Data Usage and Strategic Pricing: Does Platform Entry Benefit Independent Traders?*

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Abstract

Platforms greatly facilitate transactions between buyers and sellers. This allows platforms to gather detailed information on transactions and tailor their strategies when introducing their own products that compete with independent traders. Concerns have been raised that such an information advantage of the platform can hurt traders. However, we show that the usage of more detailed and individualised information by the platform can actually benefit traders by relaxing competition between them. This occurs as traders have more incentives to raise their prices in order to hide the popularity of their products and prevent entry of the platform in their product categories. The competition relaxing effect is particularly strong when traders are close substitutes and face little demand uncertainty within their category. In such cases, both platforms and traders could benefit from more individualised information usage, but consumers are hurt. However, when competition between sellers is weak, consumers could benefit from more data usage due to the elimination of double marginalisation.

Keywords: Platform entry, Independent traders, Strategic pricing, Individualised information;

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1 Introduction

Many platforms serve the dual roles of both an intermediary and a trading party. For example, Amazon runs the Amazon Marketplace, which facilitates transaction between independent sellers and customers, and sells its own private labels such as the Amazon Basics via the Marketplace. Google operates the Google Play Store, which connects app developers and app users, and at the same time develops its own apps such as Chrome and Maps. In the cloud computing market, infrastructure providers such as Amazon supply their own software in addition to providing hosting services for third party software developers. In these markets, platforms can gather unprecedented amounts of data and information on trading parties. Hence, it is not surprising that platforms might feed the information they gather from various traders into their own product development and trading strategies. This has triggered wide public debate and major investigations from authorities. For instance, the European Commission has started a formal investigation,[1] and the Department of Justice of the United States is under pressure to open such an investigation against Amazon for potential abuse of its market position.[2]

A key issue in such investigations is the potential use of information on independent sellers by the platform to cherry-pick products of which they can sell or develop their own versions. For instance, Amazon has been alleged to use sales information on individual sellers to target the best selling items when introducing its private labels, whilst its privacy policy says that only category sales information would be used.[3] This has unsettled many independent sellers, who fear that they may be disadvantaged by Amazon. A common argument is that these sellers are hurt when the platform enters to compete and replace them. However, instead of focusing solely on the ex post impact of platform entry on independent sellers, we look at the market more dynamically to take into account how independent sellers price strategically ex ante in response to potential platform entry. We show that the platform's use of individual information in determining its sales strategy can in some cases benefit independent sellers.

Specifically, we consider a two period model, where there are two product categories (e.g. clothing and shoes) and there are two sellers in each category. In the first period, two sellers in each of the two categories choose their prices. In doing so, they face demand uncertainty at

[1] "Antitrust: Commission opens investigation into possible anti-competitive conduct of Amazon", European Commission. See `https://ec.europa.eu/commission/presscorner/detail/en/IP_19_4291` (Accessed June 17, 2020).

[2] "GOP Sen. Hawley asks DOJ to open a criminal investigation into Amazon", CNBC. See `https://cnb.cx/3ddx01j` (Accessed June 17, 2020).

[3] "Amazon Scooped Up Data From Its Own Sellers to Launch Competing Products", Wall Street Journal. See `https://on.wsj.com/33eNSls` (Accessed June 17, 2020).

both the category level and the individual level within each category. Specifically, the market size of each category is randomly drawn from a distribution. Within each category, a seller can be either the strong seller or the weak one with equal probability.[4] In the second period, the platform decides to introduce its own version of one product, depending on whether and which sales information in the first period it uses. If the platform enters, then it replaces the original seller within that category. Then, the two sellers in each category, either the platform and one original seller or two original sellers, compete in prices under full information. We consider three regimes of information usage in determining the entry strategy of the platform. Under random entry, the platform enters with a randomly selected product without using any first period sales information. Under category entry, the platform enters with a randomly selected product in the higher first period sales category using only category sales information, e.g. the platform enters with its own brand of shoes if the first period sales of shoes is higher than that of clothing, and enters with its own brand of clothing otherwise. Under targeted entry, the platform enters with the product of the best selling individual item using detailed individual sales information, e.g. the platform enters with its own brand of the best selling item amongst all four products, either shoes or clothing. Since the second period competition unravels under full information, we focus on the impacts on the first period prices.

Under random entry, the first period prices and sales do not affect the entry decision of the platform and hence are independent from second period competition. This means that the first period price would be equal to the static one-period competitive price. Under both category entry and targeted entry, the first period sales affect entry and profits in the second period, which generates incentives for sellers to manipulate first period sales and reduce the chance of platform's entry into their category. Indeed, we show that the equilibrium first period prices are higher under both category entry and targeted entry than random entry. Moreover, we show that the equilibrium prices are higher under targeted entry than category entry. The reason is as follows. First, under category entry, the entry probability of the platform depends on the total sales of each category, to which each seller contributes a proportion. Under targeted entry, however, the individual sales of the strong firm in each category fully determines the entry probability of the platform. Hence, the individual price has a larger impact on platform's entry when a seller turns out to be the strong one. We call this the 'deaveraging' effect. Second, under category entry, a seller is only replaced with probability half when the platform enters its category, but under targeted entry, it is replaced with probability one when it is the strong

[4] To be more precise, as we show in Section 3, at equal prices, the strong seller obtains a higher market share within the category.

seller. This makes it more valuable to keep the platform out. We call this the 'replacement' effect for the strong seller. These two effects together imply stronger incentives to raise price under targeted entry. Third, under targeted entry, the weak seller in a category does not risk being replaced, hence, it has less incentive to prevent platform entry. We call this the 'replacement' effect for the weak seller. In addition, by reducing its price, it decreases the sales of the strong seller, which makes platform entry less likely. That is, the incentive to be competitive is aligned with the incentive to prevent platform entry. We call this the 'entry easing' effect. When the platform charges a per unit fee to sellers, these two latter effects imply an incentive to reduce price under targeted entry; however, when the platform charges a proportional fee to sellers, these two effects imply an incentive to raise price under targeted entry, which may be stronger or weaker than that under category entry. In sum, we show that, the two effects on the strong seller always dominate, and the equilibrium prices are higher under targeted entry than category entry, i.e. when the platform uses more individualised information to formulate its entry strategy.

This means that whereas usage of more individualised information by the platform hurts independent sellers in the second period by replacing the strong seller with a higher probability, it softens price competition between sellers in the first period, which may benefit the sellers instead. Hence, if the competition softening effect is strong enough, sellers may benefit overall from targeted entry by the platform, which is in contrast with the common wisdom that platform entry hurts the sellers. We show that this is indeed the case when competition between sellers is intense enough, which occurs if the products of sellers are close substitutes and the demand uncertainty within a category is low, i.e. when demands within a category are sufficiently symmetric. Moreover, this is true no matter whether the sellers pay a per unit or a proportional commission fee. Instead, when competition between sellers is low, sellers are hurt by more individualised information usage even if the first period prices are higher. The reason is that in such cases, the equilibrium prices under random entry is close to the static profit maximizing prices, and thus the equilibrium prices under category entry and targeted entry are too high and reduce sellers' profits. That is, the sellers are not only hurt in the second period due to platform entry but also in the first period due to overly high prices.

For the platform, relaxed first period competition does not necessarily benefit it, depending on the structure and the level of the commission fee. In the case of per unit fee, the platform is actually hurt by higher prices in the first period, as a higher price lowers the volume of transaction and hence the total commission fees. In the case of proportional fee, the platform could still be hurt when the first period prices exceed the static profit-maximizing prices. Clearly, if the level of fee is sufficiently low, given the product characteristics, any potential first period loss is outweighed by the second period gain from entering with the more popular product and hence the platform benefits overall from more individualised information usage. However, when these fees are non-negligible, the platform faces a trade-off between exploiting the data advantage in the second period and dampening the volume of transaction in the first period when using more individualised information, and we show that category entry achieves a delicate balance and generates a higher profit than both targeted entry and random entry when competition between sellers is sufficiently intense. On the other hand, with proportional fee, the platform's interest is more aligned with the sellers, and it benefits from targeted entry whenever the sellers benefit when competition between sellers is intense. Yet, under both fee structures, when competition between sellers is weak, the platform faces a more pronounced trade-off between losses in the first period and gains in the second period when using more individualised information, and the preferred level of information usage depends on the level of fees.

For consumers, they are clearly hurt by the platform's usage of individualised information in the first period as they face higher prices. They are also hurt in the second period under proportional fee, as the platform, by partially internalising the profit of the seller, pushes up market prices when it enters. Hence, consumer surplus is the lowest under targeted entry and highest under random entry when proportional fees are used. However, under per unit fee, consumers benefit in the second period as the entry of the platform eliminates double marginalisation for the more popular item and reduces market prices. However, if the level of the commission fee is sufficiently low, any benefit from eliminating double marginalisation is limited and outweighed by the losses in the first period and consumers are hurt overall by more individualised information usage. Even when these fees are not negligible, we show that consumers are still hurt by targeted entry when the demand uncertainty within category is sufficiently low, as the difference between the strong and the weak seller is relatively small and hence the benefit from eliminating double marginalisation for the strong product is also small. However, when the demands between weak and strong becomes sufficiently asymmetric, consumer could actually benefit from targeted entry when the platform enters with the most popular item and offers it at a lower price. Table 1 summarises these welfare effects under different regimes of information usage.

In summary, our analysis provides new insights into the discussion about platform's collection and usage of information. We show independent sellers are not always hurt, and they may actually benefit from the use of more individualised information and more cherry-picking by the platform, which helps to relax competition between sellers before platform entry. This happens

Table 1: Welfare Effects of Information Usage*

		Per unit fee		Proportional fee	
Competition between sellers**		Low	High	Low	High
Seller profits		$N > C > T$	$T > N > C$	$N > C > T$	$T > N > C$
Platform profits	$r \to 0$	$T > C > N$			
	$r > 0$	$T/N > C$	$C > T/N$	$T/C/N$	$T > C > N$
Consumer welfare	$r \to 0$	$N > C > T$		$N > C > T$	
	$r > 0$	$T/N > C$	$N/C > T$		

*N - No information usage or random entry; C - Usage of category sales information or category entry; T - Usage of individual sales information or targeted entry; r - Level of commission fee; $'>'$ means a strict preference; $'/'$ means the preference amongst the options are ambiguous and depend on parameters.

**This is measured by the degree of substitution between sellers and the level of demand uncertainty at the individual product level.

when competition between sellers is sufficiently strong, for instance, when products are close substitutes and demand uncertainty within category is low. The impact of data usage on the platform and consumers depend on both the level and the structure of commission fees. When the level of commission fees is sufficiently low, the platform prefers more information usage whereas the consumers prefer less. When these fees are non-negligible, from the perspective of the platform, being able to commit to category information usage could benefit all parties compared to no commitment, especially in the case of proportional fee and weak competition between sellers, whereas with per unit fee and weak competition, the sellers could still benefit from such commitment but the platform and consumers lose. Moreover, in such cases, a stronger commitment to no information usage could even benefit all parties. For consumers, more individualised information usage would only benefit them under per unit fee and low degree of competition between sellers, such that the benefit from eliminating double marginalisation is sufficiently large. From a regulatory perspective, whilst restricting usage of individual level information, i.e. moving from targeted entry to category entry, could hurt at least one party when sellers compete fiercely, a similar intervention of moving to category entry or a further move towards random entry could benefit all parties when competition between sellers is weak.

The article proceeds as follows: We review the related literature in Section 2, Section 3 presents the model. The equilibrium analysis is in Section 4 and the impact of information usage on different parties is in Section 5. Section 6 provides further discussions and Section 7 concludes. All the proofs are provided in the Appendices.

2 Literature Review

Our article is closely related to the literature studying the impact of platform entry on independent sellers. Empirically, Zhu and Liu (2018) shows that Amazon is more likely to enter and compete with independent sellers, who have higher sales and better reviews and grow with less effort. They also show that platform entry increases demand and reduces shipping costs, but discourages sellers from growing their businesses. Similarly, Wen and Zhu (2019) show that Google's entry into the mobile app market shifts innovation to unaffected and new apps and may reduce wasteful development efforts. On the theoretical side, facing the threat of platform entry, a seller with private information on demand may try to hide that information from the platform by reducing valuable services as shown by Jiang et al. (2011), or by downsizing the order as in Li et al. (2014). Both articles assume the presence of asymmetric information with only one seller, and analyses how platform entry may exacerbate such a problem. However, in this article, the sellers do not hold private information on demand but they face competition. The sellers can alter their prices to affect the market outcome and manipulate the sales information, and we emphasise the strategic interaction among sellers and show that this may actually benefit the sellers. In addition, we analyse the role of information usage by the platform in shaping the interaction among sellers. This differentiates our article from other recent contributions such as Etro (2020) and Hagiu et al. (2020), both of which focus on whether platforms should enter the product market with their own products instead of data usage by platforms.

Our article is in close relation to the literature on limit pricing as in Milgrom and Roberts (1982) and signal jamming as in Fudenberg and Tirole (1986). The main message from these strands of literature is that the established firm can take competitive actions to influence the inference of the entrant, so as to affect the decision of the entrant on whether to remain in or enter the market. Similar to this literature, in our model the established firms, i.e. independent sellers, try to manipulate the inference of the entrant, i.e. the platform, and prevent entry. Yet, our article differs in several ways. First, the decision to remain or enter in these literatures depends on expected future profits and hence the established firms behave in a competitive way to reduce the profit of the entrant and prevent future competition. Instead, the decision to enter in this article depends on current sales and hence the established firms behave in an anti-competitive way to reduce their own profits by increasing prices, so as to prevent future replacement. Second, the impact of limit pricing or signal jamming eventually hurts the entrant as they are forced to stay out of the market. In the contrary, both the established firms and the entrant could benefit from the incentives to manipulate signals in our model. Third, the existing literature focuses on horizontal competitors, the firms in this article (sellers and the platform) are in a relationship with both vertical and horizontal elements, as independent sellers rely on the platform to make sales and at the same time they face potential competition from the platform.

This further relates our article to the large literature on vertical integration, the competitive effects of which has been excellently summarised by Riordan (2008). There has been a more recent literature on vertical integration in platform markets. Much attention has been drawn by the use of exclusive contents, as studied by, for instance, Lee (2013) and D'Annunzio (2017), and the potential bias of the platform in favour of their own contents, as studied by, for instance, De Corniere and Taylor (2014, 2019). We take a different perspective by looking at the impact of platform integration on the pre-integration market instead of the post-integration market. Our results highlight that focusing solely on the ex post effect may overlook important incentives and market dynamics in the ex ante competition stage.

Focusing on the retailing sector, our article is related to literature on private labels, especially on their impacts on national brands. For instance, Hoch (1996) gives an overview on how national brands can respond to the introduction of private labels, and Putsis (1997) and Gabrielsen and Sørgard (2007) show that national brands may price higher to soften competition with private labels. Our article differs from this literature in several ways. First, the private label literature is mainly in the context of a wholesale mode, i.e. the manufacturer and the retailer negotiate on the wholesale price and the retailer determines all the retailing prices. Instead, our analysis focuses on the agency model, i.e. the retailer (the platform in our case) only determines the commission fees but the manufacturers (the sellers in our case) directly set the retailing prices for their products. Second, instead of focusing on the ex post impact of private labels on national brands and how national brands react, we explore the ex ante impact of potential private label introductions on competition between national brands. Third, due to the vast amount of data available to platforms compared to traditional retailers, the platforms are able to introduce their private labels based on different sets of information, an aspect that is not covered by the existing literature.

Focusing on the implications of different extents of information usage by the platform, our article is related to the literature on contests and incentive for teams. For instance, McAfee and McMillan (1991) compare the case where the principal can observe team performance only to the case where the principal can observe individual performance. Marino and Zabojnik (2004) study a model of internal competition for corporate resources. Our setup can be more broadly interpreted as a contest between sellers for not getting the attention of the platform, and our results show that making individualised information available to the principal can benefit both the team members and the principal.

3 The model

We consider a platform that facilitates transactions between two groups, interpreted as 'buyers' and 'sellers'.[5] There are different categories of products transacted via the platform (e.g. clothing and shoes) and, within each category, sellers provide differentiated products. For our purpose, we suppose there are two categories, A and B, and two sellers in each category, namely, $A1, A2, B1$, and $B2$.

We follow Shubik and Levitan (1980) and assume that the demands in category i ($i = A, B$), which are independent from that in category $i' \neq i$, are given by

$$\begin{aligned} q_{i1} = & \quad \epsilon_i w_{i1}(1 - p_{i1} + \beta(\bar{p}_i - p_{i1})), \\ q_{i2} = & \quad \epsilon_i w_{i2}(1 - p_{i2} + \beta(\bar{p}_i - p_{i2})), \end{aligned} \tag{1}$$

where $w_{ij} (j = 1, 2)$ represents the strength of product j in category i with $w_{i1} + w_{i2} = 1$. The market size of category i is denoted by ϵ_i, distributed on $[0, a]$ according to $F(\epsilon_i)$, and the density function is given by $f(\epsilon_i)$. We assume that $f'(\epsilon) \geq 0$ to guarantee that the profit functions are concave in our analysis. The degree of product differentiation is measured by $\beta \in [0, \infty)$. The two sellers sell independent products if $\beta = 0$ and sell homogeneous products if $\beta \to \infty$. Lastly, $\bar{p}_i = \sum_{j=1,2} w_{ij} p_{ij}$ is the weighted average price within category, which allows us to write the demands as

$$\begin{aligned} q_{i1} = & \quad \epsilon_i w_{i1}(1 - p_{i1} + \beta(1 - w_{i1})(p_{i2} - p_{i1})), \\ q_{i2} = & \quad \epsilon_i (1 - w_{i1})(1 - p_{i2} + \beta w_{i1}(p_{i1} - p_{i2})), \end{aligned} \tag{2}$$

We assume that with probability 50%, we have $(w_{i1}, w_{i2}) = (w, 1 - w)$; and with probability 50%, we have $(w_{i1}, w_{i2}) = (1 - w, w)$, with $w \in (1/2, 1]$. That is, the sellers face two types of demand uncertainty, at the category level and at the individual level. The former is captured by ϵ_i, which can be simply interpreted as the number of consumers who want to buy a product in category i. The latter is captured by the randomness of w_{ij}, which means each seller can be either the strong seller or the weak one.[6] As shown by Shubik and Levitan (1980), this demand function can be derived from the following utility function of a representative consumer:

$$U = q_{i1} + q_{i2} - \frac{1}{2(1 + \beta)} [\frac{q_{i1}^2}{w_{i1}} + \frac{q_{i2}^2}{w_{i2}} + \beta(q_{i1} + q_{i2})^2]. \tag{3}$$

[5] These groups of users can be interpreted more broadly as, for instance, app developers and app users.

[6] We assume there is strict uncertainty at the seller level, i.e. $w > 1/2$. This is to ensure the existence of an equilibrium in the situation of targeted entry.

Without loss of generality, we assume that all sellers and the platform (in the case of entry) can produce the product at zero costs.[7] However, when selling through the platform, sellers need to pay a commission to the platform, denoted by r. We will discuss both cases when r is a fixed amount per transaction (per unit fee) and when r is a percentage of the price (proportional fee).[8]

We consider the following two-period game:

At $t = 1$: At the beginning of the first period, each seller chooses a price, before the realisation of demand uncertainty at both the category level and the individual level. Then the demand uncertainties realise and each seller obtains the corresponding profits.

At $t = 2$: After observing the sales in the first period, at the category level or at the individual level, the platform decides to introduce its own version of one product. Then sellers and the platform compete and obtain the corresponding profits.

To facilitate our analysis, we denote the first period profit per consumer of seller j in category i by $\pi_{ij}(w_{ij}, r; p_{ij}, p_{ij'}), i = A, B; j = 1, 2$, given by

$$\pi_{ij}(w_{ij}, r_u; p_{ij}, p_{ij'}) = w_{ij}(p_{ij} - r_u)(1 - p_{ij} + \beta(1 - w_{ij})(p_{ij'} - p_{ij})), \tag{4}$$

in the case of per unit fee, and given by

$$\pi_{ij}(w_{ij}, r_p; p_{ij}, p_{ij'}) = (1 - r_p)w_{ij}p_{ij}(1 - p_{ij} + \beta(1 - w_{ij})(p_{ij'} - p_{ij})), \tag{5}$$

in the case of proportional fee. The total first period profit is then given by $\epsilon_i \pi_{ij}$. To save notation in the following analysis, we use r when the analysis applies to both per unit fee and proportional fee, and we distinguish between r_u and r_p when the two cases differ.

In the second period, we assume that the platform only introduces its own version for one product. This reflects the 'cherry-picking' behaviour observed in practice, and the platform's commitment to promote participation of independent sellers instead of invading every category. As a benchmark, we consider first the case where the platform can commit not to use any first period sales information and enter with a randomly selected item. We call this 'random entry'. When the platform does make use of some first period sales information, we distinguish between two types of entry related to information usage by the platform. First, the platform can use information on category sales only and enters with a product in the higher first period sales category. However, the platform does not use information on the sales of individual products,

[7]Our main results remain valid when the platform is more or less efficient than the independent sellers in terms of producing or sourcing the product, so long as the difference is not too large.

[8]Per unit fee is a common assumption in the literature; see, for instance, Jiang et al. (2011). Proportional fees are also observed in practice and can be justified on different grounds by, e.g. Shy and Wang (2011) and Wang and Wright (2017).

so it enters with a randomly selected product within the category. We call this type of entry 'category entry'. Second, the platform can use detailed information on individual sales in the first period and enters with the same product as the highest first period sales seller. We call this type of entry 'targeted entry'. In either case, we assume that once the platform enters, it drives out the seller which sells the same product, and the remaining sellers within each category (original sellers or the platform) compete under full information by choosing their prices. This is reasonable given that the product sold by the platform is often displayed at prominent positions and may benefit from certain forms of prioritisation.[9]

Hence, in the second period, we have two situations for category $i = A, B$. First, there is no platform entry. So the two original sellers remain to compete and each firm j chooses a price to maximise its profit, given by $\epsilon_{ij}\pi_{ij}(w_{ij}, r; p_{ij}, p_{ij'})$, with π_{ij} following from Equation (4) and (5). We denote the resulting competitive profit per consumer of the strong seller by $\pi^N(w, r)$ and the competitive profit per consumer of the weak seller by $\pi^N(1-w, r)$, with a total second period profit of $\epsilon_i\pi^N(w, r)$ and $\epsilon_i\pi^N(1-w, r)$ respectively. Second, the platform enters and competes with the remaining seller. Denote the platform's strength by w_I and that of the remaining seller by w_S, where w_I and w_S can be either w or $1-w$ with $w_S + w_I = 1$, depending on which product the platform introduces. Let p_I and p_S be the prices of the platform and the seller. In the case of per unit fee, the platform's objective is to maximize

$$\epsilon_i w_I p_I(1 - p_I + \beta(1 - w_I)(p_S - p_I)) + r_u\epsilon_i w_S(1 - p_S + \beta(1 - w_S)(p_I - p_S)),$$

which consists of the profit from sales of its own version and the commission from the seller. The seller's objective is to maximise

$$\epsilon_i w_S(p_S - r_u)(1 - p_S + \beta(1 - w_S)(p_p - p_S)).$$

In the case of proportional fee, the platform maximizes

$$\epsilon_i w_I p_I(1 - p_I + \beta(1 - w_I)(p_S - p_I)) + r_p\epsilon_i w_S p_S(1 - p_S + \beta(1 - w_S)(p_I - p_S)),$$

and the seller maximizes

$$(1 - r_p)\epsilon_i w_S p_S(1 - p_S + \beta(1 - w_S)(p_I - p_S)).$$

In either case, we denote the resulting competitive profit per consumer for the platform by $\pi_I(w_I, r)$ and the per consumer profit for the remaining seller by $\pi_S(w_S, r)$. Furthermore, we assume r_u and r_p are relatively small such that in both category entry and targeted entry all sellers make positive profit when the platform enters:[10]

[9] See, for instance, https://www.wired.co.uk/article/amazon-eu-competition-marketplace-analysis.

[10] For instance, Amazon adopts both per unit fees and proportional fees which go up to 45.9% in the UK, whilst Apple's App Store charges a proportional fee up to 30%.

Assumption 1. *$r_u \le 1/2$ and $r_p \le 1/2$.*

Both the sellers and the platform discount the second period profit by $\delta > 0$. We can interpret the first period as an information-gathering stage where there is demand uncertainty, and the second period as the competition stage under complete information. The relative length of the two stages over the life cycle of a product is then measured by δ. A higher δ means a longer competition stage with a relatively quick information gathering stage. Whilst we do not restrict the relative length of the two periods, we assume that δ is not too large such that an interior equilibrium exists.[11]

As sellers are symmetrically uninformed at the beginning, we focus on the symmetric subgame Nash equilibrium where all sellers charge the same price in the first period and investigate the impact of the platform's information usage and entry on the equilibrium price and payoffs of different parties.

4 Strategic Pricing under Platform Entry

4.1 Random entry - No information usage

As a benchmark, we consider the case when the platform can commit not to use any information and introduces its own version of a randomly selected product. In this case, the prices and sales in the first period have no effect on the second period entry and profits. So, we focus on the first period. In search for a symmetric equilibrium where all sellers charge p^N in the first period, let us assume all other sellers are charging this equilibrium price, whereas seller $A1$ contemplates to charge a slightly different price $\tilde{p}$, its expected profit is (to ease the exposition, we drop the subscripts in the profit functions)

$$\begin{aligned}\Pi(\tilde{p}, p^N) = \; & \textstyle\int_0^a \epsilon_A \Big(\frac{1}{2}\big(\pi(w, r; \tilde{p}, p^N) + \delta(\frac{1}{2}\pi^N(w, r) + \frac{1}{2}\frac{\pi_S(w,r)}{2})\big) \\ & + \tfrac{1}{2}\big(\pi(1-w, r; \tilde{p}, p^N) + \delta(\tfrac{1}{2}\pi^N(1-w, r) + \tfrac{1}{2}\tfrac{\pi_S(1-w,r)}{2})\big)\Big) dF(\epsilon_A).\end{aligned}$$

That is, with probability 1/2, $A1$ is the strong seller and obtains a per consumer profit of $\pi(w, r; \tilde{p}, p^N)$ in the first period. In the second period, with probability 1/2, the platform does not enter category A, so it obtains a profit of $\pi^N(w, r)$. With the other probability 1/2, the platform enters category A but only replaces $A1$ with probability 1/2; with the remaining probability 1/2, the platform replaces $A2$ and $A1$ obtains a profit of $\pi_S(w, r)$. This is represented by the first line of the above equation. With probability 1/2, $A1$ is the weak seller and its expected profit is given by the second line of the above equation where we simply replace w with $1 - w$.

[11] See the proofs of Lemma 2 and Lemma 3 for details.

The optimal $\tilde{p}$ satisfies

$$0 = \frac{\partial \Pi(\tilde{p}, p^N)}{\partial \tilde{p}} = \int_0^a \epsilon_A \frac{\pi_p(w, r; \tilde{p}, p^N) + \pi_p(1-w, r; \tilde{p}, p^N)}{2} dF(\epsilon_A),$$

where π_p denotes the first order partial derivatives. We can show that

Lemma 1. *In the case of random entry, a symmetric equilibrium (p^N, p^N) exists and satisfies*[12]

$$0 = \int_0^a \epsilon_A \frac{\pi_p(w, r; p^N, p^N) + \pi_p(1-w, r; p^N, p^N)}{2} dF(\epsilon_A). \tag{6}$$

4.2 Category Entry

Now we consider the situation when the platform only uses category sales information. To work out the equilibrium prices, we start with the second period. After the entry of the platform, the competitive prices and profits only depend on the strength of each products and the commission fee paid by sellers. For the platform, it enters into the category with higher first period total sales, i.e. it enters with a product in category i, $i = A, B$, if

$$q_i = q_{i1} + q_{i2} > q_{i'} = q_{i'1} + q_{i'2}.$$

Back to the first period, each seller chooses a price to maximise its total expected profit across the two periods. Similar as above, if all other firms charge the equilibrium price p^C and firm $A1$ contemplates to charge a different price $\tilde{p}$, it obtains an expected profit of

$$\begin{aligned}
&\Pi(\tilde{p}, p^C) \\
= \ &\textstyle\int_0^a \epsilon_A \big(\frac{1}{2}[\pi(w, r; \tilde{p}, p^C) + \delta Prob_s(q_A < q_B)\pi^N(w, r) + \delta(1 - Prob_s(q_A < q_B))\frac{1}{2}\pi_S(w, r)] \\
&+\tfrac{1}{2}[\pi(1-w, r; \tilde{p}, p^C) + \delta Prob_w(q_A < q_B)\pi^N(1-w, r) + \delta(1 - Prob_w(q_A < q_B))\tfrac{1}{2}\pi_S(1-w, r)]\big) dF(\epsilon_A),
\end{aligned}$$

where $Prob_s(q_A < q_B)$ is the probability of platform not entering category A when $A1$ is the strong seller and $Prob_w(q_A < q_B)$ is the probability of platform not entering category A when $A1$ is the weak seller. We can show that

Lemma 2. *In the case of category entry, a symmetric equilibrium exists and satisfies*

$$0 = \int_0^a \epsilon_A \Big(\frac{\pi_p(w, r; p^C, p^C) + \pi_p(1-w, r; p^C, p^C)}{2} + \frac{\delta}{2}\frac{\epsilon_A f(\epsilon_A)}{1 - p^C} M^C(w, r)\Big) dF(\epsilon_A), \tag{7}$$

where $M^C(w, r) = w(\pi^N(w, r) - \frac{\pi_S(w,r)}{2}) + (1-w)(\pi^N(1-w, r) - \frac{\pi_S(1-w,r)}{2})$.

[12] Since first period prices do not affect the entry of the platform or prices in the second period, the equilibrium price p^N is also the equilibrium price when the platform commits not to enter.

4.3 Targeted entry

Finally, we consider the situation when the platform enters with the same product as the highest first period sales seller, i.e. the platform enters with product j in category i if

$$q_{ij} = \max_{k\in\{A,B\},l\in\{1,2\}} q_{kl}.$$

Similar as above, we focus on the symmetric price equilibrium in the first period where all sellers charge a price of p^T. If all other firms are charging the equilibrium price and $A1$ contemplates to charge a different price $\tilde{p}$, its expected profit is given by

$$\begin{aligned}
&\Pi(\tilde{p}, p^T) \\
= \quad &\textstyle\int_0^a \epsilon_A \big(\frac{1}{2}[\pi(w, r; \tilde{p}, p^T) + \delta(1 - Prob(q_{A1} = \max_{k\in\{A,B\},l\in\{1,2\}} q_{kl})\pi^N(w, r)] \\
&+\frac{1}{2}[\pi(1-w, r; \tilde{p}, p^T) + \delta(1 - Prob(q_{A2} = \max_{k\in\{A,B\},l\in\{1,2\}} q_{kl})\pi^N(1-w, r) \\
&+\delta Prob(q_{A2} = \max_{k\in\{A,B\},l\in\{1,2\}} q_{kl})\pi_S(1-w, r)]\big)dF(\epsilon_A).
\end{aligned}$$

That is, when $A1$ is the strong seller, it obtains a positive profit in the second period when it is not the best seller in the first period, which occurs with probability $1 - Prob(q_{A1} = \max_{k\in\{A,B\},l\in\{1,2\}} q_{kl}$. When $A1$ is the weak seller instead, it obtains a profit of $\pi^N(1-w, r)$ when the strong seller $A2$ is not the best seller in the first period, which occurs with probability $1 - Prob(q_{A2} = \max_{k\in\{A,B\},l\in\{1,2\}} q_{kl}$, and it obtains a profit of $\pi_S(1-w, r)$ otherwise. We can show that

Lemma 3. *In the case of targeted entry, a symmetric equilibrium exists and satisfies*

$$0 = \int_0^a \epsilon_A \Big(\frac{\pi_p(w, r; p^T, p^T) + \pi_p(1-w, r; p^T, p^T)}{2} + \frac{\delta}{2}\frac{\epsilon_A f(\epsilon_A)}{1 - p^T} M^T(w, r)\Big)dF(\epsilon_A), \tag{8}$$

where $M^T(w, r) = (1 + \beta(1-w))\pi^N(w, r) - \beta(1-w)(\pi^N(1-w, r) - \pi_S(1-w, r))$.

4.4 Impact of targeted entry

Now we are ready to show our main result:

Proposition 1. *In both cases of per unit fee and proportional fee, the equilibrium first period price is higher under targeted entry than under category entry, and both are higher than under random entry, that is,* $p^T > p^C > p^N$.

To understand Proposition 1, note that if $\delta = 0$, we have $p^T = p^C = p^N$ as the first period price has no influence on the second period profits. As long as $\delta > 0$, sellers have incentives to manipulate the first period sales so as to influence the platform's entry decision. In the case of category entry, this incentive is represented by $M^C(w, r)$. Specifically, a seller ij obtains a profit of $\pi^N(w_{ij}, r)$ if there is no platform entry, higher than $\pi_S(w_{ij}, r)/2$ if there is platform entry (note that the platform only enters with the same product as seller ij with probability 50%). Hence, there is an incentive to lower the chance of platform entry in category i by increasing the price. In addition, the platform's entry decision depends on the total sales of category i, for which seller ij contributes a proportion of w when it is the strong seller and a proportion of $1-w$ when it is the weak seller.

Now consider the case of targeted entry, the incentives of seller ij changes in several ways. First, if it turns out to be the strong seller, its own sales fully determines the probability of platform's entry in category i, hence, the impact of its own price on whether entry occurs is larger than that under category entry and proportional to $1 + \beta(1-w)$ instead of w, when comparing $M^T(w, r)$ and $M^C(w, r)$ in Lemma 2 and Lemma 3. We call this the 'deaveraging effect'. Second, if it turns out to be the strong seller, it loses the whole competitive profit $\pi^N(w, r)$ and earns zero profit in the second period in the case of targeted entry instead of earning $\pi_S(w, r)/2$ in the case of category entry. We call this the 'replacement effect' for the strong firm. These two effects together mean that the seller has stronger incentives to raise price. Third, if it turns out to be the weak seller, it would not be replaced when the platform enters. Hence, it earns a profit of $\pi_S(1-w, r)$ instead of $\pi_S(1-w, r)/2$. This reduces its incentives to prevent platform entry. We call this the 'replacement effect' for the weak firm. Finally, if it turns out to be the weak seller, decreasing its price actually reduces the probability of entry in category i as it decreases the sales of the strong seller ij', which determine the platform's entry strategy. Specifically, the impact of its price on platform entry becomes $-\beta(1-w)$ instead of $1-w$. That is, the incentives to be competitive are aligned with entry prevention. We call this the 'entry easing effect'. Under proportional fee, the weaker seller actually benefits from the strong seller being replaced as the platform partially internalises the profit of the weak seller, i.e. $\pi^N(1-w, r_p) - \pi_S(1-w, r_p) < 0$. As a result, the last two effects create an incentive to raise price, which may be weaker or stronger than that under category entry. Instead, under per unit fee, the weak seller is hurt by platform entry as the platform is more efficient than the replaced strong seller, i.e. $\pi^N(1-w, r_p) - \pi_S(1-w, r_p) > 0$. Hence, the last two effects create an incentive to lower price as this prevents platform entry. Overall, Proposition 1 demonstrates that the two effects on the strong seller always dominate and the net effect is a higher price under targeted entry.

Let us consider a few special cases to get further insights on Proposition 1. First, if $w = 1$, i.e. the demand for an individual product is either zero or non-zero, both effects on the weak seller disappear as its sales are zero in any case and its price has no influence on the strong seller's sales. The deaveraging effect on the strong seller also disappears, as its price fully determines the total sales, which is also its individual sales. Hence, only the replacement effect for the strong seller remains, which says that a seller loses more when the platform enters and replaces it in the case of targeted entry. As a consequence, the first period price is unambiguously higher under targeted entry. Second, if $\beta = 0$, i.e. when the two sellers in a category sell independent products, the entry easing effect disappears as one seller's price does not affect the other's sales. However, the deaveraging and the replacement effects are still present, which makes the price unambiguously higher under targeted entry. Finally, we might consider an intermediate case of information usage by the platform, where it decides the category to enter based on category sales and the product to introduce based on individual sales within that category. In this case, the replacement effects disappear as the strong seller is always replaced in the case of platform entry, whereas the deaveraging and the entry easing effects are still present, with the former dominating.

5 How does information usage affect different groups?

5.1 Sellers

The key message from the above analysis is that competition between sellers in the first period is relaxed when the platform uses more detailed sales information in order to determine its entry strategy. Hence, sellers may be better off under targeted entry than under category entry. Indeed, we can show that:

Proposition 2. *Under both per unit and proportional fees, there exists a* $\hat{w} \in (1/2, 1]$ *such that for any* $w < \hat{w}$*, the profits of the sellers are higher under targeted entry than category entry if* $\beta > \hat{\beta}(w)$*. If* $w = 1$ *or* $\beta = 0$*, the profits of sellers are lower under targeted entry than category entry.*

The proposition shows that targeted entry can benefit sellers when competition is intense between them. The intuition follows from Proposition 1: targeted entry lowers the profit of sellers in the second period as it is more likely that the platform replaces the strong seller; however, targeted entry also relaxes competition in the first period as sellers try to hide their sales and keep the platform from entering their category. In balance, if the latter effect is strong enough, the sellers can benefit. This happens when competition between sellers is intense, which occurs when either β is large (so products of different sellers are close substitutes) or w is small (so demand uncertainty/consumer preference within a category is weak). On the other hand, when β is small or w is large, actual competition between sellers is weak: the products are nearly independent in the former case and the price of one product has little effect on the other's sales in the latter case. This means that the equilibrium price under random entry would be very close to the static profit maximising price (exactly equal if $w = 1$ or $\beta = 0$), which in turn means that the price tends to be too high under category entry compared to the static profit maximising level, and targeted entry further raises the price and reduces profits of sellers in the first period.

The same intuition applies when comparing the profit of sellers under targeted entry and random entry and we can show that the same result holds if ϵ_i is distributed uniformly:[13]

Proposition 3. *Under both per unit and proportional fees, if $F(\epsilon_i) = \epsilon_i/a$, there exists a $\hat{w} \in (1/2, 1]$ such that for any $w < \hat{w}$, the profits of the sellers are higher under targeted entry than random entry if $\beta > \hat{\beta}(w)$. If $w = 1$ or $\beta = 0$, the profits of sellers are lower under targeted entry than random entry.*

Remark: Similarly, we can show that the profits of sellers are always lower under category entry than random entry when $w = 1$ or $\beta = 0$. However, when $w \to 1/2$, the profits are still lower under category entry even if $\beta \to \infty$. Our numerical results show that the profits of sellers are always lower under category entry than random entry when ϵ_i follows the uniform distribution, i.e. under category entry the benefit of softened competition in the first period is not strong enough to compensate the loss in the second period due to platform entry.[14]

5.2 Platform

For the platform, if the commission fees are zero, either per unit or proportional, it does not earn anything from sellers in the first period but it clearly benefits from more information usage in the second period, as it can guarantee itself to sell the more popular product. Therefore, it benefits overall. Moreover, we can show the following when r is sufficiently small:

Proposition 4. *Under both per unit fee and proportional fee, for given w and β, there exists $\bar{r}(w, \beta)$ such that the platform's profit is higher under targeted entry than under category entry, both of which are higher than under random entry, if $r < \bar{r}(w, \beta)$.*

That is, given the product characteristics, the platform generally prefers entry with more detailed information usage when the fees are sufficiently low, as the second period gain dominates any potential loss in the first period. Such losses occur under per unit fee as a reduction in the

[13] A comparison of profits for a general distribution function $F(\epsilon_i)$ would depend on the exact shape of the distribution function.

[14] The analytical comparison is complex due to high non-linearity in profit functions.

total volume of transaction due to higher prices, and they occur under proportional fee when competition is weak as the equilibrium prices are higher than the static profit maximising prices. Therefore, when commission fees are sufficiently low, both the platform and the sellers prefer targeted entry when competition between sellers is intense. However, their interests are not aligned when competition between sellers is weak. In such cases, the platform prefers targeted entry, whereas the sellers prefer category entry or even random entry.

However, for a fixed non-negligible commission fee, the platform may still be hurt by targeted entry if competition between sellers is sufficiently intense. This is especially true in the case of per unit fee, as the volume of transactions is negatively affected by higher prices under targeted entry. Hence, this could hurt the platform in the first period and its total profit. Indeed, we can show that:

Proposition 5. *Under per unit fee, for any $r_u > 0$, there exists $\tilde{w} \in (1/2, 1]$ such that, the platform's total expected profit is higher under category entry than under targeted entry if $w < \tilde{w}$. When w is sufficiently small and β is sufficiently large, the platform's profit is higher under category entry than random entry; Furthermore, in such cases, if $\epsilon_i, i = A, B$ are uniformly distributed, there exists $\tilde{r}_u \in (0, 1/2)$ such that the profit of the platform is higher under random entry than targeted entry if $r_u > \tilde{r}_u$.*

That is, when demand uncertainty within category is sufficiently low (i.e. when w is low) and products within category are sufficiently homogeneous, the platform's profit could be lowest under targeted entry whilst the sellers prefer targeted entry. In some sense, this shows that there exists certain conflict of interest between the platform and the sellers. Intuitively, this is because sellers prefer higher prices to boost profit, whereas the platform prefers lower prices to increase the volume of transaction, and such a conflict is more pronounced when the commission fees are high. Yet, under proportional fee, the platform and the sellers have more aligned interests. This is because if sellers benefit overall, they must earn higher profits in the first period given that they are hurt in the second period. This means the platform also earns more in the first period, hence, it benefits overall. That is,[15]

Proposition 6. *Under proportional fees, the profit of the platform is higher under targeted entry whenever the profits of sellers are higher under targeted entry than under category entry or random entry.*

It may be tempting to think that the platform prefers targeted entry when demand uncertainty within category is high, i.e. when w is high, as the benefit of entering with the

[15] The proof is straightforward and hence omitted.

strong product is larger. However, the platform's relative preference for targeted entry can be non-monotone in w, and its profit can be lower under targeted entry than category entry for sufficiently large w. For instance, at $w = 1$ and with uniformly distributed ϵ_i, we can show that under per unit fee, the platform's profit under targeted entry is lower than category entry if

$$r_u(1-r_u)\big(\frac{2\sqrt{3}}{\sqrt{3-2\delta}+\sqrt{3-4\delta}}+2\big) > 1,$$

and lower than under random entry if

$$r_u(1-r_u)\big(\frac{16}{5}\frac{\sqrt{3}}{\sqrt{3}+\sqrt{3-4\delta}}+2\big) > 1.$$

Both conditions are satisfied when both r_u and δ are large enough.

Under proportional fee, the profit is lower under targeted entry than under category entry if

$$\frac{1}{2}\big(\frac{2\sqrt{3}}{\sqrt{3-2\delta}+\sqrt{3-4\delta}}-1\big) > \frac{1-r_p}{r_p},$$

and lower than under random entry if

$$\frac{4}{5}\big(\frac{2\sqrt{3}}{\sqrt{3}+\sqrt{3-4\delta}}-1\big) > \frac{1-r_p}{r_p},$$

again, both conditions are satisfied when r_p and δ are large enough.[16]

The intuition is that under per unit fee, the platform loses in the first period due to higher prices and lower volume of transactions. Under proportional fee, at $w = 1$, the random entry equilibrium price is the static profit maximizing price, and thus the equilibrium prices under both category entry and targeted entry are above the static profit maximising prices, which means lower profits for sellers in the first period. When r is large (under either per unit fee or proportional fee), the platform puts a higher weight on the sales or the revenues of the sellers, which is more negatively affected by higher prices under targeted entry. Moreover, such an upward distortion in price is more likely when sellers put a higher weight on the second period profit and hence have higher incentives to prevent platform entry, i.e. when δ is high. Hence, the profit of the platform can be lowest under targeted entry if both r and δ are large enough. Analogously, we can show that, with $w = 1$ and uniformly distributed ϵ_i, the platform's profit is lower under category entry than random entry under per unit fee if

$$r_u(1-r_u)[\frac{8\sqrt{3}}{\sqrt{3}+\sqrt{3-2\delta}}+2] > 1,$$

and under proportional fee if

$$2\big(\frac{2\sqrt{3}}{\sqrt{3}+\sqrt{3-2\delta}}-1\big) > \frac{1-r_p}{r_p}.$$

[16]For this to occur under proportional fee, we need r_p greater than 1/2. As shown in the proof of Proposition 1, our main results under proportional fee hold for $r_p < 88\%$.

As above, the conditions are satisfied when r and δ are large enough. Combining these with the conditions above for targeted entry, we can show that under per unit fee, the platform's profit is highest under either targeted entry or random entry, but under proportional fee, any mode of entry could be the most preferred one for the platform, depending on the commission rate and the discount factor.

5.3 Consumers

Finally, we discuss the impact on consumers. Clearly, consumers are hurt in the first period when the platform uses more individualised information in determining its entry strategy, resulting in higher prices. However, in the second period, consumers may be hurt or benefit from the platform's use of detailed information, depending on the commission fee structure. First, we have[17]

Proposition 7. *Under proportional fee, consumer surplus is lowest under targeted entry and highest under random entry.*

The intuition is as follows. Consumers are hurt not only in the first period due to higher prices but also in the second period due to relaxed competition. This is because, under proportional fee, the competition between a seller and the platform is less intense than that between two independent sellers, as the platform internalises partially the profit of the seller via the commission fee. This competition relaxing effect is stronger when the platform sells the strong product, which has a larger impact on consumer surplus.

However, under per unit fee, consumers can benefit from the platform's entry, due to the elimination of double marginalisation, which results in lower prices. Such a benefit becomes larger when the platform sells the strong product, i.e. when it uses more individualised information. Hence, consumer surplus in the second period is higher under targeted entry. The overall effect is thus ambiguous and depends on the rate of commission fee. Clearly, if $r_u \to 0$, consumer surplus is lowest under targeted entry and highest under random entry, as the benefit from eliminating double marginalisation is limited. Nevertheless, for any $r_u > 0$, we can show that

Proposition 8. *Under per unit fee, there exists a $\mathring{w}$ such that consumer surplus is lower under targeted entry than category entry if $w < \mathring{w}$.*

The intuition is as follows. When moving from category entry to targeted entry, consumers gain in the second period as they now purchase the strong product from the platform and double

[17] The proof for this result is straightforward and hence omitted.

marginalisation is eliminated for this product. However, if w is small and close to $1/2$, such gain for consumers from purchasing the strong product from the platform in the second period is low as the difference between the weak and the strong product is limited. Hence, the loss in the first period dominates. However, consumer surplus can be either higher or lower under category entry than under random entry, as consumers benefit from platform entering the category with higher demand under category entry in the second period whilst losing in the first period due to higher prices. Generally, consumer surplus is higher under category entry if r_u is sufficiently large.

For larger w, the benefit from eliminating double marginalisation is more significant and targeted entry may be welfare improving for consumers if the commission fees are high enough. For instance, when $\epsilon_i, i = A, B$ are uniformly distributed and $w = 1$, consumer welfare is higher under targeted entry than category entry if

$$(1 - r_u)^2[1 + \frac{1}{2}(1 + \frac{2\sqrt{3}}{\sqrt{3 - 2\delta} + \sqrt{3 - 4\delta}})] < 1,$$

and higher than under random entry if

$$(1 - r_u)^2[1 + \frac{4}{5}(1 + \frac{2\sqrt{3}}{\sqrt{3} + \sqrt{3 - 4\delta}})] < 1,$$

both are satisfied when r_u is sufficiently large, i.e. when double marginalisation is significant. In addition, we can show that in this case, consumer surplus is higher under category entry than random entry if

$$(1 - r_u)^2[1 + 2(1 + \frac{2\sqrt{3}}{\sqrt{3} + \sqrt{3 - 2\delta}})] < 1,$$

which could not be satisfied for $r_u \leq 1/2$. Hence, consumer surplus is always lower under category entry compared to random entry as the losses in the first period dominates. Therefore, under per unit fee and weak competition between sellers, consumers may prefer either more individualised information usage to reap the benefit from eliminating double marginalisation or no information usage to avoid high prices in the first period.

6 Discussion and extensions

More than two sellers

The mechanism identified in the article naturally extends to the situation with more than two sellers in each category. Although a full analysis would require specifications of the demand system for more sellers, the intuition for a higher price under targeted entry than category entry continue to hold. Moreover, the incentive to raise first period prices may even be stronger when there are more sellers. This is because with more sellers and under category entry, each seller contributes to a small share of the total sales of a category (which is w in our two sellers setup). Hence, the deaveraging effect is stronger under targeted entry, when one's own sales fully determine the entry probability. Also, this means the entry easing effect gets weaker when there are more sellers, as each seller's price affects the top seller to a lesser extent. Additionally, the replacement effects under targeted entry gets stronger with more sellers, compared to category entry, under which each seller is less likely to be replaced. In sum, the incentives to raise price are higher under targeted entry, and even more so when there are more sellers.

Asymmetric Categories

By assuming the two categories are symmetric, we simplify the analysis without losing much insight. Our analysis largely remains the same if the aggregate uncertainty of different categories follow different distributions, as only the realisation of the demand uncertainty affects the entry decision of the platform, but not the distribution. However, we may expect the impact of targeted entry on prices to be weaker when the expected market sizes of different categories differ more. This is because ex ante the strong category is more likely to be the top sales category or contain the top seller, hence, the incentives for sellers to manipulate sales and mislead the platform is weaker. Nevertheless, all the effects identified in our analysis remain, albeit to a differing extent.

Seller information advantage

We may consider a situation where the sellers know the strength of their individual products, but not the category market size in the first period, i.e. they have certain information advantage over the platform. In such a case, we no longer have a symmetric equilibrium in the first period, as the strong seller and the weak seller would charge different prices.[18] However, we are still able to compare their prices under different regimes of information usage. For the strong firm, both the deaveraging effect and the replacement effect are present, but the entry easing effect does not apply to the strong seller, as its own sales determine the platform's entry in the case of targeted entry. Hence, the strong firm tends to set a higher price under targeted entry. For the weak firm, the replacement effect and the entry easing effect apply, which means the weak firm tends to set a lower price under targeted entry under per unit fee, but may set a higher or a lower price under targeted entry under proportional fee. The overall impact is then ambiguous,

[18] The equilibrium prices would be determined by two non-linear equations. This points to the advantage of our approach in obtaining explicit and meaningful results.

as prices are strategic complements. In general, when w is large and/or β is small, prices of both the strong and the weak firms tend to be higher under targeted entry as the entry easing effect is weak and complementarity of prices means that the weak firm also charges a higher price. On the other hand, when w is small and/or β is large, the strong firm tends to charge a higher price under targeted entry, whereas the weak firm charges a lower price when the entry easing effect is sufficiently strong. However, the overall effect on profits of sellers, the platform and consumers are similar to our main analysis, as the strong firm accounts for the larger part of sales and hence has a higher impact.

Entry by other independent sellers

We have focused on the entry by the platform, mainly to relate our insights to the discussion surrounding the behaviour of large trading platforms. However, our analysis applies equally to entry by other independent sellers, who rely on the information provided by the platform. This would affect the second period competition. Compared to the platform, independent sellers does not internalise the profits of existing sellers via commission fees, which makes them tougher competitors. This in turn means that consumers surplus would be higher in the second period. However, they may be less efficient than the platform, especially in the case of per unit fee, as the double marginalisation problem still exists, which, instead, lowers consumer surplus in the second period. Nevertheless, these mechanisms only affect the second period profits of sellers without changing their incentives to manipulate sales in the first period, hence, we would still expect first period prices to be higher under targeted entry.

Separation between information and sales

Among the recent criticisms against platforms, one of the key issue is the dual role played by the platform as a seller and as an intermediary, which holds a large amount of sensitive information. One commonly proposed regulation is to break up the two roles.[19] In our set-up, this can be interpreted in two different ways.

First, there could be a financial separation between the sales team and the intermediary team. This means that the sales team does not take into account the commission fees when setting its prices, which makes the platform a tougher competitor upon entry. As a consequence, consumers are more likely to benefit from platform entry, whereas sellers are more likely to be hurt. However, as long as the sales team uses sales information from the intermediary team,

[19] "Bezos will 'break up his own company' before regulators do, Atlantic writer who profiled the CEO predicts", CNBC. See, `https://cnb.cx/3djYHFQ` (Accessed 20/6/2020).

targeted entry still induces higher prices in the first period.

Second, there could be a commitment for the sales team to not use any information from the intermediary team, which means that the sales team would get the same information as any other independent sellers. Hence, our analysis remains largely unchanged, treating the sales team as an independent seller. Moreover, in this case, the platform is still a more efficient competitor and hence likely to enter and replace existing sellers.

7 Conclusion

In this article, we consider the impact of platform entry on competition between independent traders, when the platform can base its entry decision on different sets of information. We show that entry based on more individualised information may benefit the sellers by relaxing ex ante competition between sellers, who endeavour to manipulate sales information to influence the platform's entry strategy. Our analysis generates new insights into the ongoing discussion about the dual role of platform as a trader and an intermediary, by taking into account the different extents of data usage.

Furthermore, our results shed light on the policy discussion surrounding digital giants, especially how they might abuse their market positions by holding and analysing unprecedented amount of data. We highlight the importance of market dynamics and demonstrate the significance of considering the impacts of regulation or policy change on ex ante competition in addition to their impacts on ex post competition.[20] From a regulatory perspective, potential intervention in the market should take into account the level and the structure of commission fees and the intensity of competition amongst sellers. For example, under per unit fee, we show that restricting usage of individualised information may benefit the consumers and the platform but hurt the sellers when competition between sellers is intense. However, when competition becomes weaker, restricting individualised information usage could hurt the consumers. Alternatively, under proportional fees, a further restriction on the use of category information could benefit all parties.

Our work can be extended in several directions. We have focused on the strategic pricing of independent sellers, an equally important decision of sellers is innovation and experimentation of products. It would be valuable and interesting to investigate how information usage by the platform affects the intensity and diversity of experimentation by independent sellers. In addition, our analysis proceeds with a single platform, it would be interesting to think about

[20]See also Lam and Liu (2020) for a related discussion in the context of data portability and Coyle (2018) for a practical discussion of competition policy in digital markets.

the information strategy of platforms when they face competitors and how this would impact sellers' pricing and homing decisions.

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A Proof of Lemma 1

Since both $\pi(w, r; \tilde{p}, p^N)$ and $\pi(1-w, r; \tilde{p}, p^N)$ are concave in $\tilde{p}$, if a symmetric equilibrium (p^N, p^N) exists it must satisfy Equation (6), which is equivalent to

$$\pi_p(w, r; p^N, p^N) + \pi_p(1-w, r; p^N, p^N) = 0.$$

It is easy to check that the left hand side is positive at $p^N = r$ (the competitive price) and negative at $p^N = p^m = \frac{1+r}{2}$ (the monopoly price), where $r = r_u$ in the case of per unit fee and $r = 0$ in the case of proportional fee. Therefore, a symmetric equilibrium must exists with $p^N \in (r, p^m)$.

B Proof of Lemma 2

Let us assume all other sellers are charging the equilibrium price p^C, whereas seller $A1$ contemplates to charge a slightly different price $\tilde{p}$. The expected profit of $A1$ is given by

$$\begin{aligned}
& \Pi(\tilde{p}, p^C) \\
= \ & \int_0^a \epsilon_A\big(\tfrac{1}{2}[\pi(w, r; \tilde{p}, p^C) + \delta Prob_s(q_A < q_B)\pi^N(w, r) + \delta(1 - Prob_s(q_A < q_B))\tfrac{1}{2}\pi_S(w, r)] \\
& + \tfrac{1}{2}[\pi(1 - w, r; \tilde{p}, p^C) + \delta Prob_w(q_A < q_B)\pi^N(1 - w, r) + \delta(1 - Prob_w(q_A < q_B))\tfrac{1}{2}\pi_S(1 - w, r)]\big)dF(\epsilon_A).
\end{aligned}$$

That is, when $A1$ turns out to be the strong firm, it obtains a profit of $\pi(w, r; \tilde{p}, p^C)$ in the first period. In the second period, it obtains a profit of $\pi^N(w, r)$ when the platform does not enter category A, which happens if $q_A < q_B$. Otherwise, the platform enters category A and replaces $A2$ with probability half, in which case $A1$ obtains a profit of $\pi_S(w, r)$. This explains the first line and the second line can be explained similarly when $A1$ is the weak firm.

Specifically, $Prob_s(q_A < q_B)$ is the probability of no platform entry in category A when seller $A1$ is the strong firm, given by,

$$\begin{aligned}
& Prob_s(q_A < q_B) \\
= \ & Prob(\epsilon_A(w(1 - \tilde{p} + \beta(w\tilde{p} + (1 - w)p^C - \tilde{p})) + (1 - w)(1 - p^C + \beta(w\tilde{p} + (1 - w)p^C - p^C))) < \\
& \epsilon_B(w(1 - p^C + \beta(wp^C + (1 - w)p^C - p^C)) + (1 - w)(1 - p^C + \beta(wp^C + (1 - w)p^C - p^C)))) \\
= \ & Prob(\epsilon_A(w(1 - \tilde{p}) + (1 - w)(1 - p^C)) < \epsilon_B(1 - p^C)) \\
= \ & 1 - F(\epsilon_A(w\tfrac{1-\tilde{p}}{1-p^C} + 1 - w))),
\end{aligned}$$

and $Prob_w(q_A < q_B)$ is the probability of no platform entry in category A when seller $A1$ is the weak firm, given by,

$$\begin{aligned}
& Prob_w(q_A < q_B) \\
= \ & Prob(\epsilon_A((1 - w)(1 - \tilde{p} + \beta w(p^C - \tilde{p})) + w(1 - p^C + \beta(1 - w)(\tilde{p} - p^C))) < \\
& \epsilon_B(w(1 - p^C + \beta w(p^C - p^C)) + (1 - w)(1 - p^C + \beta w(p^C - p^C)))) \\
= \ & Prob(\epsilon_A((1 - w)(1 - \tilde{p}) + w(1 - p^C)) < \epsilon_B(1 - p^C)) \\
= \ & 1 - F\big(\epsilon_A\big((1 - w)\tfrac{1-\tilde{p}}{1-p^C} + w\big)\big).
\end{aligned}$$

Thus, we can rewrite $\Pi(\tilde{p}, p^C)$ as

$$\begin{aligned}
\Pi(\tilde{p}, p^C) = \ & \int_0^a \epsilon_A\big(\tfrac{\pi(w,r;\tilde{p},p^C)+\pi(1-w,r;\tilde{p},p^C)}{2} + \delta\tfrac{\pi^N(w,r)+\pi^N(1-w,r)}{2} \\
& -\tfrac{\delta}{2}F(\epsilon_A(w\tfrac{1-\tilde{p}}{1-p^C} + 1 - w))(\pi^N(w, r) - \tfrac{\pi_S(w,r)}{2}) \\
& -\tfrac{\delta}{2}F(\epsilon_A((1 - w)\tfrac{1-\tilde{p}}{1-p^C} + w))(\pi^N(1 - w, r) - \tfrac{\pi_S(1-w,r)}{2})\big)dF(\epsilon_A).
\end{aligned}$$

The optimal price $\tilde{p}$ then satisfies

$$\begin{aligned} 0 = & \tfrac{\partial \Pi(\tilde{p},p^C)}{\partial \tilde{p}} \\ = & \textstyle\int_0^a \epsilon_A \big(\tfrac{\pi_p(w,r;\tilde{p},p^C)+\pi_p(1-w,r;\tilde{p},p^C)}{2} \\ & + \tfrac{\delta}{2} \tfrac{\epsilon_A w}{1-p^C} f(\epsilon_A(w\tfrac{1-\tilde{p}}{1-p^C}+1-w)))(\pi^N(w,r)-\tfrac{\pi_S(w,r)}{2}) \\ & + \tfrac{\delta}{2} \tfrac{\epsilon_A(1-w)}{1-p^C} f(\epsilon_A((1-w)\tfrac{1-\tilde{p}}{1-p^C}+w)))(\pi^N(1-w,r)-\tfrac{\pi_S(1-w,r)}{2})\big)dF(\epsilon_A), \end{aligned}$$

where π_p denotes the partial derivation with respect to price. Furthermore, we have

$$\begin{aligned} & \tfrac{\partial^2 \Pi(\tilde{p},p^C)}{\partial \tilde{p}^2} \\ = & \textstyle\int_0^a \epsilon_A \big(\tfrac{\pi_{pp}(w,r;\tilde{p},p^C)+\pi_{pp}(1-w,r;\tilde{p},p^C)}{2} \\ & - \tfrac{\delta}{2} \big(\tfrac{\epsilon_A w}{1-p^C}\big)^2 f'(\epsilon_A(w\tfrac{1-\tilde{p}}{1-p^C}+1-w)))(\pi^N(w,r)-\tfrac{\pi_S(w,r)}{2}) \\ & - \tfrac{\delta}{2} \big(\tfrac{\epsilon_A(1-w)}{1-p^C}\big)^2 f'(\epsilon_A((1-w)\tfrac{1-\tilde{p}}{1-p^C}+w)))(\pi^N(1-w,r)-\tfrac{\pi_S(1-w,r)}{2})\big)dF(\epsilon_A). \end{aligned}$$

In the case of per unit fee, we have $\pi^N(w,r_u) > \pi_S(w,r_u)$ and $\pi^N(1-w,r_u) > \pi_S(1-w,r_u)$ due to the fact that the platform is a tougher competitor compared to an independent seller, as a consequence of double marginalisation. In the case of proportional fee, we can check that both $\pi^N(w,r_p) - \frac{\pi_S(w,r_p)}{2}$ and $\pi^N(1-w,r_p) - \frac{\pi_S(1-w,r_p)}{2}$ are proportional to

$$(2r_p^2 - 12r_p + 9)\beta^4 w^2(1-w)^2 + (24-16r_p)\beta^2(1+\beta)w(1-w) + 16(1+\beta)^2,$$

which is always positive for $r_p < 1/2$. Together with $f' \geq 0$ and $\pi_{pp} < 0$, we must have $\frac{\partial^2 \Pi(\tilde{p},p^C)}{\partial \tilde{p}^2} < 0$, i.e. the profit function is concave.

Thus, if a symmetric equilibrium exists it must satisfy

$$0 = \int_0^a \epsilon_A \big(\frac{\pi_p(w,r;p^C,p^C) + \pi_p(1-w,r;p^C,p^C)}{2} + \frac{\delta}{2} \frac{\epsilon_A f(\epsilon_A)}{1-p^C} M^C(w,r) \big) dF(\epsilon_A), \tag{6}$$

where $M^C(w,r) = w(\pi^N(w,r) - \frac{\pi_S(w,r)}{2}) + (1-w)(\pi^N(1-w,r) - \frac{\pi_S(1-w,r)}{2})$. From Lemma 1, the first part in the bracket is negative for p^C sufficiently large. However, the second part in the bracket is positive and increasing in p^C. Thus, to ensure that an equilibrium exists, we need δ not be too large. Specifically, we need

$$\begin{aligned} & (2 + (1+r_u)(1+2\beta w(1-w)))^2 \\ & -8(1+\beta w(1-w))\big[1 + r_u(1+2\beta w(1-w)) + \delta M^C(w,r_u) \tfrac{\int_0^a \epsilon_A f(\epsilon_A) dF(\epsilon_A)}{\int_0^a \epsilon_A dF(\epsilon_A)}\big] > 0, \end{aligned}$$

in the case of per unit fee; or

$$((1-r_p)(3+2\beta w(1-w)))^2 - 8(1-r_p)(1+\beta w(1-w))\big[1-r_p+\delta M^C(w,r_p)\frac{\int_0^a \epsilon_A f(\epsilon_A) dF(\epsilon_A)}{\int_0^a \epsilon_A dF(\epsilon_A)}\big] > 0,$$

in the case of proportional fee.

In either case, there exist two solutions, denoted by p^{C-} and p^{C+}, to Equation (6) with $p^{C-} < p^{C+}$. However, the equilibrium where all firms charge p^{C+} is not stable as $\frac{\partial \Pi(p,p)}{\partial \tilde{p}} < 0$ for $p < p^{C+}$ and $\frac{\partial \Pi(p,p)}{\partial \tilde{p}} > 0$ for $p > p^{C+}$. Thus, there exists a stable symmetric equilibrium where all sellers charge a price of p^{C-}.

C Proof of Lemma 3

Suppose all the other sellers are charging the equilibrium price p^T and seller $A1$ contemplates to charge a slightly different price $\tilde{p}$, its expected profit is given by

$$
\begin{aligned}
&\Pi(\tilde{p}, p^T) \\
= \; & \int_0^a \epsilon_A \Big(\tfrac{1}{2}[\pi(w, r; \tilde{p}, p^T) + \delta(1 - Prob(q_{A1} = \max_{k\in\{A,B\}, l\in\{1,2\}} q_{kl})\pi^N(w, r)] \\
& + \tfrac{1}{2}[\pi(1-w, r; \tilde{p}, p^T) + \delta(1 - Prob(q_{A2} = \max_{k\in\{A,B\}, l\in\{1,2\}} q_{kl})\pi^N(1-w, r) \\
& + \delta Prob(q_{A2} = \max_{k\in\{A,B\}, l\in\{1,2\}} q_{kl})\pi_S(1-w, r)]\Big) dF(\epsilon_A).
\end{aligned}
$$

That is, when $A1$ is the strong seller in category A, it only gets a positive profit in the second period if it is not the best seller in the first period, i.e. when its sales is lower than the strong seller in category B, which happens with probability

$$
\begin{aligned}
& 1 - Prob(q_{A1} = max_{k\in\{A,B\}, l\in\{1,2\}} q_{kl}) \\
= \; & Prob(\epsilon_A w(1 - \tilde{p} + \beta(1-w)(p^T - \tilde{p})) < \epsilon_B w(1 - p^T)) \\
= \; & 1 - F\big(\epsilon_A\big(\tfrac{1-\tilde{p}+\beta(1-w)(p^T-\tilde{p})}{1-p^T}\big)\big).
\end{aligned}
$$

When $A1$ is the weak seller in category A, it gets a profit $\pi^N(1-w, r)$ when the strong seller $A2$ is not the best seller and hence no platform enters in category A, whereas it gets a profit of $\pi_S(1-w, r)$ when the strong seller $A2$ is indeed the best seller and replaced by the platform in the second period, and we have

$$
\begin{aligned}
& Prob(q_{A2} = \max_{k\in\{A,B\}, l\in\{1,2\}} q_{kl}) \\
= \; & Prob(\epsilon_A w(1 - p^T + \beta(1-w)(\tilde{p} - p^T)) > \epsilon_B w(1 - p^T)) \\
= \; & F\big(\epsilon_A\big(1 + \beta(1-w)\tfrac{\tilde{p}-p^T}{1-p^T}\big)\big).
\end{aligned}
$$

Thus, we can write the expected profit of $A1$ as

$$
\begin{aligned}
& \Pi(\tilde{p}, p^T) \\
= \; & \int_0^a \epsilon_A \Big(\tfrac{\pi(w,r;\tilde{p},p^T)+\pi(1-w,r;\tilde{p},p^T)}{2} + \delta \tfrac{\pi^N(w,r)+\pi^N(1-w,r)}{2} \\
& - \tfrac{\delta}{2} F\big(\epsilon_A\big(\tfrac{1-\tilde{p}+\beta(1-w)(p^T-\tilde{p})}{1-p^T}\big)\big)\pi^N(w, r) \\
& - \tfrac{\delta}{2} F\big(\epsilon_A\big(1 + \beta(1-w)\tfrac{\tilde{p}-p^T}{1-p^T}\big)\big)(\pi^N(1-w, r) - \pi_S(1-w, r))\Big) dF(\epsilon_A).
\end{aligned}
$$

The optimal price satisfies

$$
\begin{aligned}
0 = \; & \tfrac{\partial \Pi(\tilde{p}, p^T)}{\partial \tilde{p}} \\
= \; & \int_0^a \epsilon_A \Big(\tfrac{\pi_p(w,r;\tilde{p},p^T)+\pi_p(1-w,r;\tilde{p},p^T)}{2} \\
& + \tfrac{\delta}{2} \tfrac{\epsilon_A}{1-p^T}(1 + \beta(1-w))\pi^N(w, r) f(\epsilon_A\big(\tfrac{1-\tilde{p}+\beta(1-w)(p^T-\tilde{p})}{1-p^T}\big)) \\
& + \tfrac{\delta}{2} \tfrac{\epsilon_A}{1-p^T}\beta(1-w)(\pi_S(1-w, r) - \pi^N(1-w, r)) f\big(\epsilon_A\big(1 + \beta(1-w)\tfrac{\tilde{p}-p^T}{1-p^T}\big)\big)\Big) dF(\epsilon_A).
\end{aligned}
$$

Furthermore, we have

$$\begin{aligned}
& \frac{\partial^2\Pi(\tilde{p},p^T)}{\partial\tilde{p}^2} \\
= & \int_0^a \epsilon_A\Big(\tfrac{\pi_{pp}(w,r;\tilde{p},p^T)+\pi_{pp}(1-w,r;\tilde{p},p^T)}{2} \\
& -\tfrac{\delta}{2}\big(\tfrac{\epsilon_A}{1-p^T}(1+\beta(1-w))\big)^2\pi^N(w,r)f'(\epsilon_A\big(\tfrac{1-\tilde{p}+\beta(1-w)(p^T-\tilde{p})}{1-p^T}\big)) \\
& +\tfrac{\delta}{2}\big(\tfrac{\epsilon_A}{1-p^T}\beta(1-w)\big)^2(\pi_S(1-w,r)-\pi^N(1-w,r))f'\big(\epsilon_A\big(1+\beta(1-w)\tfrac{\tilde{p}-p^T}{1-p^T}\big)\big)\Big)dF(\epsilon_A).
\end{aligned}$$

In the case of per unit fee, we have $\pi_S(1-w,r_u) < \pi^N(1-w,r_u)$, together with $f' > 0$, we must have $\frac{\partial^2\Pi(\tilde{p},p^T)}{\partial\tilde{p}^2} < 0$.

In the case of proportional fee, we have $\pi_S(1-w,r_p) > \pi^N(1-w,r_p)$. Hence, global concavity is not guaranteed. However, we can show that locally the profit functions is concave for $\tilde{p}$ in the neighbourhood of p^T. This is because

$$(1+\beta(1-w))^2\pi^N(w,r_p) > (\beta(1-w))^2(\pi_S(1-w,r_p)-\pi^N(1-w,r_p)),$$

due to the fact that $\pi^N(w,r_p)+\pi^N(1-w,r_p) > 2\pi^N(1-w,r_p) > \pi_S(1-w,r_p)$ for $r_p \le 1/2$. Therefore, if a symmetric equilibrium exists it must satisfy

$$0 = \int_0^a \epsilon_A\big(\frac{\pi_p(w,r;p^T,p^T)+\pi_p(1-w,r;p^T,p^T)}{2} + \frac{\delta}{2}\frac{\epsilon_A f(\epsilon_A)}{1-p^T}M^T(w,r)\big)dF(\epsilon_A), \tag{9}$$

where $M^T(w,r) = (1+\beta(1-w))\pi^N(w,r)+\beta(1-w)(\pi_S(1-w,r)-\pi^N(1-w,r))$. Similar to the proof of Lemma 2, one stable symmetric equilibrium exists if δ is not too large, specifically, if

$$\begin{aligned}
& (2+(1+r_u)(1+2\beta w(1-w)))^2 \\
& -8(1+\beta w(1-w))\big[1+r_u(1+2\beta w(1-w))+\delta M^T(w,r_u)\tfrac{\int_0^a\epsilon_A f(\epsilon_A)dF(\epsilon_A)}{\int_0^a\epsilon_A dF(\epsilon_A)}\big] > 0,
\end{aligned}$$

in the case of per unit fee; or

$$((1-r_p)(3+2\beta w(1-w)))^2-8(1-r_p)(1+\beta w(1-w))\big[1-r_p+\delta M^T(w,r_p)\frac{\int_0^a\epsilon_A f(\epsilon_A)dF(\epsilon_A)}{\int_0^a\epsilon_A dF(\epsilon_A)}\big] > 0,$$

in the case of proportional fee.

D Proof of Proposition 1

Compare Equation (7) and Equation (8), when evaluated at the same price $p^C = p^T = p^*$, the two equations only differ in the terms $M^C(w,r)$ and $M^T(w,r)$. We have

$$\begin{aligned}
& M^C(w,r) - M^T(w,r) \\
= & w(\pi^N(w,r)-\tfrac{\pi_S(w,r)}{2})+(1-w)(\pi^N(1-w,r)-\tfrac{\pi_S(1-w,r)}{2}) \\
& -((1+\beta(1-w))\pi^N(w,r)+\beta(1-w)(\pi_S(1-w,r)-\pi^N(1-w,r))) \\
= & -(1+\beta)(1-w)(\pi^N(w,r)-\pi^N(1-w,r))-\tfrac{w\pi_S(w,r)+(1-w)\pi_S(1-w,r)}{2}-\beta(1-w)\pi_S(1-w,r) \\
< & \ 0,
\end{aligned}$$

where the last inequality follows from $\pi^N(w,r) > \pi^N(1-w,r)$ for any $w > 1/2$. Thus, $M^C(w,r) < M^T(w,r)$ and we must have $p^C < p^T$ given that the profit functions are concave.

Compare Equation (6) and Equation (7), when evaluated at the same price, the only difference is $M^C(w,r)$. Under per unit fee, this is always positive as $\pi^N(w,r_u) > \pi_S(w,r_u)$ for any $w > 1/2$. Hence, we must have $p^C > p^N$. To see this, consider seller $A1$, when the platform does not enter category A, the two sellers' profits are given by

$$\pi_{A1}(p_{A1},p_{A2}) = \epsilon_A w_{A1}(p_{A1}-r_u)(1-p_{A1}+\beta(1-w_{A1})(p_{A2}-p_{A1})),$$

and

$$\pi_{A2}(p_{A1},p_{A2}) = \epsilon_A(1-w_{A1})(p_{A2}-r_u)(1-p_{A2}+\beta w_{A1}(p_{A1}-p_{A2})).$$

The competitive prices satisfy the following first order conditions

$$\frac{\partial \pi_{A1}(p_{A1},p_{A2})}{\partial p_{A1}} = \epsilon_A w_{A1}\big[1-p_{A1}+\beta(1-w_{A1})(p_{A2}-p_{A1})-(1+\beta(1-w_{A1}))(p_{A1}-r_u))\big],$$

and

$$\frac{\partial \pi_{A2}(p_{A1},p_{A2})}{\partial p_{A2}} = \epsilon_A(1-w_{A1})\big[1-p_{A2}+\beta w_{A1}(p_{A1}-p_{A2})-(1+\beta w_{A1})(p_{A2}-r_u))\big].$$

If the platform enters with the product of $A2$, the platform's profit is

$$\pi_p(p_{A1},p_{Ap}) = \epsilon_A[(1-w_{A1})p_{Ap}(1-p_{Ap}+\beta w_{A1}(p_{A1}-p_{Ap}))+r_u w_{A1}(1-p_{A1}+\beta(1-w_{A1})(p_{Ap}-p_{A1}))],$$

with the first order condition given by

$$\frac{\partial \pi_p(p_{A1},p_{Ap})}{\partial p_{Ap}} = \epsilon_A\big[(1-w_{A1})\big(1-p_{Ap}+\beta w_{A1}(p_{A1}-p_{Ap})-(1+\beta w_{A1})p_{A2}\big)+\beta r_u w_{A1}(1-w_{A1})\big].$$

Since $r_u(1+\beta w_{A1})(1-w_{A1}) > r_u\beta w_{A1}(1-w_{A1})$, it is apparent that

$$\frac{\partial \pi_{A2}(p_{A1},p_{A2})}{\partial p_{A2}} > \frac{\partial \pi_p(p_{A1},p_{Ap})}{\partial p_{Ap}},$$

when evaluated at $p_{Ap} = p_{A2}$. That is, the best response of the platform is a lower price than the seller. Therefore, the equilibrium price is lower when the platform enters, i.e. $\pi^N(w,r_u) > \pi_S(w,r_u)$.

However, under proportional fee, we have $\pi_S(w,r_p) > \pi^N(w,r_p)$ and $\pi_S(1-w,r_p) > \pi^N(1-w,r_p)$. This is because, under proportional fee, when the seller competes with the platform, the competitive price is higher as the platform partially internalises the seller's profit through the commissions, whereas competition between two independent sellers is more intense when the platform does not enter. Hence, it could happen that $M^C(w, r_p) < 0$, which implies $p^C < p^N$. Yet, when $r_p \leq 1/2$, we always have $M^C(w, r_P) > 0$. To see this, we have

$$M^C(w, r_p) \propto (2r_p^2 - 12r_p + 9)\beta^4 w^2(1-w)^2 + (24 - 16r_p)\beta^2(1+\beta)w(1-w) + 16(1+\beta)^2.$$

The second plus the third term is always positive for any $\beta \geq 0$, while the first term, especially $(2r_p^2 - 12r_p + 9)$ is positive for $r_p \leq 1/2$.[21] Hence, $M^C(w, r_p) > 0$ if $r_p \leq 1/2$ and thus $p^C > p^N$ for any β under proportional fee.

E Proof of Proposition 2

Define $E = \int_0^a \epsilon_i dF(\epsilon_i)$, $V = \int_0^a \epsilon_i^2 f(\epsilon_i) dF(\epsilon_i)$, $W = \int_0^a \epsilon_i F(\epsilon_i) dF(\epsilon_i)$, and assume that they all exist and are finite. Then we can rewrite the profit under category entry as

$$\begin{aligned}\Pi(p^C, p^C) = \; & E\big(\tfrac{\pi(w,r;p^C,p^C)+\pi(1-w,r;p^C,p^C)}{2} + \delta\tfrac{\pi^N(w,r)+\pi^N(1-w,r)}{2}\big) \\ & -\tfrac{\delta W}{2}(\pi^N(w,r) - \tfrac{\pi_S(w,r)}{2} + \pi^N(1-w,r) - \tfrac{\pi_S(1-w,r)}{2}),\end{aligned}$$

where p^C satisfies

$$\frac{E}{2}(\pi_p(w, r; p^C, p^C) + \pi_p(1-w, r; p^C, p^C)) + \frac{\delta V}{2(1-p^C)} M^C(w, r) = 0.$$

The profit under targeted entry can be rewritten as

$$\begin{aligned}\Pi(p^T, p^T) = \; & E\big(\tfrac{\pi(w,r;p^T,p^T)+\pi(1-w,r;p^T,p^T)}{2} + \delta\tfrac{\pi^N(w,r)+\pi^N(1-w,r)}{2}\big) \\ & -\tfrac{\delta W}{2}(\pi^N(w,r) + \pi^N(1-w,r) - \pi_S(1-w,r)),\end{aligned}$$

where p^T satisfies

$$\frac{E}{2}(\pi_p(w, r; p^T, p^T) + \pi_p(1-w, r; p^T, p^T)) + \frac{\delta V}{2(1-p^T)} M^T(w, r) = 0.$$

We have $\Pi(p^T, p^T) > \Pi(p^C, p^C)$ if

$$\begin{aligned}& E[(\pi(w,r;p^T,p^T) + \pi(1-w,r;p^T,p^T)) - (\pi(w,r;p^C,p^C) + \pi(1-w,r;p^C,p^C))] \\ & > \tfrac{\delta W}{2}(\pi_S(w,r) - \pi_S(1-w,r)).\end{aligned} \tag{10}$$

Notice that, under per unit fee,

$$\pi(w, r_u; p, p) + \pi(1-w, r_u; p, p) = (p - r_u)(1-p),$$

and

$$\pi_p(w, r_u; p, p) + \pi_p(1-w, r_u; p, p) = 1 - p - (1 + 2\beta w(1-w))(p - r_u).$$

[21] In fact, the first term is non-negative for $0 \leq r_p \leq \frac{6-3\sqrt{2}}{2} \approx 88\%$. Thus, Proposition 1 holds as long as $r_p \leq 88\%$. To avoid confusion, we assume both r_u and r_p are not greater than 1/2 in the main analysis.

Denote $\Lambda = 1 + 2\beta w(1-w)$, then the equilibrium prices are the solution to

$$(1-p)^2 - \Lambda(p - r_u)(1-p) + \frac{\delta V}{E} M = 0,$$

given by

$$p = \frac{2 + \Lambda(1 + r_u) - \sqrt{\Lambda^2(1-r_u)^2 - 4(1+\Lambda)\frac{\delta V M}{E}}}{2(1+\Lambda)}, \tag{11}$$

where $M = M^C$ under category entry and $M = M^T$ under targeted entry. Then, we can write

$$\pi(w, r_u; p, p) + \pi(1-w, r_u; p, p) = \frac{1}{\Lambda}\big[(1-p)^2 + \frac{\delta V M}{E}\big]. \tag{12}$$

Combining Equation (11) and (12), we can rewrite Condition (10) as

$$\begin{aligned} & V(M^T - M^C)\big[1 - \tfrac{1}{\Lambda}\tfrac{2}{\sqrt{1 - \frac{4\delta V}{E(1-r_u)^2}\frac{1+\Lambda}{\Lambda}\frac{M^T}{\Lambda}} + \sqrt{1 - \frac{4\delta V}{E(1-r_u)^2}\frac{1+\Lambda}{\Lambda}\frac{M^C}{\Lambda}}}\big] \\ & > \tfrac{W}{2}(1+\Lambda)(\pi_S(w, r_u) - \pi_S(1-w, r_u)). \end{aligned} \tag{13}$$

We always have $M^T > M^C$ from Proposition 1, and $\pi_S(w, r_u) > \pi_S(1-w, r_u)$ for any $w > 1/2$. If either $\beta = 0$ or $w = 1$, we have $\Lambda = 1$, then both terms in the square root are smaller than 1, which means the left hand side of the above condition is negative. Hence, in these cases, the profit under targeted entry is always lower than under category entry.

Furthermore, we have

$$\begin{aligned} \pi^N(w, r_u) &= \tfrac{(1-r_u)^2 w(1-w)(1+w)^2\beta^3 + o(\beta^3)}{9w^2(1-w)^2\beta^4 + o(\beta^4)}, \\ \pi^N(1-w, r_u) &= \tfrac{(1-r_u)^2 w(1-w)(2-w)^2\beta^3 + o(\beta^3)}{9w^2(1-w)^2\beta^4 + o(\beta^4)}, \\ \pi_S(w, r_u) &= \tfrac{w(1-w)(1+w-2r_u)^2\beta^3 + o(\beta^3)}{9w^2(1-w)^2\beta^4 + o(\beta^4)}, \\ \pi_S(1-w, r_u) &= \tfrac{w(1-w)(2-w-2r_u)^2\beta^3 + o(\beta^3)}{9w^2(1-w)^2\beta^4 + o(\beta^4)}. \end{aligned}$$

Hence, for a given w, we have $\lim_{\beta\to\infty} M^C = 0$, and

$$\begin{aligned} \lim_{\beta\to\infty} M^T &= \tfrac{(1-w)[(1-r_u)^2 w(1-w)((1+w)^2 - (2-w)^2) + w(1-w)(2-w-2r_u)^2]}{9w^2(1-w)^2}, \\ &= \tfrac{3(1-r_u)^2(2w-1) + (2(1-r_u)-w)^2}{9w}, \end{aligned}$$

which means $\lim_{\beta\to\infty} 1 - \frac{1}{\Lambda}\frac{1}{\sqrt{1 - \frac{4\delta V}{E(1-r_u)^2}\frac{1+\Lambda}{\Lambda}\frac{M^T}{\Lambda}} + \sqrt{1 - \frac{4\delta V}{E(1-r_u)^2}\frac{1+\Lambda}{\Lambda}\frac{M^C}{\Lambda}}} = 1$. On the right-hand side of Condition (13), we have

$$\begin{aligned} \lim_{\beta\to\infty}(1+\Lambda)(\pi_S(w, r_u) - \pi_S(1-w, r_u)) &= \tfrac{2w^2(1-w)^2[(1+w-2r_u)^2 - (2-w-2r_u)^2]}{9w^2(1-w)^2} \\ &= \tfrac{2(3-4r_u)(2w-1)}{9}. \end{aligned}$$

Then, Condition (13) is satisfied for $\beta \to \infty$ if

$$\frac{W}{V} < \frac{3(1-r_u)^2(2w-1) + (2(1-r_u)-w)^2}{w(3-4r_u)(2w-1)} = \frac{3(1-r_u)^2}{w(3-4r_u)} + \frac{(2(1-r_u)-w)^2}{(3-4r_u)w(2w-1)}.$$

Notice that the right hand side is decreasing in w for $w \in (1/2, 1)$. It goes to infinity when $w \to 1/2$ and equals $R(r_u) = \frac{7r_u^2 - 10r_u + 4}{3 - 4r_u}$ when $w = 1$. We have $R(r_u)$ decreasing in r_u for $r_u \in [0, 1/2]$ with $R(0) = 4/3$ and $R(1/2) = 3/4$.

Therefore, there exists a $\hat{w}$, which is equal to 1 if $W/V \leq 3/4$ or if $3/4 < W/V \leq 4/3$ and r_u sufficiently small, such that Condition (13) is satisfied for β sufficiently large, i.e. $\Pi(p^T, p^T) > \Pi(p^C, p^C)$.

Similarly, under proportional fees, we have

$$\pi(w, r_p; p, p) + \pi(1 - w, r_p; p, p) = (1 - r_p)p(1 - p);$$

and

$$\pi_p(w, r_p; p, p) + \pi_p(1 - w, r_p; p, p) = (1 - r_p)(1 - p - (1 + 2\beta w(1 - w))p).$$

Following similar steps as under per unit fees, we can show that the sellers obtain higher profits under targeted entry than category entry if

$$\begin{aligned} & V(M^T - M^C)\big[1 - \tfrac{1}{\Lambda}\frac{2}{\sqrt{1 - \frac{4(1+\Lambda)}{\Lambda(1-r_p)}\frac{\delta V}{E}\frac{M^T}{\Lambda}} + \sqrt{1 - \frac{4(1+\Lambda)}{\Lambda(1-r_p)}\frac{\delta V}{E}\frac{M^C}{\Lambda}}}\big] \\ > \ & \tfrac{W}{2}(1 + \Lambda)(\pi_S(w, r_p) - \pi_S(1 - w, r_p)). \end{aligned} \qquad (14)$$

In addition, we have

$$\begin{aligned} \pi^N(w, r_p) = \ & \tfrac{(1-r_p)w(2+\beta(1+w))(2+\beta(3-w)+\beta^2(1-w^2))}{(4(1+\beta)+3\beta^2 w(1-w))^2}, \\ \pi^N(1 - w, r_p) = \ & \tfrac{(1-r_p)(1-w)(2+\beta(2-w))(2+\beta(2+w)+\beta^2 w(2-w))}{(4(1+\beta)+3\beta^2 w(1-w))^2}, \\ \pi_S(w, r_p) = \ & \tfrac{(1-r_p)w(2+\beta(1+w))(2+\beta(3-w)+\beta^2(1-w^2))}{(4(1+\beta)+(3-r_p)\beta^2 w(1-w))^2}, \\ \pi_S(1 - w, r_p) = \ & \tfrac{(1-r_p)(1-w)(2+\beta(2-w))(2+\beta(2+w)+\beta^2 w(2-w))}{(4(1+\beta)+(3-r_p)\beta^2 w(1-w))^2}. \end{aligned}$$

When either $\beta = 0$ or $w = 1$, we have $\Lambda = 1$, which means the left hand side Condition (14) is always negative, hence the profit under targeted entry is lower than under category entry. For any other $w < 1$, we have $\lim_{\beta\to\infty} M^C = 0$, and $\lim_{\beta\to\infty} \frac{M^T}{\Lambda} = 0$. Moreover,

$$\lim_{\beta\to\infty}(1 + \Lambda)(\pi_S(w, r_p) - \pi_S(1 - w, r_p)) = \frac{6(1 - r_p)(2w - 1)}{(3 - r_p)^2},$$

and

$$\lim_{\beta\to\infty} M^T = (1 - r_p)\big[\frac{3(2w - 1)}{9w} + \frac{(2 - w)^2}{w(3 - r_p)^2}\big].$$

Hence, Condition (14) is satisfied if

$$\frac{W}{V} < \frac{(3 - r_p)^2}{9w} + \frac{(2 - w)^2}{3w(2w - 1)}.$$

The right hand side is decreasing in w, goes to infinity when $w \to 1/2$, and approaches $\frac{(3-r_p)^2}{9} + \frac{1}{3}$ when $w \to 1$. Thus, we have the same result as under per unit fee: there exists a $\hat{w} \in (1/2, 1]$, and for any $w < \hat{w}$, the profit under targeted entry is higher than under category entry if $\beta > \beta(\hat{w})$.

F Proof of Proposition 3

Now consider the comparison between targeted entry and random entry. We have

$$\Pi(p^N,p^N) = E\Big(\frac{\pi(w,r;p^N,p^N)+\pi(1-w,r;p^N,p^N)}{2} + \delta\frac{\pi^N(w,r)+\pi^N(1-w,r)}{4} + \delta\frac{\pi_S(w,r)+\pi_S(1-w,r)}{8}\Big).$$

Hence, $\Pi(p^T,p^T) > \Pi(p^N,p^N)$ if

$$\begin{aligned} & E[(\pi(w,r;p^T,p^T)+\pi(1-w,r;p^T,p^T)) - (\pi(w,r;p^N,p^N)+\pi(1-w,r;p^N,p^N))] \\ > \ & \delta\big(\tfrac{W}{2}(\pi^N(w,r)+\pi^N(1-w,r)-\pi_S(1-w,r)) - \tfrac{E}{4}(\pi^N(w,r)+\pi^N(1-w,r) - \tfrac{\pi_S(w,r)+\pi_S(1-w,r)}{2})\big). \end{aligned}$$

Under per unit fee, similar as before, we can rewrite the left-hand side of the above condition using the equilibrium prices and the fact that p^N corresponds to $M^N = 0$, giving us,

$$\begin{aligned} & VM^T\Big(1 - \frac{1}{\Lambda}\frac{2}{1+\sqrt{1-\frac{4\delta V}{E(1-r_u)^2}\frac{1+\Lambda}{\Lambda}\frac{M^T}{\Lambda}}}\Big) \\ > \ & (1+\Lambda)\big[\tfrac{2W-E}{4}(\pi^N(w,r_u)+\pi^N(1-w,r_u)-\pi_S(1-w,r_u)) + \tfrac{E}{8}(\pi_S(w,r_u)-\pi_S(1-w,r_u))\big]. \end{aligned} \tag{15}$$

Note that the right-hand side is non-negative. This is because $\pi_S(1-w,r_u) < \frac{\pi_S(w,r_u)+\pi_S(1-w,r_u)}{2}$, and $W > E/2$. The latter follows from $2W - E = \int_0^a \epsilon_i(2F(\epsilon_i)-1)dF(\epsilon_i) > 0$ as $\int_0^a 2F(\epsilon_i) - 1dF(\epsilon_i) = 0$.

As before, if $\beta = 0$ or $w = 1$, then $\Lambda = 1$ which means that the left-hand side is negative, hence, $\Pi(p^T,p^T) < \Pi(p^N,p^N)$. For $w < 1$, we have

$$\lim_{\beta\to\infty} VM^T\Big(1 - \frac{1}{\Lambda}\frac{2}{1+\sqrt{1-\frac{4\delta V}{E(1-r_u)^2}\frac{1+\Lambda}{\Lambda}\frac{M^T}{\Lambda}}}\Big) = V\frac{3(1-r_u)^2(2w-1)+(2(1-r_u)-w)^2}{9w},$$

which is always positive and finite. On the right hand side of Condition (15), we have shown that

$$\lim_{\beta\to\infty}(1+\Lambda)(\pi_S(w,r_u)-\pi_S(1-w,r_u)) = \frac{2(3-4r_u)(2w-1)}{9},$$

which is increasing in w and approaches zero when $w \to 1/2$. In addition, we have

$$\begin{aligned} & \lim\nolimits_{\beta\to\infty}(1+\Lambda)(\pi^N(w,r_u)+\pi^N(1-w,r_u)-\pi_S(1-w,r_u)) \\ = \ & 2w(1-w)\tfrac{(1-r_u)^2 w(1-w)((1+w)^2+(2-w)^2) - w(1-w)(2-2r_u-w)^2}{9w^2(1-w)^2} \\ = \ & \tfrac{2}{9}\big((1-r_u)^2((1+w)^2+(2-w)^2) - (2-2r_u-w)^2\big), \end{aligned}$$

which is also increasing in w and approaches $\frac{1}{9}r_u^2 - \frac{2}{3}r_u + \frac{1}{2}$, which is always positive for $r_u \in [0,1/2]$, when $w \to 1/2$. Hence, whether Condition (15) holds depends on the exact distribution $F(\epsilon_i)$, which determines the value of V, W, E.

If ϵ_i is uniformly distributed on $[0,a]$, we have $E = a/2$, $W = a/3$, and $V = a/3$. For $\beta \to \infty$, Condition (15) becomes

$$\frac{3(1-r_u)^2(2w-1)+(2(1-r_u)-w)^2}{3w} - \frac{(1-r_u)^2((1+w)^2+(2-w)^2)-(2-2r_u-w)^2}{12} - \frac{(3-4r_u)(2w-1)}{8} > 0,$$

the left-hand side of which is decreasing for $w \in (1/2, 1)$ and is always positive when $w = 1/2$. Hence, there exists a $\hat{w}$ such that for $w < \hat{w}$, we have $\Pi(p^T, p^T) > \Pi(p^N, p^N)$ when β is sufficiently large.

In the case of proportional fees, the profit is higher under targeted entry if

$$\begin{aligned} & VM^T\Big(1 - \tfrac{1}{\Lambda}\frac{2}{1+\sqrt{1-\frac{4\delta V}{E(1-r_p)}\frac{1+\Lambda}{\Lambda}\frac{M^T}{\Lambda}}}\Big) \\ > \ & (1+\Lambda)\big[\tfrac{2W-E}{4}(\pi^N(w, r_p) + \pi^N(1-w, r_p) - \pi_S(1-w, r_p)) + \tfrac{E}{8}(\pi_S(w, r_p) - \pi_S(1-w, r_p))\big], \end{aligned} \tag{16}$$

which cannot be satisfied when either $\beta = 0$ or when $w = 1$. When $w < 1$, have

$$\lim_{\beta\to\infty} VM^T\Big(1 - \frac{1}{\Lambda}\frac{2}{1+\sqrt{1-\frac{4\delta V}{E(1-r_p)}\frac{1+\Lambda}{\Lambda}\frac{M^T}{\Lambda}}}\Big) = V(1-r_p)\Big[\frac{3(2w-1)}{9w} + \frac{(2-w)^2}{w(3-r_p)^2}\Big],$$

$$\lim_{\beta\to\infty}(1+\Lambda)(\pi_S(w, r_p) - \pi_S(1-w, r_p)) = \frac{6(1-r_p)(2w-1)}{(3-r_p)^2},$$

and

$$\lim_{\beta\to\infty}(1+\Lambda)(\pi^N(w, r_p)+\pi^N(1-w, r_p)-\pi_S(1-w, r_p)) = 2(1-r_p)\Big[\frac{(1+w)^2+(2-w)^2}{9} - \frac{(2-w)^2}{(3-r_p)^2}\Big].$$

In the case of uniform distribution, Condition (16) becomes

$$\frac{2w-1}{9w} + \frac{(2-w)^2}{3w(3-r_p)^2} + \frac{1}{12}\frac{(2-w)^2}{(3-r_p)^2} - \frac{1}{12}\frac{(1+w)^2+(2-w)^2}{9} + \frac{3(2w-1)}{8(3-r_p)^2} > 0,$$

as above, the left-hand side is decreasing for $w \in (1/2, 1)$ and is always positive when $w = 1/2$. Hence, there exists a $\hat{w}$ such that for $w < \hat{w}$, we have $\Pi(p^T, p^T) > \Pi(p^N, p^N)$ when β is sufficiently large.

G Proof of Proposition 4

Under per unit fee, for given w and β, the platform's profit under targeted entry is

$$\Pi^{IT} = 2Er_u(1-p^T) + \delta E_{\epsilon_A,\epsilon_B}\max(\epsilon_A, \epsilon_B)\pi_I(w, r_u) + \delta E_{\epsilon_A,\epsilon_B}\min(\epsilon_A, \epsilon_B)r_uQ(w, \beta),$$

where $Q(w, \beta)$ is the per consumer demand for the two products in the category where the platform does not enter. The platform's profit under category entry is

$$\Pi^{IC} = 2Er_u(1-p^C)+\delta E_{\epsilon_A,\epsilon_B}\max(\epsilon_A, \epsilon_B)\frac{\pi_I(w, r_u)+\pi_I(1-w, r_u)}{2}+\delta E_{\epsilon_A,\epsilon_B}\min(\epsilon_A, \epsilon_B)r_uQ(w, \beta).$$

Denote $X = E_{\epsilon_A,\epsilon_B}\max(\epsilon_A, \epsilon_B)$ and $Y = E_{\epsilon_A,\epsilon_B}\min(\epsilon_A, \epsilon_B)$, the platform's profit is higher under targeted entry if

$$\delta X\frac{\pi_I(w, r_u) - \pi_I(1-w, r_u)}{2} > 2Er_u(p^T - p^C).$$

Clearly, the left hand side is always positive for any $w > 1/2$ and the right hand side approaches zero when r_u approaches zero. Thus, the condition holds for r_u small enough.

The platform's profit under random entry is given by

$$\Pi^{IN} = 2Er_u(1-p^N) + \delta E\frac{\pi_I(w,r_u)+\pi_I(1-w,r_u)}{2} + \delta Er_uQ(w,\beta).$$

Thus, using the fact that $X+Y=2E$, $\Pi^{IC} > \Pi^{IN}$ if

$$\delta(X-E)[\frac{\pi_I(w,r_u)+\pi_I(1-w,r_u)}{2} - r_uQ(w,\beta)] > 2Er_u(p^C - p^N).$$

It can be readily checked that the left hand side is strictly positive whereas the right hand side approaches zero as $r_u \to 0$. Hence, the condition holds for r_u small enough. Together, for small enough r_u, we have $\Pi^{IT} > \Pi^{IC} > \Pi^{IN}$.

Similarly, under proportional fee, the platform's profit under targeted entry is

$$\Pi^{IT} = 2Er_pp^T(1-p^T) + \delta X\pi_I(w,r_p) + \delta Y\frac{r_p}{1-r_p}(\pi^N(w,r_p) + \pi^N(1-w,r_p)).$$

The platform's profit under category entry is

$$\Pi^{IC} = 2Er_pp^C(1-p^C) + \delta X\frac{\pi_I(w,r_p)+\pi_I(1-w,r_p)}{2} + \delta Y\frac{r_p}{1-r_p}(\pi^N(w,r_p) + \pi^N(1-w,r_p)),$$

and its profit under random entry is

$$\Pi^{IN} = 2Er_pp^N(1-p^N) + \delta E\frac{\pi_I(w,r_p)+\pi_I(1-w,r_p)}{2} + \delta E\frac{r_p}{1-r_p}(\pi^N(w,r_p) + \pi^N(1-w,r_p)).$$

Therefore, the profit is higher under targeted entry than category entry if

$$\delta X\frac{\pi_I(w,r_p)-\pi_I(1-w,r_p)}{2} > 2Er_p[p^C(1-p^C) - p^T(1-p^T)],$$

and the profit is higher under category entry than random entry if

$$\delta(X-E)[\frac{\pi_I(w,r_p)+\pi_I(1-w,r_p)}{2} - \frac{r_p}{1-r_p}(\pi^N(w,r_p)+\pi^N(1-w,r_p))] > 2Er_p[p^N(1-p^N) - p^C(1-p^C)].$$

Similar argument as above implies that both conditions are satisfied if r_p is small enough.

H Proof of Proposition 5

For the first part, from the proof of Proposition 4, we have $\Pi^{IT} < \Pi^{IC}$ if

$$\delta X\frac{\pi_I(w,r_u)-\pi_I(1-w,r_u)}{2} < 2Er_u(p^T - p^C).$$

Moreover, we have

$$\lim_{w\to 1/2} \pi_I(w,r_u) - \pi_I(1-w,r_u) = 0,$$

while $p^T - p^C$ is strictly positive from Proposition 1 for $w \to 1/2$. Hence, there must exist a $\tilde{w}$ small enough, such that the above condition holds and thus the profit is higher under category entry.

For the second part, we have $\Pi^{IC} > \Pi^{IN}$ if

$$\delta(X - E)[\frac{\pi_I(w, r_u) + \pi_I(1 - w, r_u)}{2} - r_u Q(w, \beta)] > 2Er_u(p^C - p^N),$$

where

$$p^C - p^N = \frac{\delta V}{E} \frac{2}{\Lambda(1 - r_u)} \frac{M^C}{1 + \sqrt{1 - \frac{4\delta V}{E(1-r_u)^2} \frac{1+\Lambda}{\Lambda} \frac{M^C}{\Lambda}}}.$$

When $w \to 1/2$ and $\beta \to \infty$, the condition is satisfied if

$$(X - E)\frac{19r_u^2 - 21r_u + 9}{18} > 0,$$

which is always satisfied for $r_u \leq 1/2$. Hence, the profit is higher under category entry than random entry.

For the last part, we have $\Pi^{IT} < \Pi^{IN}$ if

$$\delta[(X - E)\big(\pi_I(w, r_u) - r_u Q(w, \beta)\big) + E\frac{\pi_I(w, r_u) - \pi_I(1 - w, r_u)}{2}] < 2Er_u(p^T - p^N).$$

In addition, we have

$$p^T - p^N = \frac{\delta V}{E} \frac{2}{\Lambda(1 - r_u)} \frac{M^T}{1 + \sqrt{1 - \frac{4\delta V}{E(1-r_u)^2} \frac{1+\Lambda}{\Lambda} \frac{M^T}{\Lambda}}}.$$

With uniform distribution, we have $X = 2a/3$ and $E = a/2$. Furthermore, when $w \to 1/2$ and $\beta \to \infty$, the above condition becomes

$$\frac{19r_u^2 - 21r_u + 9}{18} < \frac{8r_u(2(1 - r_u) - 1/2)^2}{9(1 - r_u)},$$

which is satisfied if $r_u > \tilde{r}_u \approx 0.23$. Hence, for relatively large r_u, the profit is lower under targeted entry than under random entry if both w is sufficiently small and β is sufficiently large.

I Proof of Proposition 8

Denote $p_I(w_I, r)$ and $p_S(w_S, r)$ as the prices charged by the platform and the remaining seller in the category where the platform enters with the product of strength w_I in the second period, and $p^N(w)$ and $p^N(1 - w)$ as the prices charged by the strong seller and the weak seller in the second period when the platform does not enter. Moreover, let $CS(p_1, p_2)$ denote the per consumer surplus in a category when the price of the strong product is p_1 and that of the weak product is p_2. The expected aggregate consumer surplus under category entry is given by

$$CS^C = 2E \cdot CS(p^C, p^C) + X\frac{CS(p_I(w, r), p_S(1 - w, r)) + CS(p_S(w, r), p_I(1 - w, r))}{2} + Y \cdot CS(p^N(w), p^N(1 - w)),$$

and under targeted entry given by

$$CS^T = 2E \cdot CS(p^T, p^T) + X \cdot CS(p_I(w,r), p_S(1-w,r)) + Y \cdot CS(p^N(w), p^N(1-w)).$$

Thus, consumer surplus is lower under targeted entry if

$$X \frac{CS(p_I(w,r), p_S(1-w,r)) - CS(p_S(w,r), p_I(1-w,r))}{2} < 2E(CS(p^C, p^C) - CS(p^T, p^T)).$$

Clearly, the right hand side of the condition is always strictly positive according to Proposition 1, and the left hand side approaches zero when $w \to 1/2$ as $(p_I(w,r), p_S(1-w,r)) \to (p_S(w,r), p_I(1-w,r))$ when $w \to 1/2$. Thus, the condition must be satisfied for w sufficiently close to 1/2.