Competition Through Recommendations

Robin Ng*

17 October 2025

latest version here

Abstract

This paper examines how a two-sided platform designs its recommender system to be informative about value-for-money and how competition affects this design. More informative recommendations generate ranking and screening effects: they steer demand toward high value-for-money products, intensifying price competition between firms, which drives out lower quality firms. Hence, more informative recommendations benefit consumers but reduce per-transaction revenue. A monopolist platform still prefers informative recommendations due to demand expansion. Competing platforms choose even more informative recommendations than a monopolist. Moreover, if entrant platforms cannot design informative systems, incumbents may strategically reduce informativeness. This illustrates how market power can explain *ensh*ttification*.

JEL: D21, L10, L86

Keywords: Digital economy, Recommender systems, Two-sided platforms

*Department of Economics and MaCCI, University of Mannheim; robin@robinng.com

This project has especially benefited from early discussions with Paul Belleflamme, Francis Bloch and Bernard Caillaud. Additionally, I thank Philipp Brunner, Christoph Carnehl, Ben Casner, Johannes Johnen, Muxin Li, Martin Peitz, Andrew Rhodes, Nicolas Schutz, Anton Sobolev, André Stenzel, Roland Strausz, Greg Taylor, Tat-How Teh and participants of the COREBB seminar, CRC TR 224 Retreat, MaCCI IO Day, Lisbon Meeting, MaCCI Summer Institute, Bern Micro Theory Seminar, Toulouse IO Seminar, MaCCI/EPoS Workshop on Digital Markets, MaCCI Annual Conference, Berlin Micro Theory Seminar, Econometric Society World Congress, Nanyang Technological University, ESMT, University of Copenhagen, INFORMS Annual meeting for their many helpful comments.

I am also grateful for the support from the Fédération Wallonie-Bruxelles (FWB) Action de recherche concertée grant 19/24-101, the Belgian National Fund for Scientific Research (FNRS) Aspirant research fellowship (FC46885), the Deutsche Forschungsgemeinschaft (DFG) through CRC TR 224 (Project B05).

1 Introduction

A key feature of modern online platforms (e.g., search engines, e-commerce websites, social media) is their ability to provide relevant suggestions to users navigating an overwhelming volume of information. Early recommender systems employed simple rules, relying on consumer ratings to recommend products to others. Today, platforms rely on complex (and often opaque) algorithms, coupled with granular data on user behavior, to design recommender systems. Growing consumer reliance on recommender systems and the rise of opaque data-driven algorithms have elevated concerns about their design. In response, regulators have introduced measures to protect consumers and promote competition on and between platforms.[1]

This paper explores how two-sided platforms optimally design their recommender systems, focusing on how competitive pressures between platforms shape the precision of their recommendations. I consider a two-sided platform that recommends products to consumers based on value-for-money. Firms produce products with different qualities and face no marginal costs. Firms may choose to enter the platform at no cost, setting prices and paying the platform an ad-valorem fee. Consumers face some inertia when joining a platform.[2] Upon joining the platform, consumers observe product recommendations and purchase a product, which they may return for free if the product provides negative utility.

On the platform, firms with higher value-for-money are displayed more prominently, and consumers are more likely to engage with them. The platform may augment its recommender system to be more (or less) informative about value-for-money. A more informative recommender system means consumers are more likely to engage with firms providing a higher value-for-money.

A more informative recommender system causes firms with higher value-for-money to obtain substantially more demand—a ranking effect. This causes firms to compete more fiercely in prices to be ranked better. Intensified price competition leads lower quality firms to become unprofitable and exit the market—a screening effect.

Although screening retains only higher quality firms on the platform, ranking causes prices to fall significantly. As a result, a more informative recommender system leads a platform charging ad-valorem fees to earn less per-transaction revenue. However, both ranking and screening work to improve consumer surplus. Ranking results in cheaper products, both ranking and screening increase the likelihood that consumers engage with higher quality products. Hence, more informative recommender systems enable a platform to attract more consumers, a demand expansion.

Using this demand expansion–per-transaction revenue trade-off, I show that a monopolist platform augments its recommender system to be more informative about value-for-money. This improves consumption utility, attracting more consumers to the platform. Lowest quality firms exit the market because of the screening effect. Of firms remaining on the platform, all firms face a negative price effect due to fiercer price competition, and lower quality firms face a negative demand effect as consumers are directed towards firms with higher value-for-money.

[1]The Competition and Markets Authority, Cyberspace Administration of China, European Commission, and Federal Trade Commission are examples of such regulators.

[2]This may be a result of lack of willingness to join the platform for example, because they simply prefer not to shop online, have privacy concerns or resistance to big corporations.

Only the highest quality firms experience a positive demand effect that dominates the price effect, allowing them to obtain higher profits.

Many platforms use complex algorithms when implementing their recommender systems, raising concerns that recommendations may not be well justified. To understand concerns about recommender system opacity, I consider a model of naive consumers failing to take into account how firms update prices following the implementation of an informative recommender system. Instead, these consumers believe recommender systems only reflect value-for-money. Here, platforms prefer less informative recommender systems, but also make lower profits than they would if consumers were not naive. Hence, it is in the platform's interest to be voluntarily transparent, and educate consumers, about its recommender system. This suggests that platforms and regulators may have aligned interests in transparency and consumer education.[3]

In the monopoly setting, I also show how costly production inherently leads firms to set higher prices. This enables a platform taking ad-valorem fees to improve its recommender system, thereby favoring consumers. I show that the above results are robust to (i) restricting free returns; (ii) allowing the platform to design recommender systems less informative than value-for-money; and (iii) a more general class of recommender systems.

When a new platform enters the market and consumers single-home, a unique symmetric equilibrium arises in which both platforms choose more informative recommender systems than a monopolist would. More informative recommender systems improve consumer surplus, which makes the platforms more appealing to consumers. As a result, consumers on the incumbent platform benefit in both the intra- and infra-marginal sense. Existing consumers gain more surplus in expectation and new consumers are attracted to the platform. Additionally, some consumers with high inertia of joining the incumbent—who would have been inactive in the monopoly setting—may now become active on the entrant. This finding also highlights how competition between platforms can lead to downstream competition between firms within a platform.

However, the algorithms used to design these recommender systems require substantial data about products and consumer behavior. Hence, it is less feasible for an entrant to create recommender systems that are as informative as the incumbent. To understand these implications of platform entry, I first consider the extreme environment where the entrant is unable to use recommender systems. Here, the incumbent instead prefers recommender systems that are less informative of value-for-money than a monopolist would. This is because the screening effect leads relatively lower quality firms on the incumbent platform to migrate to the entrant. However, on the entrant platform, such firms are relatively higher quality, which increases the expected surplus consumers receive there. Hence, by lowering the informativeness of its recommender system, the incumbent lowers the level of screening, reducing competition for consumers from the entrant.

I also show that, as the entrant adopts more informative recommender systems, the incumbent responds by improving its recommender system, benefiting consumers. In this sense, better data access could level the playing field between platforms and serve to improve consumer

[3]For example, the European Union's (EU) Digital Services Act (DSA) requires platforms to be transparent about the factors taken into account by their recommender system.

surplus, lending support for data sharing obligations mandated in the European Union's (EU) Digital Markets Act (DMA).

Additionally, I study two environments of asymmetric competition between platforms. First, I allow consumers to have asymmetric inertia. If consumers face a higher inertia of joining the entrant, the entrant selects more informative recommender systems than the incumbent. Second, if platforms compete sequentially, competition causes the incumbent to improve its recommender system, but consumers are still worse off than when platforms compete simultaneously.

I also evaluate the role of multi-homing. When considering costly firm entry onto platforms, I show only the highest quality firms multi-home, and costly firm entry can raise the expected utility consumers receive from the incumbent compared to costless entry. I allow consumers to multi-home by searching across platforms. This leads to a symmetric equilibrium in which platforms focus on raising per-transaction revenues by worsening recommender systems.

Taken together, this paper shows how the competitive environment affects the decision to design informative recommender systems. The results closely resemble changes to recommender systems on platforms such as Amazon: A new platform with naive consumers prefers a recommender system that purely reflects value-for-money. As consumers learn how the platform's recommender system works, becoming less naive, the platform is incentivized to design more informative recommender systems. Competition further induces informative recommender systems. However, when a monopoly is established, recommender systems deteriorate. This offers an explanation for platform degradation, colloquially referred to as *ensh*ttification*.[4]

The rest of the paper is structured as follows: Section 2 describes and analyzes a monopolist platform, with extensions discussed in Section 3. Section 4 introduces competition to the model, and Section 5 shows extensions to this setting. Finally, Section 6 reviews the literature and Section 7 concludes. Proofs can be found in Appendix A and details of some extensions are left to Appendix B.

2 Monopoly

To guide exposition and highlight the trade-offs faced by platforms in isolation, I first consider a monopolist setting. Consider an environment with the following agents: consumers, firms, and a monopolist incumbent platform.

Consumers. There exists a unit mass of consumers each demanding a single unit of product. Consumers have homogeneous preference for products, but face heterogeneous inertia when joining the platform. This inertia is independently and identically drawn from a uniform distribution with support, $c_i \sim U[0,1]$.[5] Consumers choose to join the platform if their expected utility from doing so overcomes this inertia. Upon joining the platform, consumers receive product recommendations and select a particular product to purchase. Consumption utility is the difference between the product's quality and its price, $u(\alpha_j, p_j) = \alpha_j - p_j$, where α_j is the product quality of some firm j and p_j its price.[6] Let n represent the mass of consumers joining

[4]The term *ensh*ttification* was popularized in 2022 by Cory Doctorow to describe the growing difficulties one faces when searching for products on Amazon. The term was named 'word of the year' by the American Dialect Society (2023) and Macquarie Dictionary (2024).

[5]I relax this assumption in Appendix B, allowing for more general distributions of c_i.

[6]Consumer inertia does not feature in their consumption utility as consumption occurs after they have joined the platform. In other words, one can think of inertia as similar to a sunk cost.

the platform.

Firms. There exists a unit mass of single-product firms. Firms sell homogeneous products, with heterogeneous quality independently and identically drawn from a continuous uniform distribution, $\alpha_j \sim U[0,1]$ is the private quality information drawn by firm j. Firms may only sell through the platform. In other words, there is no direct channel of sales. Firms face zero marginal cost of production and no entry costs. However, they pay a commission fee, $r \in (0,1)$, on revenue to the platform. Each firm selects a price, p_j, to maximize its profits, $\pi(D_j(\lambda, \alpha_j, p_j, \mathbf{p}_{\text{-}j}), p_j) = D_j(\lambda, \alpha_j, p_j, \mathbf{p}_{\text{-}j})(1-r)p_j$ where $D_j(\lambda, \alpha_j, p_j, \mathbf{p}_{\text{-}j})$ is the demand firm j, with quality α_j and setting price p_j, obtains given prices of all other firms on the platform, represented by the vector $\mathbf{p}_{\text{-}j}$, and λ represents the recommender system adopted by the platform. Firms are active if they make weakly positive profits, and where they make zero profits firm prefer to sell rather than not. Therefore, a firm makes two decisions: The choice of joining the platform and its selling price. Let $\mathbf{N}$ represent the set of firms joining the platform.

Platform. The incumbent is a monopolist platform acting as an intermediary between firms and consumers. The platform earns revenue from an exogenously determined ad-valorem commission fee charged to firms, $r \in (0,1)$.[7] Hence, the profits of the platform is $\Pi = r \int_{h \in \mathbf{N}} D_h(\lambda, \alpha_h, p_h, \mathbf{p}_{\text{-}h}) p_h \; d\alpha_h$. The platform may learn the quality of firms, and provides recommendations through a listing to consumers following some recommender system.[8] Let the recommender function $\lambda(\alpha_j, p_j, \mathbf{p}_{\text{-}j}, \sigma)$ be the probability at which consumers interact with the listing of a particular firm j, where σ is determined by the platform and governs the shape of the probability density function. To aid exposition, I suppose $\sigma \in \mathbb{R}_+$ and in Appendix B show that results are robust to $\sigma \in \mathbb{R}$.

Hence, the demand firm j faces can be written as $D_j(\lambda, \alpha_j, p_j, \mathbf{p}_{\text{-}j}, \sigma) = n \times \lambda(\alpha_j, p_j, \mathbf{p}_{\text{-}j}, \sigma)$, where the mass of consumers joining the platform are those whose expected utility exceeds inertia, $E[u] > c_i$ such that $n = E[u]$ and

$$E[u] = \int_{h \in \mathbf{N}} \lambda(\alpha_h, p_h, \mathbf{p}_{\text{-}h}, \sigma)(\alpha_h - p_h) \; d\alpha_h. \tag{1}$$

The firms and platform's profits respectively evaluate to

$$\pi(\lambda(\alpha_j, p_j, \mathbf{p}_{\text{-}j}, \sigma), p_j) = n\lambda(\alpha_j, p_j, \mathbf{p}_{\text{-}j}, \sigma)(1-r)p_j \tag{2}$$

$$\Pi = nr \int_{h \in N} \lambda(\alpha_h, p_h, \mathbf{p}_{\text{-}h}, \sigma) p_h \; d\alpha_h. \tag{3}$$

Because firms higher on a list are more likely to receive interactions with consumers, I model

[7]For example, historically, eBay charges a nominal listing fee and charges a commission which is a percentage of the final transaction value. In 1998, the listing fee was between 25 cents and 2 dollars and the commission fee between 1.25% and 5% of final transaction value (eBay, 1998). In 2005, The New York Times (2005) reported the commission fee would increase from 5.25% to 8%.

[8]In practice, platforms are not able to directly observe firm quality. Instead, they learn about firm quality by aggregating feedback from consumers. Hence, it is not possible for platforms to simply direct consumers to the 'best' firm as without feedback the platform is unable to identify such a firm.

recommender systems following a Tullock contest (Tullock, 1980):

$$\lambda(\alpha_j, p_j, \mathbf{p}_{\text{-}j}, \sigma) = \begin{cases} \frac{\alpha_j - p_j - \sigma}{\int_{h \in \mathbf{N}} \alpha_h - p_h - \sigma \, d\alpha_h} & \text{if } \alpha_j - p_j - \sigma \geq 0 \\ 0 & \text{otherwise.} \end{cases} \tag{4}$$

This modified Tullock contest assumes that consumers receive positive surplus from a transaction. In Appendix B, I relax this assumption and allow consumers to be recommended and consume products that provide negative consumption utility, and also show that the main findings apply to a class of more general recommender functions that recommend firms to consumers based on relative consumption utility.

This recommender system is reminiscent of how consumers do not simply observe a single recommendation when searching on platforms. Instead, consumers observe a list of products, and are more likely to interact with products featured more prominently on the list. Moreover, when $\sigma = 0$, platforms provide exactly value-for-money recommendations. This is of particular interest because platforms initially, and can easily and directly, rely on consumers ratings, reviews and feedback to populate their recommendations. Prior work has also shown such consumer generated feedback reflects value-for-money (Li and Hitt, 2010; Cai et al., 2014; Neumann et al., 2018; Luca and Reshef, 2021; Carnehl et al., 2025). In other words, a platform can indirectly learn about the quality of the firm only after some transactions have occurred and, in equilibrium, ranks firms with higher value-for-money higher on the list.

Additionally, mature platforms, and those with the ability to invest in other recommendation tools may offer a recommender system different from value-for-money. Instead, their recommendations may be more informative about consumption utility through the use of tools such as sophisticated recommendation scoring rules (Amazon, 2024; Xu, 2022), verification processes (Google, 2024; Tripadvisor, 2024), 'badges' and awards (Booking, 2024; Airbnb, 2024), buy-boxes, and limited time deals. These recommendation tools, still based on value-for-money, allow platforms to effectively skew recommendations in favor of products which consumers prefer more, $\sigma > 0$ represents this outcome. In other words, higher levels of σ reflects recommendations which are more informative about consumption utility, consumers recognizing such recommendations, and anticipating a higher value-for-money, select them with a higher probability.

In addition to highlighting the effects of the model, studying a monopolist platform reflects the status of Very Large Online Platforms (VLOPs), defined and regulated by the EU's DSA, and Gatekeepers, defined and regulated by the EU's DMA, and their role as key intermediaries between firms and consumers. Some examples include Amazon store, Google Play, Google Maps, Google Shopping, Google Search, Alibaba AliExpress, Meta Facebook, and Apple AppStore. Importantly, DSA article 27 expressly targets the design of recommender systems, requiring enhanced transparency and user agency.

The sequence of events follows: (1) firms learn their quality and the platform announces σ; (2) firms decide to join the platform and the platform learns the quality of firms which join; (3) firms joining the platform set prices; (4) consumers decide to join the platform and make a consumption decision. I search for a subgame perfect Nash equilibrium.

2.1 No recommender system

I first construct a baseline in which the incumbent does not implement a recommender system and consumers engage with firms at random. In other words,

$$\lambda(\alpha_j, p_j, \mathbf{p}_{\text{-}j}, \sigma) = \begin{cases} \frac{1}{\int_{h\in\mathbf{N}} 1 \; d\alpha_h} & \text{if } \alpha_j - p_j - \sigma \geq 0.^{9} \\ 0 & \text{otherwise.} \end{cases}$$

This is reminiscent of the early days of e-commerce on the internet (e.g. eBay) prior to the implementation of seller feedback systems. Platforms had little means of identifying firm characteristics and by extension unable to provide recommendations to consumers. To find the most optimistic outcome without recommender systems, I search for prices which maximize total welfare. In equilibrium, the socially optimal price levels are $p_j = 0$, and the total welfare and consumer surplus is 1/2.[10]

2.2 Value-for-money recommendations

As more transactions occur on a platform, it is able to gather feedback about firms from consumer purchase behavior, and ratings and reviews.[11] This allows them to learn how the value-for-money products provide, and in turn list products with higher value-for-money more prominently than those with lower value-for-money. Hence, it is natural to consider a recommender system which captures value-for-money.

Illustrating recommender systems that purely reflect value-for-money also serves to highlight the ranking effect introduced by recommender systems. Constraining $\sigma = 0$:

$$\lambda^v(\alpha_j, p_j, \mathbf{p}_{\text{-}j}) = \begin{cases} \frac{\alpha_j - p_j}{\int_{h\in\mathbf{N}} \alpha_h - p_h \; d\alpha_h} & \text{if } \alpha_j - p_j \geq 0 \\ 0 & \text{otherwise.} \end{cases}$$

Because $\alpha_j \geq p_j$ so consumers always purchase if they join the platform, the mass of consumers is given by

$$n^v = E[u^v] = \int_{g\in\mathbf{N}} \frac{\alpha_g - p_g}{\int_{h\in\mathbf{N}} \alpha_h - p_h \; d\alpha_h} (\alpha_g - p_g) \; d\alpha_g.$$

Each firm's profit function evaluates to

$$\pi(\lambda^v(\alpha_j, p_j, \mathbf{p}_{\text{-}j}), p_j) = n^v \frac{\alpha_j - p_j}{\int_{h\in\mathbf{N}} \alpha_h - p_h \; d\alpha_h} (1 - r) p_j.$$

Notice that each firm is unable to unilaterally influence n^v, and the firm j maximizes its profits

[9] In a slight abuse of notation, I impose that this is equivalent to setting $\sigma = -\infty$.

[10] Details can be found in Appendix B.

[11] While dynamic collection and use of transaction records and consumer feedback (ratings and reviews) is not explicitly modeled, platforms can use such data to approximate the value-for-money of products (Li and Hitt, 2010; Gutt and Herrmann, 2015; Neumann et al., 2018; Luca and Reshef, 2021).

by setting the optimal price $p_j^v = \alpha_j/2$.[12] Accounting for prices,

$$\lambda^v(\alpha_j, p_j^v, \mathbf{p}_{\text{-}j}) = \begin{cases} \frac{\alpha_j}{\int_{h\in\mathbf{N}} \alpha_h \; d\alpha_h} & \text{if } \alpha_j \geq 0 \\ 0 & \text{otherwise,} \end{cases}$$

which shows how value-for-money recommender systems creates a *ranking effect*, where higher quality firms are now able to capture a larger share of demand relative to lower quality firms.

To understand the market effects, it is immediate to compute the profits and consumer surplus. The platform and firms share the total profit 1/9, while consumer surplus is 1/3. Hence, comparing value-for-money recommender systems to the welfare-optimal outcome with no recommender system:

Remark 1. *When implementing value-for-money recommendations:*

1. *Consumer surplus falls and less consumers join the market.*
2. *Total welfare falls.*

Although consumers may purchase higher quality products more often, due to the increase in prices they receive less surplus and are less likely to join the platform.

2.3 Informative recommendations

While the previous two subsections ignore the platform's strategy, they closely capture historical events. Now consider a platform being able to design a recommender system which emphasizes value-for-money, by choosing σ to maximize its profits.

Consumers join the platform if their expected utility from doing so exceeds inertia and $\alpha_j - p_j - \sigma \geq 0$ means they always purchase if they join the platform. The mass of consumers evaluates to $n^m = \int_{g\in\mathbf{N}} \frac{\alpha_g - p_g - \sigma}{\int_{h\in\mathbf{N}} \alpha_h - p_h - \sigma \; d\alpha_h} (\alpha_g - p_g) \; d\alpha_g$.

Firms are unable to unilaterally influence consumers entry decision, and each firm j maximizes its profit

$$\pi(\lambda(\alpha_j, p_j, \mathbf{p}_{\text{-}j}, \sigma), p_j) = n^m \frac{\alpha_j - p_j - \sigma}{\int_{h\in\mathbf{N}} \alpha_h - p_h - \sigma \; d\alpha_h} (1-r) p_j$$

setting the optimal price $p_j^* = \frac{\alpha_j - \sigma}{2}$. More informative recommendations (larger σ) leads to fierce price competition, which leads firms to set lower prices. Higher quality firms setting higher prices than lower quality firms. Accounting for prices,

$$\lambda(\alpha_j, p_j^*, \mathbf{p}_{\text{-}j}, \sigma) = \begin{cases} \frac{\alpha_j - \sigma}{\int_{h\in\mathbf{N}} \alpha_h - \sigma \; d\alpha_h} & \text{if } \alpha_j - \sigma \geq 0 \\ 0 & \text{otherwise.} \end{cases}$$

This formulation shows how for informative recommendations further highlights the ranking effect as the relative likelihood of obtaining some demand increases for higher quality firms and decreases for lower quality firms. As a result, higher quality firms are more profitable than lower quality firms as they benefit from higher prices and receive more demand.

Additionally, informative recommendations (larger σ) introduces a screening effect where

[12] If the firm faces some costs (e.g. marginal cost of production) qualitatively similar effects apply, see Section 3.

low quality firms receive zero demand. Because informative signals mean firms have to provide higher value-for-money to consumers to obtain demand, such low quality firms have to set much lower prices. However, if a firm has to set prices below marginal cost to attract demand, it rather becomes inactive. In other words, a firm is only active if $\alpha_j \geq \sigma$. The resulting ranking and screening effects are illustrated by Figure 1, and Lemma 1 summarizes findings about firms.

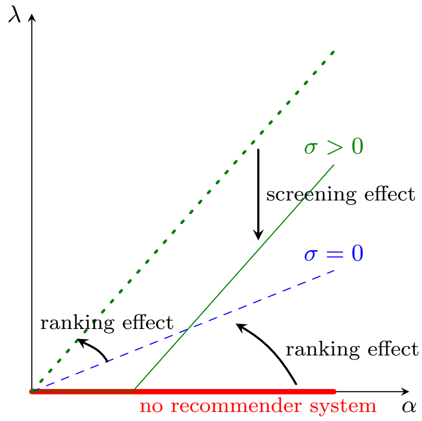

Figure 1: When no recommender system is used, all firms have equal probability (zero mass) of being selected by consumers (thick red line). When $\sigma = 0$, a ranking effect, a rotation, is introduced (dashed blue line). When $\sigma > 0$, the ranking effect is more pronounced (dotted green line) and an additional screening effect, a translation, is introduced (solid green line).

Lemma 1.

- *Under informative recommendations, relatively higher quality firms make more profit than relatively lower quality firms.*
- *When $\sigma > 0$, only firms with sufficiently high quality, $\alpha_j > \sigma$, are active on the incumbent.*
- *When recommendations are excessively informative, $\sigma \geq 1$, all firms become inactive.*

Notice that the outside option for firms is zero as there is no direct channel of sales. Hence, as an implication of Lemma 1, firms with quality lower than σ exit the market. This provides the following corollary:

Corollary 1. *There exists a cutoff firm, $\bar{\alpha} = \sigma$, above which all firms are active on the incumbent platform, and below which all firms are inactive.*

Finally, consider the incumbent's problem. Given consumer entry, firm pricing decisions and $\bar{\alpha} = \sigma$, the platform's profit function (3) evaluates to

$$\Pi = n^m r \int_{\sigma}^{1} \lambda(\alpha_h, p_h^*, \mathbf{p}_{\text{-}h}, \sigma) p_h^* \, d\alpha_h = \frac{1+2\sigma}{3} r \frac{1-\sigma}{3}.$$

The platform optimizes its recommender system by balancing demand for the platform and the revenue it is able to extract from firms. On the one hand, more informative recommendations leads to demand expansion in two ways: First, consumers have a higher probability of transacting with higher quality firms. Second, firms set lower prices which provides consumers with a larger share of the transaction surplus. On the other hand, per-transaction revenue suffers as firms lower prices.

In equilibrium, Proposition 1 shows the platform prefers recommendations which are more informative about consumption utility than recommendations that are purely based on value-for-money.

Proposition 1. *There exists a unique subgame perfect Nash equilibrium where the incumbent platform sets $\sigma^m = 1/4$, designing recommender systems which are more informative than value-for-money recommendations.*

2.4 Welfare discussion

More informative recommendations make consumers better off as they are more likely to purchase from a higher quality firm and, given quality, pay lower prices. Hence, consumers are better off when a platform adopts informative recommendations rather than value-for-money recommendations. Additionally, when comparing informative recommendations to no recommender system, despite paying higher prices consumers can be just as well off as no recommender system. This is because they transact with higher quality firms more often, allowing them to obtain an on average higher surplus. Therefore, in equilibrium, consumers weakly prefer using a monopolist platform with informative recommendations over one with no recommender system. Corollary 2 summarizes these results.

Corollary 2. *On the monopolist, consumer surplus increases when recommendations are more informative ($\sigma \uparrow$). In equilibrium, consumer surplus on the monopolist with informative recommendations is* $1/2$.

The platform's profit is $r/8$ and the total profit firms make is $(1-r)/8$. Although aggregate firm profit is larger than value-for-money recommendations ($\sigma = 0$), not all firms benefit from informative recommendations and those which do, do so unequally. For intuition, recall from Corollary 1 that some lowest quality firms are screened off the market. Hence, these firms become inactive and cannot benefit from informative recommendations. The remaining firms see informative recommendations affect their demand through two channels: (i) the entry of infra-marginal consumers, benefiting all active firms, (ii) a redistribution of demand from lower to higher quality firms benefits(harms) higher(lower) quality firms. Moreover, more informative recommendations leads to fiercer price competition and all active firms set lower prices. Hence, for some highest quality firms the demand effects dominate the price effect but for the remaining firms, the benefits from the introduction of infra-marginal consumers is unable to dominate both the negative redistribution and price effects. Corollary 3 formalizes this.

Corollary 3. *When recommendations are more informative ($\sigma \uparrow$), firms with quality above some cutoff, $\hat{\alpha}$, receive higher profits, while all other firms receive less profit. This cutoff is increasing in σ.*

Although consumers are indifferent between a monopolist platform with informative recommender system and no recommender system, because the total profit of the platform and firms is $1/8$, informative recommender systems can improve total welfare.

User agency A monopolist platform thus has an incentive to use informative recommendations. Since informative recommender systems improves total welfare and makes consumers at least as well off as no recommender system, this shows a platform providing a recommender service is able to generate value in the market. Importantly, when left to their own devices (to select products based solely on consumer feedback or not using recommender systems), consumers are worse off than following the platform's informative recommendation (Corollary 2). This suggests that DSA article 27 requiring platforms to provide consumers the ability to modify the main parameters of a search cannot improve consumer surplus and hence consumers are unlikely to rely on such features when interacting with recommender systems. In other words, article 27 imposes a superficial and costly requirement onto the way recommender systems are designed while having no (or negative) effect on both welfare and consumer surplus.

3 Monopoly extensions

3.1 Naive consumers

The main analysis assumes consumers fully understand the equilibrium implications of how platforms design recommender systems. However, given the complexity of recommender systems, there are concerns that consumers may not fully understand these implications. One possible scenario is that consumers do not correctly anticipate how firms adjust prices in response to the platform's recommender system. To capture this, I model naive consumers who fail to recognize how firms account for σ in their pricing strategy, even when firms actually do.

Because naive consumers do not anticipate how firms reduce prices in response to more informative recommender systems, they believe the effect of more informative recommender systems on their utility is smaller than it actually is. Hence, their decision to join the platform is less responsive to σ. Intuitively, the platform responds by lowering σ. If informative recommender systems are less likely to attract consumers, then the platform can focus on obtaining higher per-transaction revenues by emphasizing value-for-money less (lower σ) which reduces price competition between firms. In equilibrium, the platform sets $\sigma^N = 0$. Since the platform earns lower profits as it deviates from $\sigma^m = 1/4$, it makes less profit when consumers are naive.

Transparency and public education This result has a number of implications. For regulators, the result supports regulatory concerns that lack of transparency about how complex recommender systems work can lead to worse recommendations, these concerns are validated as consumers can be worse off than with no recommender systems. If regulations such as the DSA article 27—which requires transparency of recommender systems to consumers—can make the implications of recommender systems, in particular how its design may affect firms' prices and entry decisions, more salient to consumers, this can reduce naivete which in turn leads to the design of more informative recommender systems and improve consumer surplus. For the platform, it makes larger profits when consumers are not naive, which suggests that if the cost of designing more informative recommender systems is sufficiently low, platforms too prefer to educate consumers about their recommender systems. Hence, when it comes to recommender systems, although platforms and regulators may face different goals, it is possible the act of transparency and consumer education works towards achieving their respective goals.

For details, see Appendix B.

3.2 Marginal costs

The main analysis assumes firms face zero marginal cost of production. Here, I relax this assumption and suppose all firms face a marginal cost of production e. Proposition 2 shows that the platform prefers more informative recommendations when firms face a higher marginal cost. Note that to cover marginal costs, at a given σ, any firm of quality α_j has to set higher prices. This has two effects. First, some lower quality firms become inactive as they are unable to both cover the increases in marginal cost and induce positive demand from consumers following (4). Second, because the platform charges an ad-valorem fee, when firms raise prices the platform's per-transaction revenue increases. Both effects serve to improve platform's per-transaction revenue. Hence, the platform can focus on serving its other trade-off: designing more informative recommender systems to attract more consumers.

Proposition 2. *A monopolist platform designs more informative recommender systems when firms face higher marginal cost of production.*

3.3 Robustness checks

In Appendix B, I show that the platform's trade-offs and welfare effects are robust to: (i) *no free returns* such that consumers may end up purchasing, and keeping, a product which provides negative consumption utility. (ii) *Uninformative recommendations and distributional assumptions.* I allow $\sigma \in \mathbb{R}$ such that a platform can also design recommender systems which are more noisy about consumption utility. I additionally allow c_i to be drawn from a triangular distribution with support $[0, 1]$ and peak 1. (iii) *General recommender functions* by adopting more general contest success function that depend on relative consumption utility. For details, see Appendix B.

4 Competition

While most commonly discussed online platforms seem like monopolist in their own markets, they often face competition and coexist with smaller, lesser known, platforms. For example Amazon competes with Newegg in the computer hardware market and more generally with big-box stores and discounters such as Walmart and Zalando.

In this section, I explore the situation where two platforms, $k \in \{I, E\}$ the incumbent and entrant respectively, compete simultaneously in their recommender systems. Firms may choose to multi-home and joining each platform is costless for the firm. Consumers' inertia to join each platform, $c_{i,k}$, is independently and identically drawn from a uniform distribution with support $[0, 1]$. Consumers do not multi-home and join the platform which provides the highest expected utility, $E[u_k] - c_{i,k}$. Hence, the mass of consumers joining each platform k is

$$n_k = \begin{cases} E[u_k] - \frac{E[u_{\text{-}k}]^2}{2} & \text{if } E[u_k] \geq E[u_{\text{-}k}] \\ E[u_k](1 - E[u_{\text{-}k}] + \frac{E[u_k]}{2}) & \text{if } E[u_k] < E[u_{\text{-}k}] \end{cases} \tag{5}$$

where the expected utility from joining either platform follows (1). Let the subscript $k \in \{I, E\}$ represent the decisions on each platform k.

To provide a baseline for the model with competition, I first consider an entrant with no recommender system and later allow the entrant to use informative recommendations.

4.1 Entrant: no recommender system

Studying an entrant with no recommender system aligns with the situation where new platforms may be unable to provide recommendations, for example, due to a lack of technology or data. Using this as a baseline also draws attention to a key dynamic faced by the incumbent: On its own, competition can lower the incumbent's incentive to provide informative recommendations.

Following the model of no recommender system in Section 2.1, the welfare-optimal price on the entrant platform with no recommender system is $p_{j,E} = 0$.

On the incumbent platform, recall that firms are unable to unilaterally influence consumers arrival to the platform. Hence, firms joining the incumbent adopt the same price strategy as on a monopolist platform, $p^*_{j,I} = \frac{\alpha_j - \sigma_I}{2}$. Despite the presence of the entrant, firms compare being on the incumbent platform and face an outside option of zero. Because the strategies of firms are identical to Section 2.3, firms face the same price strategy and outside option of zero profits, Lemma 1 applies to the incumbent in this setting.

Although firms can multi-home, Corollary 4 shows that they prefer to single-home, with higher quality firms being active on the incumbent and lower quality firms active on the entrant. This is analogous to Corollary 1. The key distinction between Corollary 1 and Corollary 4 is that firms now have the choice to be active on the entrant, continuing to sell but making zero profits.

Intuitively, all firms prefer being on the incumbent, as this allows them to make positive profits. When a firm is active on the incumbent, it does not multi-home. This is because multi-homing raises the expected utility that consumers receive on the entrant, which draws consumers away from the incumbent, see (5). Hence, by joining the entrant, and making zero profits, the firm may improve its demand but lowers its profit as it competes with itself for consumers. However, because firms prefer selling to not selling, if a firm is screened off from the incumbent, it joins and sells on the entrant.

Corollary 4. *There exists a cutoff firm $\bar{\alpha} = \sigma$, above which all firms are only active on the incumbent, and at and below which all firms are only active on the entrant.*

Applying this result, the expected utility on the incumbent and the entrant are

$$E[u_I] = \frac{1 + 2\sigma_I}{3} \qquad\qquad E[u_E] = \frac{\sigma_I}{2}.$$

Since $\sigma_I \in [0, 1)$ such that $E[u_I] > E[u_E]$,[13] the demand on either platform is

$$n_I = \frac{1 + 2\sigma_I}{3} - \frac{\sigma_I^2}{8} \qquad\qquad n_E = \frac{\sigma_I}{2}(1 - \frac{1 + 2\sigma_I}{3} + \frac{\sigma_I}{4})$$

which is illustrated on Figure 2. The presence of the entrant distorts the incumbent's incentive to provide informative recommendations. When the incumbent provides more informative recommendations, it screens firms of relatively lower quality off the platform. However, these firms are of relatively higher quality compared to firms on the entrant. Because firms prefer to be active rather than not, they join the entrant and improve the expected utility that consumers receive from joining the entrant. This negatively impacts the mass of consumers joining the

[13] If $\sigma_I \geq 1$ all firms join the entrant.

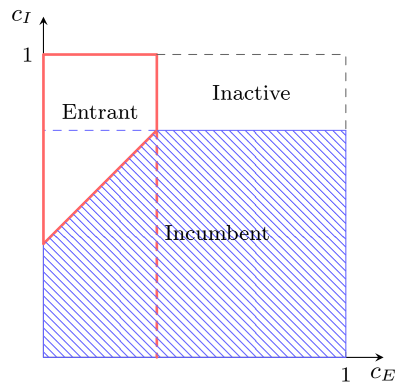

Figure 2: Consumers choice of platform: Consumers in the red bounded region join the entrant. Consumers in the blue shaded region join the incumbent. The remaining consumers do not join any platform.

incumbent. As a result, an incumbent considering consumers' incentives to switch between platforms prefers a less informative recommender system than a monopolist. This is expressed in Proposition 3.

Proposition 3. *There exists a unique subgame perfect Nash equilibrium where the incumbent facing an entrant with no recommender system adopts* $\sigma_I = 2/9$.

Notice that $\sigma_I < \sigma^m$. Hence, when facing an entrant with no recommender system, an incumbent makes its recommender system less informative. Recall the expected utility on the incumbent, $\frac{1+2\sigma_I}{3}$, is increasing in σ_I. Hence, expected utility on the incumbent is lower in the face of competition. This is a result of both increasing prices and lower firm quality on the incumbent platform. Hence, any gains in consumer surplus arising from the entrance of a competing platform is driven by infra-marginal consumers becoming active in the market.

Remark 2. *An entrant with no recommender system improves consumer surplus,* 16/27. *These gains are driven by consumers becoming active on the entrant rather than more informative recommendations.*

Importantly, competition alone is insufficient to foster trust in recommender systems, and can instead result in some form of platform degradation.

4.2 Entrant: informative recommendations

To fully understand how competing platforms design their recommender systems, I now turn to the situation where the entrant also adopts an informative recommender system, (4). Allow the incumbent and entrant to simultaneously decide σ_I and σ_E respectively.

In equilibrium, the mass of consumers joining platform k is given by (5) and consumers always purchase following entry. Since individual firms are unable to influence consumers' platform choice, on each platform all firms adopt the same price strategy as Section 2.3, $p^*_{j,k} = \frac{\alpha_j - \sigma_k}{2}$. Further, all firms with sufficiently high quality, $\alpha_j > \sigma_k$ are able to make a positive profit on the platform k. Since multi-homing is costless, and firms can make a positive profit if their quality is sufficiently high, analogous to Corollary 1, any firm with $\alpha_j > max\{\sigma_I, \sigma_E\}$ is active on both platforms.

Proposition 4. *There exists a unique symmetric equilibrium where platforms adopt* $\sigma_I = \sigma_E =$

$\sigma^s \equiv \frac{5-3\sqrt{2}}{2}$.

The platforms simultaneously select σ_k, facing a symmetric problem. Hence, there exists a symmetric equilibrium in which both platforms adopt more informative recommender systems than a monopolist ($\sigma^s > \sigma^m$). This means that competing platforms leads to firms on both platforms setting lower prices, and additionally higher quality firms are recommended to consumers more often than on the monopolist. Hence, competition between informative recommender systems can improve the surplus of both infra-marginal and intra-marginal consumers.

Additionally, competing platforms lead to more informative recommendations, which causes firms on a given platform to compete more fiercely in prices. This highlights the importance of considering potential downstream effects of encouraging competition between platforms.

Data sharing obligations. A practical question arises: Can an entrant design recommender systems as well as the incumbent? Indeed, to build informative recommender systems, platforms require past consumer transactions and feedback. New entrants to a market are unlikely to easily amass such data. Data sharing obligations such as those imposed by the DMA on Gatekeepers could mitigate this issue. If individual firms are able to take past transaction information to other platforms, this can reduce their switching cost as they bring along reputation and customer feedback which can be used to develop an entrant's recommender system. As a result, firms can obtain similar profits on the new platform, encouraging multi-homing. Likewise, if consumers can easily transfer past transaction information to a new platform, this reduces switching costs. This way, data sharing obligations potentially allows entrants to develop informative recommender systems similar to incumbents.

The following remark helps to understand how an entrant's limited ability affects the incumbent's recommender system.

Remark 3. *In the scenario where an entrant is unable to design recommender systems as informative as the incumbent, constraining $\sigma_I > \sigma_E$, then $\frac{\partial \sigma_I}{\partial \sigma_E} > 0$. The presence of an entrant adopting recommender systems more informative of value-for-money improves the informativeness of the incumbents recommender system.*

Platform degradation It is useful to now recall that $\sigma^N = 0 < \sigma^m = 1/4 < \sigma^s = \frac{5-3\sqrt{2}}{2}$, and that $\frac{\partial \sigma_I}{\partial \sigma_E} > 0$. This aligns with how recommender systems on platforms such as eBay and Amazon have changed with market environments: When recommender systems were first introduced, consumers may not have understood their implications, and monopolist platforms like eBay adopted recommender system that purely reflects value-for-money (σ^N). As consumers learned that recommender systems reflect value-for-money, the platform is incentivized to design more informative recommender systems (until σ^m). Competition further induces informative recommender systems ($\frac{\partial \sigma_I}{\partial \sigma_E}$), and leads to recommender systems highly informative of consumption utility (σ^s). However, if a platform is able to establish market dominance (e.g. a monopoly), recommender systems become less informative (σ^m). Therefore, competition between platforms may offer an explanation for the degradation of platforms recently highlighted by the popular media. Indeed, recommender systems might have become worse with instilled monopolies, but consumers are still better off than without recommender systems (Corollary 2).

The following section provides extensions to the model of competition.

5 Competition extensions

I first consider environments which result in platform asymmetry, then discuss the roles of costly firm entry and consumer multi-homing.

5.1 Asymmetric equilibria

Asymmetric consumer inertia It is likely that consumers face less inertia joining an established platform due to switching costs, familiarity, or other peer-based network effects. Following from the model of competition, one can model this situation as the distribution of inertia to join the entrant being higher than the incumbent in a first order stochastic dominant sense. I show that the entrant prefers to design more informative recommender systems. While this result may be difficult to observe in a dominated space like e-commerce, it is easily observed on social media platforms. For example, TikTok having better recommendation algorithms than Instagram (Gerbaudo, 2024).

For details, see Appendix B.

Sequential equilibrium From the model of competition, suppose that the entrant designs its recommender system before the incumbent. For example, the incumbent may have more flexibility or market power, allowing it to design its recommender system in response to the entrant.[14] Hence, the timing of the game follows: The entrant selects σ_E; the incumbent selects σ_I; firms decide which platform to join and sets its price on each platform; consumers choose which platform to join and make their consumption decision. In this setting, I show that the incumbent prefers a more informative recommender system than the entrant, however, this is strictly lower than the symmetric equilibrium. Importantly, recall that consumer surplus is increasing in the informative of recommender systems on both platforms. Hence suggesting that consumers are worse off when platforms act sequentially rather than simultaneously.

For details, see Appendix B.

5.2 Costly firm entry

For simplicity, the main model supposes that firms face no entry cost. To highlight the effects of costly entry, suppose firms are able to multi-home and joining the first platform is free but joining the second platform is costly. Moreover, allow platforms compete in a sequential fashion. For exposition, suppose the platform designing the more informative recommender system is the incumbent. Proposition 5 describes firms strategies.

Proposition 5. *Given* (6) *and* $\sigma_E < \sigma_I$*, firms face unique cutoff strategies such that:*

- *A lowest quality group of firms which are inactive in the market,* $\alpha_j \leq \sigma_E$*;*
- *A second lowest quality group of firms which are active only on the entrant,* $\alpha_j \in (\sigma_E, \underline{\alpha}]$*,* $\underline{\alpha} > \sigma_I$*;*
- *A second highest quality group of firms which are active only on the incumbent,* $\alpha_j \in (\underline{\alpha}, \tilde{\alpha}]$*,* $\tilde{\alpha} > \sigma_I$*;*
- *A highest quality group of firms which are active on both platforms,* $\alpha_j > \tilde{\alpha}$*,* $\tilde{\alpha} > \sigma_I$*,*

[14] This is without loss, one can alternatively choose to assign the entrant to be more profitable, or have more capacity for flexibility, or the ability to design better recommender systems, and hence move second.

where $\tilde{\alpha}$ is increasing in the entry cost. Note it is possible that $\underline{\alpha} = \tilde{\alpha}$.

The first group of firms arises as a direct consequence of Lemma 1. Some firms never find it profitable to join any platform because they always receive zero demand from the platforms.

The second group of firms are only active on the entrant. This includes the group of firms which can never make a profit on the incumbent, $\alpha_j \leq \sigma_I$. However, it also includes some firms which despite being able to make positive profit on the incumbent prefer to join the entrant as they become a 'big fish in a small pond', rather than a 'small fish in a big pond', allowing them to capture a larger share of the surplus on the entrant than on the incumbent as they face weaker competition.

The rest of the firms are active on the incumbent as, despite setting lower unit prices, the quality of firms on the incumbent is higher and this attracts more consumers, hence allowing these firms to make a larger profit on the incumbent. Finally, note that only the highest quality firms, $\alpha_j > \sigma_I$, make enough profit from joining a second platform and multi-home.

Implications Fix some (σ_I, σ_E) pair and suppose $\tilde{\alpha} > \underline{\alpha} > \sigma_I$. Then it must be that some firms with quality $\alpha_j \in (\sigma_I, \underline{\alpha}]$ exit the incumbent and join only the entrant. This raises the expected quality of firms on the incumbent relative to costless entry. Moreover, there exists some firms with quality $\alpha_j \in (\underline{\alpha}, \tilde{\alpha}]$ which exit the entrant and only join the incumbent. This lowers the expected quality of firms on the entrant. This means, unlike the sequential equilibrium with costless entry, for any given (σ_I, σ_E) pair, consumers expected utility from the incumbent is higher with costly entry while the expected quality from the entrant lower. Therefore, costly firm entry can limit the competitiveness of entrant platforms.

5.3 Multi-homing consumers

The main competition model supposes consumers cannot multi-home. To understand how multi-homing consumers can influence the design of recommender systems, I employ the use of a search model. The game follows: Platforms simultaneously decide on the design of their recommender system. Firms then choose which platform to join and set prices. Following which, consumers choose to join a platform and realize the platforms recommendation. Consumers may then choose to buy immediately or visit the second platform. If consumers visit the second platform, they are provided a recommendation from that platform. Consumers have perfect recall. I search for a symmetric equilibrium where $\sigma_I = \sigma_E = \sigma^h$.

Proposition 6. *There exists a unique symmetric equilibrium where platforms prefer a less informative recommender system than when it is a monopolist, $\sigma^h < \sigma^m$.*

In equilibrium, consumer behavior is similar to a search model with recall. Consumers first join the platform which provides the highest expected utility less inertia. Consumers that obtained both a sufficiently poor recommendation and face a low inertia from the second platform would then choose to search the second platform. All other consumers purchase immediately following the recommendation on the first platform. Consumers that searched both platforms evaluate the product which provides the highest utility and purchases said product.

It is intuitive to see why platforms prefer less informative recommendations. Because some consumers would receive both a poor recommendation and have very low inertia of joining the second platform. Retaining consumers become more difficult for the platform. Despite making recommender systems more informative, the platform will always lose some consumers. Hence, consumer multi-homing makes it more difficult for platforms to improve transaction volume. A platform then favors its other trade-off, improving per-transaction revenues, and does so by designing a less informative recommender system.

Consumer loyalty This finding suggests a potential channel of platform degradation is a result of consumer behavior. If consumers find it easy to compare between platforms, platforms have less incentive to design informative recommender systems. This means encouraging consumer search can lead to lower consumer surplus. And speaks to how broader considerations need to be made when imposing regulations that can result in reduced consumer loyalty.

6 Related literature

This paper explores how platforms compete in the design of their recommender systems. In an emerging literature on the design of *recommender systems*, Peitz and Sobolev (Forthcoming) and Li et al. (2020) model horizontally differentiated products, Peitz and Sobolev (Forthcoming) show a platform may choose to bias its recommendation when consumers have strong preferences, and Li et al. (2020) show that a recommender system which directs consumers to the product offering the highest net utility can make some sellers worse off and lead to lower prices. Zhou and Zou (2023) studies a model of vertical differentiation and describes how the accuracy of quality-based recommendations can abate price competition by firms, leading to higher prices, making consumers worse off. Like Zhou and Zou (2023), I consider a model of vertical differentiation but consider how platforms may choose the accuracy of value-for-money based recommendations. However, unlike them, in the monopoly setting I find more informative recommender systems lead to lower prices, making some sellers worse off which has nuanced implications for firms participation decisions. Whereas the aforementioned papers focus on a monopolist platform, to the best of my knowledge, this paper is the first to provide a tractable model of how competing platforms design their recommender systems.

My model is perhaps most similar to Casner and Teh (Forthcoming) in that both papers similarly adopt contest success functions with some precision to model platform recommender systems. Their paper focuses its attention on how firms design their products in response to a platform's fee structure and implementation of the recommender system (or lack thereof). In contrast, my paper fixes the platform's fee structure and asks what the optimal recommender system design is under this technology.[15]

In many settings, platforms adopt *non-price strategies*. On monopolist platforms, Johnen and Ng (2024) model value-for-money ratings and discuss how platforms can facilitate consumer ratings, and find that consumer surplus is maximized with a moderate level of facilitation. I adopt a similar notion of value-for-money but adapt it to a model of recommendations. Models of recommendations are similar to models of certification such as Celik and Strausz (2025) which discusses the optimal information disclosure by a platform when there is uncertainty over firms; and Bedre-Defolie et al. (2024) which finds certification can lead sellers to exert more effort. In the monopoly platform model, my results mirror theirs in that the platform prefers a recommender system which is somewhat informative about consumption utility, and

[15] In Appendix B, I provide conditions for when my results hold for more general contest success functions.

this leads to firms setting lower prices. Nocke and Strausz (2023) characterizes when a platform is able to build its collective reputation even as individual firms have their own incentives, and this is similar to how consumers in my model are attracted to platforms which provide more informative recommendations raising the collective reputation of the platform. Hagiu and Wright (2024) looks at a platform's decision to raise consumer awareness of the presence of other sellers. Sellers then compete in prices for aware buyers. My model similarly studies how active firms to compete in prices for consumers attention, and additionally allows for the platform to make some (higher value-for-money) sellers prominent.

Whereas the aforementioned papers focus on understanding the implications of a monopolist platform adopting non-price strategies, this paper examines the role of non-price strategies by *competing two-sided platforms*. When two-sided platforms compete, Chellappa and Mukherjee (2021) and Hałaburda and Yehezkel (2013) show, when information is asymmetric, platforms prefer to hide information where possible. Considering consumers with a bias for a particular platform, Hałaburda and Yehezkel (2016) discusses the effects this can have on a platform's fee and fee structure. Choi (2010) describes how tying products can improve consumer surplus when consumers can multi-home. Many others have also explored the intricate effects of platforms deciding fee structure and setting fees in competing two-sided markets (Rochet and Tirole, 2003; Caillaud and Jullien, 2003; Armstrong, 2006; Damiano and Hao, 2008; Jullien, 2011; Amaldoss et al., 2024; Belleflamme and Peitz, 2019; Bakos and Halaburda, 2020; Belleflamme and Peitz, 2010; Teh, 2022; Karle et al., 2020; Bar-Isaac and Shelegia, Forthcoming; Choi and Jeon, 2023). This paper focuses on the design of recommender systems.

A substantial literature starting with Armstrong et al. (2009) studies prominence in *consumer search on platform markets*. Generally, these models focus on a single prominent firm and how steering and vertical integration can influence firms desire to become prominent. I abstract away from the search element of such models and study how platforms may make a group of firms more prominent by introducing (or reducing) noise in the market. I use this model to examine the issues of firm participation on platforms and competition between platforms. Perhaps most similar in spirit within this literature is De Corniere (2016) which considers a search model where firms pay for prominence and determine the broadness of keywords used in consumer search. He shows there exists an equilibrium where firms prefer the same broadness of search regardless of search engine competition. If, instead, the search engine determines the broadness of keywords, it prefers less accurate keyword matching than firms. Analogously, my model explores the degree of recommendation precision on a platform but focuses on the platform's optimal precision rather than a firm's. In my mechanism, a platform directly chooses the level of precision rather than indirectly as a result of its fee structure.

More recently, there has been growing interest in the role of *algorithms*. A focus of this literature is algorithmic pricing, showing algorithms lead to tacit collusion, for which Assad et al. (2021) provides a comprehensive survey. On understanding the role of data sharing and its impact on algorithms, Bergemann and Bonatti (2024) discusses how data is necessary to drive algorithms, showing privacy rules can protect consumers from targeted advertising, and Petropoulos et al. (2023) shows information sharing between platforms can improve competition. While I do not explicitly model the role of data, in the event where the absence of data sharing can make inhibit entrant platforms' ability to design informative recommender systems, in line with Petropoulos et al. (2023), my results suggests that entrant platforms may find it difficult to attract high quality firms. However, I show entrant platforms can still create competitive pressures on the incumbent platform to improve its recommender system.

7 Conclusion

Recommender systems are an integral component of the online economy, enabling users to navigate and manage an overwhelming volume of information. I show that platforms face a trade-off when designing these systems: Recommender systems that are more informative about consumption utility intensify price competition between firms on the platform since providing more consumption utility increases demand for the firm. Lower quality firms are unable to compete and may exit the market. While both effects improve consumer surplus, which attracts more consumers to the platform, a platform charging ad-valorem fees obtains lower per-transaction revenue.

On a monopoly platform, I show the platform prefers recommender systems which are more informative about consumption utility than purely value-for-money recommendations. I study how consumer naivete can affect the design of recommender systems. Because consumers do not fully anticipate how the recommender system affects their surplus, their decision to join the platform becomes less sensitive how the system is designed. Hence, the platform has less incentive to design informative systems to attract consumers, instead focusing on enabling firms to set higher prices. I also examine the role of costly production, and find this causes firms to set higher prices. Hence, softening the platform's incentive to raise prices and instead focus on attracting consumers with more informative recommender systems. Finally, I provide some robustness checks to show the generality of these results.

A key contribution of this paper is its analysis of platform competition. When platforms compete, if the entrant has a recommender system that is uninformative of value-for-money, the incumbent prefers less informative systems than a monopolist does. However, as the entrant develops more informative recommender systems, the incumbent also improves its recommender system. I find a unique symmetric equilibrium in which both platforms prefer recommender systems that are more informative about consumption utility than a monopolist does, showing that competition indeed results in better recommendations. Using this insight, I discuss how modern data-driven recommender systems may prevent entrants from designing informative recommender systems, and how data portability and data-sharing obligations can result in recommender systems that are more useful for consumers. Combining my findings on monopoly and competing platforms provides insight on how market power can be a contributing factor to platform degradation, at least as it relates to how consumers may perceive recommender systems to be less useful.

I explore how asymmetries can affect the way competing platforms design recommender systems. First, if consumers face higher inertia to joining the entrant, the entrant prefers even more informative recommender systems than the incumbent to attract consumers, combined with the data-driven nature of recommender systems, this reflects some of the difficulties a new platform faces when entering the market. Second, supposing platforms compete sequentially, the incumbent prefers more informative systems than the entrant but still less so than when platforms compete simultaneously.

I also examine the scope of firm and consumer multi-homing. First, I consider firms costly entry onto platforms. This makes multi-homing only possible for the highest quality firms, which serves to raise the expected utility consumers receive from the incumbent as fewer relatively lower (middle and lowest) quality firms are active on the incumbent. Second, I allow consumers to multi-home and find a unique symmetric equilibrium where platforms prefer less informative recommendations than when consumers cannot multi-home. This is because when consumers are able to search across platforms, each platform finds it more difficult to retain consumers and instead focuses on raising per-transaction revenues.

References

Airbnb (2024). *Guest favourites and highlights.* URL: `https://www.airbnb.com/help/article/3495.` (visited on 12/2024).

Amaldoss, Wilfred, Jinzhao Du, and Woochoel Shin (2024). "Pricing strategy of competing media platforms". *Marketing Science* 43.3, pp. 488–505.

Amazon (2024). *Recommendations - Amazon Customer Service.* URL: `https://www.amazon.com/gp/help/customer/display.html?ref_=hp_left_v4_sib&nodeId=GE4KRSZ4KAZZB4BV` (visited on 12/2024).

Armstrong, Mark (2006). "Competition in two-sided markets". *The RAND Journal of Economics* 37.3, pp. 668–691.

Armstrong, Mark, John Vickers, and Jidong Zhou (2009). "Prominence and consumer search". *The RAND Journal of Economics* 40.2, pp. 209–233.

Assad, Stephanie, Emilio Calvano, Giacomo Calzolari, Robert Clark, Vincenzo Denicolò, Daniel Ershov, Justin Johnson, Sergio Pastorello, Andrew Rhodes, Lei Xu, et al. (2021). "Autonomous algorithmic collusion: Economic research and policy implications". *Oxford Review of Economic Policy* 37.3, pp. 459–478.

Bakos, Yannis and Hanna Halaburda (2020). "Platform competition with multihoming on both sides: Subsidize or not?" *Management Science* 66.12, pp. 5599–5607.

Bar-Isaac, Heski and Sandro Shelegia (Forthcoming). "Monetizing steering". *Journal of Political Economy Microeconomics.*

Bedre-Defolie, Özlem, Bjørn Olav Johansen, and Leonardo Madio (2024). "Design and governance of quality on a digital platform". Mimeo.

Belleflamme, Paul and Martin Peitz (2010). "Platform competition and seller investment incentives". *European Economic Review* 54.8, pp. 1059–1076.

— (2019). "Platform competition: Who benefits from multihoming?" *International Journal of Industrial Organization* 64, pp. 1–26.

Bergemann, Dirk and Alessandro Bonatti (2024). "Data, competition, and digital platforms". *American Economic Review* 114.8, pp. 2553–2595.

Booking (2024). *Becoming certified.* URL: `https://partner.booking.com/en-gb/learn-more/becoming-certified.` (visited on 12/2024).

Cai, Hongbin, Ginger Zhe Jin, Chong Liu, and Li-an Zhou (2014). "Seller Reputation: From Word-of-Mouth to Centralized Feedback". *International Journal of Industrial Organization* 34, pp. 51–65.

Caillaud, Bernard and Bruno Jullien (2003). "Chicken & egg: Competition among intermediation service providers". *The RAND Journal of Economics*, pp. 309–328.

Carnehl, Christoph, André Stenzel, Kevin Ducbao Tran, and Maximilian Schäfer (2025). "Value for Money and Selection: How Pricing Affects Airbnb Ratings". *Working Paper.*

Casner, Ben and Tat-How Teh (Forthcoming). "Content-hosting platforms: discovery, membership, or both?" *The RAND Journal of Economics.*

Celik, Gorkem and Roland Strausz (2025). "Informative Certification: Screening vs. Acquisition". *CRC TRR 190 Discussion paper* 525.

Chellappa, Ramnath K and Rajiv Mukherjee (2021). “Platform preannouncement strategies: The strategic role of information in two-sided markets competition”. *Management Science* 67.3, pp. 1527–1545.

Choi, Jay Pil (2010). “Tying in two-sided markets with multi-homing”. *The Journal of Industrial Economics* 58.3, pp. 607–626.

Choi, Jay Pil and Doh-Shin Jeon (2023). “Platform design biases in ad-funded two-sided markets”. *The RAND Journal of Economics* 54.2, pp. 240–267.

Damiano, Ettore and Li Hao (2008). “Competing matchmaking”. *Journal of the European Economic Association* 6.4, pp. 789–818.

De Corniere, Alexandre (2016). “Search advertising”. *American Economic Journal: Microeconomics* 8.3, pp. 156–188.

Gerbaudo, Paolo (2024). “TikTok and the algorithmic transformation of social media publics: From social networks to social interest clusters”. *New Media & Society*.

Google (2024). *Google — Understand missing & delayed reviews.* URL: `https://support.google.com/business/answer/10313341?hl=en#:~:text=Usually%2C%20missing%20reviews%20are%20removed,relevant%2C%20helpful%2C%20and%20trustworthy.` (visited on 12/2024).

Gutt, Dominik and Philipp Herrmann (2015). “Sharing Means Caring? Hosts’ Price Reaction to Rating Visibility”. *ECIS* 54, p. 14.

Hagiu, Andrei and Julian Wright (2024). “Optimal discoverability on platforms”. *Management Science*.

Hałaburda, Hanna and Yaron Yehezkel (2013). “Platform competition under asymmetric information”. *American Economic Journal: Microeconomics* 5.3, pp. 22–68.

— (2016). “The role of coordination bias in platform competition”. *Journal of Economics & Management Strategy* 25.2, pp. 274–312.

Johnen, Johannes and Robin Ng (2024). “Harvesting Ratings”. *CRC TR 224 Discussion Paper* 509.

Jullien, Bruno (2011). “Competition in multi-sided markets: Divide and conquer”. *American Economic Journal: Microeconomics* 3.4, pp. 186–219.

Karle, Heiko, Martin Peitz, and Markus Reisinger (2020). “Segmentation versus agglomeration: Competition between platforms with competitive sellers”. *Journal of Political Economy* 128.6, pp. 2329–2374.

Li, Lusi, Jianqing Chen, and Srinivasan Raghunathan (2020). “Informative Role of Recommender Systems in Electronic Marketplaces: A Boon or a Bane for Competing Sellers.” *MIS Quarterly* 44.4.

Li, Xinxin and Lorin M. Hitt (2010). “Price Effects in Online Product Reviews: An Analytical Model and Empirical Analysis”. *MIS Quarterly* 34.4, pp. 809–831.

Luca, Michael and Oren Reshef (2021). “The Effect of Price on Firm Reputation”. *Management Science* 67.7, pp. 4408–4419.

Neumann, Jürgen, Dominik Gutt, and Dennis Kundisch (2018). “A Homeowner’s Guide to Airbnb: Theory and Empirical Evidence for Optimal Pricing Conditional on Online Ratings". *Working Papers Dissertations 43, Paderborn University, Faculty of Business Administration and Economics.*, p. 23.

Nocke, Volker and Roland Strausz (2023). "Collective brand reputation". *Journal of Political Economy* 131.1, pp. 1–58.

Peitz, Martin and Anton Sobolev (Forthcoming). "Inflated recommendations". *The RAND Journal of Economics.*

Petropoulos, Georgios, Bertin Martens, Geoffrey Parker, and Marshall W Van Alstyne (2023). "Platform Competition and Information Sharing". *CESifo Working Paper.*

Rochet, Jean-Charles and Jean Tirole (2003). "Platform competition in two-sided markets". *Journal of the European Economic Association* 1.4, pp. 990–1029.

Teh, Tat-How (2022). "Platform governance". *American Economic Journal: Microeconomics* 14.3, pp. 213–254.

The New York Times (2005). *eBay's joy ride: Going once...* URL: https://www.cnet.com/tech/tech-industry/ebays-joy-ride-going-once/ (visited on 12/2024).

Tripadvisor (2024). *Tripadvisor Help Center.* URL: https://www.tripadvisorsupport.com/en-US/hc/traveler/articles/396#:~:text=In%20some%20cases%2C%20we%20will,take%20longer%20to%20be%20published. (visited on 12/2024).

Tullock, Gordon (1980). "Efficient rent seeking". *Toward a Theory of the Rent-Seeking Society.* Ed. by James Buchanan, Gordon Tullock, and Robert Tollison. College Station: Texas A&M University Press, pp. 3–15.

Xu, Chen (2022). *Improving shopping recommendations for customers through EBay's Relevance Cascade model.* URL: https://innovation.ebayinc.com/tech/engineering/improving-shopping-recommendations-for-customers-through-ebays-relevance-cascade-model/ (visited on 12/2024).

Zhou, Bo and Tianxin Zou (2023). "Competing for recommendations: The strategic impact of personalized product recommendations in online marketplaces". *Marketing Science* 42.2, pp. 360–376.

eBay (Sept. 1998). *eBay INC. Quarterly Report September 30, 1998.* Tech. rep.

A Proofs

Proof of Lemma 1. To prove the first statement, consider the profit function of a firm,

$$\pi(\alpha_j) = n\frac{\alpha_j - \sigma}{\int_{h\in\mathbf{N}} \alpha_h - \sigma \ d\alpha_h}(1-r)\frac{\alpha_j - \sigma}{2}.$$

Higher quality firms are both able to set higher prices and obtain a larger share of demand.

The second statement follows from λ. For some $\sigma > 0$, if $\sigma \geq \alpha_j$, firms with quality α_j are never recommended to consumers, and inactive on the platform. Hence, only firms with $\alpha_j > \sigma$ are active on the incumbent.

To show the third statement, see that the second statement implies any $\sigma \geq 1$ means all firms receive no demand (or profits) and are inactive on the platform. □

Proof of Corollary 1. For a firm to be active, it has to make positive profit on the platform. Since firms have no outside option, they are active on the platform as long as $\pi(\lambda(\alpha_j, p_j, \mathbf{p}_{\text{-}j}, \sigma), p_j) \geq 0$ and $\alpha_j - p_j - \sigma \geq 0$, Since profits are increasing in α_j, there is a lowest quality firm, $\bar{\alpha}$, such that $\pi(\bar{\alpha}) = 0$ which is the highest quality firm that is inactive on the platform. All firms with quality above $\bar{\alpha}$ make strictly more profit than $\bar{\alpha}$, hence make positive profit and are active on the platform. Other firms with quality at or below $\bar{\alpha}$ do not make positive profit and are inactive. Hence, to find this cutoff quality level $\bar{\alpha}$, $\pi(\lambda(\bar{\alpha}, p_j^*, \mathbf{p}_{\text{-}j}, \sigma), p_j^*) = 0$

$$\frac{1+\bar{\alpha}+\bar{\alpha}^2 - 3\sigma^2}{3(1+\bar{\alpha}-2\sigma)}\frac{2(\bar{\alpha}-\sigma)}{(1-\bar{\alpha})(1+\bar{\alpha}-2\sigma)}(1-r)\frac{\bar{\alpha}-\sigma}{2} = 0.$$

Any $\bar{\alpha}$ that makes $\pi(\lambda(\bar{\alpha}, p_j^*, \mathbf{p}_{\text{-}j}, \sigma), p_j^*) = 0$, must satisfy either $1+\bar{\alpha}+\bar{\alpha}^2-3\sigma^2 = 0$ or $\bar{\alpha}-\sigma = 0$. Since $1+\bar{\alpha}+\bar{\alpha}^2-3\sigma^2 = 0$ implies the platform receives zero demand, and this would imply an inactive market, this implies all firms are inactive, a contradiction to the cutoff rule. Therefore, $\bar{\alpha} = \sigma$. □

Proof of Proposition 1. To see this, observe that $n = \frac{1+2\sigma}{3}$, $\frac{\partial n}{\partial \sigma} = \frac{2}{3} > 0$; and $\int_{\bar{\alpha}}^1 \lambda(\alpha_h, p_h^*, \mathbf{p}_{\text{-}h}, \sigma)p_h^* \ d\alpha_h = \frac{1-\sigma}{3}$, $\frac{\partial}{\partial\sigma}\int_{\bar{\alpha}}^1 \lambda(\alpha_h, p_h^*, \mathbf{p}_{\text{-}h}, \sigma)p^*(\alpha_h) \ d\alpha_h = -\frac{1}{3} < 0$. The platform's profit is $\Pi = r\frac{(1+2\sigma)(1-\sigma)}{9}$ and balancing the mass of consumers and per-transaction revenue, $\frac{\partial \Pi}{\partial\sigma} = r\frac{1-4\sigma}{9} > 0$ at $\sigma = 0$ and $\frac{\partial^2\Pi}{\partial\sigma^2} = -\frac{4r}{9} < 0$, it sets the optimal $\sigma^M = \frac{1}{4}$. □

Proof of Corollary 2. Observe that total consumer surplus on the monopolist is given by (1), $\frac{1+2\sigma}{3}$, which is strictly increasing in σ. Total consumer surplus with no recommender technology is $\frac{1}{2}$. And $\frac{1+2\sigma}{3} > (=)\frac{1}{2} \Leftrightarrow \sigma > (=)\frac{1}{4}$. □

Proof of Corollary 3. To see how a firm's profit changes with σ,

$$\frac{\partial\pi(\alpha_j)}{\partial\sigma} = \frac{2(1-r)(\alpha_j-\sigma)}{3(1-\sigma)^3}((\alpha_j-\sigma)(2+\sigma) + (1+2\sigma)(1-\sigma)$$

and $\frac{\partial\pi(\alpha_j)}{\partial\sigma} > 0 \Leftrightarrow \alpha_j > \hat{\alpha} \equiv \frac{(1+2\sigma)(1-\sigma)}{2+\sigma} + \sigma > \sigma$, and $\frac{\partial\pi(\alpha_j)}{\partial\sigma} = 0 \Leftrightarrow \alpha_j = \hat{\alpha}$.

To see that the cutoff $\hat{\alpha}$ is increasing in σ, $\frac{\partial\hat{\alpha}}{\partial\sigma} = \frac{5-4\sigma-\sigma^2}{(2+\sigma)^2} > 0$. □

Proof of Corollary 4. From Corollary 1, only firms with quality $\alpha_j > \sigma_I$ may be active on the incumbent. Notice that although firms are able to multi-home, firms with quality $\alpha_j > \sigma_I$ do not join the entrant in addition to the incumbent. This is because for all firms, $\pi_E(\alpha_j) = 0$. Hence, if a firm multi-homes and joins the entrant this induces more consumers to join the entrant, which draws demand away from the incumbent which reduces their own profits.

For firms, $\alpha_j \leq \sigma_I$, they are unable to be active on the incumbent. Although they make zero profit on the entrant, firms prefer selling to not and are therefore active only on the entrant. □

Proof of Proposition 2. A firm's profit function becomes $\pi(\alpha_j) = n\lambda(\alpha_j, p_j, \mathbf{p}_{\text{-}j}, \sigma)(p_j - e)$, and the profit maximizing price is $\frac{\alpha_j - \sigma + e}{2}$. Only firms with quality $\alpha_j > \sigma + e$ are profitable, and hence active, on the platform. Consumer utility, (1), and platform profits, (3), become $E[u] = \frac{1+2\sigma-e}{3}$ and $\Pi = \frac{1+2\sigma-e}{3} r \frac{1-\sigma+2e}{3}$. The platform's optimal recommender system design is $\sigma^* = \frac{1+5e}{4}$. □

Proof of Proposition 3. To see this, observe that $\Pi_I^R = (\frac{1+2\sigma_I}{3} - \frac{\sigma_I^2}{8}) r \frac{1-\sigma_I}{3}$, $\frac{\partial \Pi_I^R}{\partial \sigma_I} = \frac{r(8-38\sigma_I+9\sigma_I^2)}{72}$, > 0 when $\sigma_I = 0$ and $\frac{\partial^2 \Pi_I^R}{\partial \sigma_I^2} = \frac{r(9\sigma_I - 19)}{36}$, < 0 for all $\sigma_I \in [0,1]$. Therefore, there is only one feasible solution and $\sigma_I^R = \frac{2}{9}$. □

Proof of Proposition 4. I show that there exists a unique symmetric equilibrium. To see this, I first show that the equilibrium cannot be asymmetric. I then show the symmetric equilibrium.

Without loss of generality, suppose to a contradiction that there is an asymmetric equilibrium such that $\sigma_I > \sigma_E$. This implies $E[u_I] = \frac{1+2\sigma_I}{3} > \frac{1+2\sigma_E}{3} = E[u_E]$, and the mass of consumers joining either platform is $n_I = \frac{5-4\sigma_I-4\sigma_E^2+12\sigma_I}{18}$ and $n_E = \frac{(1+2\sigma_E)(5+2\sigma_E-4\sigma_I)}{18}$. The profit function of either platform becomes $\Pi_I = n_I r \frac{1-\sigma_I}{3}$ and $\Pi_E = n_E r \frac{1-\sigma_E}{3}$, which are concave in σ_I and σ_E respectively. The best response function of either platform is $\sigma_I = \frac{7+4\sigma_E+4\sigma_E^2}{24}$ and $\sigma_E = \frac{4\sigma_I + \sqrt{37-44\sigma_I+16\sigma_I^2} - 4}{6}$, since all other solutions lie outside the range of $\sigma_k \in [0,1]\ \forall k$. This solves $\sigma_I = \frac{5-3\sqrt{2}}{2}$ and $\sigma_E = \frac{5-3\sqrt{2}}{2}$. A contradiction.

Suppose instead the equilibrium is symmetric, such that $E[u_I] = \frac{1+2\sigma_I}{3}$, and $E[u_E] = \frac{1+\sigma_E}{3}$, then the mass of consumers joining either platform is $n_k = \frac{5+12\sigma_k-4\sigma_{\text{-}k}-4\sigma_{\text{-}k}^2}{18}$. The profit function of either platform becomes $\Pi_k = n_k r \frac{1-\sigma_k}{3}\ \forall k$, which is concave in σ_k. The best response function of platform k is $\sigma_k = \frac{7+4\sigma_{\text{-}k}+4\sigma_{\text{-}k}^2}{24}$. Then $\sigma_k = \frac{5-3\sqrt{2}}{2}$ is the only solution which satisfies the condition $\sigma_k \in (0,1)$. Note that $\Pi_k = r(\frac{3}{2} - \sqrt{2})$. □

Proof of Proposition 5. I search for an equilibrium in firm cutoff strategies. Recall that consumers join the platform which provides them with the highest expected utility less inertia, and purchase from the recommended firm.

Consider now the firms' problem. First observe that firms are unable to unilaterally affect demand with their prices. Therefore, a firm on either platform sets the price $\frac{\alpha_j - \sigma_k}{2}$. Now note that a firm either joins no, one , or both platforms. Recall from Lemma 1 that on a given platform higher quality firms obtain higher profits. This means that only firms with sufficiently high quality are able to make enough profits to join both platforms. Let the cutoff of firms that multi-home be $\tilde{\alpha}$ such that all firms with quality above $\tilde{\alpha}$ prefer to multi-home. Also from Lemma 1, firms with quality below σ_k are inactive on platform k therefore it must be that for any $\alpha_j \leq \min\{\sigma_I, \sigma_E\}$, these firms are inactive, and for any firm with quality $\alpha_j \in (\sigma_{\text{-}k}, \sigma_k]$ where $\sigma_{\text{-}k} < \sigma_k$ these firms are only active on the platform $\text{-}k$.

It remains to show which platform the firms with quality $\alpha_j \in (\sigma_k, \tilde{\alpha}]$ choose to join. When choosing which platform the join, the firms evaluate the following: $n_k(1-r)\frac{\alpha_j - \sigma_k}{\int_{h\in \mathbf{N}_k} \alpha_h - \sigma_k \; d\alpha_h}\frac{\alpha_j - \sigma_k}{2}$ selecting the platform which provides it with the highest profit. Without loss of generality, suppose that $\sigma_k > \sigma_{\text{-}k}$ and suppose there is a cutoff firm $\underline{\alpha} \geq \sigma_k$ such that all firms above join the incumbent and those below do not. Since the profits of the incumbent is increasing in α, such firm must weakly prefer the incumbent,

$$n_k \frac{\underline{\alpha} - \sigma_k}{\int_{\underline{\alpha}}^1 \alpha_h - \sigma_k \; d\alpha_h} \frac{\underline{\alpha} - \sigma_k}{2} \geq n_{\text{-}k} \frac{\underline{\alpha} - \sigma_{\text{-}k}}{\int_{\tilde{\alpha}}^1 \alpha_h - \sigma_{\text{-}k} \; d\alpha_h + \int_{\sigma_{\text{-}k}}^{\underline{\alpha}} \alpha_h - \sigma_{\text{-}k} \; d\alpha_h} \frac{\underline{\alpha} - \sigma_{\text{-}k}}{2}$$

$$\Leftrightarrow n_k \frac{(\underline{\alpha} - \sigma_k)^2}{\int_{\underline{\alpha}}^1 \alpha_h - \sigma_k \; d\alpha_h} \geq n_{\text{-}k} \frac{(\underline{\alpha} - \sigma_{\text{-}k})^2}{\int_{\tilde{\alpha}}^1 \alpha_h - \sigma_{\text{-}k} \; d\alpha_h + \int_{\sigma_{\text{-}k}}^{\underline{\alpha}} \alpha_h - \sigma_{\text{-}k} \; d\alpha_h}$$

$$\Leftrightarrow X(\underline{\alpha} - \sigma_k)^2 \geq (\underline{\alpha} - \sigma_{\text{-}k})^2, \tag{6}$$

where $X = \frac{n_k(\int_{\tilde{\alpha}}^1 \alpha_h - \sigma_{\text{-}k} \; d\alpha_h + \int_{\sigma_{\text{-}k}}^{\underline{\alpha}} \alpha_h - \sigma_{\text{-}k} \; d\alpha_h)}{n_{\text{-}k}(\int_{\underline{\alpha}}^1 \alpha_h - \sigma_k \; d\alpha_h)}$.

To show that the equilibrium in cutoff strategies exists, it must be that any firm with quality $\alpha_j > \underline{\alpha}$ does not prefer to switch from the incumbent to the entrant. To see this, consider the following: suppose to a contradiction there exists firms of some quality $\alpha'_j \in (\underline{\alpha}, \tilde{\alpha})$ which prefers to join the entrant instead. Note that such firm cannot unilaterally change the mass of consumers joining the platform nor how other firms join the platform. Hence, if (6) holds, it must be that the firm only switches if

$$(\alpha'_j - \sigma_{\text{-}k})^2 > (\alpha'_j - \sigma_k)^2 X \Leftrightarrow \frac{\alpha'_j - \sigma_{\text{-}k}}{\alpha'_j - \sigma_k} > \sqrt{X}.$$

Note from (6) that $\sqrt{X} \geq \frac{\underline{\alpha} - \sigma_{\text{-}k}}{\underline{\alpha} - \sigma_k}$, then it is only possible for $\frac{\alpha'_j - \sigma_{\text{-}k}}{\alpha'_j - \sigma_k} > \frac{\underline{\alpha} - \sigma_{\text{-}k}}{\underline{\alpha} - \sigma_k} \Leftrightarrow \frac{\underline{\alpha} - \sigma_k}{\alpha'_j - \sigma_k} > \frac{\underline{\alpha} - \sigma_{\text{-}k}}{\alpha'_j - \sigma_{\text{-}k}}$ which cannot be true because $\sigma_k > \sigma_{\text{-}k}$. Therefore these is no profitable deviation for firms of α'_j quality.

□

Proof of Proposition 6. First note that consumers always receive a positive utility from purchasing the product which is recommended by the platform. This means consumers always purchase in the last stage. The expected utility from joining either platform is given by (1). Given this, I search for a symmetric equilibrium in platform strategies where $\sigma_I = \sigma_E = \sigma^h$. To save on notation, I drop the platform subscripts. Recall from Lemma 1 that all firms with quality above σ^h will join both platforms. In any such symmetric equilibrium, it must be that the expected utility from either platform is the same, $E[u^h]$. Therefore, the initial mass of consumers joining either platform is $n_{int} = E[u^h](1 - \frac{E[u^h]}{2})$. Note this means consumers join the platform for which they have a lower inertia of joining first.

Upon joining the platform k, some firm with quality α' is recommended to the consumer with probability $\lambda(\alpha', p_k, \mathbf{p}_k, \sigma_k)$. Consumption utility from this interaction is $\alpha' - p_k$. Then the expected gains from search is $E[\Delta(\alpha')] = \int_{\alpha'}^1 (\alpha_h - p_h)\lambda(\alpha_h, p_h, \mathbf{p}_{\text{-}h}, \sigma_{\text{-}k}) \; d\alpha_h$. The consumer joins the second platform if $E[\Delta(\alpha')] > c_{i,\text{-}k}$. Hence, the probability a consumer searches is $E[\Delta(\alpha')]$. The mass of consumers who stop and purchase from firm α' on platform k is $n_{immediate}(\alpha', p, \mathbf{p}) = n_{int}\lambda(\alpha', p, \mathbf{p})(1 - E[\Delta(\alpha')])$.

Consumers who continue searching return to firm α' on platform k if the recommended product on platform -k has quality below α'. This occurs with probability $\Lambda(\alpha', p, \mathbf{p})$, where $\Lambda(\alpha', p, \mathbf{p}) = \int_{\sigma^h}^{\alpha'} \lambda(\alpha_h, p_h, \mathbf{p}_{\text{-}h})\ d\alpha_h$. Hence, the return demand is $n_{return}(\alpha', p, \mathbf{p}) = n_{int}\lambda(\alpha', p, \mathbf{p})E[\Delta(\alpha')]\Lambda(\alpha', p, \mathbf{p})$.

Finally, consider the new demand from platform -k. Since the platforms are symmetric, the mass of consumers initially joining the platforms are the same. Suppose a consumer is recommended some α'' on platform -k. Then their expected gains from search is $E[\Delta(\alpha'')]$ and the mass of consumers searching k after visiting $-k$ is $\int_{\sigma^h}^{1} n_{int}\lambda(\alpha_h, p_h, \mathbf{p}_{\text{-}h})E[\Delta(\alpha_h)]\ d\alpha_h$. On platform k, these consumers are matched with firm α' with probability $\lambda(\alpha', p, \mathbf{p})$. They choose to purchase from α' if $\Pr(\alpha' \geq \alpha'') = \Lambda(\alpha', p, \mathbf{p})$. Therefore, the mass of new consumers purchasing from α' on platform k is $n_{new}(\alpha', p, \mathbf{p}) = \int_{\sigma^h}^{1} n_{int}\lambda(\alpha_h, p_h, \mathbf{p}_{\text{-}h})E[\Delta(\alpha_h)]\ d\alpha_h \times \lambda(\alpha', p, \mathbf{p})\Lambda(\alpha', p, \mathbf{p})$.

Therefore the total mass of consumers engaging with firm α' on platform k is $n(\alpha', p, \mathbf{p}) = n_{immediate} + n_{return} + n_{new} =$

$$n_{int}\lambda(\alpha', p, \mathbf{p})\left(1 - E[\Delta(\alpha')](1 - \Lambda(\alpha', p, \mathbf{p})) + \Lambda(\alpha', p, \mathbf{p})\int_{\sigma^h}^{1} \lambda(\alpha_h, p_h, \mathbf{p}_{\text{-}h})E[\Delta(\alpha_h)]\ d\alpha_h\right).$$

Consider the firm α' pricing strategy, observe that its profit function is $n(\alpha', p, \mathbf{p})p(1 - r)$. Because firms are only able to unilaterally influence $\lambda(\alpha', p, \mathbf{p})$ through its numerator, a firm's optimal pricing strategy is the same as in the main model, $p^*_{j,k} = \frac{\alpha_j - \sigma_k}{2}$.

Finally, I turn to the platform's problem. In the symmetric equilibrium, platforms select $\sigma_k = \sigma^h$ to maximize $\Pi = r\int_{\sigma^h}^{1} n(\alpha_h, p_h, \mathbf{p}_{\text{-}h})p(\alpha_h)\ d\alpha_h$. Then applying the functional form of λ and accounting for prices,

$$\lambda(\alpha_j) = \frac{2(\alpha_j - \sigma^h)}{(1 - \sigma^h)^2}$$

$$\Lambda(\alpha_j) = \frac{(\alpha_j - \sigma^h)^2}{(1 - \sigma^h)^2}$$

$$E[\Delta(\alpha_j)] = \frac{(1 - \alpha_j)(1 + \alpha_j + \alpha_j^2 - 3\sigma^{h2})}{3(1 - \sigma^h)^2}$$

$$n_{int} = \frac{1 + 2\sigma^h}{3}(1 - \frac{1 + 2\sigma^h}{6}).$$

Therefore, the platform's problem evaluates to become $\frac{(1-\sigma^h)(5-2\sigma^h)(1+2\sigma)(4319+181\sigma^h)}{226800}$, and $\sigma^h = 0.144$. which is a local maxima with the relevant range of $\sigma \in [0, 1)$. □

B Online Appendix

B.1 Transparency and public education

The main analysis assumes consumers fully understand the equilibrium implications of how platforms design recommender systems. However, given the complexity of recommender systems, there are concerns that consumers may not fully understand its implications. I model such naive consumers as consumers who may observe they are receiving useful recommendations from the platform but do not anticipate how firms adjust prices in response to the platform's recommender system. In other words, while a platform may select some $\sigma \neq 0$ and firms may price their products in response to this design, naive consumers fail to recognize how firms account for σ in their pricing strategy, and over anticipate firm exit.

Recall that consumers join the platform based on their expected utility, such that are unable to unilaterally affect the mass of consumers joining the platform. Hence a firm's decision to be active and its price is independent of consumers decision to join the platform. Therefore, firms adopt the same pricing strategy regardless of consumers naivete, $p_j^* = \frac{\alpha_j - \sigma}{2}$ and there is a unique cutoff $\bar{\alpha} = \sigma$ such that only firms with quality above the cutoff are active on the platform (Corollary 1).

Naifs failing to anticipate how σ affects prices, means they believe each firm sets $p_j^N = \frac{\alpha_j}{2}$, and expect consumption surplus of $\frac{\alpha_j}{2}$ from each transaction. They anticipate to be matched to firms following

$$\lambda(\alpha_j, p_j^N, \mathbf{p}_{-j}^N, \sigma) = \begin{cases} \frac{\alpha_j - p_j^N - \sigma}{\int_{h \in \mathbf{N}} \alpha_h - p_h^N - \sigma \; d\alpha_h} & \text{if } \alpha_j - p_j^N - \sigma \geq 0 \\ 0 & \text{otherwise.} \end{cases}$$

Therefore, they believe firms are active only if $\alpha_j > 2\sigma$. And naifs expected utility from the platform is $\int_{2\sigma}^{1} \frac{\alpha_j - 2\sigma}{\int_{2\sigma}^{1} \alpha_h - 2\sigma \; d\alpha_h} \frac{\alpha_j}{2} \; d\alpha_j$, the mass of naifs joining the platform is $\frac{1+\sigma}{3}$.

Corollary 5. *Naifs' decision to join a platform differ from non-naifs in two ways: (i) they expect the consumption utility of $\alpha_j - p_j^N = \frac{\alpha_j}{2}$ from firm α_j; (ii) they overestimate the amount of screening, and believe only firms with $\alpha_j > 2\sigma$ are active.*

Proof of Corollary 5. Naifs' expected utility is $E[u^N] = \int_{h \in \mathbf{N}^N} \lambda^N(\alpha_h)(\alpha_h - p^N(\alpha_h)) \; d\alpha_h$. Effect (i) is immediate as they believe they receive $\alpha_j - \frac{\alpha_j}{2} = \frac{\alpha_j}{2}$ from a transaction with firms of quality α_j. To see effect (ii) consider the condition for firm exit. Firms exit if (a) they have to set negative prices, or (b) they receive no demand. Since naifs believe $p^N = \frac{\alpha_j}{2} > 0$, they do not anticipate firm exit due to negative prices. Firms receive demand based on $\lambda(\alpha_j)$, this means naifs believe firms become inactive if $\frac{\alpha_j}{2} - \sigma < 0 \Leftrightarrow \alpha_j < 2\sigma$. Therefore, $n^N = E[u^N] = \frac{1+\sigma}{3}$. □

The first effect in Corollary 5 shows how naifs, failing to account for how recommender systems more informative of value-for-money can drive price competition, anticipate firms set higher prices. Thus, conditional on interacting with a particular firm, consumers expect less value. The second effect in Corollary 5 discusses how naive consumers overestimate the degree of screening which occurs. Because firms are only recommended to consumers if $\alpha_j - p_j^N - \sigma > 0 \Leftrightarrow \alpha_j > 2\sigma$, consumers overestimate the quality of firms on the platform (recall from Corollary

1 firms join if $\alpha_j > \sigma$). This second effect dominates and, in expectation, naifs are more willing to join the platform.

Proposition 7. *There exists a unique subgame perfect Nash equilibrium where a monopolist platform facing naive consumers sets* $\sigma^N = 0$.

Proof of Proposition 7. To see this, observe that the mass of consumers joining the platform is $\frac{1+\sigma}{3}$. The platforms and firms correctly anticipate firm's strategy and all firms with quality $\alpha_j > \sigma$ join the platform. Thus the platform's profit function is $\Pi = r\int_\sigma^1 \frac{1+\sigma}{3}\frac{\alpha_j-\sigma}{\int_\sigma^1 \alpha_h - \sigma\, d\alpha_h}\frac{\alpha_j-\sigma}{2}\, d\alpha_j = r\frac{1+\sigma}{3}\frac{1-\sigma}{3}$. Then taking the first derivative with respect to σ, $\frac{-2\sigma}{9} < 0$ indicating that the platform prefers $\sigma = 0$. □

For some intuition, first notice that the firm optimal strategy is independent of consumer naivete and the platform's per-transaction revenue is decreasing in σ. Then observe that naifs are inherently more willing to join the platform, the mass of naifs joining the platform is less elastic than non-naifs. In other words, a more informative recommender system improves demand from naive consumers by a smaller amount. This translates to a smaller benefit to platforms. Therefore, it is immediate to see that a platform prefers less informative recommender systems when it faces naive consumers.

Observe that platform's profit when consumers are naive is $\frac{r}{9}$, which is lower than when consumers are not naive, $\frac{r}{8}$. Further, recall from Corollary 2, consumer surplus improves when recommender systems are more informative, and the recommender system has to be sufficiently informative for consumers to be as well off as no recommender system. Hence, when consumers are naive, their overconfidence in the recommender system can lead to worse surplus outcomes than no recommender systems.

B.2 No free returns

I show the effects of consumers not having free returns by relaxing the assumption that firms must offer a positive utility to get the attention of consumers. Instead, consumers have a probability of engaging with all firms, this probability is increasing in the value-for-money the firms offer and even those with negative value-for-money have a positive probability engaging with consumers. To capture this, let

$$\lambda(\alpha_j, p_j, \mathbf{p}_{-j}, \sigma) = \frac{\alpha_j - p_j - \sigma + \overline{u}}{\int_{h\in\mathbf{N}} \alpha_h - p_h - \sigma + \overline{u}\, d\alpha_h}$$

where the additional $\overline{u}$ is the highest utility consumers can get from a particular firm in equilibrium. This allows all firms to have at least some positive demand. Recall then that some mass of consumers choose to join the platform and firms are unable to unilaterally influence this mass of consumers. The firms maximize their profits

$$(1-r)n\frac{\alpha_j - p_j - \sigma + \overline{u}}{\int_{h\in\mathbf{N}} \alpha_h - p_h - \sigma + \overline{u}\, d\alpha_h}p_j$$

by setting the price $\frac{\alpha-\sigma+\overline{u}}{2}$, rewriting firms profit function,

$$(1-r)n\frac{(\alpha_j-\sigma+\overline{u})^2}{2\int_{h\in\mathbf{N}}\alpha_h-\sigma+\overline{u}\ d\alpha_h}.$$

Observe that the firms profits are increasing in α_j and note that a firm is only active if $\alpha_j-\sigma+\overline{u}>0$. Further, consumption utility from α_j is $\alpha_j-p_j=\frac{\alpha_j+\sigma-\overline{u}}{2}$ which is increasing in α. Therefore, $\overline{u}\equiv\frac{1+\sigma}{3}$, the equilibrium utility received from the highest quality firm. I now check which firms are active at a given σ. Firms which are active require $\alpha_j-\sigma+\overline{u}>0\Leftrightarrow\alpha_j>\frac{2\sigma-1}{3}$. Therefore all firms are active unless $\sigma>\frac{1}{2}$.

Suppose first that $\sigma\leq\frac{1}{2}$ such that all firms are active. Then consumer surplus and the mass of consumers joining the platform evaluates to $n=\frac{2+4\sigma-4\sigma^2}{15-12\sigma}$. The firm's profit function becomes $\pi(\alpha_j)=(1-r)n\frac{(1+3\alpha_j-2\sigma)^2}{3(5-4\sigma)}$. The platform's profit function is $r\frac{2+4\sigma-4\sigma^2}{15-12\sigma}\frac{7-10\sigma+4\sigma^2}{15-12\sigma}$, which is strictly increasing over $\sigma\in[0,\frac{1}{2}]$. Therefore, it can never be optimal for the platform to set such a σ.

Now suppose otherwise, that $\sigma>\frac{1}{2}$. The mass of consumers joining the platform and the profits of a firm with quality α_j are

$$n=\frac{1+4\sigma}{9}$$
$$\pi(\alpha_j)=(1-r)\frac{1+4\sigma}{9}\frac{(1+3\alpha_j-2\sigma)^2}{4(2-\sigma)^2}.$$

This means the platform's profit function is

$$r\frac{1+4\sigma}{9}\frac{2(2-\sigma)}{9}$$

and the profit maximizing level of σ is $\frac{7}{8}$. As before, I recover the standard two-sided platform arguments that the platform is balancing elasticities across both sides of the market. Importantly, in this scenario the platform also prefers only positive σ, recommender systems that are more informative of value-for-money.

B.3 Uninformative recommendations and distributional assumptions

The main model restricts $\sigma\in\mathbb{R}_+$ such that recommender systems are at least as informative as value-for-money. Relaxing this assumption, allow $\sigma\in\mathbb{R}$. Further, to understand how consumer inertia can play a role in the platform's decision, relax the assumption that $c_i\sim U[0,1]$ and allow this to follow some generic distribution, T with support $[0,1]$. Lemma 8 addresses the question of when a monopolist platform may prefer recommendations less informative than value-for-money.

Proposition 8. *A monopolist platform prefers recommendations which are more informative than value-for-money unless the distribution of consumer inertia is too 'bottom-heavy'. In the special case where T is uniform, a monopolist always prefers recommendations which are more informative than value-for-money.*

The intuition is simple, suppose consumer inertia is bottom-heavy, that is most consumers have low inertia. Then a platform improving the informativeness of its recommender system is only able to attract marginally more consumers. However, recall more informative recommender systems lead firms to compete more aggressively in prices, which lowers the platform's per-transaction revenue. Hence, if the platform is only able to attract marginally more consumers, it may instead prefer uninformative recommender systems.

Proof of Proposition 8. I first consider the special case where T is uniform $[0,1]$. Observe from (4) that if $\sigma < 0$ consumers only purchase from a firm if $\alpha_j + \sigma > 0$. Otherwise, consumers may purchase and return the product, which is equivalent to zero demand. To ensure there is at least some firm where consumers purchase, it must be $\sigma > -1$. This also implies that only firms with $\alpha_j > -\sigma$ are active on the platform. Next observe that firms are only recommended to consumers with positive probability if $\alpha_j - \sigma > 0$. To ensure there is at least some firm which is recommended to consumers, it must be $\sigma < 1$. Turning to the firm problem, firms join the platform as long as they make positive profit. There is no direct sales channel or outside option. Firms are unable to individually influence platform demand, n. To maximize their profits, firms set $p^* = \frac{\alpha_j - \sigma}{2}$. This means firms want to be active whenever $\alpha_j > \sigma$. As a result, if $\sigma < 0$, all firms want to be active in the market, but only those with $\alpha_j > -\sigma$ make sales. Now consider a platform strategy. Note that if $\sigma \geq 0$, I recover the result in the main model. Suppose the platform sets $\sigma < 0$. Then $E[u] = \frac{1-\sigma-2\sigma^2}{3(1-3\sigma)}$. The platform's profit function is $\Pi = \frac{1-\sigma-2\sigma^2}{3(1-3\sigma)} r \frac{1-4\sigma+7\sigma^2}{3(1-3\sigma)}$. This is strictly increasing in σ, $\frac{\partial \Pi}{\partial \sigma} = \frac{1+3\sigma+3\sigma^2-59\sigma^3+84\sigma^4}{9(1-3\sigma)^3} > 0 \; \forall \sigma \in (-1, 0)$. Therefore, $\sigma < 0$ cannot be an equilibrium.

Now consider the case where consumer inertia follows a generic distribution T and let t represent its PDF.

Solving the game by backward induction, recall that consumers form expected utility following (1) and firms set prices $\frac{\alpha_j - \sigma}{2}$, this is true for all $\sigma \in [-1, 1]$. Then suppose $\sigma < 0$. Consumers expected utility is $\frac{1-\sigma-2\sigma^2}{3(1-3\sigma)}$. The mass of consumers joining the platform is $T(\frac{1-\sigma-2\sigma^2}{3(1-3\sigma)})$, and since $t > 0$ and $\frac{1-\sigma-2\sigma^2}{3(1-3\sigma)}$ is increasing in σ, it must be that the mass of consumers joining the platform is increasing in σ. The platform's profit function is now $\Pi = rT(\frac{1-\sigma-2\sigma^2}{3(1-3\sigma)}) \frac{1-4\sigma+7\sigma^2}{3(1-3\sigma)}$. Then $\frac{\partial \Pi}{\partial \sigma} = rt(\cdot) \frac{2(1-2\sigma+3\sigma^2)}{3(1-3\sigma)^2} \frac{1-4\sigma+7\sigma^2}{3(1-3\sigma)} - \frac{rT(\cdot)(1-14\sigma+21\sigma^2)}{3(1-3\sigma)^2}$. This is positive as long as t is sufficiently large. Then considering the case where $\sigma > 0$, we know the platform's profit function is $\Pi = rT(\frac{1+2\sigma}{3}) \frac{1-\sigma}{3}$, and $\frac{\partial \Pi}{\partial \sigma} = rt(\cdot) \frac{2}{3} \frac{1-\sigma}{3} - \frac{rT(\cdot)}{3}$. Evaluating this at $\sigma = 0$, we have $rt(\frac{1}{3}) \frac{2}{9} - \frac{rT(\frac{1}{3})}{3}$, which is positive if t is sufficiently large. In other words, that the firm can attract sufficiently many consumers following an increase in σ, it is willing to make its recommender system at least as informative as value-for-money. The distribution of consumers cannot be too 'bottom-heavy'.

□

B.4 General recommender function

To relax the contest success function that represents the recommender system, observing that an increase in σ is identical to a right shift in the distribution of consumer utility. This is akin to a first order stochastic dominance. Hence, allow a general recommender technology which depends on value-for-money. Then, without loss, consider a recommender technology $q(\alpha_j, p_j)$ which first order stochastic dominates another recommender technology $l(\alpha_j, p_j)$.

Proposition 9. *A monopolist platform prefers q to l if and only if its per-transaction revenue using q is sufficiently high,* (7) *holds. This per-transaction revenue can be lower than that of l. When consumers are naive, the monopolist platform is more likely (compared to before) to prefer q to l if and only if $E_q[\alpha_j - p_j^*] > E_q[\alpha_j - p_j^l]$.*

If the recommender system is sufficiently informative of utility, then per-transaction revenues can be made up for by higher volume of sales.

Proof of Proposition 9. Consider the following recommender systems $q(\alpha_j, p_j)$ and $l(\alpha_j, p_j)$ where both functions are weakly increasing in consumption utility, $\alpha_j - p_j$. In other words, they are weakly increasing in the first argument, quality, and weakly decreasing in the second, price. The functions have respective CDFs Q and L and without loss of generality, suppose Q first order stochastic dominates L such that $E_q[\alpha_j - p_j] \geq E_l[\alpha_j - p_j]$ for every α_j with strict inequality for at least some α_j. Recall consumers have a uniformly distributed inertia of joining the platform. Then the profit function of any firm on the platform adopting the recommender system $k \in \{q, l\}$ is $\int_0^1 k(\alpha_h, p_h)u(\alpha_h, p_h)\, d\alpha_h\, k(\alpha_j, p_j)p_j(1-r)$. Note that because the recommender functions can possibly assign a firm with quality α_j to receive a recommendation with probability 0, this is equivalent to saying that the integral is over all firm qualities, rather than the set of firms N. Following the logic that an individual firm is unable to unilaterally influence consumer's decision to join the platform, this means a firm's profit maximizing price is $p_j^* = -\frac{k(\alpha_j, p_j^*)}{k_2'(\alpha_j, p_j^*)}$. Then the platform's profit function is $\Pi = -r\int_0^1 k(\alpha_h, p_h^*)(\alpha_h + \frac{k(\alpha_h, p_h^*)}{k_2'(\alpha_h, p_h^*)})\, d\alpha_h \int_0^1 \frac{(k(\alpha_j, p_j^*))^2}{k_2'(\alpha_j, p_j^*)}\, d\alpha_j$. Note that $\int_0^1 k(\alpha_h, p_h^*)(\alpha_h + \frac{k(\alpha_h, p_h^*)}{k_2'(\alpha_h, p_h^*)})\, d\alpha_h = E_k[\alpha_j - p_j^*]$. Then the recommender system q is preferred to l if

$$-rE_q[\alpha_j - p_j^*]\int_0^1 \frac{(q(\alpha_h, p_h^*))^2}{q_2'(\alpha_h, p_h^*)}\, d\alpha_h > -rE_l[\alpha_j - p_j^*]\int_0^1 \frac{(l(\alpha_h, p_h^*))^2}{l_2'(\alpha_h, p_h^*)}\, d\alpha_h$$

$$\Leftrightarrow -\int_0^1 \frac{(q(\alpha_h, p_h^*))^2}{q_2'(\alpha_h, p_h^*)}\, d\alpha_h > -\int_0^1 \frac{(l(\alpha_h, p_h^*))^2}{l_2'(\alpha_h, p_h^*)}\, d\alpha_h \frac{E_l[\alpha_j - p_j^*]}{E_q[\alpha_j - p_j^*]}, \tag{7}$$

where $\frac{E_l[\alpha_j - p_j^*]}{E_q[\alpha_j - p_j^*]} \in (0, 1)$ and $-\int_0^1 \frac{(k(\alpha_j, p_j^*))^2}{k_2'(\alpha_j, p_j^*)}\, d\alpha_j$ is the average per-transaction revenue. Hence, if the average per-transaction revenue following q is sufficiently large (and need not be larger than l), the platform prefers q. Note it is possible for the per-transaction revenue of q to be less than l and the platform would still prefer q because more consumers join the platform if the recommender function sufficiently favors products which provide higher value-for-money.

Now, allow consumers to be naive such that they do not correctly anticipate the effect that the change in recommender technology has on firms pricing strategy.

Suppose, without loss of generality, that consumers believe firms pricing strategy always follows the recommender system l. Then the profit function of firms when the recommender system is l are $\int_0^1 l(\alpha_h, p_h)u(\alpha_h, p_h)\, d\alpha_h\, l(\alpha_j, p_j)p_j(1-r)$ and their corresponding pricing strategy are $p_j^l = -\frac{l(\alpha_j, p_j^l)}{l_2'(\alpha_j, p_j^l)}$. The platform's profit function is $\Pi^l = -r\int_0^1 l(\alpha_h, p_h^l)(\alpha_h + \frac{l(\alpha_h, p_h^l)}{l_2'(\alpha_h, p_h^l)})\, d\alpha_h \int_0^1 \frac{(l(\alpha_j, p_j^l))^2}{l_2'(\alpha_j, p_j^l)}\, d\alpha_j$.

When the recommender system is q, because consumers are naive, $n^q = \int_0^1 q(\alpha_h, p_h^l)u(\alpha_h, p_h^l)\, d\alpha_h$. Hence, the profit function of firms are

$\int_0^1 q(\alpha_h, p_h^l)u(\alpha_h, p_h^l)\ d\alpha_h\, q(\alpha_j, p_j)p_j(1-r)$. However, because firms cannot unilaterally influence consumer's decision to join the platform, their profit maximizing price is $p_j^q = -\frac{q(\alpha_j, p_j^q)}{q_2'(\alpha_j, p_j^q)}$. The platform's profit function is now $\Pi^q = -r\int_0^1 q(\alpha_h, p_h^l)(\alpha_h + \frac{l(\alpha_h, p_h^l)}{l_2'(\alpha_h, p_h^l)})\ d\alpha_h \int_0^1 \frac{(q(\alpha_j, p_j^q))^2}{q_2'(\alpha_j, p_j^q)}\ d\alpha_j$.

Then the recommender system q is preferred to l if

$$-rE_q[\alpha_j - p_j^l]\int_0^1 \frac{(q(\alpha_h, p_h^q))^2}{q_2'(\alpha_h, p_h^q)}\ d\alpha_h > -rE_l[\alpha_j - p_j^l]\int_0^1 \frac{(l(\alpha_h, p_h^l))^2}{l_2'(\alpha_h, p_h^l)}\ d\alpha_h$$

$$\Leftrightarrow -\int_0^1 \frac{(q(\alpha_h, p_h^q))^2}{q_2'(\alpha_h, p_h^q)}\ d\alpha_h > -\int_0^1 \frac{(l(\alpha_h, p_h^l))^2}{l_2'(\alpha_h, p_h^l)}\ d\alpha_h \frac{E_l[\alpha_j - p_j^l]}{E_q[\alpha_j - p_j^l]}.$$

In other words, if $E_q[\alpha_j - p_j^*] > E_q[\alpha_j - p_j^l]$ then the platform is likely to prefer recommender system q to l when compared to non-naive consumers.

□

B.5 Asymmetric consumer inertia

From the base model, allow for the following modification: Suppose consumer inertia for each platform is drawn from different distributions. For tractability, let the inertia of the incumbent platform $c_{i,I}$ be drawn from a uniform distribution R with support $[0, 1]$ and the inertia of the entrant $c_{i,E}$ be drawn from a triangular T distribution with support $[0, 1]$ with peak 1. Proposition 10 summarizes the results of this modification.

Proposition 10. *There exists a unique equilibrium where* $\sigma_E = 0.368 > \sigma_I = 0.0474$.

This shows that the platform facing higher consumer inertia prefers to design a more informative recommender system. Intuitively, this is because the entrant has to create more incentives for consumers to join the platform. Hence, this platform is more willing to give up more per-transaction revenue than the incumbent to attract consumers.

Proof of Proposition 10. The expected utility from joining either platform is $\frac{1+2\sigma_k}{3}\ \forall k \in \{I, C\}$. The mass of consumers joining either platform is given by

$$\begin{aligned} n_I &= \int_0^{E[u_E]} R(E[u_I] - E[u_E] + c_{i,E})t(c_{i,E})\ dc_{i,E} + R(E[u_I])(1 - T(E[u_E])) \\ &= \frac{26 - 3\sigma_E - 3\sigma_E^2 - \sigma_E^3 + 27\sigma_I}{81} \\ n_E &= \int_0^{E[u_I]} T(E[u_E] - E[u_I] + c_{i,I})r(c_{i,I})\ dc_{i,I} + T(E[u_E])(1 - R(E[u_I])) \\ &= \frac{7 + 9\sigma_E^2 - 3\sigma_I + \sigma_I^3 + 3\sigma_E(5 - 2\sigma_I - \sigma_I^2)}{81} \end{aligned}$$

Since the firms' pricing strategy is independent of the mass of consumers joining the platform, $p_{j,k}^* = \frac{\alpha_j - \sigma_k}{2}\ \forall k \in \{I, C\}$. And the per-transaction revenue for a platform k is $r\frac{1-\sigma_k}{3}$. Thus, on the incumbent

On the incumbent,

$$\Pi_I = r\frac{26 - 3\sigma_E - 3\sigma_E^2 - \sigma_E^3 + 27\sigma_I}{81}\frac{1 - \sigma_I}{3}$$

and it is immediate to see $\sigma_I = \frac{1+3\sigma_E+3\sigma_E^2+\sigma_E^3}{54}$ maximizes profits.

On the entrant,

$$\Pi_E = r\frac{7+9\sigma_E^2-3\sigma_I+\sigma_I^3+3\sigma_E(5-2\sigma_I-\sigma_I^2)}{81}\frac{1-\sigma_E}{3}$$

and $\sigma_E = \frac{2\sigma_I+\sigma_I^2-2+\sqrt{28-17\sigma_I-9\sigma_I^2+\sigma_I^3+\sigma_I^4}}{9}$ maximizes its profit. Solving for σ_I and σ_E, it is possible to obtain the numerical solution $\sigma_I = 0.0474$ and $\sigma_E = 0.368$.

□

B.6 Sequential equilibrium

Formally, from the model of competition, suppose, without loss of generality, that the entrant designs its recommender system before the incumbent.[16] Hence, the timing of the game follows: The entrant selects σ_E, the incumbent selects σ_I, firms decide which platform to join and sets its price on each platform, consumers choose which platform to join and make their consumption decision.

Proposition 11. *There exists a unique equilibrium where $\sigma_E = 0.311 < \sigma_I = 0.356 < \sigma^s \equiv \frac{5-3\sqrt{2}}{2}$ where the platforms make $\Pi_I = 0.0911r$ and $\Pi_E = 0.0866r$.*

This shows that the platforms makes more profits is they participate in a sequential manner and because consumer surplus is strictly increasing in both σ_E and σ_I they become worse-off when platforms decide on their recommender system sequentially.

Proof of Proposition 11. Following backward induction, note that consumers join the platform which give them the highest expected utility less inertia and always purchase from the recommended firm.

I now show that all firms with quality $\alpha_j > \sigma_k$ are active on platform k. On the platform k, any firm with quality larger than σ_k. Since firms face no cost of multi-homing and on the margin firms are unable to influence demand for a platform, the benefit from joining an additional platform is larger than the cost of doing so. Therefore, any firm with quality $\alpha_j > \sigma_k$ is active on the platform k.

Next, consider the strategies of the incumbent. Here consider two cases, $E[u_I] \geq E[u_E]$ and $E[u_E] > E[u_I]$. Since all firms join a platform if they are able to, $E[u_k] = \frac{1+2\sigma_k}{3}$, and the mass of consumers joining either platform is

$$n_k = \begin{cases} \frac{5+12\sigma_k-4\sigma_{\text{-}k}-4\sigma_{\text{-}k}^2}{18} & \text{if } \sigma_k \geq \sigma_{\text{-}k} \\ \frac{(1+2\sigma_k)(5+2\sigma_k-4\sigma_{\text{-}k})}{18} & \text{otherwise} \end{cases}$$

and the profit of the incumbent is

$$\Pi_I = \begin{cases} r\frac{(1-\sigma_I)(5+12\sigma_I-4\sigma_E-4\sigma_E^2)}{54} & \text{if } \sigma_I \geq \sigma_E \\ r\frac{(1-\sigma_I)(1+2\sigma_I)(5+2\sigma_I-4\sigma_E)}{54} & \text{otherwise.} \end{cases}$$

[16] This is without loss, one can alternatively choose to assign the incumbent to be more profitable, or more capacity for flexibility, or more ability to design better recommender systems, and hence moves second.

Then

$$\sigma_I = \begin{cases} \frac{7+4\sigma_E+4\sigma_E^2}{24} & \text{if } \sigma_I \geq \sigma_E \\ \frac{4\sigma_E+\sqrt{37-44\sigma_E+16\sigma_E^2}-4}{6} & \text{otherwise} \end{cases}$$

solves the incumbent's problem.

Turning to the first stage of the game, the entrant maximizes its profit

$$\Pi_E = \begin{cases} r\frac{(1+2\sigma_E)(1-\sigma_E)(23+8\sigma_E-4\sigma_E^2)}{324} & \text{if } \sigma_I \geq \sigma_E \\ r\frac{(1-\sigma_E)(8-16\sigma_E^2+\sqrt{37-44\sigma_E+16\sigma_E^2}+4\sigma_E(20-\sqrt{37-44\sigma_E+16\sigma_E^2}))}{243} & \text{otherwise.} \end{cases}$$

Then in equilibrium, σ_E and σ_I are

$$\sigma_E = \begin{cases} 0.3113 & \text{if } \sigma_I \geq \sigma_E \\ 0.3583 & \text{otherwise,} \end{cases}$$

$$\sigma_I = \begin{cases} 0.3597 & \text{if } \sigma_I \geq \sigma_E \\ 0.3765 & \text{otherwise.} \end{cases}$$

Note that if $\sigma_E > \sigma_I$, then there is a contradiction. Therefore, in equilibrium $\sigma_E = 0.311$ and $\sigma_I = 0.356$, which satisfy $\sigma_k \in (0,1)$. The profits of the platforms are $\Pi_E = 0.0866r$ and $\Pi_I = 0.0911r$.

□