$. The profit functions are now given by $p_A(\tilde{\theta}_0 + (\theta^{*2} - \tilde{\theta}_0^{\,2})/2)$ and $p_{NA}(1 - \tilde{\theta}_0 - (\theta^{*2} - \tilde{\theta}_0^2)/2)$ whenever $\theta^* \geq \tilde{\theta}_0$. By differentiating the profit functions and solving for prices, we can obtain an explicit function for the addictive platform's second period profits as a function of θ^* and use it to determine how those profits vary with θ^*, as the following lemma shows.

Lemma 2. *For $\gamma \to 0$, there exists $\tilde{\theta}_0 < \bar{\theta}^* < 1$ such that the addictive platform's second period profit is increasing in θ^** for $\theta^* > \bar{\theta}^*$.

Proof. Solving the first order conditions for prices gives:

$$p_A = \frac{(2 + \theta^{*2})\sqrt{(k - \Delta v)^2 + 8k^2\theta^{*2}} - (k - \Delta v)(2 + 3\theta^{*2})}{8\theta^*}$$

$$p_{NA} = \frac{(2 - \theta^{*2})\sqrt{(k - \Delta v)^2 + 8k^2\theta^{*2}} - (k - \Delta v)(2 - 3\theta^{*2})}{8\theta^*} \tag{7}$$

In these expressions, $\Delta v = v_A - v_{NA}$. Using these prices, we get that $\tilde{\theta}_0 = \frac{3k - \Delta v - \sqrt{(k - \Delta v)^2 + 8k^2\theta^{*2}}}{4k}$. Substituting these into the addictive platform's profit function and taking the derivative with respect to θ^* , and using $\Delta v = xk$ with $x \in (0, 1)$, gives:

$$\frac{k\{-\theta^{*2}(2 + \theta^{*2})(2 - 3\theta^{*2}) + (1 - x)(4 - 5\theta^{*4})\sqrt{(1 - x)^2 + 8\theta^{*2}} - (1 - x)^2(4 - 3\theta^{*4})\}}{16\theta^{*3}\sqrt{(1 - x)^2 + 8\theta^{*2}}} \tag{8}$$

This has the sign of the curly braces term in the numerator. Because $x \in (0, 1)$, setting the curly braces term to zero has only one non-zero real solution for θ^{*2}:

$$\theta^{*2} = (11 + 2x - x^2 - (1 - x)\sqrt{13 - 2x + x^2})/18 \tag{9}$$

The curly braces term is negative for very small θ^{*2} and positive for $\theta^{*2} = 1$. Hence $\bar{\theta}^*$ is a unique minimum, so the platform's second period profit is increasing in θ^* if and only if $\theta^* > \bar{\theta}^*$. □

Lemma 2 means that for any $\theta^* \geq \tilde{\theta}_0$, the addictive platform's second period profit will be maximized at either $\theta^* = \tilde{\theta}_0$ or $\theta^* = 1$. Writing $\tilde{\theta}_0 = \frac{3k-\Delta v-\sqrt{(k-\Delta v)^2+8k^2\theta^{*2}}}{4k}$ in terms of x, we find that $\tilde{\theta}_0 = (3 + x - \sqrt{5 + 2x + x^2})/2$. Subtracting profit at $\theta^* = \tilde{\theta}_0$ from profit at $\theta^* = 1$ yields an expression that is decreasing in x and equals zero at $x = 0.35285$. This establishes the next result:

Lemma 3. *If the addictive platform's quality advantage is less than* 0.35285 *the size of the harm from addiction, then for* $\gamma \to 0$*, the addictive platform's second period profit is maximized when all consumers join the platform in the first period; Otherwise, it is maximized when* $\theta^* = \tilde{\theta}_0 = (3 + x - \sqrt{5 + 2x + x^2})/2$ *consumers purchase in the first period.*

Lemma 3 shows that if network effects are small and the addictive platform's quality advantage (gross of addiction costs) is not too great, then the addictive platform can increase its second period profits by ensuring that all (or almost all) consumers use it's platform in the first period.

Together, Lemmas 1, 2, and 3 imply that in period 1, the first mover may choose to be addictive even if absent the risk of entry it would prefer to be non-addictive, and even when such a non-addictive monopoly would yield greater social welfare. This is for two reasons. First, by expanding its customer base in the first period, the addictive platform can reduce the profits of a non-addictive entrant, thereby possibly blocking entry when the fixed cost of entry is sufficiently high. Second, in the event that entry by a non-addictive platform occurs, expanding its first period customer base may increase the addictive platform's second period profits at the expense of the non-addictive entrant.

3.2 First period with threat of entry

Now consider the incentives of the incumbent platform in period 1 when there is possible entry in period 2. It needs to choose whether to be addictive or non-addictive. If it chooses to be non-addictive, this would invite entry by an addictive platform. If it chooses to be addictive, it needs to decide if it wants to expand period 1 output beyond the monopoly level, so as to partly or fully exclude a non-addictive entrant.

Again, for simplicity we focus for now on the no network effects case. First, consider the problem in the first period for a consumer who expects to join the non-addictive platform in period 2 if she is not addicted in period 1. Consider consumer θ who is indifferent in period 1 between joining the addictive incumbent or not. Her indifference is despite the prospects of becoming addicted and the knowledge that the addictive incumbent exploits addicted consumers in period 2. Hence if the indifferent consumer avoids addiction in period 1, at least for sufficiently small $\frac{k}{v_A}$, she will not join the addictive platform in period 2, regardless of whether there was entry of a non-addictive platform.[6] She will either join the non-addictive platform in the event of entry or not join any platform if there is no entry. Denote the probability that the non-addictive platform enters in period 2 by q $(0 \leq q \leq 1)$ and the addictive monopoly incumbent's period 1 price by p_{A1}. The indifferent consumer has the following expected utility from joining the addictive platform in period 1 :

$$v_A - p_{A1} - \theta k + q\{\theta(v_A - p_A - k) + (1-\theta)(v_{NA} - p_{NA})\} + (1-q)\theta(v_A - p_{A2} - k) \quad (10)$$

In (10), p_A and p_{NA} are the period 2 prices given entry as determined in subsection 3.1. p_{A1} is the monopoly price the addictive incumbent charges in period 1 and p_{A2} is the monopoly price it charges in period 2 if entry did not occur. If the non-addictive platform enters in period 2, then the indifferent consumer joins the addictive platform again in period 2 if she became addicted in period 1 (and then she suffers the harm from addiction again). If she

[6] We demonstrate this explicitly in the proof of Lemma 4 below.

did not become addicted in period 1, as noted above, she joins the non-addictive platform. If there is no entry, then the consumer joins the addictive platform again in period 2 if and only if she was addicted in period 1.

If the indifferent consumer waits until period 2 in order to join the non-addictive platform, then her expected utility is:

$$q(v_{NA} - p_{NA}) \tag{11}$$

Using the prices given entry determined in sub-section 3.1, the difference in expected utility from joining the addictive incumbent in period 1 versus waiting for the non-addictive platform until period 2 for the consumer at $\theta = \theta^*$ is:

$$v_A - p_{A1} + \theta^*\{(1-q)(v_A - p_{A2}) - 2k + (q/4)(3k + \Delta v - \sqrt{(k-\Delta v)^2 + 8k^2\theta^{*2}})\} \tag{12}$$

Thus, all consumers will purchase in the first period ($\theta^* = 1$) even if there is no quality advantage ($\Delta v = 0$) if and only if $p_{A1} \leq v_A + (1-q)(v_A - p_{A2}) - 2k$. Totally differentiating (12) with respect to p_{A1} and using that this expression is zero for the marginal consumer, shows that, not surprisingly, more consumers purchase in the first period when prices are lower:

$$\frac{d\theta^*}{dp_{A1}} = -\frac{\theta^*\sqrt{(k-\Delta v)^2 + 8k^2\theta^{*2}}}{(v_A - p_{A1})\sqrt{(k-\Delta v)^2 + 8k^2\theta^{*2}} + 2k^2 q\theta^{*3}} \tag{13}$$

At $\Delta v = 0$ and $\theta^* = 1$, (13) turns into $\frac{d\theta^*}{dp_{A1}} = -\frac{3}{3(v_A - p_{A1}) + 2kq}$.

For the addictive platform, we can express the two period profit maximization problem as follows, taking into account that by Lemma 1, q, the probability of entry, depends negatively on θ^* (and θ^*, in turn, depends on p_{A1}) :

$$\Pi(p_{A1}) = p_{A1}\theta^* + q(\theta^*)\pi_{2E}(\theta^*) + (1 - q(\theta^*))\pi_{2M}(\theta^*) \tag{14}$$

Total profits are just profits from period 1, $p_{A1}\theta^*$, plus the probability of entry times profit given entry (denoted $\pi_{2E}(\theta^*)$) plus the probability of no entry times the profit from being a monopoly in the final period (denoted $\pi_{2M}(\theta^*)$). By Lemma 2, $\pi_{2E}(\theta^*)$ is increasing in the neighborhood of $\theta^* = 1$ and by Lemma 3 is globally maximized at $\theta^* = 1$ for small Δv. $\pi_{2M}(\theta^*)$ is also obviously increasing in θ^*, since the more consumers that are addicted, the more consumers who disregard the harm from addiction, increasing their marginal value of the platform.

We can write the firm's marginal profit as follows:

$$\Pi'(p_{A1}) = \theta^* + \frac{d\theta^*}{dp_{A1}}\{p_{A1} - q'(\theta^*)(\pi_{2M}(\theta^*) - \pi_{2E}(\theta^*)) + q(\theta^*)\pi'_{2E}(\theta^*) + (1-q(\theta^*))\pi'_{2M}(\theta^*)\} \quad (15)$$

Notice that if θ^* is close to 1 (which will be optimal if v_A is sufficiently large)[7], then the term in the curly braces is unambiguously larger than p_{A1}, and the addictive platform will charge a lower first period price in the two period case than is statically optimal in a one period case.

Intuitively, an addictive monopoly may want to reduce prices in period 1 also absent the threat of entry, because then it can recruit more consumers in period 1 and exploit the addicted ones in period 2. On the other hand, with the threat of entry, by Lemma 1, reducing its first period price can deter entry. Hence the threat of entry increases the incumbent's incentive to reduce prices compared to the case absent the threat of entry when the second effect dominates the first.

To determine the formal condition for this, recall that $\pi_{2E}(\theta^*) = p_A(\tilde{\theta} + (\theta^{*2} - \tilde{\theta}^2)/2)$ and $\tilde{\theta} = \frac{\Delta v - p_A - p_{NA}}{k}$. Using the second period prices derived in subsection 3.1, for $\theta^* = 1$, we have (defining $x = \Delta v/k$):

$$\pi_{2E} = \frac{k}{128}(3\sqrt{9-2x+x^2} - 5(1-x))(11 + 2x - x^2 - (1-x)\sqrt{9-2x+x^2}) \quad (16)$$

$$\pi'_{2E}(\theta^*) = \frac{k11 + 2x - x^2 - (1-x)\sqrt{9-2x+x^2})}{16\sqrt{9-2x+x^2}} \quad (17)$$

[7] See the proof of Lemma 4.

To determine the addictive platform's monopoly profits in period 2, note that if θ^* consumers join in period 1 then there will be $\theta^{*2}/2$ addicted consumers in period 2. The remaining density of consumers for $\theta \leq \theta^*$ is $1-\theta$ and for $\theta > \theta^*$ it is 1. So, if θ^* is large enough (so that the marginal consumer in period 2 has $\theta \leq \theta^*$, then period 2 monopoly profits are given by $\pi_{2M}(\theta^*) = p_{A2}(\theta^{*2}/2 + \theta_M - \theta_M^2/2)$, where $\theta_M = (v_A - p_{A2})/k$ is the marginal consumer in period 2. The profit maximizing price is then $p_{A2} = \{2(v_A - k) + \sqrt{(v_A-k)^2 + 3k^2(1+\theta^{*2})}\}/3$. This makes

$$\begin{gathered}\pi_{2M}(\theta^*) = -\tfrac{v_A}{27\alpha^2}(2(1-\alpha)+ \\ \sqrt{(1-\alpha)^2 + 3\alpha^2(1+\theta^{*2})})((1-\alpha)^2 - 3\alpha^2(1+\theta^{*^2}) \\ +\alpha(1-\alpha)\sqrt{(1-\alpha)^2+3\alpha^2(1+\theta^{*^2})})\end{gathered} \tag{18}$$

where $\alpha \equiv k/v_A < 1$. We can now evaluate the terms in (15) to determine when the threat of entry (i.e., any $q > 0$) induces the addictive incumbent to charge lower or higher prices in period 1 than it would without the threat of entry (i.e., $q = 0$). By deriving the difference between the addictive incumbent's marginal profits for $q > 0$ and for $q = 0$, and since $\frac{d\theta^*}{dp_{A1}} < 0$, the profit maximizing first period price is smaller (larger) due to the threat of entry if and only if:

$$-q'(\theta^*)(\pi_{2M}(\theta^*) - \pi_{2E}(\theta^*)) - q(\theta^*)(\pi'_{2M}(\theta^*) - \pi'_{2E}(\theta^*)) \tag{19}$$

is positive (negative). The sign of (19) depends on $\frac{q'(\theta^*)}{q(\theta^*)}$, which is the hazard rate for the probability of entry as a function of θ^*. In particular, (19) is positive (so that the threat of entry causes the addictive incumbent to reduce prices in period 1) if and only if:

$$\frac{q'(\theta^*)}{q(\theta^*)} < \frac{\pi'_{2E}(\theta^*) - \pi'_{2M}(\theta^*)}{\pi_{2M}(\theta^*) - \pi_{2E}(\theta^*)} \tag{20}$$

Note that both sides of (20) are negative: $\pi'_{2E}(\theta^*) < \pi'_{2M}(\theta^*)$, because reducing price increases second period monopoly profits absent entry more than it increases second period duopoly profits in the event of entry. The more negative is the hazard rate, the more effective is low pricing in deterring entry as opposed to just raising second period monopoly profits absent entry. To derive the critical hazard rate analytically, we solve for θ^* near 1 and for the case where the platforms' baseline quality is the same:

Proposition 1. *At $\Delta v = 0$, the threat of entry increases (decreases) the addictive platform's incentive to serve all first period consumers if and only if the hazard rate for the probability of entry as a function of θ^* is sufficiently negative at $\theta^* = 1$; that is $\frac{q'(\theta^*)}{q(\theta^*)} < -\frac{18(2\sqrt{7-2\alpha+\alpha^2}-(5-4\alpha))}{4(7-2\alpha+\alpha^2)^{3/2}-(95-60\alpha+12\alpha^2+4\alpha^3)}$ at $\theta^* = 1$. This critical hazard rate is increasing (becomes less negative) in $\alpha = \frac{k}{v_A}$, the ratio of the value of the platform to the cost of addiction.*

Proof. $-q'(\theta^*)(\pi_{2M}(\theta^*) - \pi_{2E}(\theta^*)) - q(\theta^*)(\pi'_{2M}(\theta^*) - \pi'_{2E}(\theta^*)) > 0$ if and only if $\frac{q'(\theta^*)}{q(\theta^*)} < \frac{(\pi'_{2E}(\theta^*)-\pi'_{2M}(\theta^*))}{(\pi_{2M}(\theta^*)-\pi_{2E}(\theta^*))}$. Using the expressions for $\pi_{2M}(\theta^*)$ and $\pi_{2E}(\theta^*)$ derived above in the vicinity of $\theta^* = 1$, we obtain that $-\frac{(\pi'_{2E}(\theta^*)-\pi'_{2M}(\theta^*))}{(\pi_{2M}(\theta^*)-\pi_{2E}(\theta^*))} = -\frac{18\alpha^2(2\sqrt{1-2\alpha+7\alpha^2}+(4-5\alpha))}{4(1-2\alpha+7\alpha^2)^{3/2}-(4-12\alpha+60\alpha^2+95\alpha^3)}$. The derivative of $-\frac{18\alpha^2(2\sqrt{1-2\alpha+7\alpha^2}+(4-5\alpha))}{4(1-2\alpha+7\alpha^2)^{3/2}-(4-12\alpha+60\alpha^2+95\alpha^3)}$ with respect to α is:

$$\frac{-36\alpha[8-38\alpha+42\alpha^2-11\alpha^3+143\alpha^4-2(1-4\alpha)(4+\alpha-2\alpha^2)\sqrt{1-2\alpha+7\alpha^2}]}{[4(1-2\alpha+7\alpha^2)^{3/2}-(4-12\alpha+60\alpha^2+95\alpha^3)]^2} > 0$$

□

For a sufficiently negative hazard rate, the benefit from deterring entry creates a greater incentive to serve all consumers in the first period so as to reduce the entrant's profit and make it less likely to enter, above and beyond the incentive the addictive platform would have to recruit all consumers as an uncontested monopoly. If entry is not too likely and serving more consumers significantly reduces the probability of entry, then the threat of entry induces the addictive platform to charge lower prices in period 1. Conversely, if entry is very likely and recruiting more consumers has a small effect on the probability of entry, the prospects of entry actually cause the addictive platform to recruit less consumers in period 1 than in the case without the threat of entry. Although, by Lemma 1, recruiting more consumers in period 1 reduces the probability of entry, the addictive incumbent understands that entry is likely despite its efforts. In such a case, recruiting more consumers in period 1 sacrifices period 1 profits more than it raises period 2 profits. Second-period profits are affected by the above-mentioned "price effect": the incumbent exploits addicted consumers in period 2, and consequently charges a high price, thereby reducing its market share.

We can gain further insight into which effect is likely to dominate by using the non-addictive entrant's second period profits given entry. Given that the cost of entry has a cumulative distribution function of G and an associated density of g, we can write the hazard rate as $\frac{q'(\theta^*)}{q(\theta^*)} = \frac{g(\pi_{NA})d\pi_{NA}/d\theta^*}{G(\pi_{NA})}$. At $\theta^* = 1$ and $\Delta v = 0$, $\pi_{NA} = k/4$ and $d\pi_{NA}/d\theta^* = -k/2$. If entry costs are distributed uniformly on (a, b) and $k/4 \in (a, b)$, then the hazard rate is $\frac{-2k}{k-4a}$. Thus, even if the distribution of entry costs starts at zero ($a = 0$), then the threat of entry leads to reduced first period prices for any $\alpha > 1.09$. If $a > 0.024k$, then the threat of entry leads to reduced first period prices for any $\alpha \leq 1$.

We can also examine how the threat of entry affects the incentive of the first mover to choose to be addictive versus non-addictive. If there were no threat of entry, being a non-addictive platform would be more profitable unless the quality advantage of the addictive platform was sufficiently large. To see this, note that a non-addictive monopoly platform could extract the entire surplus by charging v_{NA} and earning $2v_{NA}$ over both periods. For any $k > 0$, the total surplus available from an addictive platform is strictly less than v_A per period, and the addictive platform cannot capture the entire surplus due to consumer heterogeneity in the expected cost of addiction. In fact, as the next lemma shows, without the threat of entry, the first mover will choose to be non-addictive whenever an addictive platform's quality advantage is less than the cost of addiction.

Lemma 4. *(addictiveness is only to exclude) If $\Delta v \leq k$, then a two period monopolist earns greater profit with a non-addictive platform than with an addictive one.*

Proof. The indifferent consumer in period 1 expects to purchase from an addictive monopoly in period 2 if and only if she becomes addicted in period 1, since prices will be higher in period 2. Thus, her expected utility from joining an addictive platform in period 1 is:

$$v_A - p_{A1} + \theta^*(v_A - p_{A2} - 2k) \tag{21}$$

Substituting for the optimal second period monopoly price, we get the condition for the indifferent consumer:

$$\theta^* = \frac{3(v_A - p_{A1})}{v_A(4\alpha - 1 + \sqrt{(1-\alpha)^2 + 3\alpha^2(1+\theta^{*2})})} \tag{22}$$

Totally differentiating this with respect to p_{A1} and then substituting using (22) gives:

$$\frac{d\theta^*}{dp_{A1}} = -\frac{\theta^*\{3(v_A - p_{A1}) + v_A(1-4\alpha)\theta^*\}}{(v_A - p_{A1})\{3(v_A - p_{A1}) + v_A(1-4\alpha)\theta^*\} + (v_A\alpha\theta^{*2})^2} \tag{23}$$

The best scenario for an addictive monopolist is where its quality advantage is such that it optimally prices so as to serve all consumers in period 1 (i.e., $\theta^* = 1$). We differentiate the two period monopoly profit for the addictive platform, $p_{A1}\theta^* + \pi_{2M}(\theta^*)$ with respect to p_{A1} and evaluate this at the p_{A1} in which $\theta^* = 1$, using the expression for $\frac{d\theta^*}{dp_{A1}}$ derived in (23). The first order condition is:

$$\frac{1 - 2\alpha + 10\alpha^2 - (7 - 10\alpha)\sqrt{1 - 2\alpha + 7\alpha^2}}{1 - 2\alpha + 10\alpha^2 - (1 - 4\alpha)\sqrt{1 - 2\alpha + 7\alpha^2}} \tag{24}$$

This is increasing in α and negative for $\alpha < 0.508$. Thus, we know that it is optimal for an addictive monopoly to price such that all consumers buy in period 1 for $\alpha < 0.508$. Because the profit of a monopoly addictive platform is decreasing in α, this shows that if an addictive monopoly is less profitable than a non-addictive monopoly in this case, then an addictive monopoly is always less profitable.

We next evaluate $p_{A1}\theta^* + \pi_{2M}(\theta^*)$ at p_{A1} such that $\theta^* = 1$ and subtract $2v_{NA}$, the profits of a non-addictive monopolist. Using the change of variables $\Delta v = xk = x\alpha v_A = x\alpha(v_{NA} + \Delta v)$, we can write $\Delta v = \frac{x\alpha}{1-x\alpha} v_{NA}$, where $x, \alpha < 1$. This gives the following expression for the profit difference:

$$\frac{-v_{NA}}{27\alpha^2(1-x\alpha)}\{1-3\alpha+3\alpha^2+53\alpha^3-54\alpha^4-(1-2\alpha+2\alpha^2)\sqrt{1-2\alpha+7\alpha^2}\} \tag{25}$$

Because the curly braces term is always positive for any $\alpha < 0.508$, we know a non-addictive monopoly is always more profitable than an addictive monopoly profit. □

Recall that the condition $\Delta v \leq k$ simply means that the non-addictive platform is optimal for at least some consumers. When that is the case, Lemma 4 indicates that without the threat of entry, the monopoly platform always prefers to be non-addictive. This implies that if the incumbent chose to be addictive, it must be due to the exclusionary effect. The next lemma shows that if there is entry, both the incumbent and the entrant's second period profits are greater if they are the addictive platform and their rival is the non-addictive one as long as the addictive platform's baseline value advantage is at least 30% of the cost of addiction.

Lemma 5. *In the vicinity of $\theta^* = 1$: (i) Second period profits of a non-addictive entrant are smaller than for an addictive entrant for $\Delta v > 0.293k$ (so, an addictive incumbent has weakly better prospects of blocking entry than a non-addictive incumbent); (ii) In the event of entry, second period profits of a non-addictive incumbent are smaller than for an addictive incumbent for $\Delta v > 0.22k$.*

Proof. To prove part (i), if the incumbent is non-addictive, then the period 2 competition is isomorphic to Hotelling competition with only one directional transportation costs. As such, the profits of the incumbent and entrant are $\{\frac{(2k-\Delta v)^2}{9k}, \frac{(k+\Delta v)^2}{9k}\}$ respectively. We derived the addictive incumbent's profit given entry in (16). We derive the non-addictive entrant's profit similarly ($\pi_{NA}(\theta^*) = p_{NA}(1-\tilde{\theta}-(\theta^{*2}-\tilde{\theta}^2)/2)$), and recall that $\tilde{\theta} = \frac{\Delta v - p_A - p_{NA}}{k}$. Using the second period prices derived in subsection 3.1, for $\theta^* = 1$, we have (again, with $x = \Delta v/k$):

$$\pi_{NA} = \frac{k}{128}(\sqrt{9 - 2x + x^2} + (1 - x))(5 + 2x - x^2 - (1 - x)\sqrt{9 - 2x + x^2}) \tag{26}$$

Subtracting the entrant's profit when the incumbent is the addictive platform (so the entrant is non-addictive) from an addictive entrant's profit when the incumbent is non-addictive gives:

$$\frac{k}{576}(1 + 209x + 37x^2 + 9x^3 - 9(3 - 2x + x^2)\sqrt{9 - 2x + x^2})) \tag{27}$$

This is positive if and only if $x > 0.293$, meaning that for larger x, the addictive entrant earns greater profit when the incumbent is non-addictive.

To prove part (ii), subtracting the incumbent's second period profit if it is the addictive platform (so the entrant is non-addictive) from the incumbent's second period profit when it is non-addictive gives:

$$\frac{k}{576}(-625 + 607x - 37x^2 - 9x^3 - 9(19 - 2x + x^2)\sqrt{9 - 2x + x^2})) \tag{28}$$

This is positive if and only if $x > 0.224$, meaning that for larger x, the incumbent earns greater profit when it is addictive. □

This implies that there are many cases in which the incumbent prefers being addictive rather than non-addictive, even when its quality advantage is smaller than the cost of addiction. Being an addictive incumbent sacrifices first period profits (this follows immediately from Lemma 4), but it raises second period profits. If the first mover chooses to be non-addictive, this invites entry by an addictive rival, and, by part (ii) of Lemma 5, second-period profits would be larger for the first mover if it chooses to be addictive, even if entry of a non-addictive rival was not blocked. By part (i) of the lemma, taking account of the fact that being addictive reduces the probability of entry further strengthens the motivation to be an addictive incumbent. It implies that for any given distribution of entry costs, the prospects of blocking entry and remaining a monopoly in the second period are larger for an addictive incumbent. Moreover, in a model where the period of potential entry lasts longer than the initial period where there is no entry, this motivation to be addictive would be further magnified. Thus, lemmas 4 and 5 generate the following result.

Proposition 2. *If the first mover chooses to be addictive, it can only be due to the threat of entry, not as a profit-maximizing strategy ignoring entry.*

Proposition 2 summarizes the results of the prior lemmas to show that the first mover may prefer to be addictive not as competition on the merits but rather as a strategy that is designed to reduce an entrant's profit, thereby deterring entry, even though this would not be the optimal strategy in the absence of competition. Note that, for a small enough quality advantage of an addictive platform, social welfare would be higher with a non-addictive monopoly. In future drafts, we expect to show how social welfare can be higher also when the incumbent is non-addictive and the entrant is addictive than when the first mover is addictive and the second non-addictive. This implies that an antitrust prohibition on using addictiveness as an exclusionary tool can promote social welfare, and may also promote consumer welfare in certain cases.

4 Conclusion

We have shown that the threat of entry, absent any regulatory intervention, can harm social welfare, by inducing an incumbent social media platform to be addictive so as to hinder entry by a non-addictive entrant. Addictive design of the incumbent's platform can serve as an exclusionary device because both addicted and invulnerable consumers become uncontestable by the non-addictive entrant. One might expect vulnerable consumers who are fully rational ex ante to wait for the non-addictive entrant. Yet, they may not do so, due to a collective action problem among consumers and an externality imposed on the entrant. Hence, the incumbent prefers to be addictive and aggressively recruit a large group of consumers when it is a monopoly. This expands the number of addicted consumers, with the accompanying exclusionary effect on the non-addictive entrant, whereas social welfare would be higher with a non-addictive monopoly or a duopoly including a large non-addictive platform and a small addictive one. Current antitrust doctrine can cope with this outcome by condemning the use of addictiveness of the platform as an exclusionary tool.

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