Retailer-led Marketplaces*

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Abstract

We study the incentives of an online retailer to open up its storefront by operating a marketplace for third party sellers. The marketplace can expand the product assortment offered on the storefront but exposes the retailer to competition. We develop a novel model of marketplace entry and price competition to analyze the interactions that arise, where third party sellers benefit from private information about the potential demand for some products but the retailer has two distinct advantages: it charges an ad-valorem fee on the sales of marketplace sellers and has a captive segment of consumers who are inattentive or loyal to the retailer. Our analysis reveals various non-trivial implications of fees in online marketplaces. On the one hand, lower fees increase the profitability of seller entry into products that are a priori unprofitable for the retailer to supply, and this provides an opportunity for the retailer to learn about the demand for these products. On the other hand, higher fees soften price competition between the retailer and sellers when they both supply the same product. We examine the implications and anticompetitive effects of marketplace fees, explain why the properties of retailer-led marketplaces contribute to soften price competition, and show how the retailer manages his own product entry choices and those of third party sellers to maximize marketplace profits.

Keywords: Observational Learning, Entry, Price competition, Marketplace Management, Assortment Depth

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1 Introduction

The rise of retailer-led marketplaces operated by dominant online retailers such as Amazon or Jingdong,[1] and more recently adopted by traditional brick-and-mortar retailers such as Walmart or Carrefour, have transformed the retail landscape over the last two decades. These retailers initially started as resellers, purchasing products from suppliers and selling them to consumers, but chose to open their online storefronts to third party sellers by allowing them to list product offers and sell to their customer base. In doing so, they operate simultaneously as a retailer and as a marketplace host, providing a platform for their potential competitors to sell in exchange for charging fees on their sales revenues. These retailer-led marketplaces already account for a substantial share of online retail sales and their growth continues apace, so understanding the drivers of their emergence and the interactions they generate between all the parties involved is a key question for the recent evolution of retail.

Retailer-led marketplaces have several potential benefits for participants. For consumers, they provide access to a deep product assortment that includes the products supplied by the leading retailer as well as all those supplied by third party sellers. The opportunity for several firms to supply the same product and thereby compete for consumer demand also disciplines prices on the storefront. Consumers can also expect an adequate level of service, given that the leading retailer monitors storefront activity and sets baseline service requirements for third party sellers to meet. For third party sellers, the storefront provides access to the leading retailer's customer base. It also provides the infrastructure required to facilitate and process retail transactions, including order and payment processing, and in some cases warehousing services for the storage of merchandise, order picking, delivery logistics, and even returns processing. For many sellers, these benefits are enough to compensate for marketplace fees, service requirements, and competition on the storefront.

The benefits for the retailer leading the marketplace are not so obvious. Marketplaces enable these retailers to bring additional products to their storefronts and to collect marketplace fees from third party sellers. Both effects can be substantial. For example, Amazon.com listed 353 million products as of May 2016, out of which only 12 million were sold by Amazon directly. And marketplace sales represented 68% of total sales on Amazon's storefront as of 2018 (this includes third party sales of the products also sold by Amazon).[2] The size of the marketplace, however, does not explain its profitability for the retailer. The supply of previously unavailable products on the storefront would only seem desirable in so far as they are successful and the retailer himself could not supply them. And the arrival of these third party sellers to the storefront also brings competition, particularly for the retailer who would otherwise enjoy a monopoly within the confines of its own storefront.[3] Moreover, given the economies of scale

[1] Jingdong is is one of the two main B2C online retailers in China by transaction volume and revenue.

[2] See 'Watch out, retailers. This is just how big Amazon is becoming,' CNBC, July 13th 2018, https://www.cnbc.com/2018/07/12/amazon-to-take-almost-50-percent-of-us-e-commerce-market-by-years-end.html. See also 'How Many Products Does Amazon Carry?' Retail Touchpoints, https://www.retailtouchpoints.com/resources/type/infographics/how-many-products-does-amazon-carry.

[3] To the extent the retailer has some market power, the within-storefront market power can translate outside of the storefront.

enjoyed by the retailer in the operation of its supply chains, online storefront, warehousing, and fulfillment logistics, it is likely that third party sellers exhibit weaker bargaining power vis-a-vis suppliers and are burdened by higher costs. So what can leading retailers achieve with a marketplace that they cannot do without?

In this paper, we present a novel model to explain the rationale driving retailer-led marketplaces and the implications for all participants.

Two observations inform our model. The knowledge about consumer demand is a fundamental challenge in retail, and the scale of this challenge grows with the size of the product assortment a retailer manages. In traditional brick-and-mortar, product assortment sizes are constrained by store footprint and shelf space. Stocking a low-demand product on the shelves can preclude stocking a more profitable and higher demand product, so retailers need to identify and supply the latter. For a brick-and-mortar retailer such as Walmart, this implies selecting and supplying 120-140 thousand different products in each store.[4] Walmart tackles this challenge by continuously monitoring and analyzing the performance of its stores and attempting to identify and respond to local demand conditions. In online retail, however, assortment sizes are no longer constrained by physical store footprints, and a storefront can serve a whole national market and beyond. For an online retailer capable of stocking millions of different products, selecting which ones to stock is a daunting challenge. While many popular products in high demand may not be difficult to identify, for example by monitoring the stocking choices of brick and mortar competitors, the information required to estimate the demand for lower-popularity products is unlikely to be available. And learning about consumer demand by experimenting with millions of products can be very costly. Yet if such information exists, it may well be dispersed across smaller sellers who are better informed than the retailer about their own product niches and areas of expertise.[5] A marketplace can therefore be an effective mechanism for the retailer to aggregate and acquire such information.

A second observation that informs our analysis is that competition on the storefront between a leading retailer and a third party seller is asymmetric. While firms compete on the storefront by quoting prices for the exact same product, this is not an instance of direct price competition due to two main factors. The first factor at play is that the retailer charges an ad-valorem fee on the competitor's sales, which means that he stands to profit even when losing sales to the other firm. And the second factor is that the retailer is likely to enjoy consumer loyalty given his flagship role running the storefront. This consumer loyalty is often explained by higher quality of service with respect to delivery, returns, and aftersales support. While the retailer sets minimum service requirements for third party sellers, these are unlikely to match those offered directly by the retailer. Loyalty may also be driven by consumer inattentiveness, given the retailer's ability to steer demand on its storefront when generating search results or

[4]Walmart reports that its discount stores stock on average 120000 items and its supercenters about 142000 different items. See 'Our Retail Divisions,' Walmart.com, https://corporate.walmart.com/newsroom/2005/01/06/our-retail-divisions

[5]For example, a small entrepreneurial seller may be the first to recognize the potential of a given toy to become a new bestseller, or an artisan trader may be best positioned to know about seasonal demand for traditional products in certain regions.

selecting the default vendor for each product.[6]

Based on the above observations, we build a model where there is a large number of products which differ in their popularity or demand volume. There is a monopolist (the leading retailer, "he") who operates a marketplace and makes choices about marketplace fees, which products to supply as a reseller, and what price to quote for each product. And there is a third party seller ("she") for each product who may be better informed than the monopolist about its popularity, and chooses whether to supply it on the storefront and what price to quote. Our model has two key stages where the monopolist and a third party seller interact. There is an entry game where both firms choose whether to supply or not each product, and there is a price competition game where firms price products they have both chosen to supply (in our setup, one can think of each product as a separate market). We also model two sales periods, such that first period outcomes can inform decisions in the second period. This is most relevant for the monopolist, who is less informed about the popularity of some products than the third party seller. First period entry choices and sales observed in the marketplace will enable the monopolist to learn about the popularity of some products.

Our model produces several insights into the mechanisms at play in retailer-led marketplaces. Our analysis of the pricing game reveals that both marketplace fees and consumer loyalty weaken the intensity of competition. Marketplace fees allow the monopolist to appropriate some of the profits generated by its competitor, so they reduce his incentives to undercut her price. Consumer loyalty implies that the monopolist can profit from his segment of captive consumers by charging a high price and selling only to them, so the larger the share of loyal consumers the stronger the incentives to target this segment instead of undercutting the competitor. These results underscore how price competition in retailer-led marketplaces differ from the benchmark case of Bertrand price competition. Even though both firms compete by setting prices for the exact same product, the key properties of these product markets contribute to reduce the intensity of competition between the leading retailer and third party sellers.

Our analysis of the entry game explains how the marketplace mechanism enables the monopolist to profit from the private information held by third party sellers. Operating a marketplace generates a fundamental tradeoff for the monopolist. The downside are lower profits due to competition, as the monopolist is better off supplying a product under monopoly rather than competing with third party sellers to supply it (or in some cases, ceding the product market to the third party). The marketplace implies that the monopolist becomes exposed to third party entry on products he is fully informed about and would choose to enter, which reduces the monopolist's profits. The upside is the opportunity to learn about the popularity of products the monopolist is not informed about as well as the marketplace fees generated from their

[6]For example, Amazon promotes some products in its search results (with badges such as *Amazon's Choice*) and selects a default vendor in the buy box or buy button for each product page. Clearly, these choices can steer consumers to some products and some vendors over others, and while some consumers (non-loyals) may be willing to exert the additional effort required to evaluate all available options, other consumers (loyals) may be happy to follow the default choices. Amazon does not disclose the exact factors and decision rules that determine which product listings or vendors are promoted, and recent reports suggest that Amazon's profits play an important role in doing so. See 'Amazon Changed Search Algorithm in Ways That Boost Its Own Products,' *The Wall Street Journal*, September 16th 2019.

sales. The marketplace ensures that some third party sellers enter and supply such products, and this increases the monopolist's profits. In some cases, after observing third party sales, the monopolist will choose to also enter and compete with the third party.

The optimal product entry choices of the monopolist depend on several factors. For high popularity products on which competition can be profitably sustained by both firms, the monopolist will choose to enter as soon as popularity information is available to him. In other cases, however, the monopolist will strategically choose not to enter and cede the product market to the third party seller. For products of intermediate popularity, even though competition can be sustained, the monopolist can reap higher profits through marketplace fees by allowing the third party to monopolize the product market. And for the case of products where the monopolist is uninformed but competition precludes entry by a third party seller, the monopolist is better off choosing not to enter even when competing would be the most profitable option. In these cases, the monopolist strategically commits not to act on the information revealed by third party sales. Thus maximizing profits from the marketplace requires the retailer to carefully manage product entry choices and to build a reputation not to be overly aggressive.

Marketplace fees are a key strategic choice for the monopolist, and affect both product entry choices and price competition. When setting the marketplace fee, the monopolist faces a tradeoff between the number of products supplied on the storefront and the profits generated on each of them. On the one hand, a lower marketplace fee ensures that entry is profitable for a third party seller even for the case of low-popularity products, thus increasing the number of products supplied on the storefront for which the monopolist has no information. On the other hand, a higher marketplace fee increases the profits generated by the monopolist in active product markets. Where the monopolist competes with a third party seller, it softens the intensity of competition. And where a third party seller monopolizes supply, it increases the profits appropriated by the monopolist. This anticompetitive effect of the marketplace fee implies that a higher fee is beneficial to some third party sellers, as it reduces the threat of entry by the monopolist and allows them to monopolize their product market. In general, the optimal marketplace fee will be lower when there is a large number of products the monopolist is uninformed about and which can be profitably supplied given their popularity and the cost structure of firms. Thus a low fee is also conducive to deep product assortment on the storefront.

1.1 Literature

Retailer-led marketplaces have emerged as an important phenomenon in online retail in the last two decades. The early literature on e-commerce focused on the opportunity for increased price competition to foster more efficient markets. Bakos (1997, 2000) formalized the argument and later expanded it by analyzing how a reduction in consumer search costs, enabled by e-commerce facilitating price and product comparisons across sellers, can increase price competition. The implications were tested in an early study by Brynjolfsson and Smith (2000) by analyzing the prices of homogeneous goods across brick-and-mortar and Internet retailers. They found that average prices for books and CDs were 9-16% lower on the Internet – even after accounting for handling fees, shipping costs, and sales taxes – though there was significant price dispersion across Internet retailers.

The findings in this early literature supported the view that the Internet is a more efficient channel than brick-and-mortar in terms of price levels and menu costs, consistent with increased price competition. While price dispersion was recognized to reflect retailer heterogeneity in terms of branding, awareness, and trust, the level of prices fueled an expectation that the Internet could become an efficient marketplace where consumers would shop across independent retailers. However, two decades later, this retailer heterogeneity has enabled dominant players to create, grow, and control their own marketplaces, to the extent that the largest one in the United States (Amazon) now accounts for almost half of online retail sales in the country. Understanding the strategic interactions that arise within these marketplaces is now key to understanding the market forces that are shaping online retail.

A retailer hosting a marketplace operates as a two-sided platform, intermediating between consumers on one side and marketplace sellers on the other. Our work therefore relates to the growing literature on multisided platforms pioneered by Rochet and Tirole (2003), Caillaud and Jullien (2003), and Armstrong (2006). In our case, the multisided platform intermediates retail transactions and creates value by reducing transaction costs for participants by providing a storefront, search functionality, payment clearing, reputation mechanisms, and policing marketplace rules. A novelty present in our model is the participation of the platform in one of the sides, by acting as another seller in the marketplace it operates. To the best of our knowledge, the opportunity for the platform to participate in one of the sides has not been explored in the literature, which has typically focused on scenarios where the platform as a distinct role to that of participants.Unlike this earlier literature, we consider a hybrid platform where the platform hosts other sellers via an agency model while simultaneously selling goods via the traditional resale model. This induces interest conflict that has been studied in somewhat different contexts.[7]

In related work, Hagiu and Wright (2015) study the firm's choice between operating as a reseller and operating as a marketplace (delegating supply to third party sellers). Their focus is on the asymmetries between the firm and potential marketplace sellers to execute the right marketing activities, internalize spillovers across products, or differences in marginal costs that render either the reselling or marketplace solution optimal. In contrast, we focus on the case where the main benefit of marketplace sellers is private information about the demand for products, which is revealed in the marketplace and can be exploited by the firm hosting it. Thus we show that a marketplace can be optimal even when firms are symmetric in their retail capabilities. Our analysis is also complementary in that we examine the competitive interactions that arise between firms when both models coexist simultaneously – when the firm hosting the marketplace also participates as a seller.

Zhu and Liu (2018) explore the empirical evidence on Amazon's entry choices across products supplied by third party sellers. Their work is closely related to ours as it examines the

[7] [10] study an intermediary that advises consumers while selling one of the two available products.

platform's choice to enter and compete with marketplace sellers. They show that Amazon enters a small subset of the third-party product space (approximately 3% over a ten month period), chooses to enter only successful products (those with high sales and/or better consumer reviews), and has limited impact on product prices though it benefits consumers through the lower shipping costs offered by Amazon.

Jiang, Jerath and Srinivasan (2011) analyze the strategic interaction that arises between a third-party seller operating on Amazon and Amazon itself due to the entry threat of the latter. Their analysis focuses on Amazon's ability to identify when the product supplied by the seller is in high-demand. If Amazon determines that a product is of high-demand and enters the product-market, it drives the third party's profit to zero and effectively replaces it as the sole seller for the product. However, Amazon observes sales volume for products supplied on its marketplace but not the precise effort exerted by sellers. One of the insights of their analysis is that third-party sellers may strategically choose to lower their effort on Amazon (negatively impacting their sales) to mitigate Amazon's entry threat. A seller supplying a high-demand product could exert a low level of effort (still complying with Amazon's baseline service requirements), and Amazon would be unable to determine whether the product is in high or low-demand. Moreover, due to this incentive for sellers to reduce their effort, Amazon may be better off when it can commit not to enter the product-markets of third-parties.

The focus of our work differs in several aspects. First, we incorporate the entry choice of third-party sellers into our model. Sellers are forward-looking and anticipate Amazon's entry threat and the impact this will have on their profits. Second, we model competition between Amazon and third-party sellers when both are active in a given product-market. We show that the advantage enjoyed by Amazon as the platform owner can soften competition intensity and allow third-party sellers to continue to derive some profit after its entry. This combination of elements implies that the focus of our exercise is on the implications for the product space rather than the efforts exerted by sellers. Our model explains the equilibrium depth of the assortment supplied on the platform and characterizes the supply configurations that arise across the assortment.

Our work also relates to the store-within-a-store phenomenon observed in brick-and-mortar retail, where retailers allow manufacturers to operate autonomous stores within their own stores. Examples include department stores allowing major cosmetic brands to run boutiques within their stores (e.g., Chanel, Estée Lauder) or electronics retailers hosting ministores managed by major technology manufacturers (e.g., Apple, Samsung). Jerath and Zhang (2010) analyze the retailer's decision when charging manufacturers a fixed fee (a periodic rent), and find that hosting these stores can maximize channel profit when the impact of double marginalization by the retailer is large and the resulting price competition is not too intense. The marketplace model we present in this paper is relevant to this problem when the retailer charges manufacturers an ad-valorem sales fee, a practice which is also observed in the retail industry. While the focus of our analysis is not on the factors examined above, our approach provides a new avenue to examine these retail channel arrangements.

2 The model

A monopoly retailer A purchases products from suppliers and resells them to consumers, and may choose to open a marketplace by allowing third party sellers to sell through its storefront. We refer to M as a monopolist ("he") due to the market power it accrues when controlling the marketplace, though this can expose it to competition with a third party seller ("she").

There is a unit mass of products indexed by $i \in [0, 1]$ that can be potentially sold to consumers. For each product i there is a unit mass of identical consumers who may want to purchase up to one unit of product i. All products are independent of each other, that is to say that demand for product i does not depend on price of any other product $j \neq i$. We assume that consumers' willingness to pay is the same for all the consumers, and is v^i for product i. This implies that the monopoly price is v^i .[8] Without loss, we index products in the order of increasing v^i, thus we will use v instead of i to refer to a product. The distribution of v has a well-behaved CDF $G(v)$.If the platform sells product v then it has to incur a marginal cost c_M per unit. The marginal cost is assumed to be the same for all products for simplicity. c_M captures the (unmodeled) per-unit price charged by the manufacturer or supplier of the product, as well as stocking, handling, and shipping costs incurred by the monopolist to supply each unit to consumers. If the product is also sold by a third-party seller T^v (see details below), the marginal cost of the third-party is c_T. We assume that $c_T \geq c_M$ in line with the intuition that a dominant platform can negotiate (weakly) better wholesale price, enjoys better economies of scale, etc.

There are two types of products. First, there are *mainstream* products which are in proportion θ. The platform knows of these products (unlike the next type) and can sell them through its storefront. For each such product there is one third-party seller T^v that is potentially able to sell i through the platform (subject to the terms set by the platform, as discussed below).

Second, there are *niche* products in proportion $1 - \theta$. M is initially unaware of these products, but the moment they are sold through its storefront by a third-party seller T_v, M can at no cost also start selling these products. As with mainstream products, there is one third-party seller per each such product. Whether the distribution of v depends on the product type (mainstream vs niche) will play an important role. We will consider two interesting cases, one where mainstream products are the highest v products, and the other where the distribution of v is independent of product type.

The monopolist can operate a marketplace by opening up its storefront, providing third party sellers with access to its consumer base in exchange for two-party tariff consisting of an ad-valorem fee f on their sales revenues and per unit fee t on units sold. As a result, if T_v becomes the sole supplier of product v on M's marketplace and charges price p_T^v she earns $((1 - f)p_T^v - c_T - t)$, and M earns a fee $fp_T^v + t$. If M and T both supply product v on the storefront, then they compete by simultaneously setting prices p_M and p_T^v. The monopolist

[8] As a result of this inelastic demand assumption the model is devoid of deadweight losses from price distortions due to market power and or taxation. This means that when M sets its fees, it does not worry about losing revenue due to shrinking demand. For the same reason, when we conduct welfare analysis, M's fees or lack of competition do not cause any welfare losses.

enjoys two advantages over T: it charges fee f on T's sales as described above, and it enjoys some degree of consumer loyalty. More specifically, a fraction λ of consumers prefers to purchase from M provided that $p_M \leq 1$. The remaining $1 - \lambda$ consumers purchase from the firm that sets the lowest price. λ captures all the advantages that the platform enjoys over third-party sellers. First, it has better reputation. Second, the platform can manipulate how various sellers are displayed to consumers, and may well do so in its favor. For now we will take λ as given, but will later analyze how M would want to change λ. For most of the analysis we assume that $\lambda > \frac{1}{e}$,which ensures that for any fees M prefers to compete for in market rather than let T monopolize it and collect fees.

The monopoly faces a capacity constraint k, such that if can only enter fraction k of all possible products. When $k = 0$, the monopolist is effectively unable to act as a retailer and thus derives profits solely from running the marketplace.[9] When $k = 1$, the monopolist is unconstrained and thus in principle could sell all products.

The timing of the game is as follows. In stage zero, M decides whether to open a marketplace and announces marketplace fees (f, t). After this, T^v decides whether to sell good v. Having observed T^v's decision, M decides to enter market v. For a niche product v, M can only enter if T^v has entered.[10] Once entry decisions are made, firms set prices in each product market they have entered, effectively competing in the product markets where both M and T are active, and consumers realize their purchasing decisions.

3 Price competition

We next solve the price competition game that arises between M and T in product markets where both firms enter and supply. The solution to this game identifies $\pi_M^d(v)$ and $\pi_T^d(v)$, the profits per market derived by firms under duopoly. These in turn pin down entry decisions for various markets. In the following section, we build on this solution to examine M's optimal marketplace fee.

Our price competition model is an asymmetric game where M benefits from a share λ of loyal consumers in the population and charges an ad-valorem fee f and unit tariff t on T's sales price. These two features of the problem have a substantial impact on the outcome of price competition. A Bertrand-equivalent outcome where one of the firms is driven out of the market and derives zero profits is a corner case, which only holds for certain parameter ranges in the form of a pure strategy equilibrium. In general, the outcome of the game is characterized by a mixed strategy equilibrium where both firms sustain positive market share and generate positive profits.

There are two points to note about the solution we derive below. We apply the following equilibrium selection criteria. Whenever multiple payoff equivalent equilibria coexist, we assume

[9] The model, thus, encompasses pure marketplaces like eBay.

[10] We do not model explicitly any timing of marketplace interactions but one can think of T entering in period 1, and M following thereafter, where we discard first-period profits assuming that they are not relevant compared to the rest of a product's lifespan.

that the monopolist prefers to supply himself rather than let the third party supply. This rules out an equilibrium where M shares or cedes the product market to T for the specific case where $c_T = c_M = 1 - f - t$, simplifying the exposition.

We start by characterizing pure strategy equilibria.

Proposition 1. *If $\frac{c_T+t}{1-f} \geq v \geq c_M$ there is a pure strategy equilibrium where A sets $p_M = v$ and T sets $p_T^* > v$, generating profits $\pi_M^d(v) = v - c_M$ and $\pi_T^d(v) = 0$. If $v < c_M$, no firm sells the good.*

Proof. Consider the case $\frac{c_T+t}{1-f} > v$. Supplying at any price $p_T \leq v$ generates negative profit for T, though A can supply profitably at price $p_M = v$. For any prices such that $p_T \leq p_M < v$, T would deviate upwards to $p_T > p_M$. So it must be the case that $p_M \leq v < p_T$, and then $p_M = v$ as otherwise A would deviate upwards. Therefore, the only pure strategy equilibrium is $p_T^* > v$ and $p_M = v$.

In the case that $\frac{c_T+t}{1-f} = v$, T is indifferent between supplying at $p_T = v$ or setting a price $p_T > v$ and not supplying. Consider an equilibrium where $p_T = v \leq p_M$ such that T supplies. It must be the case that $c_T = c_M$ for A not to undercut, but then $p_M = v < p_T$ is also an equilibrium and generates equal profits. Given our equilibrium selection criteria, we conclude that $p_T^* > v$ and $p_M = v$. □

We proceed assuming $\frac{c_T+t}{1-f} < v$ so that the above result does not apply.

Lemma 1. *If $\frac{c_T+t}{1-f} < v$ no pure strategy equilibrium exists.*

Proof. Assume the opposite, so that there is some pure strategy equilibrium (p_M, p_T^*). The prices cannot be equal. If they are so above 1, then each firm earns higher profits by deviating to price equal to 1. If $p_M = p_T^* = p^* \leq v$ then A earns $\Pi_M = (p^* - c_M)(\lambda + \frac{1-\lambda}{2}) + (fp^* + t)\frac{1-\lambda}{2}$ and T earns $\pi_T^* = ((1-f)p^* - c_T - t)\frac{1-\lambda}{2}$. If $(1-f)p^* - t > c_T$ then clearly T would undercut slightly. If $(1-f)p^* - t < c_T$ then T would be earning negative profits and thus would deviate to higher price. If $(1-f)p^* - t = c_T$ then A does not wish to undercut if $(1-f)p^* - t \leq c_M$ which can only hold for $c_T = c_M = c$. But then, M would want to charge $p_M = 1$ and earn higher profits given that $c < v(1-f) - t$. Thus equal prices are not an equilibrium. Now consider that $p_T^* < p_M$, then either T serves no consumers because $p_T^* > 1$, which clearly cannot be equilibrium, or it does serve some consumers. If $p_T^* < 1$ then T will deviate upwards to slightly below p_M. Thus $p_T^* = 1$ should hold. But then, M earns $f + t$ in equilibrium and can slightly undercut $p_T^* = 1$ and make arbitrarily close to $v - c_M > vf + t$, a profitable deviation. Now consider $p_T^* > p_M$, then A would profitably increase her price unless $p_M = 1$, but then T would like to undercut because he earns zero profit and would instead earn almost $v(1-f) - t - c_T > 0$. □

Now that we have established that there is no pure strategy equilibrium when $c_T < v(1-f) - t$, we proceed to examine the mixed strategy equilibrium. Let $M(p)$ and $T(p)$ be the equilibrium pricing CDFs for M and T, respectively.

Lemma 2. *Firms will randomize continuously on a support* $[\underline{p}, v]$ *with no gaps or point-masses, except for a point mass at* 1 *by* M.

Proof. There can be no gaps in the equilibrium price distribution for the usual reasons. Namely, if there was such a gap, then T would readily redistribute probability mass from close to the low limit of the gap to its upper bound. If M puts a point mass on some $p < 1$, T would redistribute probability mass from just above the mass to just below. If T puts a mass on some p. For any p, M would rather serve all consumers rather than only λ because $fp+t < p-c_M$ for all $p \in [\underline{p}, 1]$ we have to have $p(1-f) - t > c_T \geq c_M$ so $fp + t < p - c_M$. Given that M would rather serve consumers himself, then for the usual reasons he would redistribute mass from above p to below to increase probability of winning non-loyals. No firm would randomize alone on an interval, thus both would randomize on some common interval without point masses or gaps, except if the upper bound is 1. When charging a price at the upper bound the firms that does so earns no profits from non-loyals. If T were such a firm then she would clearly reduce the price until she earned positive expected profits, thus if there is a point mass at the highest price, it is by A. The highest price cannot be below 1, because then M would move the point mass, if such existed to 1 to earn more from loyals, and if there was no point mass then both would not charge the upper bound price and instead charge 1. Thus we conclude that $M(p)$ and $T(p)$ will be defined on $[\underline{p}, v]$, will have positive and finite derivative everywhere inside the interval, and $M(p) \leq T(v) = v$. □

We are now ready to characterize the mixed strategy equilibrium.

Proposition 2. *If* $\frac{c_T+t}{1-f} < v$ *there is a mixed strategy equilibrium where both firms randomize over price range* $[\underline{p}, v]$ *where* $\underline{p} = \max\left\{v\lambda^{1-f} + (1-\lambda^{1-f})\frac{c_M+t}{1-f}, \frac{c_T+t}{1-f}\right\}$ *according to*

$$M(p) = \min\left\{\frac{(1-f)p - c_M - t}{(1-f)p - c_T - t} - \frac{(v(1-f) - c_M - t)\lambda^{1-f}}{(1-f)p - c_T - t}, 1\right\}$$

and

$$T(p) = \frac{1}{1-\lambda}\left[1 - \left(\frac{\max\left\{(v(1-f) - c_M - t)\lambda^{1-f}, c_T - c_M\right\}}{(1-f)p - t - c_M}\right)^{\frac{1}{1-f}}\right],$$

generating profits $\pi_M^d = \underline{p} - c_M$ *and* $\pi_T^d = (1-\lambda)(\underline{p}(1-f) - c_T - t)$.

The pricing subgame generates two types of equilibria. There is a pure strategy equilibrium which arises when the third party seller is not a viable competitor, because its marginal cost is high relative to the marketplace fee $\frac{c_T+t}{1-f} \geq v$. In this equilibrium, characterized in Proposition 1, the monopolist implements the monopoly solution by setting price $p_M = 1$ and serves the whole market. When the third party seller is a viable competitor, $\frac{c_T+t}{1-f} < v$, the solution consists of a mixed strategy equilibrium where both firms price according to cumulative density functions $M(p)$ and $T(p)$ characterized in Proposition 2. This implies setting prices below the monopoly price and, for the case of the monopolist, placing a mass point on (i.e., setting with some probability) monopoly price $p_M = 1$.

The equilibria of the game described above comprises two qualitative market outcomes. In one of them, the third party seller derives zero profits. This includes the pure strategy equilibrium where $\frac{c_T+t}{1-f} \geq v$ and also the mixed strategy equilibrium when $c_T \geq (v(1-f) - c_M - t)\lambda^{1-f} + c_M$.[11] In the latter case, the third party seller is a viable, but inefficient competitor. The monopolist reacts to this by setting choke price $p_M = (c_T + t)/(1-f)$ with probability one, which is the highest price that ensures the third party cannot generate positive profit, and thus drives the third party's profits down to zero. This market outcome can be interpreted as the monopolist undercutting the third party seller and taking over the whole market, an outcome which is similar to that of the standard Bertrand price competition game where firms with a cost disadvantage are undercut by more efficient rivals. Note that this case requires $c_T > c_M$ and thus never arises for symmetric marginal costs.

The second market outcome that arises in our price competition game is one where both firms compete effectively against each other. This is the main scenario in the mixed strategy equilibrium, where both firms play non-degenerate price probability distributions, and holds whenever the third party seller is an efficient competitor $c_T < (v(1-f) - c_M - t)\lambda^{1-f} + c_M$. Both firms set prices on the support $[\underline{p}, 1]$ and generate positive market shares and profits (in expected terms), though their pricing aggressiveness differs. This case is of interest to understand how the asymmetries between both firms shape price competition in the marketplace, and we next focus on this market outcome and its properties.

The third party seller is in general more aggressive when pricing, placing higher probability on lower prices than the monopolist and thus more often becoming the cheapest option for consumers. These pricing strategies reflect the demand faced by each firm. While both firms compete for the demand of non-loyals, the monopolist also has a captive market of loyals to whom it can sell at monopoly price $p_M = 1$. The monopolist therefore faces a tradeoff between quoting the monopoly price to sell to loyals (consumer share λ), thereby allowing the third party seller to serve non-loyals (consumer share $1-\lambda$) and collecting marketplace fee $fp_T + t$ on her sales, or quoting a lower price in a bid to undercut the third party to serve the whole market. The third party seller, in turn, can only remain profitable by undercutting the monopolist and selling to non-loyals, which fuels her more aggressive pricing strategy.

The intensity of competition in the product market is reflected on the (expected) price level charged by firms, which depends on the lower bound of the price support $\underline{p}$, as well as the (expected) price differential between both firms $(p_M - p_T)$. The intensity of competition is shaped by the following factors. Consumer loyalty for the monopolist λ softens competition because it reduces the share of non-loyal consumers present in the market, weakening the monopolist's incentives to undercut the third party seller. Marketplace fees (f, t) also softens competition because they increases the profits generated when the third party seller serves non-loyal consumers, also weakening the monopolist's incentives to undercut.

[11] When $c_T \geq (1 - c_M - f)\lambda^{1-f} + c_M$ the mixed strategy equilibrium features M charging $p_M = c_T/(1-f)$ with probability one, whereas T randomizes above $p_T > p_M$ in such a way as to make M indifferent between any price above p_M, and T earns zero profits. This equilibrium is akin to Blume (2003), and clearly there is (inconsequential) multiplicity with regard to $T(p)$ in that other distributions that discourage M from increasing its price above p_M can also constitute an equilibrium.

f and t have qualitatively different effects on prices and profits. The role of t is most straightforward. First, t directly increases the marginal cost of T. More interestingly, M also acts as if its marginal cost is $c_M + t$. That is because, when attempting to sell one extra unit on average (with an appropriate price reduction), M has to directly pay c_M to produce this unit, but also because it has deprived a unit sale by T, it loses t that it could have collected from T. The role of f is different because in similar reasoning to above, when taking over one unit of sales, M suffers an opportunity cost $p_T f$, which in turn depends on the price (and thus pricing strategy) of T. This can been see in the expression

$$\pi_T^d = (1-\lambda)\left((v(1-f) - c_M - t)\lambda^{1-f} + c_M - c_T\right). \tag{1}$$

While it is easy to to show that $\frac{\partial \pi_M^d}{\partial t}, \frac{\partial \pi_M^d}{\partial f} > 0 > \frac{\partial \pi_T^d}{\partial t}$, that is M benefits form increases in its either fee (both directly by generating more tariff revenue and strategically due to relaxed price competition), one cannot a priori sign $\frac{\partial \pi_T^d}{\partial f}$. This is because while T does not like to pay higher fee f, given that higher f also reduces $M's$ incentives to undercut $T's$ price, more so the higher p_T,the overall effect is unclear. In fact, for

$$\lambda < \frac{1}{e^{\frac{1}{1-c-f-t}}}$$

we have $\frac{\partial \pi_M^d}{\partial f} > 0$, the opposite holds for $\lambda > \frac{1}{e^{\frac{1}{1-c-f-t}}}$. similarly, while $\frac{\partial \pi_M^d}{\partial \lambda} > 0$ for obvious reasons, counter-intuitively, $\frac{\partial \pi_T^d}{\partial \lambda} > 0$ may also hold due to loyal consumers' price-competition mitigating effect on firm T's profits. This is the case when $\lambda < \frac{1-f}{2-f}$ so that if the initial level of loyalty to M is low, a small increase in the number of loyals leads to an increase in profits earned by T.

Both of these factors increase the price level and price differential between both firms in equilibrium, by increasing lower bound $\underline{p}$ and the probability placed by the monopolist on mass point $p_M = v$.

The marginal costs of both firms have a more complex impact. On the one hand, the monopolist's marginal cost c_M affects the price level in equilibrium through the lower bound of the price support $\underline{p}$, which is increasing in c_M. A higher marginal cost reduces the monopolist's willingness to undercut the third party seller. On the other hand, the marginal cost differential between both firms, $c_T - c_M$ is a key factor in determining the price differential. When both firms exhibit similar marginal cost $c_T \approx c_M$, the monopolist targets loyals (high probability on mass point $p_M = 1$) and the price differential is large, because undercutting the third party is not very profitable. But when the cost disadvantage of the third party seller increases, $c_T > c_M$, the monopolist becomes more aggressive in undercutting and the price differential decreases. As the third party becomes an inefficient competitor, $c_T \to (1 - c_M - f)\lambda^{1-f} + c_M$, the monopolist has the opportunity to take over the whole market and prices aggressively by placing higher weight on lower prices than the third party. Thus the solution converges to that where the monopolist sets choke price $p_M = c_T/(1-f)$ with probability one.

The platform's profit is increasing in c_M, its own marginal cost, when $\lambda < f^{\frac{1}{1-f}}$, so that when there are few loyals around, by increasing its marginal cost, the monopolist is able to relax price competition more than enough to offset the direct (negative) effect of higher own marginal cost.

3.1 Platform choice of pricing and buy-box placement after third party price choice

Assume now that third party seller chooses p_T first. Having observed p_T, M makes two choices. First, it has to set its own price p_M. Second, it has to decide which of the two firms gets the buy box designation. The latter means that all loyals will buy from that firm. All non-loyals will continue to buy at the lowest price.

We solve this pricing game with backward induction. Assume That T has chosen some price p_T, and assume M designates T into the buy box. Given this decision, M has to consider two possibilities. If $p_M > p_T$, then M sells to no one and makes $p_T f + t$. If instead $p_M = p_T - \varepsilon$ then M makes $(p_T - c_M)(1-\lambda)$ from attentive consumers and $(p_T f + t)\lambda$ from inattentive ones. Given that profit from inattentive consumers is independent of p_M, the above comparison boils down to whether $(p_T - c_M)$ exceeds $(p_T f + t)$ or not. We know $p_T \geq \frac{c_T+t}{1-f} \geq \frac{c_M+t}{1-f}$, so $p_T - c_M > p_T f + t$, thus$p_M = p_T - \varepsilon$ is always optimal when T gets the buy box. We thus conclude that when T gets the buy box, M makes $\lambda(p_T f + t) + (1-\lambda)(p_T - c_M)$. If M gets the buy box, it has a choice between $p_M = v$, in which case it makes $\lambda(v - c_M) + (1-\lambda)(f p_T + t)$, or $p_M = p_T - \varepsilon$ where it earns $p_T - c_M$. The latter is always better for M than ceding the buy box to T. M prefers to focus on loyals when

$$p_T \leq \bar{p}_T \equiv \frac{\lambda v + (1-\lambda)(c_M + t)}{1 - f(1-\lambda)},$$

otherwise it undercuts T. Comparing to the case where T gets the buy box, we conclude that for when $p_T \leq \bar{p}_T$, M gets the buy box and charges v, otherwise it takes all consumers with $p_M = p_T - \varepsilon$ (and here buy box is irrelevant).

Now we turn to T. Anticipating the above behavior by M, T has to choose p_T. Clearly $p_T > \bar{p}_T$ cannot be profitable because T will get no demand. We thus conclude that $p_T = \bar{p}_T$ provided that $\bar{p}_T(1-f) - t \geq c_T$, which translates to

$$v \geq c_M + \frac{c_T f + t}{1-f} + \frac{c_T - c_M}{\lambda}$$

For symmetric costs, this simplifies to

$$v \geq \frac{c+t}{1-f}$$

otherwise $c_M + \frac{c_T f + t}{1-f} + \frac{c_T - c_M}{\lambda} > \frac{c_T + t}{1-f}$, so as in the baseline model, entry into duopoly is harder than into monopoly. From now on, we will focus on the symmetric case.

In equilibrium, M makes

$$\pi_M^d = (1-\lambda)(f\bar{p}_T + t) + \lambda(v - c),$$

T earns

$$\pi_T^d = (1-\lambda)(\bar{p}_T(1-f) - t - c)$$

As in the baseline model, π_M^d is monotone in λ, f and t. π_T^d is decreasing in f and t. With regard to λ, π_T^d is decreasing, except when f and λ are low, when indeed π_T^d is increasing in λ, which is because such an increase relaxes price competition.

Buy box is always given to the lowest price

Consider what happens when M is forced (by regulation) to give the buy box to the lowest priced firm. This effectively means that all demand is allocated to the lowest pricing firm. For any p_T, we have seen before that M would rather serve all demand at p_T earning $p_T - c_M$ then let T serve all demand and earn $p_T f + t$ provided that $p_T \geq \frac{c_M+t}{1-f}$, which is guaranteed by the fact that T can only serve demand for $p_T \geq \frac{c_T+t}{1-f}$, and $c_T \geq c_M$. We thus conclude that under this regulation M will undercut T, and therefore T can only charge $p_T = \frac{c_T+t}{1-f}$.

4 The marketplace in equilibrium

We proceed to solve the game by backwards induction. To simplify the exposition, we first analyze entry choices by M and T as a function of profits. That is, we characterize equilibrium entry strategies for each product type as a function of profits generated, which will depend on price competition in product markets where both M and T supply as well as marketplace fee structure (f, t) and capacity constraint of the platform k.

We use the following notation for firm profits. Let $\pi_M(v)$ and $\pi_T(v)$ denote the profits per consumer derived by M and T, respectively, for a product v. That is, when M or T operate as a monopoly, we have $\pi_M(v) = v - c_M$ or $\pi_T^m(v) = v(1-f) - c_T - t$, with superscript m to denote monopoly. Recall that the monopoly price is equal to v and T^v incurs marketplace fees $vf + t$ that have to be payed to M. Similarly, we use $\pi_M^d(v)$ and $\pi_T^d(v)$ with superscript d for the case of duopoly. We solve for duopoly profits further below, but note that they will depend on marketplace fee (f, t) given that T incurs a fee which is charged by M. Also, it must be the case that the sum of duopoly profits per consumer do not exceed (maximum) monopoly profits, $\pi_M^d(v) + \pi_T^d(v) \leq v - c_M$.

4.1 Entry choices

In order to understand entry choices, we start with T, whose choice of entry is crucial for niche markets. T^v enters a market as a monopolist (expecting no entry from M) when $v(1-f)-t > c_T$

or

$$v > v_T \equiv \frac{c_T + t}{1 - f}.$$

When T anticipates competition with M, it enters whenever $\underline{p}(1-f) - t > c_T$, which again simplifies to

$$v > \overline{v}_T \equiv \frac{c_T + t}{1 - f} + \frac{c_T - c_M}{1 - f}\left(\frac{1}{\lambda^{1-f}} - 1\right)$$

Note that when $c_T = c_M$, the two thresholds coincide, else when $c_T > c_M$, entry is harder into duopoly. This means that for niche products, entry by M discourages entry by T, and because M is not aware of niche products, such products with $v \in (v_T, \overline{v}_T]$ may potentially be withheld from consumers.

To gain some simpler insights, we will for now presume that $c_T = c_M = c$. Under this assumption, T will enter all markets with $v > v_T = \frac{c+t}{1-f}$ and will not enter all others.

Now we turn to M. Given our earlier assumption that $\lambda > \frac{1}{e}$, the monopolist prefers to enter and compete in any market over letting T monopolize it. However, if k binds, then M may not enter all the markets. k does not bind if $1 - G(c) < k$, so that the monopolist can enter all the markets where v exceeds its marginal cost. Even if k does not bind, there is a possibility that some niche products are not sold by M because T do not sell them in the marketplace. In order to understand these situations, we will need to specify how a product's mainstream/niche status is related to its v.

We have so far not specifies any relationship between mainstream status of a product and consumers' valuation v. In the baseline model we will assume that the mainstream products are the most valuable ones, i.e. top (in terms of v) fraction θ of products will be mainstream, the bottom $1 - \theta$ fraction will be niche. In an extension we will consider another interesting case where mainstream and niche products have the same distribution of v, $G(v)$.

4.2 Baseline model

Let v_θ denote that least valuable mainstream product, namely v_θ solves

$$1 - F(v_\theta) = \theta$$

or

$$v_\theta = F^{-1}(1 - \theta).$$

For the rest of the analysis of this section we will assume that $v_\theta > c$, which guarantees that M is unaware of at least some potentially profitable products.

Take f as given. M will know about (either because the product is mainstream, or because T sells it in the marketplace) all products with

$$v > \min\{v_T, v_\theta\}$$

Notice that when (i)$v_T < v_\theta$, the marginal product is one that M learns with third party entry, whereas when (ii) $v_T > v_\theta$, M knows more than what it learns from third-parties.

(i) Assume $v_T < v_\theta$. In this case M cannot sell products that Ts don't sell because M is unaware of any such product. Therefore, M will enter all markets it knows about, provided it has enough capacity, or it will enter all

$$v > \max\{v_T, v_k\}.$$

If $v_k > v_T$, then There will be sold by third party (SBT) products with $v \in [v_T, v_k)$ and sold by monopolist and third party (SBMT) markets with $v > v_k$. If $v_k \leq v_T$, there will only be SBMT markets with $v > v_T$.

Profits in this case are given by

$$\Pi_M = \int_{v_T}^{\max\{v_T,v_k\}} (vf + t)g(v)dv + \int_{\max\{v_T,v_k\}}^{\infty} \pi_M^d(v)g(v)dv$$

(ii) Assume $v_T > v_\theta$. Here M knows more products than T-s sell. M now has to decide whether to allocate all its capacity to products that Ts sell, or to sell some relatively lucrative products with $v < v_T$ as a monopolist. The essential question is whether M prefers to monopolize mainstream products with $v < v_T$ or compete in products with $v > v_T$. It is clear that of such products, M will always choose the ones with the highest v-s within its capacity.

Let us compare the profits from monopolizing product with $v_l < v_T$ and competing for a product with $v_h > v_T$. The crucial consideration here is that if M withdraws from v_h, it can still earn $v_h f + t$ from the corresponding third party seller T^{v_h} who can monopolize the product on the platform. The profit difference equals

$$\Delta(v_h) \equiv \pi_M^d(v_h) - (v_h f + t) = \left(v_h - \frac{c+t}{1-f}\right)\left(\lambda^{1-f} - f\right).$$

It is trivial to see that M loses more from not entering, the higher is v_h. This means that if M does not sell some of these products, it will be those with v close to v_T.

M is indifferent between selling product v_h alongside T^{v_h}or selling v_l alone when

$$\Delta(v_h) = v_l - c$$

The highest possiblev_l is v_T, so the most M can earn monopolizing a mainstream product is $\frac{cf+t}{1-f}$. For v_h such that

$$\Delta(v_h) > \frac{cf+t}{1-f}$$

it will prefer to enter duopoly products. From above, we can derive another important threshold

$$v_M \equiv \Delta^{-1}\left(\frac{cf+t}{1-f}\right) = \frac{\frac{(c+t)\lambda^{1-f}}{1-f} + t}{\lambda^{1-f} - f}$$

which given that $\lambda^{1-f} - f > 0$ by assumption, satisfies $v_M > v_T$. We conclude, that for all $v > v_M$, M would rather compete in duopoly for product v than instead sell $v = \frac{c+t}{1-f}$ as a monopolist.

If $v_M \leq v_k$ then M does not have enough capacity to sell sub v_T products, and therefore we will have SBT for $v \in [v_T, v_k)$ and SBMT for $v > v_k$. This earns M platform-wide profits

$$\Pi_M = \int_{v_T}^{v_k} (vf + t)g(v)dv + \int_{v_k}^{\infty} \pi_M^d(v)g(v)dv$$

If $v_M > v_k$ then M will sell some products with $v < v_T$. There will be two thresholds, $v_l \in [v_\theta, v_T)$ and $v_h \in [v_T, v_M)$ such that

$$\Delta(v_h) = v_l - c$$

which gives indifference between v_h duopoly and v_l monopoly (with T^{v_h} monopolizing v_h). We also need k to be fully used, so

$$1 - G(v_h) + (G(v_T) - G(v_l)) = k$$

Examining the two conditions above we can see that, provided $v_\theta \geq c$, which we assumed before, when $v_l > c$, we have $v_h > v_T$, so $v_h \geq v_T$ will hold. However, $v_l \geq v_\theta$ may fail. To account for this possibility, let us define v_h and v_l as the solutions to

$$1 - G(v_h) + (G(v_T) - G(v_l)) = k \tag{2}$$

and

$$v_l = \max\{\Delta(v_h) + c, v_\theta\} \tag{3}$$

We conclude that products with $v \in [v_l, v_T)$ will be sold solely by M (sold by monopolist, SBM), products with $v \in [v_T, v_h)$ will be sold only by T^v(SBT), and products with $v \in [v_h, \infty]$ will be sold by both M and T (SBMT).

Total profits of the marketplace are given by

$$\Pi_M = \int_{v_\theta}^{v_T} (v - c)g(v)dv + \int_{v_T}^{v_h} (vf + t)g(v)dv + \int_{v_h}^{\infty} \pi_M^d(v)g(v)dv$$

We will show below that (f^*, t^*) will never be in the above case because increasing f increases profits in this range.

Proposition 3. *When M has limited capacity or knowledge, $v_M \leq v_k$ or $v_\theta \geq v_T$, then its profits are given by*

$$\Pi_M = \int_{v_T}^{\max\{v_T, v_k\}} (vf + t)g(v)dv + \int_{\max\{v_T, v_k\}}^{\infty} \pi_M^d(v)g(v)dv.$$

If instead, it has sufficient capacity and knowledge, $v_M > v_k$ and $v_\theta < v_T$, then profits are given by:

$$\Pi_M = \int_{v_l}^{v_T} (v-c)g(v)dv + \int_{v_T}^{v_h} (vf+t)g(v)dv + \int_{v_h}^{\infty} \pi_M^d(v)g(v)dv.$$

4.3 Optimal fee

From the analysis of entry decisions we now turn to the optimal fee setting. In order to gain some intuitions, it will be instructive to consider some special cases.

4.3.1 Pure marketplace ($k = 0$)

In this case M does not posses any ability to sell products directly. Variety of such marketplaces are operational, eBay being the most prominent. In this case marketplace profits take the form

$$\Pi_M = \int_{v_T}^{\infty} (vf+t)g(v)dv$$

The optimal fee structure can now be pinned down easily. First, let us make the following thought experiment. Let $v_T = \frac{c+t}{1-f}$ be held constant at some level, and let t increase (and f correspondingly fall), then for a given v this change generates profit change

$$1 - \frac{v}{v_T}$$

which is negative for all $v > v_T$, thus we conclude it is never optimal to use a unit fee$t^* = 0$. We can now find optimal f from the FOC[12]

$$\int_{\frac{c}{1-f}}^{\infty} vg(v)\, dv = \frac{c^2 f}{(1-f)^3} g\left(\frac{c}{1-f}\right)$$

The RHS is the profit loss from expanding f due to reduction in marginal products that T's sell. In particular, M looses revenue of $\frac{cf}{1-f}$ on the marginal product, and by increasing f it looses $\frac{cg\left(\frac{c}{1-f}\right)}{(1-f)^2}$ marginal products due to non-entry. The LHS is the gain from increasing f, which generates extra revenue v on all products that are sold via the marketplace.

4.3.2 Unconstrained by unaware marketplace ($k = 1$ and $\theta = 0$)

In this case, when setting the fee the marketplace has to tradeoff the cannibalization of its profits in SBMT markets with gains from entry in niche markets, which in turn generates duopoly profits. Total profit is

[12]For the profit to be concave we need

$$-\frac{cg'\left(\frac{c}{1-f}\right)}{1-f} - \frac{(f+2)g\left(\frac{c}{1-f}\right)}{f} < 0$$

$$\Pi_M = \int_{v_T}^{\infty} \pi_M^d(v) g(v) dv$$

Here again, holding v_T constant, if one increases t then $\pi_M^d(v)$ falls, which is because

$$\pi_M^d(v) = v\lambda^{1-f} + (1 - \lambda^{1-f})\frac{c+t}{1-f} - c$$

so if $\frac{c+t}{1-f}$ is held fixed, reduction in f has direct negative effect on profits via reduction of λ^{1-f}. So we conclude that $t^* = 0$.

FOC is

$$\int_{\frac{c}{1-f}}^{\infty} \frac{\partial \pi_M^d(v)}{\partial f} g(v)\, dv = \frac{c^2 f}{(1-f)^3} g\left(\frac{c}{1-f}\right)$$

Given that the RHS is strictly positive, $f^* > 0$. Even when the marketplace fully relies on third parties for access to product markets, and earns duopoly profits in those markets, it never pays off to fully subsidize entry and earn profits from price competition.

As compared to the case of pure marketplace above, the RHS of the FOC is the same, the LHS is different. In fact, one can show that for a given v, $\frac{\partial \pi_M^d(v)}{\partial f} < v$, therefore the benefit of increasing s is lower for unconstrained but clueless marketplace than for pure marketplace, which means that, counterintuitively, pure marketplace charges higher fees.

4.3.3 The general case

In general the marketplace will potentially have binding capacity and knowledge constraints. Turns out that capacity is qualitatively different from knowledge limitations. In particular, when capacity is low, the marketplace will charge such a fee that regardless of its knowledge the marketplace operates in a hybrid SBT+SBMT mode, whereby most lucrative products are sold by both, and less lucrative ones are sold by third parties. When k is intermediate, depending on how much the marketplace knows, there is either no marketplace (when it knows a lot), or again there is a hybrid marketplace in SBT+SBMT mode. Finally, when k is high, depending on how much the marketplace knows there is either no marketplace, or there is one where all products are sold by both (SBMT).

Proposition 4. *There exist two thresholds, $\underline{k}$ and $\bar{k}$, and a function $\bar{\theta}(k)$, such that, when*

1. $k \leq \underline{k}$ the marketplace operates in hybrid $SBT + SBMT$ mode, where all products with $v \in [\frac{c}{1-f^*}, v_k)$ are monopolized by third parties, $v \in [v_k, \infty]$ are sold by T and M in a duopoly. The optimal fees are $t^* = 0$ and f^*that solves

$$\int_{v_T}^{v_k} vg(v)dv + \int_{v_k}^{\infty} \frac{\partial \pi_M^d(v)}{\partial f} g(v)dv = \frac{c^2 f}{(1-f)^3} g\left(\frac{c}{1-f}\right) \tag{4}$$

2. If $\underline{k} < k < \bar{k}$ the marketplace operates in hybrid $SBT + SBMT$ mode (as in case 1) when $\theta < \bar{\theta}(k)$ and is shut down otherwise. When the marketplace operates, the optimal $t^* = 0$

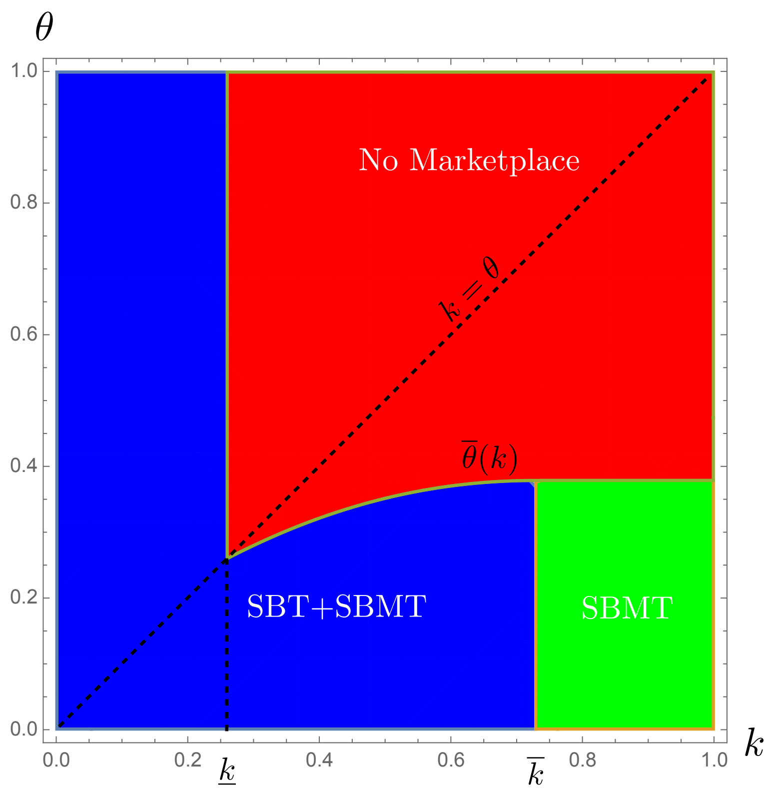

Figure 1: Marketplace regimes depending on k and λ for $G(v) = 1 - e^{(v-c)\gamma}$, $c = 4$ and $\lambda = 0.7$.

and f^* solves (4).

3. If $k \geq \bar{k}$ the marketplace operates in $SBMT$ mode when $\theta < \bar{\theta}(\bar{k})$ where all products with $v \in [v_k, \infty]$ are sold by T and M in a duopoly. When the marketplace operates, the optimal $t^* = 0$ and f^*solves

$$\int_{v_T}^{\infty} \frac{\partial \pi_M^d(v)}{\partial f} g(v) dv = \frac{c^2 f}{(1-f)^3} g\left(\frac{c}{1-f}\right)$$

If $\theta > \bar{\theta}(\bar{k})$ the marketplace is shut down.

Proof. TBA □

The above proposition is illustrated in Figure 1 for $G(v) = 1 - e^{(v-c)\gamma}$ (exponential distribution of v with scale parameter $\gamma = 2$ that is centered at c), $c = 4$ and $\lambda = 0.7$. c and γ are chosen such that average 'monopoly' margin is approximately 10%.

One can see that when $k < \theta$, whether marketplace operates or not solely depend on k because in this region the marketplace knows more than it can serve, thus particular level of θ is irrelevant. For $k > \theta$ (below the dashed diagonal line), which of three possible modes comes about depends on both k and θ.

Proposition 5. *If $k < \underline{k}$, or $k \in [\underline{k}, \bar{k}]$ and $\theta < \bar{\theta}(k)$ then*

1. f^* decreases in k and λ

2. An increase in k benefits M, consumers in SBMT markets and markets that go from SBT to SBMT. Furthermore, it benefits third party sellers in SBT markets.

3. An increase in λ benefits M, third party sellers in SBT markets, hurts consumers and sellers in SBMT markets.

Several interesting comparative statics emerge. In the blue region θ does not play a role, only $G(v)$, c, k and λ do. An expansion in k (provided that it does not lead to exit from the blue region) leads to lower fees, thus as M enters more product markets, it simultaneously lowers its optimal fee! Consumers benefit for 2 reasons. First, M's entry into SBT product markets reduces prices for those markets. Second, reduction in f^* reduces prices in SBMT markets (DO THIS IN PRICING SECTION). Given unit demand assumption, these two effects do not change total welfare[13], however welfare still goes up because reduction in f^* leads to more third party entry, and thus higher welfare. M clearly benefits from expansion in k. As for third-parties, effect on them is heterogeneous. Those third parties who start in SBT and continue in SBT, or start in SBMT and continue in SBMT, benefit because f^* goes down. Third parties that transition from SBT to SBMT are worse off.

An increase in λ has the similar effect on f. This is because when M's advantage in price competition is enhanced, it is less worried about competition in SBMT products and lowers the fee to induce entry. Effect on consumers is less obvious here. Reduction in f leads to no price movement in SBT markets. In SBMT markets both λ and f move, and in opposite direction, so the overall effect is unclear. M clearly benefits. Third parties in SBT markets benefit too, those in SBMT markets may benefit or lose because λ increases (bad) but f^* decreases (good).

Proposition 6. *If $k < \bar{k}$ and $\theta < \bar{\theta}(\bar{k})$ then*

1. f^* decreases in λ

2. An increase in λ benefits M, and hurts consumers and sellers in SBMT markets.

In the green region k plays no role, M operates the marketplace as if it is capacity unconstrained. Furthermore, θ plays no role either, because M knows so little it fully relies on third parties to bring new products to the storefront. In this region only λ plays any role, and indeed increasing λ reduces f^*. This is not to say that third parties are better off from higher λ because there is a direct negative effect that increase in λ has on their profits, but this effect at least partially is offset by lower marketplace fees. In the hybrid (blue region) regime third parties in SBT model then clearly benefit from expansion in λ because f^* goes down without any direct negative effect on their profits. One can think of λ as a catch-all parameter for various competitive advantages M enjoys because it runs the marketplace and thus can capture more demand for the same price via either manipulating the buy now algorithm (most consumers do not change the default seller when they click buy on amazon.com) or otherwise using its position to target consumers that are more prone to buy from the marketplace than from third party sellers.

[13]In a richer model with downward-sloping demand increase in k would lead to welfare gains from these two effects.

Proposition 7. *The following is true about marketplace opening/closure by M*

1. An increase in θ may never lead to marketplace opening and can lead to marketplace closure.

2. An increase in k from initially low $k < \underline{k}$ can lead to marketplace closure and never to opening.

3. When k and θ are intermediate, namely when $k \in [\underline{k}, \bar{k}]$ and $\theta \in [\bar{\theta}(\underline{k}), \bar{\theta}(\bar{k})]$, an increase in k may never lead to marketplace closure and can lead to marketplace opening.

There is an interesting range of parameters when k and θ are moderate (close to the diagonal where blue and red regions meet) where the marketplace owner may start in the red region (no marketplace), but as its k expands, it starts to operate a marketplace. The reason is that when k outgrows θ, the monopolist starts to value more the benefit of third parties bringing new products to the marketplace. This is only so when initial level of knowledge is not too high (in which case expansion in k is not sufficient to incentivize marketplace opening) or when θ is too low so that marketplace is operated regardless of level of k.

4.4 Mainstream and Niche are equally good

Now we turn to another possibility where a product's mainstream status is unrelated to its willingness to pay parameter v. This extension is interesting in that here M relies more heavily on third parties because on average products they bring to the marketplace are as valuable as those that M knows about on its own.

For $k < 1 - G(c)$ there is a possibility that M will not sell some products due to its capacity constraint. This is not entirely clear because of the presence of niche markets. There T only enter for $v > v_T$, and without T's entry A cannot enter. Therefore, k will bind when

$$\bar{k} \equiv \theta(G(v_T) - G(c)) + (1 - G(v_T)) > k.$$

$$v_T = \frac{c + t}{1 - f}$$

We will therefore consider two cases depending on k.

4.5 Unconstrained entry ($\bar{k} \leq k$)

Given the fee structure (f, t), if $\bar{k} \leq k$ we will say that A is unconstrained and thus will enter all the mainstream markets, and all the niche markets where T-s have entered previously. We will thus have the follow dichotomy of product markets.

1. Mainstream products with $v \in [c, v_T]$ will be monopolized by M. We will call such markets SBM

2. Mainstream products with $v \in [v_T, \infty]$ will be contested between M and T^v. We refer to such markets as SBMT

3. Niche products with $v \in [v_T, \infty]$ will be contested between M and T^v. SBMT

4. All other products will not be supplied.

One can then express the overall profits earned by M as

$$\Pi_M = \theta \int_c^{v_T} (v-c)g(v)dv + \int_{v_T}^{\infty} \pi_M^d g(v)dv$$

4.6 Constrained entry ($\bar{k} > k$)

When k is relatively low, M has to decide which markets to enter and of which to stay out. The essential question is whether M prefers to monopolize mainstream products with $v < v_T$ or compete in product markets with $v > v_T$. It is clear that of such products, M will always choose all the ones with highest v-s. Let us compare the profits from monopolizing product with $v_l < v_T$ and competing for a product with $v_h > v_T$. The crucial consideration here is that if M withdraws from v_h, it can still earn $v_h f + t$ from the corresponding T^{v_h} who can monopolize the product. The difference equals

$$\pi_M^d(v_h) - v_h f + t = \left(v_h - \frac{c+t}{1-f}\right)\left(\lambda^{1-f} - f\right).$$

We thus conclude that M loses more from not entering, the higher is v_h. This means that if M does not sell some of these products, it will be those with v close to v_T.

M is indifferent between selling product v_h alongside T^{v_h}or selling v_l alone when

$$\left(v_h - \frac{c+t}{1-f}\right)\left(\lambda^{1-f} - f\right) = v_l - c$$

The highest v_l is v_T, so at most M can earn $\frac{cf}{1-f}$ from entering unoccupied mainstream products. Thus for v_h such that

$$\left(v_h - \frac{c+t}{1-f}\right)\left(\lambda^{1-f} - f\right) > \frac{cf}{1-f}$$

it will prefer to enter duopoly products. From above, we can derive another important threshold

$$v_M \equiv \frac{\frac{(c+t)\lambda^{1-f}}{1-f} + t}{\lambda^{1-f} - f}$$

which given that $\lambda^{1-f} - f > 0$ exceeds v_T. For markets where A prefers to enter, T is already there. We conclude, that for all $v > \bar{v}_M$ (both for mainstream and niche), A would rather compete in duopoly than enter product $v = \frac{c+t}{1-f}$ as a monopolist.

Define

$$v_k \equiv G^{-1}(1-k)$$

as the v threshold such that$A$ can sell all products with $v > v_k$ and spend all of its capacity. If k is low enough such that

$$v_k > v_M$$

then A only enters products with $v > v_k$ alongside T^v. The threshold k for the above is

$$\underline{k} \equiv 1 - G(v_M).$$

In this case A's profit total profit is

$$\Pi_M = \int_{v_T}^{v_k} (vf + t)g(v)dv + \int_{v_k}^{\infty} \pi_M^d(v)g(v)dv$$

All that remains now is to see what happens when $k \in (\underline{k}, \bar{k})$. In this range A has enough capacity to enter all products that it prefers to enter over monopolizing mainstream products with $v \leq \frac{c+t}{1-f}$, but not enough to enter all products on offer. Recall

$$\left(v_h - \frac{c+t}{1-f}\right)\left(\lambda^{1-f} - f\right) = v_l - c \tag{5}$$

which gives indifference between v_h duopoly and v_l monopoly (with T^{v_h} monopolizing v_h). We also need k to be fully used, so

$$1 - G(v_h) + \theta(G(v_T) - G(v_l)) = k \tag{6}$$

We can find v_h from

$$1 - G(v_h) + \theta\left(G\left(\frac{c+t}{1-f}\right) - G\left(\left(v_h - \frac{c+t}{1-f}\right)\left(\lambda^{1-f} - f\right) + c\right)\right) = k$$

LHS is decreasing in v_h, so there has to be a unique solution. We thus get v_h and v_l such that A enters products with $v > v_h$ and those with $\frac{c+t}{1-f} > v > v_l$. As k approaches $\bar{k}$, v_h approaches $\frac{c+t}{1-f}$ and v_l approaches c, thus A enters all the feasible markets.

To conclude, define v_h and v_l as solutions to (5) and (6) for $k > \underline{k}$, and as $v_h = v_k$ and $v_l = \frac{c+t}{1-f}$ for $k < \underline{k}$.

A enters all the products with $v > v_h$, and those with $v \in (v_l, v_T)$, if any.

1. Mainstream products with $v \in [v_l, v_T]$ will be monopolized by M (SBM)
2. Mainstream and niche products with $v \in [v_T, v_h]$ will be monopolized by T^v(SBT)
3. Mainstream and niche products with $v \in [v_h, \infty]$ will be contested between M and T^v (SBMT)
4. All other products will not be supplied.

One can then express the overall profits earned by M as

$$\Pi_M = \theta \int_{v_l}^{v_T} (v-c)g(v)dv + \int_{v_T}^{v_h} (vf+t)g(v)dv + \int_{v_h}^{\infty} \pi_M^d(v)g(v)dv$$

4.7 Optimal marketplace fee

Optimal fee depends in a complex manner on variety of parameters, most importantly k. We will next consider several important benchmarks.

4.7.1 Pure marketplace ($k=0$)

In this benchmark we consider the possibility that the marketplace has no independent ability to supply products (eBay). In this case marketplace profits look like this

$$\Pi_M = \int_{v_T}^{\infty} (vf+t)g(v)dv$$

The optimal fee structure can now pinned down. First, let us make the following though experiment. Let $v_T = \frac{c+t}{1-f}$ be held constant at some level, and let t increase (and f correspondingly fall), then for a given v this change generates profit change

$$1 - \frac{v}{v_T}$$

which is negative for all $v > v_T$, thus we conclude the $t^* = 0$. We can now find optimal f from the FOC[14]

$$\int_{\frac{c}{1-f}}^{\infty} vg(v)\,dv = fv_T g(v_T)\frac{\partial v_T}{\partial f} = \frac{c^2 f g\left(\frac{c}{1-f}\right)}{(1-f)^3}$$

The RHS is the profit loss from expanding f due to reduction in marginal products that T's enter. In particular, A looses revenue of $\frac{cf}{1-f}$ on the marginal product, and by moving f it looses $\frac{cg\left(\frac{c}{1-f}\right)}{(1-f)^2}$ marginal products due to non-entry. The LHS is the gain from increasing f, which generates extra revenue v on all products that are sold via the marketplace.

4.7.2 Unconstrained marketplace ($k=1$ or high enough)

In this case when setting the fee the marketplace has to tradeoff the cannibalization of its profits in SBMT markets with gains from entry in niche markets. Total profit is

$$\Pi_M = \theta \int_{c}^{v_T} (v-c)g(v)dv + \int_{v_T}^{\infty} \pi_M^d(v)g(v)dv$$

[14] For the profit to be concave we need

$$-\frac{cg'\left(\frac{c}{1-f}\right)}{1-f} - \frac{(f+2)g\left(\frac{c}{1-f}\right)}{f} < 0$$

Here again, holding v_T constant, if one increases t then $\pi^d_M(v)$ falls, which is because

$$\pi^d_M(v) = v\lambda^{1-f} + (1-\lambda^{1-f})\frac{c+t}{1-f} - c$$

so if $\frac{c+t}{1-f}$ is held fixed, reduction in f has direct negative effect on profits via reduction of λ^{1-f}. So we conclude that $t^* = 0$.

FOC is

$$\int_{\frac{c}{1-f}}^{\infty} \frac{\partial \pi^d_M(v)}{\partial f} g(v)\, dv = (1-\theta)\frac{c^2 f g\left(\frac{c}{1-f}\right)}{(1-f)^3}$$

Clearly, if $\theta = 1$, then dominant marketplace closes down access to others, setting $f^* = 1$, else $f^* < 1$ and it allows limited access to niche products in order to then enter them and compete.

The RHS are the gains from increasing f via higher duopoly profits in SBMT markets. This is similar to the previous case with pure marketplace, but is lower because $\frac{\partial \pi^d_M(v)}{\partial f} < v$ for all $v > \frac{c}{1-f}$ for those cases where $\lambda^{1-f} > f$, which is assured by $\lambda > \frac{1}{e}$. The RHS is the cost of expanding f. Unlike pure marketplace, unconstrained hybrid only loses from increasing f and thus reducing T entry only in niche markets in proportion $(1-\theta)$. Notice that both LHS and RHS are lower for A, so when θ is not too low it may charge a lower fee than the pure marketplace! This is because it relies on third party sellers to bring in niche products that it then sells too, and thus may be willing to subsidize entry via lower fee. When $\theta = 0$, the marketplace charges lower fee than the pure one, because RHS is the same and LHS is lower. So pure marketplace charges a higher fee than retailer-led one if the latter enters all markets. This is not to say that T-s prefer retailer-led marketplace because lower fee is also coupled with competition with the marketplace.

Proposition 8. *There exists $\hat{\theta}$ such that, for $\theta < \hat{\theta}$ fully hybrid marketplace charges lower fee than pure marketplace.*

An increase in λ, decreases $\frac{\partial \pi^d_M(v)}{\partial f}$(require $\lambda > \frac{1}{e}$) so f^* goes down.

4.7.3 Small capacity marketplace

This case happens when at the optimal fee, the marketplace never enters SBM product markets.

In this case there are only two types of markets, $SBMT$ and SBT.

$$\Pi_M = \int_{v_T}^{v_k} (vf + t) g(v) dv + \int_{v_k}^{\infty} \pi^d_M(v) g(v) dv$$

As in all the previous cases, holding v_T constant, increasing t decreases $vf + t$ and $\pi^d_M(v)$, so $t^* = 0$. For f

$$\int_{\frac{c}{1-f}}^{v_k} v g(v)\, dv + \int_{v_k}^{\infty} \frac{\partial \pi^d_M(v)}{\partial f} g(v)\, dv = \frac{c^2 f g\left(\frac{c}{1-f}\right)}{(1-f)^3}$$

Notice that such monopolist is very similar to the non-retail one, except that it derives duopoly profits in some high v product markets. Such monopolist sets higher f^* than the pure one because it derives additional gains in markets where it enters as retailer.

As k grows, v_k declines, which given that $\frac{\partial \pi_M^d(v)}{\partial f} < v$ reduces the LHS, and reduces f^*, so expansion into more product markets will be accompanied by lower fees.

If unit of capacity costs mc, then capacity will be expanded in this regime until gain from extra capacity, $\left(v_k - \frac{c+t}{1-f}\right)\left(\lambda^{1-f} - f\right) = mc$. We can then express v_k and use FOC above to find f^*, and plug back to get k^*.

4.7.4 Intermediate capacity marketplace

In this case A chooses such a fee, and has such capacity that it enters sub-marginal products as SBM. Here whether$t^* = 0$ is optimal is unclear. First, holding v_T fixed, increase in t reduces $vf + t$ and $\pi_M^d(v)$. Second, increase in t reduces v_h and v_l, which in turn results in an increase of M's profits.[15] There will be all three types of products, SBM, SBT, and SBMT.

$$\Pi_M = \theta \int_{v_l}^{v_T} (v-c)g(v)dv + \int_{v_T}^{v_h} (vf+t)g(v)dv + \int_{v_h}^{\infty} \pi_M^d(v)g(v)dv$$

FOC is

$$\int_{v_T}^{v_h} vg(v)dv + \int_{v_h}^{\infty} \frac{\partial \pi_M^d(v)}{\partial f} g(v)\, dv + \theta \frac{cg\left(\frac{c}{1-f}\right)}{(1-f)^2}\left(\frac{c}{1-f} - v_l\right) = \frac{c^2 fg\left(\frac{c}{1-f}\right)}{(1-f)^3}$$

The RHS has the usual two terms, but now there is an additional term. This term captures gains in profits from expanding $\frac{c}{1-f}$ due to relocation of capacity from v_l to $\frac{c}{1-f}$ in the mainstream products.

This FOC calls for higher f^* than in the previous case because RHS is higher because $v_h > v_k$ and $\frac{\partial \pi_M^d(v)}{\partial f} < v$ and the presence of additional positive term. Note that as v_l approaches c from above, this condition becomes the one for unconstrained marketplace because $\theta \frac{cg\left(\frac{c}{1-f}\right)}{(1-f)^2}\left(\frac{c}{1-f} - v_l\right) = \theta \frac{c^2 fg\left(\frac{c}{1-f}\right)}{(1-f)^3}$. By the same token, as v_l approaches $\frac{c}{1-f}$, the condition becomes the same as the one for constrained marketplace. So the three cases nicely flow into each other.

5 Multiple third-party sellers

6 Entry costs instead of capacity constraints

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