Product Experimentation, Information Diffusion and Platform Encroachment*

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Abstract

Platforms provide great opportunities for independent sellers to experiment with new products. By facilitating transactions between trading parties, platforms can gather a huge amount of information about successful products, and introduce their own versions of competing products. This phenomenon of platform encroachment has received attention from various stakeholders, and concerns have been raised about how it may marginalize independent sellers and hinder the development of the ecosystem. At the same time, platforms also expedite the diffusion of information about successful products and facilitate learning and imitation from other independent sellers, which has received little attention in the literature. In this article, we explicitly account for this feature and consider a dynamic model to study the impact of platform encroachment on sellers' incentives to experiment with new products, when both the platform and independent sellers can imitate and introduce competing versions of products offered by the successful experimenter. We show that when a seller with successful experimentation holds an advantage in the product market, platform encroachment may enhance the incentives to carry out experimentation. This enhancement effect is stronger when information diffuses faster on the platform.

*We thank Amelia Fletcher, Morten Hviid, Robert Somogyi, seminar and conference participants at Leicester, Norwich and CRESSE 2022 for useful comments.

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Keywords: Platform encroachment, Product experimentation, Independent sellers, Information diffusion;

1 Introduction

Online platforms have grown rapidly in recent years. By significantly lowering the cost of entry and facilitating transactions with consumers, these platforms provide unprecedented opportunities for sellers to enter and experiment with new products and ideas. Some of these sellers grow their businesses successfully and become top sellers in their product categories, which attracts other sellers to offer similar products following the success, thanks to fast information diffusion facilitated by platforms. For example, when searching for "wireless earbuds" on Amazon, we not only see Anker, which is one of the top sellers on online trading platforms across North America and Europe for peripheral products of electronic devices, but also many other competing brands (See Figure 1).[1]

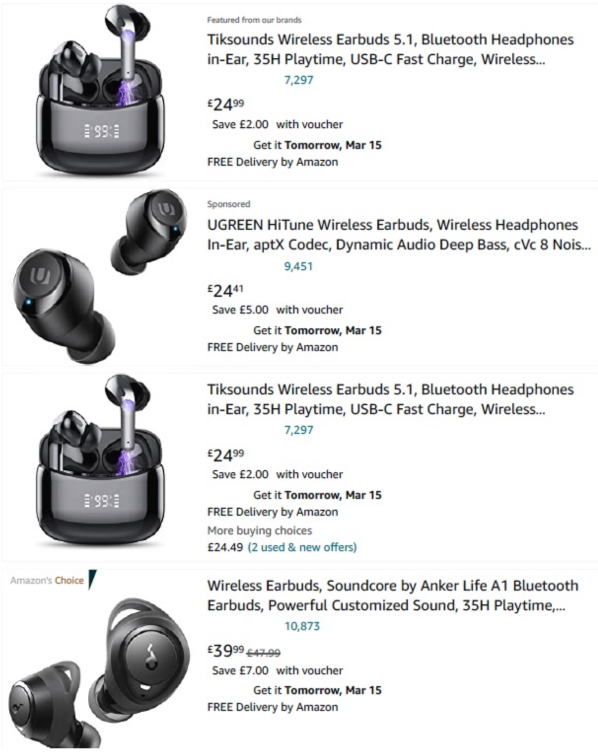


Figure 1: Product list for wireless earbuds (accessed 14 March 2022)

At the same time, platforms also provide their own versions of products and compete with these sellers on the marketplaces, for example, in the above case, Amazon offers its own earbud brand Umi. This phenomenon is commonly known as platform encroachment and has raised concerns among third party sellers as well as antitrust authorities, espe-

[1]See "The World's Top Amazon Marketplace Sellers 2021". Webretailer. Available at `https://bit.ly/3I4jYmp` (accessed 1 September 2022).

cially when platforms can gather a huge amount of information about individual sellers and use such information to tailor their product offerings.[2] So far, studies have focused on the impact of platform encroachment on competition and profits of third party sellers, but little has been done regarding the impact on product experimentation, an important practice facilitated by online trading platforms, especially when third party sellers can also imitate and enter with their own versions of competing products.

To explore this, we build a dynamic model of product experimentation on a monopolistic platform with the following features. Firstly, some sellers actively undertake product experimentation and capture a large share of the market upon success. Secondly, when a "hit" product appears in the market, thanks to developments such as sales monitoring tools, other sellers gradually learn about the success, imitate, and provide their competing versions of the product. Thirdly, the platform may also enter to compete in the market and it may learn about a successful experimentation faster than other sellers. The equilibrium experimentation rate is determined by the absolute value from successful experimentation, and the relative value of successful experimentation compared with unsuccessful experimentation. Without platform encroachment, a free-riding problem exists among sellers: a seller can wait for successful experimentation from other sellers and then imitate instead of carrying out their own costly experimentation. This option is more valuable when information diffuses faster on the platform, which decreases both the absolute value and the relative value. Hence, the equilibrium rate of experimentation is decreasing as information becomes more readily available.

To examine the impact of platform encroachment, we start with the scenario when the platform learns about successful experimentation at the same rate as other sellers. In this scenario, platform encroachment only affects the competitive profits of sellers. If the successful experimenter holds no advantage in the product market, platform encroachment either has no impact on the competitive profits of sellers when the market features free entry, which means the competitive profits of all sellers would be equal to the entry cost, or reduces the competitive profits of sellers when the market has a fixed number of sellers due to intensified competition. This means that platform encroachment does not affect the relative value but may reduce the absolute value from successful experimen-

[2]See "Amazon Scooped Up Data From Its Own Sellers to Launch Competing Products". The Wall Street Journal. Available at `https://on.wsj.com/3Q74uli` (accessed 1 September 2022).

tation. Therefore, platform encroachment either has no impact on or reduces product experimentation.

If, however, the successful experimenter enjoys certain first-mover advantages in the product market, platform encroachment can increase product experimentation by mitigating the free-riding problem. This can be achieved via two ways. Firstly, when the platform competes more intensely with imitating sellers, it enlarges the profit gap between a successful experimenter and an imitating seller, reduces the value of imitation, and hence increases the relative value of successful experimentation. Secondly, platform encroachment intensifies competition and benefits the successful experimenter by driving out some imitating sellers, which could increase both the absolute value and the relative value of successful experimentation. Moreover, the experimentation enhancement effect is stronger when information diffuses faster, as the free-riding problem is more severe.

We then discuss and extend the framework in a few directions. Firstly, we consider the platform's choice of quality for its competing brand and show that the platform may find it optimal to enter with a less premium product to boost product experimentation incentives, especially when information diffuses fast on the platform. Secondly, we consider the case where the platform has an informational advantage and learns about successful experimentation faster than other sellers. This allows the platform to enter the market earlier, which shortens the horizon for the successful experimenter to capitalize on its product innovation and brings additional negative impacts on the experimentation incentives. Finally, when sellers can choose to become an experimenter or an imitator, we demonstrate that platform encroachment may incentivize more sellers to become an experimenter and carry out product experimentation, which could bring additional benefits to the market.

The results have several managerial and regulatory implications. For the platform, the results show that platform entry does not necessarily crowd out third party sellers, it may even encourage more product experimentation by mitigating the free-riding incentives. This is more likely to be the case when the platform competes closely against imitators rather than the original experimenter. The experimentation enhancing effect is more significant and valuable when information diffuses at a faster rate, especially given the development of third-party monitoring tools that help sellers identify successful products. On the regulatory side, our results imply that platform entry could generate long-run benefits by encouraging more product experimentation, which brings new products, more varieties, and a wider range of choices for consumers. These results suggest the importance of considering *how* firms compete and *how* information diffuses in assessing the impact of platform encroachment, and weighing the benefits from enhancing experimentation against the cost arising from informational advantages.

Our analysis contributes to the recent literature studying the impact of platform encroachment. For example, Zhu & Liu (2018) show that the entry of Amazon increases demand and reduces shipping costs but discourages sellers from growing their businesses. Wen & Zhu (2019) show that Google's entry into the mobile app market shifts innovation to unaffected and new apps and reduces wasteful development efforts. He et al. (2020) demonstrate that third party sellers migrate to other retailing channels in response to the entry of a Chinese e-commerce platform. An excellent overview of the empirical literature is provided by Zhu (2019). Theoretically, Jiang et al. (2011) show that platform encroachment may induce independent sellers to reduce valuable services. The more recent literature has mainly focused on how platform entry affects competition in the market; see, for example, Anderson & Bedre-Defolie (2020), Zennyo (2021), and Hagiu et al. (2022). There has been limited work on the dynamics of the market and the role of information usage by the platform. Madsen & Vellodi (2022) and Hervas-Drane & Shelegia (2022) consider the case when only the platform learns and imitates third party sellers' products. Lam & Liu (2021) further consider when the platform has access to information at different levels of granularity. In this article, we consider instead the impact of platform entry and information usage on the incentives of product experimentation, when both the platform and third party sellers can learn and imitate. This also distinguishes our work from the literature on private labels such as Hoch (1996) and Gabrielsen & Sørgard (2007), where only the retailers can introduce competing private labels but not other manufacturers.

The article proceeds as follows. We present the main model in Section 2, and analyze the case when the platform does not hold an informational advantage in Section 3. We then discuss the optimal product selection by the platform in Section 4, the case when the platform holds an informational advantage in Section 5, and the case with an endogenous number of experimenters in Section 6. We conclude with some managerial and regulatory implications in Section 7.

2 Product experimentation without platform encroachment

We first present the model and study sellers' incentives to carry out product experimentation without the possibility of platform encroachment. We consider a monopoly platform, M, that intermediates transactions between sellers and consumers. Time is continuous and all parties have a common discount rate r, which could also measure market uncertainty. The market proceeds in three stages:

Experimentation stage

Two of the sellers, 1 and 2, experiment with new products in the market. At every instant of time, each seller $i = 1, 2$ chooses a Poisson experimentation rate x_i at a convex cost of $c(x_i) = x_i^2/2$. In the case of success, which arrives at a rate of x_i, the seller develops and monopolizes a new product, and the market moves to the learning stage.

Learning stage

Once a success happens, other sellers (the other experimenting seller and other non-experimenting sellers), and the platform become aware of the success, but they only gradually learn about the details of the successful product.[3] Specifically, we assume that when one seller succeeds, the successful experimenter obtains a flow profit of π_m. The other experimenting seller stops experimenting, and learning in the market occurs at a Poisson rate of ρ. When learning occurs, other sellers can imitate and enter the market at no cost, and the market moves to the competition stage.

Competition stage

In this stage, we assume the successful experimenter, referred to as the *leader* in the following, obtains a flow profit of π_l; and the other experimenting seller, referred to as the *follower*, and other non-experimenting sellers obtain a flow profit of π_f. We further assume that $\pi_m > \pi_l \geq \pi_f$.[4]

[3] For instance, Amazon regularly publishes category sales data, which allows firms to identify successful categories. In order to identify the successful product within the category, firms need to analyze individual sales data, which takes time but may become easier with the help of third party sales monitoring applications.

[4] Note that π_m, π_l, π_f all depend on the fees charged by the platform, which we omit to save notations.

Value function for the leader and the follower

We start with the analysis when there is no platform encroachment. In the competition stage, let

$$\Pi_l = \frac{\pi_l}{r} \text{ and } \Pi_f = \frac{\pi_f}{r}$$

denote the long-run competitive profits for the leader and the follower respectively.

In the learning stage when a seller has succeeded in product experimentation, we derive the value functions for the leader and the follower, denoted by V_l and V_f respectively. For the leader, we have:[5]

$$rV_l = \pi_m + \rho(\Pi_l - V_l).$$

That is, if learning and hence entry does not occur, the leader's value accrues by the flow profit π_m; if learning occurs, which arrives at at rate of ρ, the leader's value jumps to the long-run competitive profit Π_l. This gives us:

$$V_l = \frac{\pi_m + \rho\Pi_l}{r + \rho}.$$

Similarly, for the follower, we have:

$$V_f = \frac{\rho\Pi_f}{r + \rho}.$$

Value function before successful experimentation

Before any successful experimentation arrives, each seller $i = 1, 2$ maximizes its pre-success value, denoted by V_0, by solving:

$$rV_0 = \max_{x_i} -\frac{x_i^2}{2} + x_i(V_l - V_0) + x_j(V_f - V_0), \text{ for } j \neq i. \quad (1)$$

That is, at every instant of time, the seller incurs the flow cost of experimentation. When it succeeds in product experimentation, it becomes the leader and its value jumps to V_l; however, when the other seller succeeds, it becomes the follower and its value jumps to V_f.

The optimal experimentation rate then satisfies:

$$x_1^* = x_2^* = V_l - V_0,$$

and we have:[6]

[5] We derive this value function in the appendix, and the value functions in the following analysis can be derived similarly.

[6] All proofs are relegated to the Appendix.

Lemma 1. *The equilibrium experimentation rates are given by* $x_1^* = x_2^* = x^*$ *with*

$$x^* = \frac{V_l - V_f - r + \sqrt{(V_l - V_f - r)^2 + 6rV_l}}{3}.$$

Hence, the experimentation rate increases with the value of being the leader, and the value gap between being the leader and being the follower. The former can be interpreted as the absolute benefit from successful experimentation, and the latter as the relative benefit of successful experimentation compared with unsuccessful experimentation. When sellers heavily discount the future (that is, r is large), the experimentation rate is largely determined by the absolute benefit, in particular, the profit in the monopolization stage or the learning stage. When sellers are patient (that is, r is small), the experimentation rate depends mostly on the relative benefit, in particular, the profit difference between the leader and the follower in the competition stage. Moreover, we can show that:

Proposition 1. *The equilibrium experimentation rate* x^* *is decreasing in the information diffusion rate* ρ*.*

The reason is that the faster information diffuses in the market, the shorter the monopolization period for the successful experimenter, which lowers the value of becoming the leader and hence the absolute benefit. Moreover, faster information diffusion enables other sellers to learn and imitate faster, which further narrows the value gap between the leader and the follower and hence the relative benefit. Therefore, the equilibrium experimentation rates become lower. The result highlights the free-riding incentives in the market when information becomes more accessible, as sellers value more the option to wait and imitate instead of undertaking their own costly experimentation.

3 Platform encroachment without informational advantage

Now we consider the platform enters with its own version of products. We consider in this section the scenario when the platform has access to the same information as other sellers, and we consider in Section 5 the case when the platform has an informational advantage.

When the platform does not have an informational advantage, it follows the same learning process as other sellers. Thus, the equilibrium experimentation rate, denoted by

x^{*E}, depends on the profits of the leader and the follower in the competition stage with platform entry, denoted by π_l^E and π_f^E respectively, and it is given by:

$$x^{*E} = \frac{V_l^E - V_f^E - r + \sqrt{(V_l^E - V_f^E - r)^2 + 6rV_l^E}}{3},$$

where $V_l^E = \frac{\pi_m + \rho \Pi_l^E}{r+\rho}$ and $V_f^E = \frac{\rho \Pi_f^E}{r+\rho}$, with $\Pi_l^E = \pi_l^E / r$ and $\Pi_f^E = \pi_f^E / r$.

The impact of platform encroachment on the incentives to experiment is then two-fold. Firstly, it impacts the value from successful experimentation, that is, the value of becoming the leader. Secondly, it has an impact on the gap between the value from successful experimentation and the value from the fallback option of being the follower. We show in the following that both impacts can depend on the characteristics of the competition stage.

3.1 No first-mover advantage by the leader

When the leader does not enjoy any first-mover advantage in the competition stage (that is, sellers are symmetric), we have the following *irrelevance* result on the impact of platform entry on product experimentation, when the market features free entry:[7]

Proposition 2. *Platform encroachment has no effect on product experimentation if the market features free entry with symmetric sellers.*

This result links to a few widely used horizontal differentiation models such as the Salop model and the Logit demand model adopted by, for instance, Anderson & Bedre-Defolie (2020) and Zennyo (2021). In these models, free entry of third-party sellers pins down the competitive profit to the entry cost, that is, $\pi_l = \pi_f = \pi_l^E = \pi_f^E = F$, where F is the entry cost. Hence, the impact of platform encroachment is neutral, as it affects neither the profit of the leader nor that of the follower in the competition stage. Moreover, the irrelevance result does not depend on whether the platform enjoys an advantage in the product market or how the platform may adjust the commission fees after entry. However, without free entry and for a given number of symmetric sellers, platform encroachment can reduce incentives to experiment.

Proposition 3. *For a given number of symmetric sellers, platform encroachment reduces product experimentation.*

[7] The proofs for Proposition 2 and 3 are straightforward and hence omitted.

The reason is as follows. On one hand, as sellers are symmetric in the competition stage, platform entry does not change the relative benefit of becoming the leader . On the other hand, platform entry tends to intensify competition and reduce the profits for all sellers, in particular, the leader. This reduces the absolute benefit of becoming the leader. Hence, platform encroachment can reduce product experimentation.

3.2 First-mover advantage by the leader

When the successful experimenter enjoys a first-mover advantage in the competition stage, platform encroachment can impact the profits of the leader and the follower differently, which may lead to more product experimentation. We identify two channels through which platform encroachment could generate such positive impacts.

3.2.1 The direct channel

For a given number of sellers, n, platform encroachment could reduce the follower's profit more than the leader's, and hence directly boost the incentives of product experimentation.

Proposition 4. *If* $\pi_l^E(n) - \pi_f^E(n) > \pi_l(n) - \pi_f(n)$*, there exists a* $\bar{r} > 0$ *such that, for any* $\rho > 0$*, platform encroachment boosts product experimentation if* $r < \bar{r}$*.*

Intuitively, when sellers are patient enough or when demand is sufficiently stable (that is, r is small), the value for an experimenting seller is mostly determined by the long-run profits in the competition stage. Hence, the incentives to carry out product experimentation largely depend on the relative benefit, or the value gap between being the leader and being the follower. Under the condition of Proposition 4, platform encroachment enlarges this gap, and hence enhances the incentives. This is more likely to be the case when the platform's product competes more closely with the follower's rather than the leader's. This could also be the case when the platform biases its product recommendation towards its own product, which is more likely to affect the follower than the leader, as the leader has an advantage of being established as a salient choice in the market during the monopolization stage. The following example illustrates this direct channel.

Example 1: *Suppose there are* n *sellers, including the two experimenters and other sellers, each producing a different variety. Following Shubik & Levitan (1980), we assume* *the utility function of a representative consumer is:*

$$U = \sum_{i=1}^{n} q_i - \frac{1}{2(1+\sigma)}[2\sigma \sum_i \sum_{j>i} q_i q_j + \sum_i (\sigma + \frac{1}{w_i}) q_i^2],$$

where q_i is the consumption of product sold by seller i, σ is the degree of product differentiation, and w_i is the strength of seller i with $\sum_{i=1}^{n} w_i = 1$. The strength can be interpreted as the market share of seller i when all sellers charge the same price. This generates a demand for product i in the competition stage, given by:

$$q_i = w_i[(1+\sigma(1-w_i))(1-p_i) - \sigma \sum_{j \neq i} w_j(1-p_j)].$$

To capture the first-mover advantage, we assume that the leader has a strength of $w_l = \alpha > 1/n$, and each of the other sellers has a strength of $w_f = (1-\alpha)/(n-1)$. When the platform enters, it changes the product strengths of sellers already in the market. Specifically, let w_d denote the strength of the platform, we assume that:

$$\begin{aligned} w_l^E &= \alpha(1-\beta), \\ w_f^E &= \tfrac{(1-\alpha)(1-\gamma)}{n-1}, \\ w_d &= \beta\alpha + \gamma(1-\alpha). \end{aligned}$$

This can be interpreted as follows: platform entry does not expand the market but results in a redistribution of market shares, for example, via biased recommendations. A higher β means that the platform captures a larger part of the leader's market share, and a higher γ means that it captures a larger part of the followers' market shares. When $\beta = 0$ and $\gamma > 0$, the platform competes closely with the followers but does not reduce the strength of the leader. For simplicity, we assume zero production costs for all sellers and the platform, and the platform charges an ad valorem commission fee, denoted by s. Sellers and the platform compete by choosing their prices.

In this case, platform encroachment would hurt the follower more than the leader and enhance product experimentation when β is small and γ is large, as shown in Figure 2.

3.2.2 The indirect channel

Platform encroachment could also change the number of sellers, when the competition stage is characterized with free entry at a cost F. In this case, without any advantage over other imitators, the follower obtains a profit equal to the entry cost F, and the

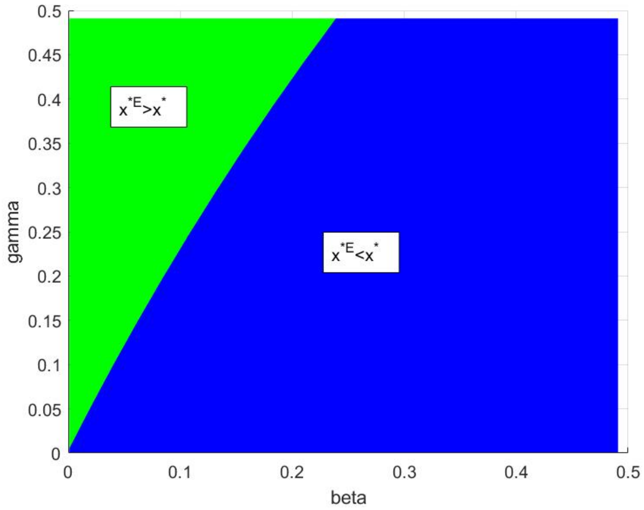


Figure 2: Comparison of equilibrium experimentation rates ($\alpha = 0.2, \sigma = 2, r = 0.01, \rho = 2, n = 10, s = 15\%$)

number of sellers in the competition stage, denoted by $\mathbb{N}$, satisfies:

$$\mathbb{N} = \pi_f^{-1}(F)$$

without platform encroachment, and:

$$\mathbb{N}^E = \pi_f^{E^{-1}}(F)$$

with platform encroachment. Naturally, as platform encroachment intensifies competition and reduces seller profits, we have $\mathbb{N}^E < \mathbb{N}$. Therefore, platform encroachment could indirectly boost the incentives of product experimentation by reducing the number of sellers and relaxing the competitive pressure faced by the leader. Then, Proposition 4 becomes:

Proposition 5. *If $\pi_l^E(\mathbb{N}^E) > \pi_l(\mathbb{N})$, there exists a $\bar{r} > 0$ such that, for any $\rho > 0$, platform encroachment increases seller experimentation if $r < \bar{r}$.*

In most commonly used models, we have $\pi_l(n) - \pi_f(n)$ decreasing with the number of sellers n. Thus, if the condition in Proposition 4 is satisfied, we have:

$$\begin{aligned}
& \pi_l^E(\mathbb{N}^E) - \pi_f^E(\mathbb{N}^E) > \pi_l(\mathbb{N}^E) - \pi_f(\mathbb{N}^E) \\
\Rightarrow \quad & \pi_l^E(\mathbb{N}^E) - \pi_f^E(\mathbb{N}^E) > \pi_l(\mathbb{N}) - \pi_f(\mathbb{N}) \\
\Rightarrow \quad & \pi_l^E(\mathbb{N}^E) > \pi_l(\mathbb{N}).
\end{aligned}$$

The second line follows because $\pi_l - \pi_f$ decreases with the number of sellers and we have $\mathbb{N}^E < \mathbb{N}$, and the third line follows because $\pi_f^E(\mathbb{N}^E) = \pi_f(\mathbb{N}) = F$. Hence, the condition in Proposition 5 is less stringent than that in Proposition 4, and platform encroachment is more likely to enhance product experimentation when we take into account how platform entry may hinder entry by other independent sellers in the competition stage. Moreover, this means that platform encroachment could enhance product experimentation even if the condition in Proposition 4 fails, as demonstrated by the following example.

Example 2: *Consider the following demand system for the competition stage:*

$$q_i = \frac{1}{n(1-\sigma)}[(a_i - p_i) - \sigma(\overline{\boldsymbol{a}-\boldsymbol{p}})], \text{ for } i \in \{1, 2, ..., n\},$$

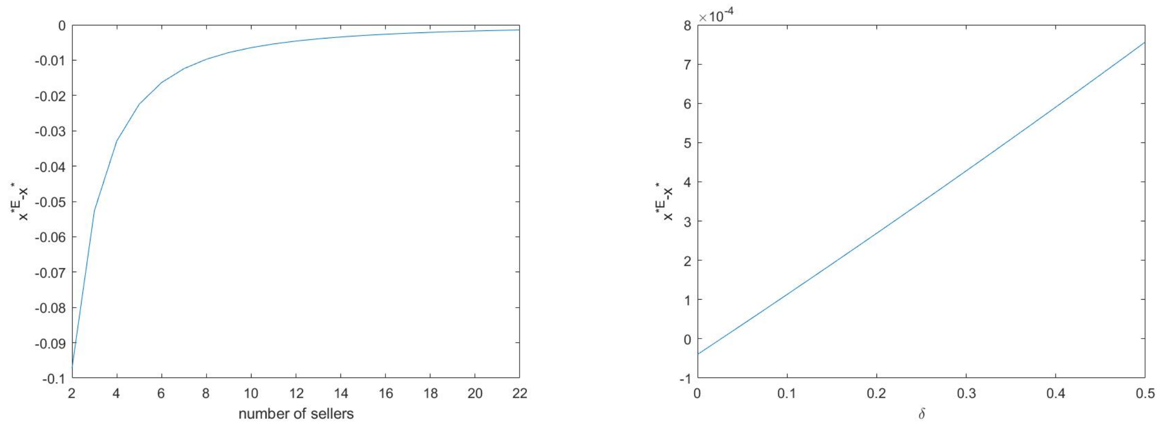
where $\overline{\boldsymbol{a}-\boldsymbol{p}} = \frac{1}{n}\sum_i (a_i - p_i)$. *The intercepts* a_i *can be interpreted as the quality of each seller* i. *To capture asymmetry among sellers, we assume that the leader has a perceived quality of* $a_l = 1 + \Delta$, *the follower has* $a_f = 1$, *and the platform has* $a_d = 1 + \delta$, *with* $\delta \in [0, \Delta]$. *That is,* Δ *can be interpreted as the first mover advantage enjoyed by the leader, and the platform may be perceived to be of a higher quality than the follower. The degree of substitution is denoted by* σ. *For simplicity, we consider* $\Delta = 1$ *and* $\sigma = 1/2$. *As above, we assume zero production costs for all sellers and the platform, the platform charges an ad valorem commission fee* s, *and sellers compete in prices. Different from Example 1, platform entry could expand the market in this case.*

For a given number of sellers, we always have $\pi_l^E - \pi_f^E < \pi_l - \pi_f$, *and hence platform encroachment reduces product experimentation. This is shown in Figure 3a for the case of* $\delta = 0.5$. *However, when we take into account the impact platform entry has on the number of active sellers, platform encroachment can instead enhance product experimentation, as shown in Figure 3b (ignoring the integer constraint on the number of sellers). This is more likely to be the case when the platform has a larger advantage over the followers, as the impact on the number of active sellers is larger.*

3.2.3 The role of information diffusion

Having shown that platform encroachment can enhance product experimentation, we now show that this positive impact is stronger with a higher rate of information diffusion.

Proposition 6. *Under conditions in Proposition 4 or 5,* $\partial(x^{*E} - x^*)/\partial\rho > 0$ *when* r *is sufficiently small.*



(a) For a given n ($\delta = 0.5$) (b) Endogenous n ($F = 0.01$)

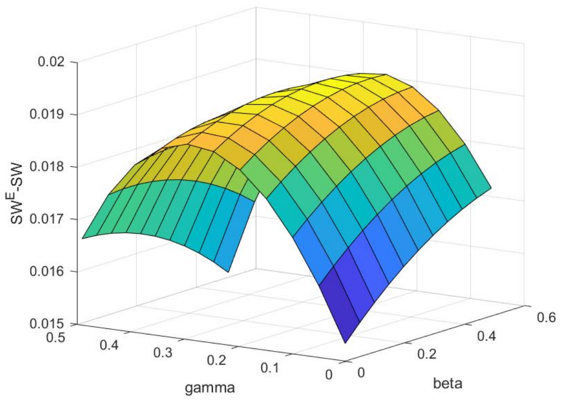
Figure 3: The impact of platform encroachment on experimentation rates ($r = 0.01, \rho = 2, s = 15\%, \Delta = 1, \sigma = 1/2$)

When information diffuses fast, the learning stage is relatively short compared to the competition stage. Thus, the value difference between the leader and the follower weighs more for the incentives of experimentation, and such difference is greater with platform entry. In other words, the free-riding problem is particularly severe under fast information diffusion, and by alleviating such a problem, platform entry can be effective in encouraging more product experimentation. This is more likely to be the case, for instance, with the development of third-party sales monitoring tools, which allows non-experimenting sellers to analyze and respond quickly to market developments.

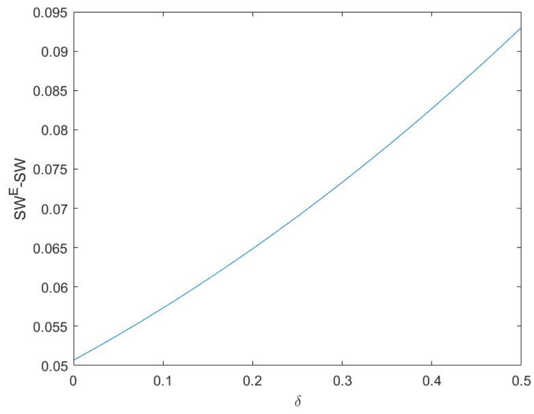
3.2.4 Welfare implications

We briefly discuss the welfare implications of platform encroachment. Platform encroachment affects welfare in two ways. Firstly, it influences the welfare in the competition stage, which can often be positive. In the case with a given number of sellers as in *Example 1*, platform encroachment enriches product variety and intensifies competition and hence increases welfare. In the case with an endogenous number of sellers as in *Example 2*, although platform encroachment may drive out some imitating sellers, it brings a higher quality product than the imitators, which could also increase welfare. Secondly, it influences the incentives to carry out product experimentation. As we have shown, this can be positive in some cases, which contributes to further welfare improvements. Indeed, in the two examples above, platform encroachment always increases welfare, as shown in

Figure 4.



(a) Welfare comparison for Example 1 ($\alpha = 0.2, \sigma = 2, n = 10$)



(b) Welfare comparison for Example 2 ($F = 0.01, \Delta = 1, \sigma = 1/2$)

Figure 4: The welfare impact of platform encroachment ($r = 0.01, \rho = 2, s = 15\%$)

4 Product selection by the platform

The framework can be extended to study the optimal product selection by the platform when it decides to enter the product market. We consider the case with a given number of sellers, and assume the platform can choose the quality of its product, denoted by δ, at $t = 0$. This reflects the observation that product selection is a long-term strategy chosen by the platform, which cannot be easily adjusted as information about successful experimentation arrives. Let $\pi_d(\delta)$ denote the flow profit of the platform in the competition stage, and the total expected value obtained by the platform at $t = 0$ can be shown to be:

$$V_d = \frac{2x^{*E}(\delta)}{r + 2x^{*E}(\delta)} \frac{\rho \frac{\pi_d(\delta)}{r}}{r + \rho}.$$

By choosing a more premium product for its brand, that is, a higher δ, the platform changes its total value in two ways. Firstly, this could increase its profit in the competition stage, $\pi_d(\delta)$. Secondly, this reduces the rate of experimentation by competing more closely with the leader with a more premium product. We can show that:

Proposition 7. *The optimal product selection δ^* is decreasing with the rate of information diffusion, ρ.*

The intuition is that although the rate of experimentation is lower when information diffuses faster, it is more responsive to platform entry as shown in Proposition 6. Hence, the platform finds it profitable to enter with a less premium product to further boost the experimentation incentives. This relates our analysis to the literature on private labels. This literature studies whether and how brick-and-mortar stores should introduce private labels, and how this would impact the strategies of national brands. In platform markets, two features stand out. Firstly, information about successful products become abundant and readily available; secondly, not only the dominant retailer, that is, the platform, can learn about popular products and introduce private labels, but also other independent sellers can learn and introduce their own competing products. We show that under such circumstances, it is beneficial for the platform to introduce private labels, especially less premium ones, when information diffuses at a faster rate.

5 Platform encroachment with informational advantage

Now we extend the analysis to the case when the platform has access to information that is not available to other sellers and hence has an informational advantage. This means that the platform can learn faster about successful experimentation and enter the market before other sellers do. Specifically, let μ be the Poisson rate at which the platform learns about successful experimentation before other sellers, and let $\pi_l^D (< \pi_m)$ be the flow profit of the leader when the platform enters before other sellers.

We first derive the value function of the leader, $\tilde{V}_l^D$, when the platform enters but not the other sellers. This satisfies:

$$r\tilde{V}_l^D = \pi_l^D + \rho(\Pi_l^E - \tilde{V}_l^D).$$

Hence, we have:

$$\tilde{V}_l^D = \frac{\pi_l^D + \rho\Pi_l^E}{r + \rho}.$$

The value function of the leader before the platform learns about the success and enters, denoted by $\tilde{V}_l^E$, then satisfies:

$$r\tilde{V}_l^E = \pi_m + \mu(\tilde{V}_l^D - \tilde{V}_l^E) + \rho(\Pi_l^E - \tilde{V}_l^E),$$

which gives us:

$$\tilde{V}_l^E = \frac{\pi_m + \mu \tilde{V}_l^D + \rho \Pi_l^E}{r + \mu + \rho}.$$

At the experimentation stage, each seller $i = 1, 2$ chooses its experimentation rate by solving:

$$r\tilde{V}_0^E = \max_{x_i} -\frac{x_i^2}{2} + x_i(\tilde{V}_l^E - \tilde{V}_0^E) + x_j(\tilde{V}_f^E - \tilde{V}_0^E),$$

where

$$\tilde{V}_f^E = \frac{\rho \Pi_f^E}{r + \rho}(= V_f^E).$$

This yields the equilibrium experimentation rate:

$$\tilde{x}^{*E} = \frac{\tilde{V}_l^E - \tilde{V}_f^E - r + \sqrt{(\tilde{V}_l^E - \tilde{V}_f^E - r)^2 + 6r\tilde{V}_l^E}}{3}.$$

Clearly, compared to no informational advantage, the equilibrium experimentation rate is lower when the platform holds an informational advantage, as we have:

$$\frac{\partial \tilde{V}_l^E}{\partial \mu} = \frac{\pi_l^D - \pi_m}{(r + \mu + \rho)^2} < 0.$$

However, compared to no platform entry, sellers would still experiment more if the informational advantage is not too large. To see this, consider $r \to 0$, so the experimentation incentives are mainly determined by $\tilde{V}_l^E - \tilde{V}_f^E$, given by:

$$\begin{aligned} \tilde{V}_l^E - \tilde{V}_f^E &= \tfrac{\pi_m + \mu \tilde{V}_l^D + \rho \Pi_l^E}{r+\mu+\rho} - \tfrac{\rho \Pi_f^E}{r+\rho} \\ &= \tfrac{\pi_m}{r+\rho} + \tfrac{\mu(\pi_l^D - \pi_m)}{(r+\rho)(r+\mu+\rho)} + \tfrac{\rho}{r+\rho}(\Pi_l^E - \Pi_f^E). \end{aligned}$$

Without platform entry, we have:

$$V_l - V_f = \frac{\pi_m}{r + \rho} + \frac{\rho}{r + \rho}(\Pi_l - \Pi_f).$$

Hence, under the conditions of Proposition 4 and 5, platform entry has two opposing effects: On one hand, it increases the profit difference $\Pi_l^E - \Pi_f^E$, which enhances experimentation incentives; On the other hand, it shortens the monopolization period of the leader, which reduces experimentation incentives, as $\pi_l^D - \pi_m < 0$. The second effect is small when the informational advantage is small, in which case platform entry could still increase experimentation rates.

6 Market structure and seller composition

In this section, we extend the analysis to consider more experimenters and provide further insights on how platform encroachment could change the composition of sellers.

6.1 More than two experimenters

We first generalize the analysis to $N > 2$ sellers who engage in product experimentation, when the platform does not have an informational advantage. We denote the value of the successful experimenter by Π_l^N and that of all followers by Π_f^N in the competition stage.

The main difference lies in the experimentation stage. Each seller $i = 1, 2, ..., N$ solves the following problem:

$$rV_0^N = \max_{x_i} -\frac{x_i^2}{2} + x_i(V_l^N - V_0^N) + \sum_{j \neq i} x_j(V_f^N - V_0^N),$$

where $V_l^N = \frac{\pi_m + \rho \Pi_l^N}{r+\rho}$ and $V_f^N = \frac{\rho \Pi_f^N}{r+\rho}$.

Following similar steps as Lemma 1, the equilibrium experimentation rates are such that $x_i^* = x_N^*$ for $i = 1, 2, ..., N$, given by:

$$x_N^* = \frac{(N-1)(V_l^N - V_f^N) - r + \sqrt{((N-1)(V_l^N - V_f^N) - r)^2 + 2r(1 + 2(N-1))V_l^N}}{1 + 2(N-1)}.$$

Similar to our main analysis, when r is small, the experimentation incentives are driven by the value difference $V_l^N - V_f^N$, which is larger when the platform competes more closely with the followers or when the platform's entry drives out more imitators. In such cases, when sellers are patient enough, platform encroachment increases product experimentation.

6.2 Endogenous experimenter

We can further extend the analysis to study the incentives to become an experimenter. Specifically, we assume that sellers need to incur a setup cost in order to become active in the market, either as an experimenter or as an imitator. To capture seller heterogeneity, we rank all sellers according to this setup cost and we identify each seller by its rank. That is, for each seller $j \in [0, \infty)$, its setup cost is $c(j)$, which is increasing in j with $c(0) = 0$ and $c(\infty) \to \infty$. In addition, if a seller decides to carry out product experimentation, it needs to incur another setup cost for experimentation, denoted by $c^e(j)$, which is also increasing in j with $c^e(0) = 0$ and $c^e(\infty) \to \infty$. All sellers have the same marginal cost of experimentation as in the main model, if they decide to carry out product experimentation.

If a seller decides to become an experimenter, it generates a value of V_0^N, when there are N experimenters. Alternatively, if a seller acts as a pure imitator, it does not carry out product experimentation but enters the market to compete and obtains the same value as a follower whenever successful experimentation and learning occur. This option has an expected value of:

$$V_I^N = \frac{Nx_N^*}{r + Nx_N^*} V_f^N.$$

The incentive to become an experimenter then depends on the difference $V_0^N - V_I^N$. When $r \to 0$, this approaches:

$$\frac{V_l^N - V_f^N}{1 + 2(N-1)},$$

which is larger whenever platform entry increases the value gap between the leader and the follower.

Therefore, for a given platform policy, the market structure is endogenously determined by two thresholds: N^e and N^i, satisfying:

$$V_0^{N^e} - V_I^{N^e} = c^e(N^e), \text{ and } V_I^{N^i} = c(N^i).$$

When the setup cost for experimentation is significantly higher than the setup cost for being active, the market features a mixture of experimenters and imitators with $N^e < N^i$: all sellers ($j \le N^i$) with a setup cost below the value of being an imitator will become active in the market, and those sellers ($0 \le j \le N^e$) with the lowest setup costs for experimentation will carry out product experimentation.

Our analysis implies that when the platform enters, it intensifies competition and reduces V_I^N, which means that fewer sellers become active in the market. However, it also increases the value difference $V_0^N - V_I^N$, which means that there are more experimenters. Thus, platform entry changes the composition of sellers by attracting more experimenters but fewer imitators.

7 Concluding remarks

We have considered a dynamic model of product experimentation on a platform when the platform may enter to compete with third party sellers. We show that platform encroachment could enhance sellers' incentives to experiment with new products by reducing the value of imitation and mitigating the free-riding problem. Furthermore, this changes the composition of sellers by bringing more experimenting sellers but fewer imitators. Such a benefit is larger when information about successful experimentation diffuses faster on the platform, in which case the platform may optimally enter with a less premium product to further curb free-riding and promote product experimentation.

We draw several policy recommendations in platform markets. Our results demonstrate the importance of considering market dynamics and indicate that it is equally important to consider *how* platforms enter and compete with third party sellers in addition to *whether* platforms should be allowed to enter with their own products whilst hosting third party sellers. For example, by considering imitation from both the platform and third party sellers, platform entry could yield the benefits of alleviating the free-riding problem and encouraging new product development, especially when the platform enters and competes closely against the imitators. This is more important when information becomes easier to access and imitation becomes more prevalent. However, such a benefit needs to be balanced against the risk of the platform taking advantage of its information gathering capability, which may stifle the incentives of product experimentation. Hence, an outright ban of platform encroachment is likely to be a sub-optimal approach to regulating platforms, but more considerations on the mode of competition and the extent of information usage could be useful.

Our work can be extended in a few directions for future research. Firstly, we have focused on sellers' incentives to carry out product experimentation, it would be interesting to investigate how these incentives interact with other features of the platform, such as the search environment and recommendation algorithms. Secondly, the contract between the platform and a seller often includes other terms and conditions in addition to the commission fee, and it would be valuable to study the optimal contract when taking into account the experimentation incentives.

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Appendices

A Derivation of the value function of the leader

Consider a small time interval Δt, we have:

$$V_l = \Delta t \cdot \pi_m + e^{-r\Delta t}(1 - e^{-\rho\Delta t})\Pi_l + e^{-r\Delta t}e^{-\rho\Delta t}V_l.$$

That is, during the time interval Δt, the leader accrues the flow profit of $\Delta t \cdot \pi_m$. With probability $1 - e^{-\rho\Delta t}$, learning occurs and the leader's value jumps to the long-run competitive profit $\Pi_l = \pi_l/r$. With probability $e^{-\rho\Delta t}$, learning does not occur and the leader's value remains at V_l.

We can rewrite the above equation as:

$$(1 - e^{-r\Delta t})V_l = \Delta t \cdot \pi_m + e^{-r\Delta t}(1 - e^{-\rho\Delta t})\Pi_l - e^{-r\Delta t}(1 - e^{-\rho\Delta t})V_l.$$

Dividing both sides by Δt yields:

$$\frac{1 - e^{-r\Delta t}}{\Delta t}V_l = \pi_m + e^{-r\Delta t}\frac{1 - e^{-\rho\Delta t}}{\Delta t}\Pi_l - e^{-r\Delta t}\frac{1 - e^{-\rho\Delta t}}{\Delta t}V_l.$$

Taking the limit as $\Delta t \to 0$, we obtain:

$$rV_l = \pi_m + \rho(\Pi_l - V_l),$$

and hence we have:

$$V_l = \frac{\pi_m + \rho\Pi_l}{r + \rho}.$$

B Proof of Lemma 1

Substituting $x_1 = x_2 = x^*$ and $V_0 = V_l - x^*$ into Equation (1), we obtain:

$$r(V_l - x^*) = (x^*)^2/2 + x^*(V_f - V_l + x^*).$$

Solving for x^*, we obtain:

$$x^* = \frac{V_l - V_f - r + \sqrt{(V_l - V_f - r)^2 + 6rV_l}}{3}.$$

C Proof of Proposition 1

We have:

$$\frac{dV_l}{d\rho} = \frac{\Pi_l(r+\rho) - \pi_m - \rho\Pi_l}{(r+\rho)^2} = \frac{\pi_l - \pi_m}{(r+\rho)^2} < 0,$$

and:

$$\frac{dV_l - V_f}{d\rho} = \frac{(\Pi_l - \Pi_f)(r+\rho) - \pi_m - \rho(\Pi_l - \Pi_f)}{(r+\rho)^2} = \frac{\pi_l - \pi_f - \pi_m}{(r+\rho)^2} < 0.$$

Since x^* is increasing in both V_l and $V_l - V_f$, we must have x^* decreasing with ρ.

D Proof of Proposition 4

For simplicity of exposition, we omit the dependence of profits on the number of sellers in this proof. Given that $\pi_l^E - \pi_f^E > \pi_l - \pi_f$, we must have $V_l^E - V_f^E > V_l - V_f$. Hence, a sufficient condition for $x^{*E} > x^*$ is:

$$(V_l^E - V_f^E - r)^2 + 6rV_l^E > (V_l - V_f - r)^2 + 6rV_l.$$

For any $\rho > 0$, this is equivalent to:

$$[(\pi_l^E - \pi_f^E) - (\pi_l - \pi_f)] \cdot [\frac{2r\pi_m + \rho(\pi_l^E - \pi_f^E + \pi_l - \pi_f)}{r^2(r+\rho)} - 2] > 6(\pi_l - \pi_l^E).$$

Note that the first square bracket on the left hand side is positive, and the second square bracket on the left hand side is decreasing in ρ. Hence, when ρ approaches infinity, the left hand side is decreasing in ρ and it approaches:

$$[(\pi_l^E - \pi_f^E) - (\pi_l - \pi_f)] \cdot [\frac{\pi_l^E - \pi_f^E + \pi_l - \pi_f}{r^2} - 2].$$

Clearly, this approaches infinity when r approaches zero. Hence, there exists a $\bar{r} > 0$, such that the above inequality is satisfied for all $\rho > 0$ when $r < \bar{r}$.

E Proof of Proposition 6

We have:

$$x^{*E} - x^* = \frac{1}{3}\Big[\frac{\rho(\pi_l^E - \pi_f^E - (\pi_l - \pi_f))}{r(r+\rho)} + \sqrt{(\frac{r\pi_m + \rho(\pi_l^E - \pi_f^E)}{r(r+\rho)} - r)^2 + 6\frac{r\pi_m + \rho\pi_l^E}{r+\rho}} - \sqrt{(\frac{r\pi_m + \rho(\pi_l - \pi_f)}{r(r+\rho)} - r)^2 + 6\frac{r\pi_m + \rho\pi_l}{r+\rho}}\Big].$$

Hence

$$\frac{\partial x^{*E}-x^*}{\partial \rho} = \frac{1}{3}\Big[\quad \frac{\pi_l^E-\pi_f^E-(\pi_l-\pi_f)}{(r+\rho)^2} + \frac{1}{2}\frac{2(\frac{r\pi_m+\rho(\pi_l^E-\pi_f^E)}{r(r+\rho)}-r)\frac{\pi_l^E-\pi_f^E-\pi_m}{(r+\rho)^2}+\frac{6r(\pi_l^E-\pi_m)}{(r+\rho)^2}}{\sqrt{(\frac{r\pi_m+\rho(\pi_l^E-\pi_f^E)}{r(r+\rho)}-r)^2+6\frac{r\pi_m+\rho\pi_l^E}{r+\rho}}} - \frac{1}{2}\frac{2(\frac{r\pi_m+\rho(\pi_l-\pi_f)}{r(r+\rho)}-r)\frac{\pi_l-\pi_f-\pi_m}{(r+\rho)^2}+\frac{6r(\pi_l-\pi_m)}{(r+\rho)^2}}{\sqrt{(\frac{r\pi_m+\rho(\pi_l-\pi_f)}{r(r+\rho)}-r)^2+6\frac{r\pi_m+\rho\pi_l}{r+\rho}}}\Big].$$

When r approaches zero, the right hand side approaches:

$$\frac{2}{3\rho^2}[\pi_l^E - \pi_f^E - (\pi_l - \pi_f)],$$

which is positive.

F Proof of Proposition 7

To save notation, we omit all the superscript E and the dependence of x^{*E} and π_d on δ in this proof. If the optimal product selection is interior, it satisfies:

$$\frac{r}{x^*(r+2x^*)}\frac{\partial x^*}{\partial \delta} + \frac{d\pi_d/d\delta}{\pi_d} = 0.$$

The second term is independent from ρ. For the first term, if ρ increases, x^* decreases according to Proposition 1, so $\frac{r}{x^*(r+2x^*)}$ increases in ρ.

Moreover, $\partial x^*/\partial\delta$, which is negative, decreases in ρ. To see this, we have:

$$\frac{\partial x^*}{\partial \delta} = \frac{1}{3}\Big[\frac{\rho}{r(r+\rho)}\frac{\partial(\pi_l-\pi_f)}{\partial\delta}(1+\frac{V_l-V_f-r}{\sqrt{(V_l-V_f-r)^2+6rV_l}}) + \frac{3\frac{\rho}{r+\rho}\frac{\partial\pi_l}{\partial\delta}}{\sqrt{(V_l-V_f-r)^2+6rV_l}}\Big].$$

The last term in the square bracket is decreasing in ρ. This is because $\partial\pi_l/\partial\delta < 0$, $\frac{\rho}{r+\rho}$ is increasing in ρ and both $V_l - V_f$ and V_l are decreasing in ρ (see proof of Proposition 1), so the last term in decreasing in ρ.

Differentiating the first two terms with respect to ρ yields:

$$\frac{1}{(r+\rho)^2}\frac{\partial(\pi_l-\pi_f)}{\partial\delta}\Big[1+\frac{V_l-V_f-r}{\sqrt{(V_l-V_f-r)^2+6rV_l}}+\frac{\rho}{r+\rho}\frac{(\pi_l-\pi_f-\pi_m)\cdot 6V_l-(\pi_l-\pi_m)\cdot 3(V_l-V_f-r)}{((V_l-V_f-r)^2+6rV_l)^{3/2}}\Big].$$

Note that $\partial(\pi_l-\pi_f)/\partial\delta < 0$. The second term in the square bracket approaches 1 and the third term approaches 0 when r approaches zero. Hence, the differentiation is negative when r is small.

Altogether, we have $\frac{r}{x^*(r+2x^*)}\frac{\partial x^*}{\partial\delta}$ decreasing in ρ when r is small. Hence, the optimal product selection δ is smaller when ρ is higher.