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Keywords: Product Entry, price competition, Marketplace fees, Buy Box, Observational Learning, Product Assortment

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Retailer-led Marketplaces*

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May 30, 2022

Abstract

Leading retailers have opened up their online storefronts to competitors by operating marketplaces for third party sellers. We develop a model of entry and price competition at the product market level, and show that the retailer softens competition through control of the storefront and benefits from third party sellers by learning about products and mitigating his own capacity constraints. We examine policy interventions and find that regulation of marketplace fees has the strongest potential to increase welfare outcomes. Our model provides novel insights into the mechanisms at play in retailer-led marketplaces and explains their prominent role in online retail.

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1 Introduction

The rise of retailer-led marketplaces operated by dominant online retailers such as Amazon or Jingdong, and more recently adopted by traditional brick-and-mortar retailers such as Walmart or Carrefour, has transformed the retail landscape over the last two decades. These retailers started out as resellers, by purchasing products from suppliers and selling them to consumers, and eventually created marketplaces by opening up their online storefronts to third party sellers willing to post their product offers alongside theirs. In doing so, they operate simultaneously as a retailer and as a marketplace owner, providing a platform for their potential competitors to sell to their customers in exchange for fees. These retailer-led marketplaces already account for a substantial share of online retail sales and their growth continues apace, to the extent

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that the largest one in the United States (Amazon) now accounts for over a third of online retail sales in the country.[1] Understanding the drivers of their emergence and the strategic interactions that arise within these marketplaces is key to understanding the recent evolution of retail.

Opening up the storefront generates new transaction opportunities for marketplace participants, but the benefits for the leading retailer are not so obvious. On initial inspection, operating a marketplace enables retailers to collect marketplace fees from third party sellers and to expand the product assortment on their storefront. Both effects can be substantial. Third party sellers accounted for 68% of total sales revenues on Amazon.com in 2018 and paid back in fees 24.8% of the sales revenues they generated ($39.7 billion). And as of May 2016, Amazon.com listed 353 million products out of which only 12 million were sold by Amazon itself.[2] Fee revenues and a larger assortment, however, do not imply profitability for the retailer. Third party sellers bring competition to the storefront, where the retailer would otherwise enjoy a (limited) monopoly. Their sales generate marketplace fees but can also result in lost sales for the retailer. Their supply of additional products on the storefront would only seem desirable if the retailer himself cannot supply them efficiently. But we should expect the retailer to enjoy cost and operational advantages over third party sellers, given the economies of scale present in managing supply chains, warehousing, and fulfillment logistics. So what can leading retailers achieve with a marketplace that they cannot do without?

In this paper, we present a novel model to analyze retailer-led marketplaces such as Amazon's and examine the implications for all participants. We build a model where a monopolist retailer operates a marketplace and interacts with third party sellers and consumers. The product space is composed of a large number of products which differ in their profitability, and their availability and price on the storefront will be endogenous and depend on the interactions arising between all participants. Our model has two key elements. There is an entry game where the monopolist and third party sellers choose which products to supply on the storefront based on the information they have about product demand. And there is a price competition game where firms in each product market supplying the same product compete against each other.

Our first main contribution with this model is to explain the rationale for retailer-led marketplaces. We show that capacity constraints that limit the variety of products the monopolist can supply and information constraints that limit his ability to identify products that are valuable to consumers (and therefore profitable to supply) can explain why it pays off to operate a marketplace. This is true even when third party sellers enjoy no cost advantage and competing with them lowers the monopolist's profitability on the products he would supply anyway. The intuition for this result rests on several mechanisms which are captured in our model. First,

[1]See 'Amazon Remains the Undisputed No. 1,' eMarketer.com, March 11th 2020, https://www.emarketer.com/content/amazon-remains-the-undisputed-no-1.

[2]For estimates of sales revenue composition and marketplace fees see 'Marketplaces Year in Review 2018,' Marketplace Pulse, https://www.marketplacepulse.com/marketplaces-year-in-review-2018. For a breakdown of Amazon.com's product assortment, see 'How Many Products Does Amazon Carry?' Retail Touchpoints, https://www.retailtouchpoints.com/resources/type/infographics/how-many-products-does-amazon-carry.

when third party sellers supply products the monopolist is uninformed about ex-ante, they are informing and providing him with the opportunity to also supply such products. Two, third party sellers may supply products the monopolist cannot due to the capacity constraint he operates under, and will pay marketplace fees to the monopolist in the process. And three, the monopolist's control of the storefront softens price competition intensity and this reduces the negative impact of third party sellers supplying products the monopolist would supply even without a marketplace. To the best of our knowledge, our model is the first to encompass these key features of retailer-led marketplaces and provide insight into the effectiveness of various policy interventions.

Capacity and information constraints are fundamental to retail activity.[3] Amazon's capacity may be large when compared to brick-and-mortar retailers, but is still finite; due to logistics efficiency, organizational complexity, or inability to identify and negotiate with every manufacturer, Amazon cannot stock all existing products. Furthermore, while Amazon is well informed about the profitability of the products it already supplies, what about the millions of products produced in the economy which it does not supply? Such knowledge may be dispersed across small sellers who are better informed about the markets they operate in, recognizing the sales potential of a new product or shifting consumer preferences in their trade. Operating a marketplace enables Amazon to learn about the profitability of such products in addition to earning fees. Our model explains the value of the marketplace for the monopolist as a mechanism to alleviate capacity constraints and acquire private information held by third party sellers.

Price competition can be very intense when sellers supply identical products (or very close substitutes) as is often the case in online storefronts. In the context of a retailer-led marketplace, however, we find that the outcome diverges from pure price competition. First, the outcome diverges because the monopolist earns fees from the sales of third party sellers, so he stands to profit when losing sales to competitors. And second, the monopolist controls the storefront and thus decides how competing offers are presented and ranked. This allows him to steer inattentive consumers towards a specific offer (which may be his own) by presenting it as the default option in the *buy box.* Consumers can readily click on the buy box to purchase from the featured seller or incur additional clicks to browse the remaining offers. As a consequence of these design choices and some prevailing degree of consumer inattentiveness, a large majority of sales for any given product go to the featured seller. Our price competition game incorporates the above two factors and explains their impact.

The second main contribution of our work is a policy analysis exercise. The growth of online marketplaces has been accompanied by heightened regulatory scrutiny across several jurisdictions, with major industry players currently facing a bevy of antitrust probes in the United States and Europe. Our model captures the essential market forces at play in a retailer-led marketplace and provides a tractable foundation to examine the impact of policy interventions

[3]See Brea-Solís, Casadesus-Masanell and Grifell-Tatjé (2014) for a performance analysis of Walmart's technology investments in information gathering and inventory management. These investments are found to be key contributors to Walmart's business performance, and include the deployment of the largest private satellite communication network in the US during the 80s which allowed the retailer to make quick and informed decisions about product supply choices across its store network.

and inform the debate. We examine the impact of several policies including a copying prohibition that restricts the monopolist's ability to enter and compete with products supplied by third party sellers and a pro-consumer rule that increases transparency in the steering mechanism to reduce consumer inattentiveness. Although these policies have desirable goals when considered in isolation, we find that they can backfire due to the monopolist's response across the various strategy levers he controls. Because these policies force the monopolist to reevaluate the tradeoff between fee revenues and third party entry, they tend to drive up marketplace fees and reduce consumer surplus.

Our policy analysis suggests that fee regulation offers the most effective avenue for intervention. Capping marketplace fees directly addresses the main distortion present in the market, namely the monopolist charging the monopoly price (fee) to sellers who have no outside venue to transact with consumers shopping on the monopolist's storefront. Fee regulation, however, is constrained by the monopolist's option to close the marketplace and become a pure retailer in response. We find that a departure from the hybrid model, either due to the monopolist closing the marketplace or ceasing his own retail operations, sacrifices the welfare benefits generated by competition and expanded product variety. Thus we advocate for a cautionary approach to fee regulation that preserves the hybrid model.

Our modeling approach has some limitations we should note upfront. Our analysis considers a monopolist retailer with a captive customer base; third party sellers cannot sell to these consumers outside of the retailer's marketplace. The literature has explored extensively competition between different retail channels, which is relevant to the case where sellers can reach these consumers through competing storefronts or other marketplaces. Instead, we focus on the case of a marketplace operating in isolation, which enables us to build a richer model of the economics forces at play inside it. The exercise is therefore most relevant to dominant retailers who benefit from significant market power.[4]

Unserved demand plays an important role in our analysis, and a marketplace can tap into such demand by expanding the product variety supplied on its storefront. We show that this is a powerful driver to explain the rationale for a marketplace, but acknowledge that complementary mechanisms may be at play which are not captured in our model. This includes the logic for becoming an "always low-prices store," where elastic demand and competition between sellers drives up demand for existing products. Or the existence of demand spillovers across products, where the retailer profits from becoming the "everything store" given that the supply

[4]Amazon is an example of a retailer-led marketplace with a loyal customer base. A 2019 survey of US consumers who shopped on Amazon in the last two years found that 66% start their search for new products on Amazon, 95% are satisfied with Amazon search results, 82% check prices on Amazon before making a purchase, 74% go to Amazon when they are ready to buy a specific product, and only 11% disagreed with the statement "I am more likely to buy products from Amazon than other E-commerce sites." Moreover, Amazon leverages its customer base to discourage third party sellers from investing in competing retail channels. If a third party seller offers consumers a lower price outside the marketplace (for instance on their own website) Amazon will penalize or disable the seller's product listing on its storefront. See 'The 2019 Amazon Consumer Behavior Report,' Feedvisor, March 19 2019, https://feedvisor.com/resources/amazon-trends/the-2019-amazon-consumer-behavior-report. See also the press release for the antitrust lawsuit filed against Amazon.com by the Washington, D.C. Attorney General, May 25 2021, https://oag.dc.gov/release/ag-racine-files-antitrust-lawsuit-against-amazon.

of additional products increases the demand for existing products. These mechanisms are compatible with the ones we study and could strengthen our results if present in the model, but are not the focus of our analysis.

In the next section, we position our paper within the relevant academic literature. Section 2 introduces the building blocks of our model and the timing of the game. We then proceed to solve the game by backwards induction. We solve the pricing subgame in Section 3, the entry subgame in Section 4, and the marketplace fee setting problem in Section 5. In Section 6 we perform a policy analysis and examine the potential for different interventions. Section 7 concludes.

1.1 Literature

Our work relates to the theoretical literature on vertical relations, platforms, and multiproduct firms. The vertical relations literature has studied the impact of different revenue models within the supply chain. Johnson (2017) examines the impact of revenue models on retailers and suppliers motivated by the practices observed in online retail. Four models are considered depending on which party sets the retail price and how sales revenues are shared, either through a wholesale price charged by the supplier or a revenue-sharing rule. Our analysis is based on the *agency* model where third party sellers set prices and pay the platform an *ad valorem* fee (i.e., revenue-sharing). Nonetheless, we also study the *consignment* model where third party sellers pay a unit fee in Appendix B.3 and show why it is dominated by the agency model in our setting.

A retailer-led marketplace intermediates transactions between third party sellers and consumers and therefore operates as a two-sided platform. The platforms literature has mostly considered settings where the platform and the agents participating on the sides have separate roles which do not overlap, though a novel feature of our model is that the platform (the leading retailer) participates as an additional seller. To understand the platform's participation it is important to examine how it impacts the agents participating on the sides. This has been studied through the lens of network effects (within-group external effects on one side of a platform) by Halaburda, Piskorski, and Yildirim (2018), Belleflamme and Peitz (2018), and Karle, Peitz and Reisinger (2020). They examine the implications of negative network effects on a platform's side (competition between sellers or participants on the same side) as well as fees (including per unit and ad valorem fees as considered here). They also flag the importance of investigating the incentives of a platform to provide buyers with first-party content when this lessens the profits of third party sellers, a line of inquiry we aim to contribute to with our present work.

Several contemporary papers also study the platform's participation in trade between the sides. Etro (2021a, 2021b), Hagiu, Teh and Wright (2020), Anderson and Bedre-Defolie (2021), Shopova (2021), and Zennyo (2021) model online marketplaces and study some form of participation by the marketplace owner. What sets our present contribution apart is the recognition of capacity and information constraints as a key mechanism to explain the platform's participation choices and the equilibrium composition of the product assortment. In addition, key choices in our modeling strategy are distinct from this growing literature. We consider a rich product space with heterogeneous products but let firms compete at the product market level by supplying perfect substitutes. This ensures our model is well suited for large marketplaces where firms operate as resellers of physical goods. We also incorporate ad valorem fees and a buy box mechanism into product market competition. This enables us to study important marketplace features and examine a rich set of relevant practices and interventions in our policy analysis.

A key focus of our analysis is the strategic role of information for a retail platform, specifically information about consumer demand which is dispersed across sellers and can be acquired and exploited by a retailer operating a marketplace. The role of information for platforms has become a recent focus of attention in the literature. Casadesus-Masanell and Hervas-Drane (2015) examined the impact of exploiting consumer information for advertising and other revenue-generating purposes. Jullien and Pavan (2019) present a general framework to analyze the challenges of information acquisition and exploitation for platforms. Our present work contributes to this strand of the literature by examining the specific mechanisms at play in the retail context.

Our work also relates to a growing strand of literature studying the practices and empirical evidence from retailer-led marketplaces. Jiang, Jerath and Srinivasan (2011) study the principal-agent problem that emerges between Amazon and a third party seller due to the threat of product market entry by the former. This threat plays an important role in our analysis, though our focus is on the competitive interaction between both parties that follows rather than third party strategies to prevent it. Zhu and Liu (2018) explore the empirical evidence on Amazon's entry choices across products supplied by third party sellers. They show that Amazon enters a small subset of the third party product space, approximately 3% over a ten month period. Amazon enters only successful products with high sales or good consumer reviews, and entry has limited effect on product prices though it benefits consumers through lower shipping costs. These findings are consistent with those predicted by our model and we discuss them further in Section 4.

2 The model

A monopoly retailer M sells directly to consumers through its storefront and operates a marketplace for third party sellers to also do so. The marketplace is a contractual arrangement that enables third party sellers to sell on the retailer's storefront in exchange for paying fees. The retailer and third party sellers operate as resellers, purchasing products from manufactures and selling them to consumers. We refer to M as a monopolist ("he") due to the market power he accrues by managing the marketplace and controlling the storefront, i.e., by setting fees and assigning the buy box as described below. The marketplace exposes him to competition with third party sellers ("she").[5]

There is a unit mass of products that differ in their value to consumers v. Product valuations are distributed according to CDF $G(v)$ with a log-concave density function $g(v)$. Further assumptions are introduced in Section 5 to ensure equilibria are well-behaved. We will refer to individual products by their valuation v, and without loss of generality index products in order of increasing valuation.

We consider the simplest possible demand structure. The demand for each product is independent of the demand for other products, so that each product is an independent product market. For each product, there is a unit mass of consumers with unit demand. That is, a product with consumer valuation v will be purchased by a unit mass of consumers if it is supplied at any price $p \leq v$, and otherwise will not be consumed. The specification implies that consumer demand is inelastic. This has welfare implications compared to a specification with elastic demand which we discuss in further detail in Section 6.

On the supply side, for each product v there is a single third party seller T_v who can supply it through the marketplace. To simplify notation we suppress subscript v and refer to every third party seller by T, though each seller can only be active in her respective product market. We assume T relies on the monopolist's storefront to reach consumers and thus her outside option is zero. Product v may be supplied on the storefront by both M and T, by one firm only, or not be supplied at all. This setup allows for duopoly competition at the product market level which simplifies the analysis, though our qualitative findings are generally robust to oligopolistic competition with additional third party sellers as shown in Appendix B.1.

We keep the cost structure simple. Firms incur marginal cost c when supplying a unit of any given product. This marginal cost can be understood to capture the (unmodeled) price charged by the manufacturer, as well as listing, stocking, handling, shipping, and customer service costs. Without loss of generality, we focus on the space of viable products which can be supplied profitably under monopoly, $G(c) = 0$.[6]

In turn, we enrich other aspects of the model to capture the asymmetries that arise between the monopolist and third party sellers given the strategic levers available to the former. A first strategic lever available to the monopolist's given his ownership of the marketplace is to set *ad valorem* fee f incurred by third party sellers. We consider a blanket tariff scheme that applies to all third party sellers across all products. In Section 5 we discuss the implications of our findings for different tariffs across different product categories, and in Appendix B.3 we show that an ad valorem fee dominates a per unit fee and is the preferred tariff scheme for the

[5]Because firms operate as resellers and do not control upstream supply, they cannot preclude competition on the storefront. A manufacturer selling its products directly on the storefront could attempt to preclude competition by refraining to serve competitors, though even this may not be effective against copying of products to supply close substitutes. For example, products supplied by Amazon under its Amazon Basics brand are often perceived by consumers to be close substitutes of original manufacturer products. We discuss copying further in Section 4 and examine its policy implications in Section 6.

[6]We discuss the implications of asymmetry in marginal costs between the monopolist and third parties in Section 4. There are scenarios where consumers may perceive differences in quality of service between both firms, for example if purchasing the product from M rather than T ensures a better delivery experience or after-sales service. Quality differences between M and T that affect consumer's willingness to pay for a product (v) are isomorphic in our model to asymmetry in marginal costs.

monopolist.

A second strategic lever available to the monopolist is to influence consumer purchasing decisions by selecting the default seller for each product through the *buy box.* To model this we let a fraction λ of consumers be *inattentive* and purchase from the seller selected by M in each product market provided that the price does not exceed v. The remaining $1-\lambda$ consumers are *attentive* and inspect all available offers, purchasing from the cheapest seller with tie-breaking in favor of M (this simplifies the exposition by avoiding the need for price undercutting arguments on behalf of M). Parameter λ can thus be interpreted as a catch-all parameter for the various competitive advantages M enjoys by controlling the storefront. Additional assumptions on λ are introduced in Section 4 to simplify the analysis.[7]

To examine the monopolist's rationale for operating a marketplace and opening up to competition we consider both information and capacity constraints. The monopolist observes the distribution of product valuations $G(v)$ but is informed only about fraction θ of products, sampled uniformly from the product space. He can sell the products he is informed about without operating a marketplace. Therefore, if $\theta = 1$, M is perfectly informed about the product space. If $\theta < 1$, he is initially unaware of fraction $1-\theta$ of products, which we refer to as *unobserved* products. M cannot sell unobserved products, because he cannot identify them or is unable to initiate upstream supply arrangements, but can learn about them by operating a marketplace. If unobserved product v is sold by T on the marketplace, then M observes the product and becomes informed about it and can also sell it (capacity permitting). This learning mechanism will play an important role in our analysis.

The monopolist is capacity constrained in his own retail operations such that he can only supply fraction k of all products. If $k = 0$, M is unable to operate as a retailer but can generate revenues by running the marketplace. If $k > 0$, M can operate as a retailer and will allocate capacity by choosing which products to sell (information permitting as described above). Products which are not sold by the monopolist may still be supplied by third party sellers through the marketplace and generate fee revenues for M. Note that this capacity constraint applies to the number of product varieties supplied (number of distinct products) rather than to the quantity of each supplied to consumers; the latter is not equivalent, despite unit demand, given that some product markets operate under duopoly in equilibrium. The constraint captures the organizational complexity of managing manufacturer relationships, logistics, product pages, and customer service for a large variety of products.

The timing of the game is as follows. In Stage 1, M announces marketplace fee f. Entry decisions take place in Stage 2. First, for each product v, seller T decides whether to sell the

[7]The inner workings of Amazon's buy box assignment algorithms have not been disclosed, though Amazon states that it considers several metrics such as price, delivery, and customer service and feedback ratings. Casual inspection suggests that Amazon regularly assigns the buy box to itself rather than to third party sellers when it supplies a given product, though this is not incompatible with the stated criteria given that Amazon is likely to outperform third party sellers in most metrics. For the purpose of our study, it seems reasonable to assume that Amazon can and will make buy box assignment choices to maximize its profits. Buy box sales have been reported to account for over 80% of all sales on Amazon's storefront, see the EU Commission Statement of Objections about Amazon Data case, November 10 2020, https://ec.europa.eu/commission/presscorner/detail/en/statement_20_2082.

product on the marketplace. Next, after observing T's entry decisions and becoming informed about unobserved products supplied on the marketplace, M decides whether to enter and sell each product v subject to information and capacity constraints. Price competition takes place in Stage 3. Motivated by the fact that M manages the marketplace and can observe the price quoted by sellers before quoting his own, we consider sequential pricing which also simplifies the analysis. For each product v, first, T quotes her price if she has entered. Second, M quotes his price if he has entered and assigns the buy box to either T or M. Finally, consumers execute purchasing decisions. We solve the game by backwards induction starting from the last stage.

3 Pricing

We start by solving the sequential price competition subgame in Stage 3. Consider the possible product market configurations for product v. The product market will operate under monopoly if only M enters or only T enters. We denote these market configurations by SBM (sold by M) and SBT (sold by T) respectively. In the first case, M monopolizes the product market, sets price $p_M = v$ and assigns the buy box to himself. All consumers purchase and the monopolist's profits are given by $\pi_M^{SBM}(v) = v - c$. There no marketplace fees levied as there are no third party sales for this product.

In the case that only T enters, M cedes the product market and assigns the buy box to T but collects fee revenues. If T sets price p_T, M collects fp_T in fee revenues and T keeps $(1-f)p_T$ of sales revenues. The third party will charge the monopoly price $p_T = v$ and resulting profits are $\pi_T^{SBT}(v) = v(1-f) - c$ and $\pi_M^{SBT}(v) = vf$. Note that this requires $v \geq \frac{c}{1-f}$ for T to earn non-negative profit (otherwise T would prefer to charge $p_T > v$ and sell to no one). The fee-adjusted marginal cost $\frac{c}{1-f}$ will play a crucial role in our forthcoming entry analysis in determining T's entry decisions.

If both M and T enter the product market it will operate under duopoly. We denote this configuration by $SBMT$ (sold by M and T). The pricing equilibrium has the following simple structure: M endogenously assigns the buy box to himself and charges inattentive consumers the monopoly price $p_M = v$ while T serves attentive consumers at a lower price given by

$$\bar{p}_T \equiv \frac{\lambda v + c(1-\lambda)}{1 - f(1-\lambda)}.$$

Price $\bar{p}_T$ is determined by M's incentives to undercut T. Namely, it is the price that renders M indifferent between undercutting to serve all consumers and setting $p_M = v$ in order to serve only inattentive consumers (at the monopoly price) and earn fee revenues from T's sales to attentives. Note that this pricing equilibrium also requires $v \geq \frac{c}{1-f}$ for T to derive non-negative profit (else $p_T > v$ and M serves the whole market). The full characterization of the duopoly equilibrium can be found in Appendix A. We next state the outcome of price competition in Stage 3.

Proposition 1. *The market for product v will operate under configuration*

1. *SBM if product v is sold only by the monopolist; M assigns the buy box to himself $B = M$ and sets price $p_M = v$, serves all consumers and derives profits $\pi_M^{SBM} = v - c$.*

2. *SBT if product v is sold only by the third party seller; M assigns the buy box to the third party $B = T$ and T sets price $p_T = v$, serves all consumers, and derives profits $\pi_T^{SBT} = (1-f)v - c$ while M derives profits $\pi_M^{SBT} = fv$ from fee revenues.*

3. *SBMT if product v is sold by both the monopolist and the third party seller; M assigns the buy box to himself $B = M$, firms set prices*

$$\begin{aligned} p_M &= \quad v \\ p_T &= \quad \bar{p}_T, \end{aligned}$$

M serves inattentive consumers and T serves attentive consumers, and firms derive profits $\pi_M^{SBMT} = \lambda(v-c) + (1-\lambda)f\bar{p}_T$ and $\pi_T^{SBMT} = (1-\lambda)(\bar{p}_T(1-f) - c)$.

We find that marketplace fees and the buy box soften price competition. When both firms compete in a product market, the monopolist serves inattentive demand at the monopoly price through the buy box and lets the third party cater to attentive demand at a lower price, collecting fee revenues on the third party's sales. The mechanisms driving this result operate as follows. First, marketplace fees allow the monopolist to appropriate some of the profits generated by his competitor, and this softens competition by reducing his incentives to undercut her price. Second, control of the buy box allows the monopolist to steer inattentive consumers to pay a higher price. In particular, the monopolist has an incentive to self-assign the buy box rather than assign it to the third party, given that he cannot fully appropriate her markup through fees. The combination of both mechanisms ensures that firms can sustain higher prices in equilibrium than they would otherwise.[8]

The result presented in Proposition 1 is based on the simplest instance of price competition where there is a single third party seller and firms price sequentially. We have analyzed other specifications of the game and found that the result is qualitatively robust. Under oligopoly, with multiple third party sellers, competition to serve attentive consumers intensifies but the buy box still enables one firm to monopolize demand from attentive consumers. In SBT configuration, the opportunity of buy box assignment ensures that $n \geq 2$ third party sellers choose to charge the monopoly price $p_T = v$ provided that consumer inattentiveness is sufficiently high $\lambda \geq \frac{n-1}{n}$. In $SBMT$ configuration, the only difference with respect to the solution described in Proposition 1 is that Bertrand competition for attentive demand drives third party seller prices down to the fee-adjusted marginal cost $p_T = \frac{c}{1-f}$. Note that the main comparative statics of p_T with respect to c and f are preserved. Our derivations for this oligopoly case can be found in Appendix B.1.

[8] Our buy box analysis illustrates why a platform owner competing with a participant on one of the platform's sides has incentives to engage in self-preferencing by steering demand towards his own offering. This problem is an instance of biased intermediation among competing sellers, where the intermediary managing the bias is aligned with one of the sellers (in our model, the intermediary and the seller are one and the same). De Cornière and Taylor (2019) study a more general version of this problem and show that the consumer impact of the intermediary's bias hinges on whether seller and consumer payoffs are in conflict or not.

We have performed extensive analysis of the simultaneous price competition game in Hervas-Drane and Shelegia (2022). The complexity of the problem increases given that the unique equilibrium is in mixed strategies, with firm prices determined by probability distributions over the price support. In Appendix B.2 we present the mixed strategy equilibrium of the simultaneous game. The monopolist quotes a higher price in expected terms than the third party seller (and places a mass point at the monopoly price), though with some positive probability he undercuts the third party and takes over the market. Note however that the mixed strategy equilibrium retains the qualitative properties of the solution derived in Proposition 1, including the comparative statics of expected prices with respect to λ, f, and c. Thus the timing of the game is not critical to our results.

Some properties of equilibrium prices merit additional discussion. With regards to the level of prices in equilibrium, some consumers purchase at the monopoly price $p = v$. This can be counterintuitive given casual observation of low prices in online storefronts. It is worth stressing that parameter v describes the maximum price consumers are willing to pay to purchase *on the online storefront.* Cavallo (2017) provides a comprehensive comparison of online and offline retail prices and finds that Amazon.com's prices ("Sold by Amazon.com" products) are 6% lower on average than those of large brick-and-mortar stores. This is compatible with our model if consumers are willing to pay less to order a product online rather than to purchase it from a brick-and-mortar store. The monopoly price in our model can be interpreted as the highest price consumers will pay before switching to a competing sales channel.

With regards to the dispersion of prices in equilibrium, we find that the monopolist generally quotes a higher price than third party sellers. There is a growing empirical literature examining the formation of prices in online marketplaces. For the most part, however, it has not examined the question of how the marketplace owner (operating as a seller) prices compared to third party sellers. One exception is Zhu and Liu (2018), who report that Amazon's entry into products previously supplied exclusively by third party sellers has limited effect on posted prices but can benefit consumers through lower shipping costs. While this finding may not be representative of Amazon's pricing choices across the whole product space, it suggests that the difference between p_M and p_T is small. Price dispersion in our model hinges on consumer inattentiveness λ and ad valorem fee f, and indeed the price gap $p_M - p_T$ decreases with λ and f and converges to zero when $\lambda \to 1$. Thus low price dispersion should be expected when the intensity of competition is low.

To conclude this section, we identify the key comparative statics derived above that are required for the remaining of our analysis. Third party seller profits satisfy $\pi_T^{SBT} > 0$ if and only if $v > \frac{c}{1-f}$, and likewise for $\pi_T^{SBMT} > 0$. This ensures that T's entry decisions depend on v, c and f but not on M's entry choices. The monopolist's profits satisfy $\frac{\partial \pi_M^{SBT}}{\partial f} - \frac{\partial \pi_M^{SBMT}}{\partial f} > 0$ so that M gains more from increasing the fee in a product market where his profits are driven exclusively by fee revenues (SBT) compared to a market where he is also an active seller ($SBMT$). This property will govern M's entry and fee setting decisions. It ensures M has incentives to reduce f when entering product markets where T is present (when SBT markets transition to *SBMT*). And conversely, a higher fee f reduce M's incentives to enter into SBT product markets (reduces $\pi_M^{SBMT} - \pi_M^{SBT}$). Finally, we also have $\frac{\partial^2 \pi_M^{SBMT}}{\partial f \partial \lambda} < 0$ so that f and λ are *substitutes* for extracting value in product markets where M competes with T. That is, M has stronger incentives to increase the fee when there are less inattentive consumers he can monopolize. We expect these comparative statics to be satisfied by a broad family of pricing models beyond the ones discussed above.

4 Entry

We turn to the entry subgame in Stage 2. Firms make entry decisions based on product market payoffs derived in the preceding section and do not incur any entry costs. We proceed to characterize entry decisions as a function of marketplace fee f set by the monopolist in Stage 1.

We start by considering T's entry problem in product market v. The third party seller will only choose to enter if she expects to derive positive profits. Given product market payoffs in Proposition 1, T will only enter to operate as a monopoly if $\pi_T^{SBT}(v) \geq 0$ and will only enter to operate under duopoly if $\pi_T^{SBMT}(v) \geq 0$. Both conditions identify the same lower boundary on v,

$$v \geq v_T \equiv \frac{c}{1-f}. \tag{1}$$

This v-threshold v_T states that the third party will enter product markets where consumer valuations are sufficiently high given marginal cost and fees.

Lemma 1. *T enters products $v \geq v_T$ and stay outs of the remaining.*

Proof. Follows directly from the analysis above. □

The result implies that product markets $v < v_T$ remain empty unless M enters. In what follows, we refer to the products T enters as *marketplace products* and to the remaining as *non-marketplace products*. Note that in the absence of fees $f = 0$ all products are marketplace products, given that $v_T = c$, and the marketplace achieves its largest feasible size. And conversely, when the fee is exceedingly high $f = 1$, then $v_T = \infty$ and all products are non-marketplace products such that the marketplace is effectively closed.

We turn to the monopolist's entry problem. The monopolist's information and capacity constraints will shape his entry strategy. The information constraint implies that M can only enter product markets he is informed about. The capacity constraint implies that M can enter at most fraction k of all products.

The monopolist's problem is straightforward when there are no marketplace products, $v_T \to \infty$. In this scenario, M relies on his own information about fraction θ of all products. Entering a non-marketplace product enables M to monopolize it and yields profits π_M^{SBM} by Proposition 1, while staying out ensures that the product market remains empty and M derives zero profits.

Given that π_M^{SBM} is increasing in v, M allocates capacity to the highest valuation observed products. Denote the lowest valuation product M will enter by v_0, where

$$v_0 = G^{-1}\left(Max\left[1-\frac{k}{\theta},0\right]\right). \tag{2}$$

When M has excess capacity given knowledge $k \geq \theta$, he is able to supply all observed products $v_0 = c$. Otherwise, if capacity binds relative to knowledge $k < \theta$, then $v_0 > c$ and he lacks capacity to supply low-valuation observed products. In both cases, unobserved products (fraction $1-\theta$ of the product space which M is uninformed about) remain unsupplied.

The monopolist's entry problem is substantially more complex in the presence of the marketplace with active third party sellers. Consider M's profitability when entering a marketplace product given Proposition 1 payoffs. Entering a marketplace product implies competing with T and yields duopoly profits π_M^{SBMT}. Staying out allows M to collect fee revenues π_M^{SBT} from T's sales. It only pays off for M to enter a marketplace product when $\pi_M^{SBMT} > \pi_M^{SBT}$, which simplifies to

$$\frac{\lambda}{(1-\lambda)} > f. \tag{3}$$

The condition is satisfied when the ratio of inattentive to attentive consumers exceeds the ad valorem fee.

We expect the empirically relevant case to be high inattentiveness λ. As noted in the introduction and discussed in the preceding section, a large majority of consumers respond in an inattentive fashion when facing the buy box and other preselected choices presented to them on the storefront. So with the goal of further simplifying the model we make the following assumption.

Assumption 1. *Over half of consumers are inattentive,* $\lambda \geq \frac{1}{2}$.

The assumption ensures that (3) is always satisfied for $f \leq 1$, so that $\pi_M^{SBMT} > \pi_M^{SBT}$ and it pays off for M to enter marketplace products $v \geq v_T$.[9] The monopolist's marginal profitability when entering one of these products can be written as follows

$$\Delta\pi_M^{SBMT-SBT}(v) \equiv \pi_M^{SBMT} - \pi_M^{SBT} = (v - v_T)\,\frac{(1-f)(\lambda - f(1-\lambda))}{1-f(1-\lambda)},$$

which is positive if $\lambda > \frac{f}{1+f}$ (this condition holds for any f by Assumption 1). Furthermore, it is increasing in product valuation v and decreasing in fee f. The higher the ad valorem fee, the lower the incentives for M to enter and compete with third parties rather than allow them to monopolize their product markets and collect fee revenues.

The monopolist's entry problem in the presence of the marketplace therefore consists of allocating capacity across two product pools: non-marketplace products $v < v_T$ and market-

[9] When $\pi_M^{SBMT} < \pi_M^{SBT}$ holds, M does not enter marketplace products and these are monopolized by third party sellers. As a result, configuration *SBMT* does not arise in equilibrium. This case is straightforward to analyze and renders the marketplace less profitable for the monopolist. In Section 6 we examine outcomes when the monopolist closes down the marketplace or his own retail operations.

place products $v \geq v_T$. Note that M is informed about share θ of non-marketplace products as well as all marketplace products (given that T's entry always informs M). The monopolist's marginal profitability when entering a product in one of these pools is given by π_M^{SBM} and $\Delta\pi_M^{SBMT-SBT}$, respectively. First, note that the marginal profitability of entry is positive in both cases, $\pi_M^{SBM} \geq 0$ and $\Delta\pi_M^{SBMT-SBT} \geq 0$ for $v \geq v_T$. Second, within each product pool, high-valuation products are more profitable to enter than low-valuation products, $\partial\pi_M^{SBM}/\partial v > 0$ and $\partial\Delta\pi_M^{SBMT-SBT}/\partial v > 0$. In particular, there exists some $v^* > v_T$ such that

$$\Delta\pi_M^{SBMT-SBT}(v^*) = \pi_M^{SBM}(v_T),$$

which has the following implication for M's entry strategy.

Lemma 2. *M will allocate capacity to enter high-valuation marketplace products $v \geq v^* > v_T$ and will only enter remaining products $v < v^*$ if he has additional capacity to do so.*

Proof. The result follows from the fact that products $v \geq v^*$ provide higher marginal profitability of entry for the monopolist than the remaining, and he is always informed about them due to third party entry. □

It is straightforward to define the level of capacity $\underline{k}$ required for M to enter all marketplace products with valuation $v \geq v^*$,

$$\underline{k} \equiv 1 - G(v^*).$$

We can pin down M's entry strategy in two corner cases. One corner case arises if $k \leq \underline{k}$, so that M exhausts his capacity simply by entering products $v \geq v^*$. Within this product range, M will enter high valuation products first given that $\partial\pi_M^{SBMT}/\partial v > 0$. The lowest valuation product M will have the capacity enter, to be defined by v_k, is given by

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

The other corner case arises when M has enough capacity to enter all products he is informed about. Capacity threshold $\bar{k}$ identifies the capacity required to do so

$$\bar{k}(\theta) \equiv \theta G(v_T) + (1 - G(v_T)),$$

where the first term on the right-hand side refers to non-marketplace products observed by M (share θ of products $v < v_T$) and the second term refers to all marketplace products. Clearly, M's capacity constraint will not bind if $k \geq \bar{k}$. Note that this requires the information constraint to be comparatively stringent $\theta \leq k$ (otherwise $\bar{k} \geq \theta > k$), and thus the threshold depends on θ.

In the central case, M has intermediate capacity $k \in (\underline{k}, \bar{k})$. This is enough capacity to enter high-valuation marketplace products $v \geq v^*$ with spare capacity remaining but insufficient to enter all products he is informed about. In this case M will select which products $v < v^*$ to enter by comparing their marginal profitability, and will allocate capacity across both the marketplace and the non-marketplace product pools. The solution is characterized by entry thresholds v_L and v_H such that the marginal profitability of entry is equalized across both products pools, $\pi_M^{SBM}(v_L) = \Delta\pi_M^{SBMT-SBT}(v_H)$. We relegate the analysis of this case to Appendix A and summarize our results below.

Proposition 2. *The product market entry choices of firms ensure the marketplace operates in*

1. ***Mode I*** *if M has low capacity $k \leq \underline{k}$; products $v \in [v_T, v_K)$ are sold under product market configuration SBT and products $v \in [v_K, \infty)$ under SBMT.*
2. ***Mode II*** *if M has intermediate capacity $k \in \left(\underline{k}, \bar{k}\right)$; fraction θ of products $v \in [v_L, v_T)$ are sold under SBM, products $v \in [v_T, v_H)$ are sold under SBT, and products $v \in [v_H, \infty)$ under SBMT.*
3. ***Mode III*** *if M has high capacity $k \geq \bar{k}$, then fraction θ of products $v \in [c, v_T]$ are sold under SBM and products $v \in [v_T, \infty)$ are sold under SBMT.*

Proof. See Appendix A. □

The entry choices of firms determine both the size and the composition of the product assortment offered on the storefront. We start by reviewing the determinants of entry for third party sellers. We refer to the products third party sellers choose to enter as *marketplace* products, and to the remaining as *non-marketplace products*. A valuation threshold v_T exists which separates both on the product space. The left panel of Figure 1 plots third party profits under monopoly π_T^{SBT} and duopoly π_T^{SBMT} over product space v (refer to the dashed lines, monopoly profits π_M are plotted as solid lines and discussed below). The third party derives higher profits when she monopolizes her product market, given that $\pi_T^{SBT} > \pi_T^{SBMT}$ for all $v > v_T$ as shown in the left panel of Figure 1, but the zero profit entry condition for v coincides in both cases, $\pi_T^{SBT}(v_T) = \pi_T^{SBMT}(v_T) = 0$. The existence of this single entry threshold v_T has two implications. First, the third party's willingness to enter is unaffected by the monopolist's entry choice. And second, marketplace activity is concentrated in the high-value segment of the product space. In effect, threshold v_T captures the size of the marketplace; the lower the threshold, the larger the mass of products supplied by third parties through the marketplace. The threshold is increasing in marginal cost c and fee f, so marketplace size will depend on the fee set by the monopolist in the first stage.

The monopolist's entry problem is more complex. A first step is to determine the monopolist's profitability when an individual product market. Entering a non-marketplace product $v < v_T$ allows the monopolist to monopolize it and derive profits π_M^{SBM}. Entering a marketplace product $v > v_T$ leads to competition and yields profits π_M^{SBMT} originating from both sales and fee revenues. However, staying out from a marketplace product generates profits π_M^{SBT} from fee revenues. When does it pay off for the monopolist to enter and compete rather than stay out and simply collect fees? Inspection of π_M^{SBMT} and π_M^{SBT} reveals that the marginal profitability of entry, which we denote by $\Delta\pi_M^{SBMT-SBT}$, is decreasing in ad valorem fee f and increasing in consumer inattentiveness λ. A higher fee f increases the monopolist's profits both when

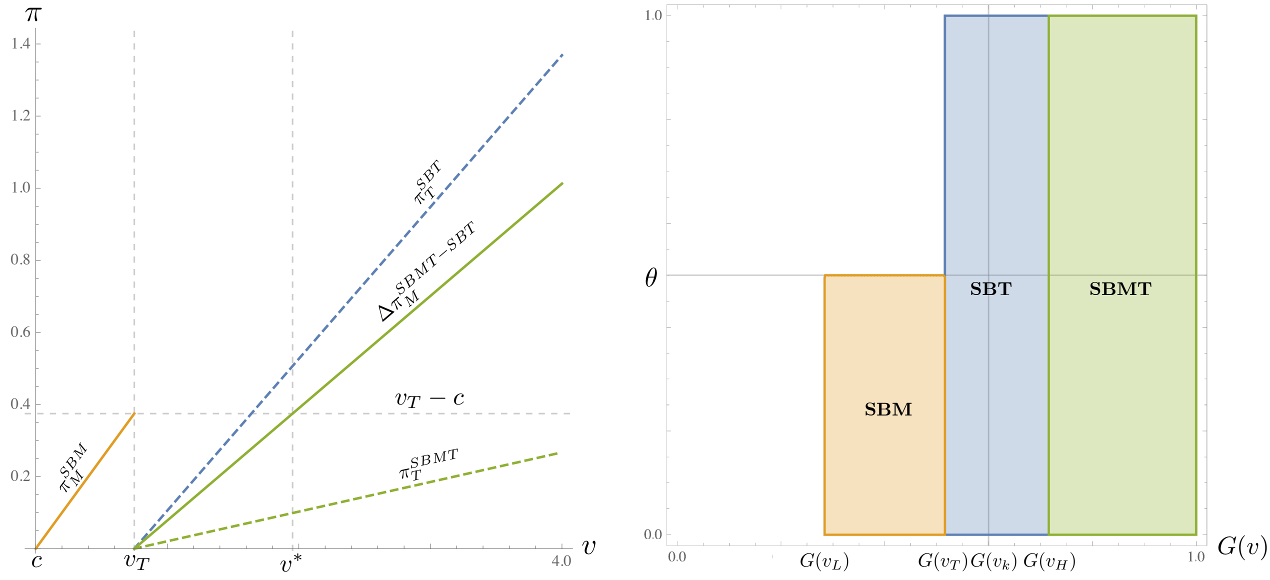

Figure 1: On the left, marginal profitability of product market entry as a function of product valuation v. The profitability of entry for firms varies under monopoly and duopoly, and the monopolist has the outside option of collecting fees. On the right, product market configurations across the product space $G(v)$ in a Mode II equilibrium of the entry subgame. The monopolist allocates capacity across two product pools (*SBM* and *SBMT*) and some products with valuations close to $G(v_T)$ remain unsupplied due to the information constraint. Plotted for $G(v) = 1 - e^{-(v-c)\gamma}$ with $\gamma = 2$, $c = 2$, $\lambda = 0.75$, $k = 0.4$, $\theta = 0.5$ and optimal fee $f^* = 0.1578$ characterized in Proposition 3.

entering and when staying out, but renders the outside option comparatively more profitable. Higher inattentiveness λ reduces the intensity of competition and this renders entry more profitable. Moreover, when a majority of consumers are inattentive $\lambda > \frac{1}{2}$, inattentiveness becomes the overriding factor and entry always pays off. Based on the evidence of inattentive consumer behavior in online storefronts we assume this to be the case.

The second step to evaluate the monopolist's entry strategy is to account for his information and capacity constraints. The left panel of Figure 1 plots the marginal profitability of entry for the monopolist over the product space, which is given by π_M^{SBM} for non-marketplace products and $\Delta\pi_M^{SBMT-SBT}$ for marketplace products (refer to the solid lines). The monopolist stands to profit from entering all product markets, but is generally unable to do so due to his constraints. The monopolist can only enter products he is informed about, which includes fraction θ of non-marketplace products and all marketplace products (having observed entry by third party sellers). The capacity constraint implies the monopolist can enter at most fraction k of the product space. These constraints shape the monopolist's entry choices and lead to the three marketplace modes identified in Proposition 2.

Consider how the monopolist allocates capacity. High-valuation marketplace products $v \geq v^*$ provide the highest profitability, so the monopolist's allocates capacity here first. If capacity is exhausted at this step, then the marketplace operates in *Mode I* and is characterized by *SBT* and *SBMT* configurations over the product space. If additional capacity is available, the monopolist allocates it across marketplace products $v \in (v_T, v^*)$ as well as non-marketplace products $v \in (c, v_T)$ that he is informed about. These two product pools offer similar profitability of entry, so the monopolist allocates capacity across both. The marketplace operates in *Mode II* if the monopolist exhausts capacity at this step before fully entering the two product pools, and is characterized by *SBM*, *SBT* and *SBMT* configurations over the product space. Note that the *SBT* range represents an entry-gap for the monopolist given that he enters products above and below this valuation range (because he allocates capacity in decreasing order of valuation over the two product pools). Only if the monopolist has enough capacity to enter all the aforementioned products, the entry-gap is closed and the marketplace operates in *Mode III* with the product space characterized by configurations *SBM* and *SBMT*.

The right panel in Figure 1 depicts the outcome of the entry subgame. The plot identifies the market configurations that arise in a Mode II marketplace as a consequence of the entry choices of firms. The horizontal axis corresponds to product valuations across the product space and the vertical axis to the fraction of products supplied. In the example plotted, the monopolist has exhausted capacity after entering products $v \in [v_L, v_T)$ and $v \in [v_H, \infty)$. Navigating the plot from left to right, low valuation products $v < v_L$ remain unsupplied. The *SBM* bar represents intermediate valuation products sold only by the monopolist. These are non-marketplace products and the monopolist is informed only about fraction θ of them, so the bar is capped at θ on the vertical axis because the remaining $1 - \theta$ remain unsupplied. The *SBT* bar represents high valuation products which are sold only by third party sellers (the entry-gap discussed above). And to the right, the *SBMT* bar represents the highest valuation products $v > v_H$ sold by both the monopolist and third parties.

Our results explain why a retailer-led marketplace is conducive to competition between the monopolist and third party sellers in the most profitable segment of the product space. And the incentives for firms to compete in this segment are reinforced by the factors that soften the intensity of price competition identified in the preceding section. We are aware of one paper that has analyzed the empirical evidence on product entry and price competition between marketplace owners and third party sellers. Zhu and Liu (2018) study Amazon's entry patterns into marketplace products and find that Amazon chooses to enter a small subset of third party products (approximately 3% of the third party product space over a ten month period), enters only successful products (those with high sales or good consumer reviews), and entry has limited effect on posted prices but can benefit consumers through lower shipping costs (often free shipping). These findings are consistent with our model. In particular, they suggest a scenario with high consumer inattentiveness λ and a monopolist with low capacity k setting a high ad valorem fee f. These parameters are conducive to a Mode I or II equilibrium with a small *SBMT* footprint over marketplace products and low price competition intensity.

The aforementioned study by Zhu and Liu (2018) provides a measure for the extent of *copying* on Amazon, that is, entry by the monopolist in an (ex-ante) unobserved product which is possible after the observing entry by a third party seller and becoming informed about the product. We explore the regulation of copying in Section 6. Amazon's effective rate of copying may be even higher than that reported. In addition to entering the product markets of successful third parties by supplying the exact same product (i.e., perfect substitutes), Amazon has expanded entry in recent years by supplying close substitutes. While these close substitutes are not technically the same product, they operate in the same product market and compete directly with those they substitute. A Wall Street Journal investigation found that Amazon copies key features of successful third party products under its own private label, Amazon Basics.[10]

The timing of our entry subgame assumes that the third party seller moves first and the monopolist second. This is only critical for products the monopolist is uninformed about, given that the informational advantage of the third party requires her to be a first-mover. For products which all firms are informed about, the timing of entry is not critical to our results; third party entry choices do not hinge on those of the monopolist so they are unaffected if the monopolist is the first-mover. With regards to cost structure, our specification assumes there are no entry costs and that marginal costs are symmetric across firms. This is convenient because it generates a single entry threshold v_T for third parties, simplifying equilibrium characterization of entry choices across the product space. Enriching the model by introducing entry costs or marginal cost asymmetry leads to different third party entry thresholds for monopoly and duopoly product markets. This gives place to additional considerations in the entry problem which are beyond the scope of our present analysis.[11]

5 Optimal fee

We are ready to solve the first stage of the game where the monopolist sets the marketplace fee. By setting f the monopolist determines the size of the marketplace v_T and in which of the three modes characterized in Proposition 2 it operates in. Based on entry and pricing strategies in the second and third stages, we can write M's total profits as a function of fees encompassing all marketplace modes as follows

[10]The Wall Street Journal found that Amazon employees "used data about independent sellers on the company's platform to develop competing products. [...] Such information can help Amazon decide how to price an item, which features to copy or whether to enter a product segment based on its earning potential." Amazon employees who spoke with the Journal noted that "pulling data on competitors, even individual sellers, was standard operating procedure when making products such as electronics, suitcases, sporting goods [...] before Amazon's private label decided to enter a product line." The report documented a specific case where Amazon entered the product market of third-party seller Fortem, who designed and sold a car-trunk organizer on Amazon in 2016 which became the best-seller in its category. Three years later, Amazon entered the product market with very similar car-trunk organizers branded under its own private label Amazon Basics. According to Amazon, sales of its own private label items accounted for 1% of physical product sales on its storefront in 2020. See 'Amazon Scooped Up Data From Its Own Sellers to Launch Competing Products,' April 24 2020, Wall Street Journal. See also 'Investors pour $1bn into buying up small merchants on Amazon,' December 22 2020, Financial Times.

[11]For example, when the third party's marginal cost is higher than that of the monopolist the v-threshold for duopoly ($SBMT$) is higher than that for monopoly (SBT). For third party sellers with products comprised between these two thresholds, threat of entry by the monopolist will preclude entry. The effect reduces the product assortment on the storefront, given that if third parties stay out the monopolist remains uninformed about some of these products. Thus the monopolist would benefit from committing not to enter these product markets. However, a credible no-entry commitment may be challenging to implement.

$$\Pi_M(k,\theta,f) = \theta \int_{v_L}^{v_T} (v-c)g(v)\,dv + \int_{v_T}^{v_H} (fv)g(v)\,dv + \int_{v_H}^{\infty} \pi_M^{SBMT}(f,v)g(v)\,dv. \quad (4)$$

Inspection of the monopolist's profit function for the case of zero fees $f = 0$ yields our first result. In the absence of fees the marketplace encompasses the whole product space $v_T = v_L = c$, and this ensures the first order condition (FOC) is always positive, $\partial\Pi_M/\partial f > 0$.

Lemma 3. *The monopolist always charges an ad valorem fee, $f^* > 0$.*

Proof. The proof follows trivially from inspection of $\partial\Pi_M/\partial f$ at $f = 0$ which obtains

$$\int_c^{v_0} vg(v)\,dv + \int_{v_0}^{\infty} \frac{\partial\pi_M^{SBMT}(f,v)}{\partial f} g(v)\,dv > 0.$$

□

There are two effects at play driving this result. First, when the marketplace fee is set to zero, a marginal increase in f triggers some sellers to exit but this does not reduce fee revenues given that no fees were collected. And second, this marginal increase in f increases fee collection in both *SBT* and *SBMT* product markets.

Consider M's problem when setting ad valorem fee f in the first stage of the game. The monopolist's profit maximization problem is well defined because Π_M is continuous in f, achieving a maximum for some $f^* \in (0,1]$. If $f^* < 1$ the marketplace will be open and if $f^* = 1$ it will be closed, given that any participating third party seller derives negative profits. To ensure tractability and simplify the analysis it is useful to focus on the following cases.

Assumption 2. *Assume the distribution of product valuations $G(v)$ is such that the monopolist's profit function $\Pi_M(k,\theta,f)$ is strictly quasi-concave in f for any k and θ.*

This assumption simplifies the profit-maximization problem and rules out equilibrium multiplicity. It is hard to verify analytically if a given distribution $G(v)$ satisfies the condition, but it is easy to do so numerically and the condition holds for a large number of distributions including the exponential distribution with CDF $G(v) = 1 - e^{-(v-c)\gamma}$ with $\gamma > 0$ and $v \in [c,\infty)$[12]

We have written M's profit function Π_M in (4) in a general form which encompasses the three possible marketplace modes characterized in Proposition 2. The FOC $\partial\Pi_M/\partial f = 0$ has one or two solutions under Assumption 2. If one solution exists, it may be an interior or a corner solution. If two solutions exist, one will be interior and the other will be a corner solution; the

[12]We use the exponential distribution of consumer valuations to illustrate our results throughout this paper because it provides a standard formulation to capture heterogeneity across the product space and describes the case where most profits are generated from a small share of products. More specifically, the exponential distribution ensures that a small share of the product space consisting of high valuation products has the potential to generate most sales and profits. This property has long been accepted in the marketing literature and states that 80% of sales are driven by 20% of products. It is often referred to as the 80/20 rule or Pareto principle, as it was first formalized by Vilfredo Pareto in his study of wealth distribution.

interior solution must be the maximizer in this case. Note that a solution f^* is a function of v-thresholds (v_L, v_T, v_H), and to constitute an equilibrium it must induce the v-thresholds it is derived from. We next characterize the conditions for each marketplace mode to hold in equilibrium.

Consider marketplace Mode III first, where $c = v_L < v_T = v_H$. The FOC then becomes,

$$\int_{v_T}^{\infty} \frac{\partial \pi_M^{SBMT}(f, v)}{\partial f} g(v)\, dv = (1-\theta)(f v_T) g\left(v_T\right) \frac{\partial v_T}{\partial f}, \tag{5}$$

where the left-hand side describes the gains of increasing f and the right-hand side describes the losses. The gains accrue from higher fee revenues from participating third party sellers, which increase with f at a rate of $\partial \pi_M^{SBMT}/\partial f$ in *SBMT* markets (no fee revenues are derived from the remaining *SBM* product markets). The losses originate from lost fee revenues due to sellers exiting the marketplace, with an increase in f driving exit at a rate $g\left(v_T\right) \partial v_T/\partial f$. These lost revenues only materialize for fraction $1-\theta$ of products which are unobserved, as otherwise M enters and replaces T's sales.

Denote by f_3^* the lowest solution to the FOC in (5), which by Assumption 2 has a solution when k is sufficiently high such that M is capacity unconstrained (always the case for $k=1$). For f_3^* to constitute an equilibrium it must satisfy the v-thresholds for Mode III, which requires that $k \geq \bar{k}$ by Proposition 2. So we define

$$\bar{k}^*(\theta) = \theta G(v_T(f_3^*)) + (1 - G(v_T(f_3^*))),$$

and a Mode III equilibrium exists with an ad valorem fee f_3^* if and only if $k \geq \bar{k}^*$, which ensures that M is capacity unconstrained, yielding profits

$$\Pi_M^{III} = \theta \int_c^{v_T} \pi_M^{SBM}(v) g(v)\, dv + \int_{v_T}^{\infty} \pi_M^{SBMT}(f_3^*, v) g(v)\, dv.$$

Consider next marketplace Mode I where $v_L = v_T < v_H = v_K$. In this case the FOC becomes

$$\int_{v_T}^{v_K} \frac{\partial \pi_M^{SBT}(f, v)}{\partial f} g(v)\, dv + \int_{v_K}^{\infty} \frac{\partial \pi_M^{SBMT}(f, v)}{\partial f} g(v)\, dv = (f v_T) g\left(v_T\right) \frac{\partial v_T}{\partial f}, \tag{6}$$

where gains on the left-hand side increase with f at a rate of v in *SBT* product markets and at a rate of $\partial \pi_M^{SBMT}/\partial f$ in *SBMT* markets, and losses on the right-hand side are driven by seller exit at a rate $g\left(v_T\right) \partial v_T/\partial f$ and a revenue loss of $f v_T$ per unreplaced marginal seller. The optimal fee must satisfy (6) for k sufficiently close to 0, and the FOC will have a unique solution.

Denote by f_1^* the unique solution to the FOC in (6) for k low enough so that $v_T(f_1^*) < v_K$. For an equilibrium, f_1^* must satisfy the v-thresholds for Mode I which requires a more stringent

$$v_K > v^*(f_1^*). \tag{7}$$

The set of k which satisfies this inequality and yields a unique solution to (6) is well defined. It must hold for sufficiently low k and will not hold for sufficiently high k. Note that both sides of the inequality are decreasing in k, given that $v^*(f_1^*)$ is increasing in f_1^* which in turn is decreasing in k. This implies that a simple upper bound on k cannot be derived. We make the following assumption to proceed.

Assumption 3. *Equation $v_K = v^*(f_1^*)$ where f_1^* solves the Mode I FOC in (6) has a unique solution in k which we denote by $\underline{k}^*$.*

The assumption ensures that inequality (7) holds for all $k \leq \underline{k}^*$ where $\underline{k}^*$ is identified by the solution to

$$1 - G\left(v^*(f_1^*)\right) = v_k.$$

The existence of a solution is assured because for $k = 0$ we have $k = 0 < 1 - G(v^*(f_1^*))$ given that $v^*(f_1^*) < \infty$, and for $k = 1$ we have $k = 1 > 1 - G(v^*(f_1^*))$ given that $v^*(f_1^*) > 0$. The preceding assumption rules out the existence of multiple solutions. Thus a Mode I equilibrium exists with an ad valorem fee f_1^* if and only if $k < \underline{k}^*$, yielding profits

$$\Pi_M^I = \int_{v_T}^{v_K} \pi_M^{SBT}(f_1^*, v) g(v)\, dv + \int_{v_K}^{\infty} \pi_M^{SBMT}(f_1^*, v) g(v)\, dv.$$

The ranking of the previously identified thresholds is made via Assumption 2 and the fact the profit function is continuous in k. This implies that when k goes from 0 to 1, the mode which occurs at the maximand f^* has to transition from Mode I to Mode II to Mode III, thus $\underline{k}^* < \bar{k}^*(\theta)$ has to hold. If $k \in (\underline{k}^*, \bar{k}^*(\theta))$ so that neither a Mode I nor a Mode III equilibrium exist, the marketplace must operate in Mode II which is characterized by $v_L < v_T < v_H$. The FOC is then given by

$$\int_{v_T}^{v_H} v g(v)\, dv + \int_{v_H}^{\infty} \frac{\partial \pi_M^{SBMT}(f, v)}{\partial f} g(v)\, dv = \left[\theta(v_L - c) + (1-\theta)(f v_T)\right] g\left(v_T\right) \frac{\partial v_T}{\partial f}. \tag{8}$$

In this case the gains on the left-hand side accrue from both SBT and $SBMT$ product markets. Losses on the right-hand side originate from the exit of third party sellers, of which share θ are replaced by M reallocating capacity from the lowest valuation products (thus sacrificing profits $v_L - c$ per replacement) and share $(1-\theta)$ remain unreplaced.

Denote by f_2^* the lowest solution to the FOC in (8). A Mode II equilibrium exists with f_2^* if it satisfies v-thresholds $v_L < v_T < v_H$, which is the case if $k \in \left(\underline{k}^*, \bar{k}^*\right)$. This yields profits

$$\Pi_M^{II} = \theta \int_{v_L}^{v_T} \pi_M^{SBM}(v) g(v)\, dv + \int_{v_T}^{v_H} \pi_M^{SBT}(f_2^*, v) g(v)\, dv + \int_{v_H}^{\infty} \pi_M^{SBMT}(f_2^*, v) g(v)\, dv,$$

where v_L and v_H are pinned down by M's entry strategy in (10).

We characterize the remaining properties of optimal fee f^* in Appendix A and present our results below.

Proposition 3. *The monopolist sets marketplace fee*

1. $f^* = f_1^*$ *if capacity is sufficiently low* $k \leq \underline{k}^*$*; the marketplace operates in Mode I and M derives profits* Π_M^I.

2. $f^* = f_2^*$ *for intermediate capacity such that* $\underline{k}^* < k < \bar{k}^*$*; the marketplace operates in Mode II and M derives profits* Π_M^{II}.

3. $f^* = f_3^*$ *if capacity is sufficiently high* $k \geq \bar{k}^*$*; the marketplace operates in Mode III and M derives profits* Π_M^{III}.

Proof. See Appendix A. □

Fees impact third party seller participation and therefore the size of the marketplace. Together with the monopolist's own product entry choices, the size of the marketplace determines in which of the three modes characterized in Proposition 2 the marketplace operates in. Proposition 3 retains the spirit of our entry results given that the three modes arise in equilibrium. The left panel in Figure 2 identifies the equilibrium region for each mode across the monopolist's capacity and information parameter space (k, θ). The diagonal $k = \theta$ separates the top-left half of the parameter space where the monopolist has enough information to use all his capacity $(\theta > k)$ from the bottom-right half where he does not $(\theta < k)$; in the latter case the monopolist needs to learn about unobserved products from the marketplace to fully utilize his capacity. The right panel in Figure 2 depicts equilibrium product market configurations over the product space as a function of capacity k. This panel corresponds to a horizontal trajectory over the left panel for a fixed θ. To understand the properties of the equilibrium it is useful to navigate these plots from left to right, given that capacity k turns out to be a strong determinant of the equilibrium outcome.

The left-most region of both plots corresponds to a marketplace operating in Mode I. This mode holds in equilibrium whenever the monopolist is very capacity constrained (low k). In this mode the monopolist allocates all his capacity to supply the highest valuation marketplace products ($SBMT$). Third party sellers compete with the monopolist to supply these products ($SBMT$) and also monopolize products in the high valuation range (SBT). As shown in the right panel (left region), this generally results in a marketplace that exceeds the monopolist's retail footprint.

The middle region in both plots corresponds to a Mode II marketplace. This mode holds in equilibrium when the monopolist has an intermediate level of capacity k. As described in our entry analysis in the preceding section, the monopolist allocates capacity across two disconnected product pools; he supplies the highest valuation marketplace products ($SBMT$) as well as intermediate valuation non-marketplace products (SBM). Third party sellers compete with the monopolist to supply the highest valuation products ($SBMT$) and monopolize high valuation products (SBT). Across Mode II equilibria, the size of the monopolist's retail footprint grows beyond that of the marketplace. The monopolist's profits are derived increasingly from his own sales revenues and the weight of fee revenues decreases. Note that the monopolist

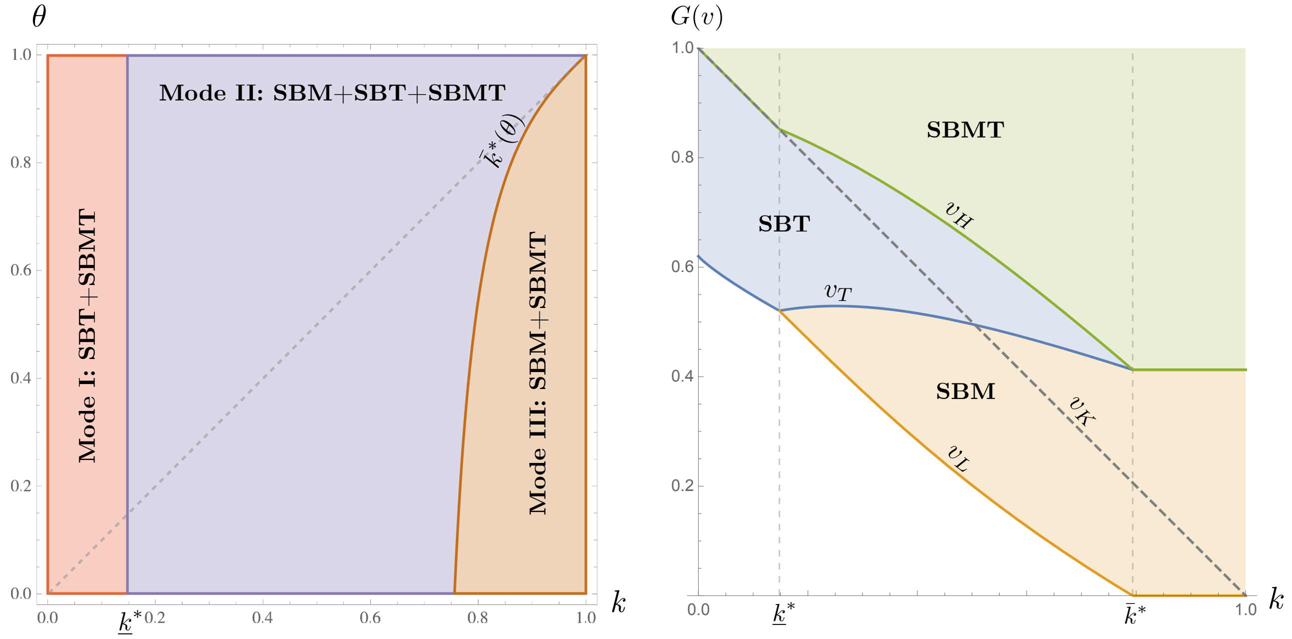

Figure 2: On the left panel, equilibrium marketplace modes over the parameter space for the monopolist's capacity k and information θ, where Mode I is on the left, Mode II in the middle, and Mode III on the right. Only one of the three modes holds in equilibrium. On the right panel, product market configurations over the product space (with valuation ranges mapped to G) as a function of capacity k. Several product market configurations coexist in equilibrium. Plotted for $G(v) = 1 - e^{(v-c)\gamma}$, $\gamma = 2$, $c = 2$, $\lambda = 0.75$, and $\theta = 0.5$ (right panel).

overtakes the marketplace but does not replace it, as the SBT range (the monopolist's entry gap) survives across Mode II equilibria.

The right-most region of the plots corresponds to a marketplace operating in Mode III. This mode holds whenever the monopolist has high capacity k and information θ is not too high, such that he operates with excess capacity.[13] Mode III is characterized by the monopolist closing the entry-gap to supply all marketplace products (SBT range transitions in full to $SBMT$), with third party sellers competing with the monopolist in every product they supply. The monopolist also supplies all non-marketplace products he is informed about (SBM). Note that $v_L = c$ does not imply that all non-marketplace products are supplied, even as $k \to 1$ (SBM area in the right-most region of the right panel), given that the monopolist is uninformed about fraction $1 - \theta$ of them. Nonetheless, in a Mode III equilibrium, the monopolist's retail footprint exceeds that of the marketplace.

Our results provide insight into the monopolist's strategy when managing a marketplace. The key to maximize profits is to exploit the marketplace to mitigate information and capacity constraints. The equilibrium identifies two avenues to achieve this. First, with regards to the information constraint, the monopolist exploits the marketplace as a learning mechanism. This

[13]Mode III only holds when $\theta < k$ because the monopolist will only enter all marketplace products (and thus transition from Mode II to Mode III) in the absence of other profitable product markets to enter. When $\theta > k$ the monopolist is informed about more valuable non-marketplace products, allocates capacity there, and as a result has insufficient capacity to enter all marketplace products and close the entry-gap (SBT survives). For this reason, the frontier between Modes II and III in Figure 2 depends on θ (i.e., the frontier is non-vertical) and Mode II holds whenever $\theta > k$.

is profitable because it increases the monopolist's entry options when allocating capacity, as manifested by the monopolist's entry into products he learns about through the marketplace ($SBMT$ range across all equilibria with $\theta < 1$). The value of the marketplace as a learning mechanism decreases with information θ and increases with capacity k, as it depends on how many unobserved products exist which the monopolist can learn about and how much capacity is available to supply them. The latter effect is visible when navigating the plots in Figure 2 from left to right, as the monopolist enters a growing share of marketplace products.[14]

Second, with regards to the capacity constraint, the monopolist exploits the marketplace to complement his own capacity allocation choices. By allocating some of his capacity to non-marketplace products instead of competing with third party sellers in as many product markets as possible, the monopolist expands the product assortment on the storefront. This manifests with the coexistence of SBM and SBT product ranges in equilibrium, given that the monopolist would reallocate capacity from the former to the later in the absence of the marketplace. Third party sellers can therefore be interpreted to supply additional capacity to the monopolist (to the extent that he partially appropriates their surplus through fees) and this enables him to serve more consumers across all active product markets. The value of the marketplace as a capacity complementor decreases with capacity k. This can be observed in the plots in Figure 2 where the SBT product range decreases when moving from left to right.

The upsides of the marketplace outlined above do not imply that *more* marketplace is always better for the monopolist. The main downside of the marketplace is competition. A larger marketplace exposes the monopolist to third party sellers in more product markets, some of which he could otherwise monopolize. This effect is compounded by the fact that growing the size of the marketplace requires the monopolist to lower the fees, which in turn intensifies competition at the product market level (see our price competition analysis in Section 3). Thus the fundamental trade-off of the marketplace for the monopolist is the opportunity to mitigate information and capacity constraints on the one hand versus the effect of increased competition on the other. And the tool of choice for the monopolist to manage this trade-off is the ad valorem fee.

The ad valorem fee determines the size of the marketplace in equilibrium. The corner cases illustrate this; if the monopolist eliminates the fee by setting $f = 0$ the marketplace encompasses the whole product space, and if he sets maximum fee $f = 1$ the marketplace is effectively closed. In Mode I, the optimal fee is decreasing in capacity k, because a higher number of $SBMT$ product markets makes a lower fee desirable, and is unaffected by information θ because the monopolist relies fully on the information generated by the marketplace. In Mode II the impact of k and θ on f^* is ambiguous due to a complex set of interactions so we cannot draw general conclusions. Figure 4, which can be found in the Appendix A, illustrates the trajectory of the optimal fee in Mode II. The optimal fee is unaffected by k in Mode III, given

[14]Our model specification assumes that the monopolist's information is independent of product valuations and equivalent to a random draw over the product space. We have examined alternative specifications where the monopolist is fully informed about high valuation products and lacking information about low valuation products. These specifications are more complex but the key qualitative mechanisms we study continue to hold.

that the monopolist operates with excess capacity, and increases with θ because the monopolist relies more on his own information and less on that generated by the marketplace. We also note that the optimal fee is decreasing in consumer inattentiveness λ across all three modes. As outlined in Section 3,fee f and inattentiveness λ operate as substitute mechanisms for the monopolist; they both soften the intensity of competition and enable him to appropriate more surplus. For this reason, an increase in inattentiveness drives the monopolist to lower the fee in order to expand the marketplace.

Marketplace owners such as Amazon, Apple, or Valve, have responded to criticism about their exercise of market power by pointing out that they have not risen their marketplace fees over time. Our analysis of optimal fee trajectories suggests caution against drawing conclusions about market power based on the fee level. While our model does not incorporate competitive interactions with other platforms (competing marketplaces), it does capture the interactions taking place within the platform in a rich fashion. And we find that there is a non-monotone relationship between the monopolist's market power vis-a-vis third parties operating on the platform and the optimal level of marketplace fees. An increase in the monopolist's market power manifested through larger capacity or better information, which reduces his reliance on third parties, may well lead to a lower fee. These fee-setting incentives are likely to be present under competition with other platforms, and hence suggest caution in drawing inferences about market power based exclusively on fee trajectories over time.

Large retailers are often active in several product categories which differ in their underlying characteristics. To the extent that these categories are independent of each other, our model can be applied at the category level to explain differences across them. Inspection of Amazon.com's marketplace fees schedule reveals that most categories have an ad valorem fee of 15% with a few notable exceptions. For example, the fee for electronics is 8% and the fee for jewelry, art, and certain collectibles goes up to 20%. This suggests that there are differences in the retailer's capacity to supply products k, information θ, or the structure of consumer preferences $G(v)$ across these categories. Moreover, there are standout cases such as the 45% fee for Amazon device accessories (such as covers for Kindle e-readers and tablets). Such high fees make it exceedingly difficult for third party sellers to operate profitably and almost foreclose the marketplace for these categories. Our equilibrium analysis suggests that Amazon is well informed and has all the capacity required to supply these categories itself and therefore little to gain from the participation of third party sellers.[15]

Our model predicts that operating a marketplace will expand the product assortment made available to consumers on the storefront. This effect can be observed in Figure 2 with the existence of the SBT and $SBMT$ product ranges across the full parameter space; the monopolist would lack the capacity or the information to supply many of these products in the absence of the marketplace. This result is relevant to the literature on the *long tail* phenomenon, which has examined the drivers of expanded product variety and better sales performance of less popular products in online retail. A stream of papers including Bar-Isaac, Caruana and Cuñat

[15] See Amazon.com's marketplace fee schedule, retrieved August 2021, https://sellercentral.amazon.com/gp/help/external/200336920.

(2012), Yang (2013), and Hervas-Drane (2015) have examined the interactions arising between consumer search strategies, supply-side decisions, and the concentration of sales across products. This literature has shown that improvements in consumer search (lower search costs, targeted search, personalized recommendations) can trigger the supply of less popular products and increase their market share. Our model contributes a novel and complementary explanation for the long tail: that these products also benefit from changes in retail intermediation facilitated by online retail, and in particular by business model innovations through retailer-led marketplaces.

6 Policy analysis

We next examine the effectiveness of behavioral and structural interventions to curtail the monopolist's market power. Our model endogenizes the key strategy levers controlled by the monopolist: choices about how to compete at the product market level (pricing, buy box assignment), choices about how to compete at the product space level (product entry), and choices about how to manage the marketplace (fees and potential closure). Because our model endogenizes the monopolist's choices across these three levers, it provides a powerful tool to study the effectiveness and consequences of policies that target them. In addition, the building blocks of our model are based on competition between perfect substitutes. This foundation is well suited for policy analysis in the context of physical retail, where sellers compete to supply the same product (from the same manufacturer) or close substitutes in the case of generic goods.

Each of the levers controlled by the monopolist is a potential target for regulation. Following this insight, a first part of our policy analysis examines targeted interventions including capping of marketplace fees, a prohibition on copying, and buy box regulation. We find that policies targeting one of these strategy levers in isolation often trigger undesired responses across the remaining. Nonetheless, our analysis identifies some effective avenues for intervention available to regulators. A second part of our policy analysis concerns structural responses and remedies. The monopolist can respond to policy intervention by closing down the marketplace to become a pure retailer, or the regulator could force such an outcome by mandating the breakup of the hybrid model.

In order to proceed it is useful to formalize notation for our welfare analysis first. Consumer surplus can be written as

$$CS = (1-\lambda)\int_{v_H}^{\infty} (v - \bar{p}_T(v))g(v)\,dv,$$

as only attentive consumers in $SBMT$ product markets purchase below their willingness to pay and derive positive surplus.

Third party profits are the sum of individual third party profits across all marketplace products,

$$\Pi_T = \int_{v_T}^{v_H} \pi_T^{SBT}(v)\, dv + \int_{v_H}^{\infty} \pi_T^{SBMT}(v)\, dv.$$

The monopolist's profits Π_M correspond to Π_M^I, Π_M^{II}, or Π_M^{III} depending on the mode the marketplace operates in. Total welfare W is given by the sum of all the preceding.

It is worth stressing that our model is built on the assumption of inelastic demand at the product market level. This implies that the welfare generated in each product market is constant, and total welfare depends on the number of active product markets or product variety. Prices only shift welfare between consumers and suppliers, and consumer surplus originates from competitive product markets ($SBMT$) where third parties quote a price below consumer's willingness to pay $p_T < v$. Inelastic demand places some limitations on our policy analysis compared to a setting with elastic demand. Our model is devoid of deadweight losses from price distortions due to market power or taxation for products supplied on the monopolist's storefront, and thus is likely to underestimate the welfare gains of introducing competition in monopolized product markets. Similarly, given that monopolized product markets generate zero consumer surplus, it can underestimate the welfare gains of additional products being supplied. These properties should be considered when interpreting our results and we revisit them in our discussion below.

6.1 Fee regulation

We start our policy analysis by examining the impact of fee regulation in a retailer-led marketplace. The marketplace fee is one of the three main strategy levers available to the monopolist. While some recent instances in the literature have explored the regulation of prices or fees in the context of online marketplaces, we are not aware of any that focuses on the tensions we study here.[16]

Proposition 4. *Fee regulation that reduces ad valorem fee f results in i) increased consumer surplus; ii) increased total welfare except, possibly, in Mode II. Furthermore, consumer surplus and total welfare are maximized when the marketplace fee is eliminated, $f = 0$.*

Proof. See Appendix A. □

Our first policy result identifies an avenue for intervention. Reducing the marketplace fee is generally desirable, and eliminating it altogether has excellent welfare potential. This result is subject to the marketplace remaining in operation, an important aspect we examine further below in Section 6.4. The intuition for the consumer welfare implications is simple. When the marketplace operates without fees $f = 0$, third parties enter across the full product space $v_T = c$ and the monopolist allocates capacity to high valuation products. Low valuation products are monopolized by third parties (SBT) and high valuation products are supplied

[16]Loertscher and Marx (2020) examine the benefits of price regulation in a monopoly market where there is a tension between privacy and price markups, as the firm appropriates the value generated by better match quality when privacy is reduced. Gomes and Mantovani (2020) examine the effectiveness of fee regulation as an alternative to price parity clauses in online marketplaces.

under competition (*SBMT*). Consumers derive surplus from the latter only, and the surplus they derive in each *SBMT* product market is increasing in v and decreasing in p_T. Therefore, consumer surplus is maximized when fees are eliminated because the most valuable products are supplied under competition at the lowest feasible price by third party sellers.

The elimination of fees generally benefits third parties. This includes third parties that would not enter otherwise, those who monopolize their product (*SBT*), and those who compete against the monopolist (*SBMT*) and do so more aggressively when fees are reduced. In some cases, third parties transitioning from *SBT* to *SBMT* due to the fee change may end up worse off in Mode II. Nonetheless, total third party profits Π_T are maximized when $f = 0$. Because the elimination of fees also maximizes product variety, we conclude that a marketplace operating under the zero-fee schedule maximizes total welfare. The monopolist is the only loser, and is always worse off when regulated in our model.

These results show that fee regulation is a promising avenue for intervention. It achieves positive welfare impact and does not trigger a response by the monopolist across the other strategy levers he controls; his choices about how to compete at the product market level and product entry strategy remain unaffected. However, our analysis has assumed so far that the marketplace remains open. The monopolist may choose to close down the marketplace if subject to fee regulation in order to operate as a pure retailer. We examine the monopolist's closure decision in response to fee regulation in Section 6.4. For clarity of exposition, we proceed first to examine other policy interventions assuming an open marketplace, and turn to structural responses and remedies thereafter.

6.2 Prohibition on copying

We refer to *copying* as entry by the monopolist in an (ex-ante) unobserved product, which is possible after the monopolist observes entry by a third party seller and becomes informed about the product. Copying can occur through the supply of a perfect substitute (the exact same product) or through a close substitute. The extent of copying in Amazon's marketplace has been studied by Zhu and Liu (2018), as discussed in Section 4, and reports by marketplace sellers suggest it is a robust and recurring phenomenon. Copying arises in our model because some third parties hold an informational advantage over the monopolist for specific products. The monopolist can leverage his position as a marketplace owner to acquire this information and exploit it in his retail operations, mitigating the informational disadvantage. This triggers an antitrust concern because the monopolist is extending his market power from one market to another, from marketplace services to retailing. Regulators have expressed concern that copying can place third party sellers at a competitive disadvantage over the long term.[17]

[17]The EU Commission issued a statement on its Amazon Data case noting that: "Amazon directly competes with the third party sellers that rely on its platform to offer their products. [...] Our concerns are [...] about the insights that Amazon Retail has about the accumulated business data of more than 800 000 active sellers in the EU, covering more than a billion different products. [...] Use of these data allows Amazon to focus on the sale of the best-selling products. This marginalises third party sellers and caps their ability to grow." See Statement of Objections about Amazon Data case, November 10 2020, https://ec.europa.eu/commission/presscorner/detail/en/statement_20_2082. Note that our model does not

To model a prohibition on copying, we consider a restriction that precludes the monopolist from copying fraction $\eta \in [0, 1]$ of unobserved products. This restricts one of the three main strategy levers of the monopolist; his product entry choices, by limiting the monopolist's ability to enter unobserved products where third parties have an informational advantage. Note that a blanket prohibition on entry across marketplace products overshoots, because it covers products where third parties do not hold an advantage. Therefore, a copying prohibition needs to be applied selectively on marketplace products and enforcement is likely to require consideration on a case-by-case basis. For this reason, we expect a prohibition to reduce copying rather than eliminate it altogether.

Proposition 5. *A prohibition on copying that increases η (reduces copying) results in i) an increase in ad valorem fee f^*; ii) a reduction in consumer surplus except, possibly in Mode II; iii) a reduction in total welfare except, possibly, in Mode II.*

Proof. See Appendix A. □

The monopolist's response to a copying prohibition is twofold. First, he reallocates capacity away from high valuation marketplace products he would otherwise copy towards lower valuation observed products. This has the effect of reducing the average valuation of *SBMT* product markets and increasing that of *SBT* product markets. And second, as a consequence of the above, he increases marketplace fee f.

The copying prohibition generally reduces consumer surplus, as both of the effects described above reduce the surplus derived by consumers in *SBMT* product markets. The potential winners from the prohibition are the third parties who are no longer copied and will monopolize their products. All third parties incur a higher fee, however, so the remaining third parties are worse off and some exit the marketplace as a result. Clearly, the monopolist is also worse off with the prohibition. Thus the prohibition generally reduces total welfare, with the possible exception of a Mode II marketplace if it triggers a large enough increase in product variety (large reallocation from *SBMT* to *SBM*).

Our analysis has identified two undesired consequences of a copying prohibition. First, by pushing the monopolist out of high valuation marketplace products (*SBMT*), it reduces competition in the most valuable segment of the product space. And second, it drives up the marketplace fee, which generally has negative welfare implications as discussed in the preceding section. The fee increase underscores the fact the monopolist controls several strategy levers and an intervention on one of them (entry choices) can trigger a response across the remaining (marketplace fee). We conclude that a prohibition on copying is unlikely to deliver welfare improvements.[18]

consider a possible scenario where the monopolist enjoys an informational advantage over third parties, such that he is better informed to enter profitable product markets. Such a scenario would trigger antitrust concerns that are not addressed by a prohibition on copying.

[18]The impact of the monopolist's capacity reallocation is stark in our model because his exit from an *SBMT* product market enables the third party to monopolize it. While the intensity of this effect could possibly be moderated in the presence of multiple third parties (not the case in our model however, see oligopoly extension in Appendix B.1), we expect the sign of the effect to be robust given the asymmetric role of the monopolist.

In our analysis above, there are no welfare gains generated from the elimination of copying costs or by fostering third party investments in product quality or cost reduction. Third parties holding an information advantage over the monopolist may be more willing to execute these investments when the threat of competition from the monopolist is removed. Hagiu, Teh and Wright (2020) explore in detail these aspects of the problem. Etro (2021a) considers the case where third party investment (via product entry) hinges on the platform's commitment not to copy. While these investment decisions are not contemplated in our model, the welfare downsides we identify suggest that the social benefits of such investments need to be significant in order to justify a prohibition.

6.3 Buy box regulation

The leading retailer's control of the buy box has become a point of contention for third party sellers and regulators. In the case of Amazon, which pioneered several aspects of the buy box assignment mechanism and whose practices have been most scrutinized, regulators have expressed concern that it fails to generate a level playing field among sellers or guide consumers to the best available offers.[19] The criticism often extends beyond the buy box to include the ranking of search results and the role of promoted elements on the storefront. This has led to proposals to implement pro-consumer policies with the goal of increasing storefront transparency. Such policies would prioritize price over other criteria for buy box assignment in order to facilitate price comparisons across sellers and separate organic and promoted elements throughout the storefront. We next study the effects of pro-consumer policies by examining the impact of a reduction in consumer inattentiveness λ.

Inattentiveness λ provides a measure of the storefront's transparency because inattentive consumers always purchase at the lowest available price. A reduction in λ curtails one of the main strategy levers available to the monopolist because it reduces the share of consumers he is able to manipulate. We examine reductions within the range $\lambda \geq \frac{1}{2}$ such that Assumption 1 remains satisfied. While this limits the effectiveness of pro-consumer policies in our analysis below, similar results apply if one considers an extreme form of such policy that implements full transparency $\lambda = 0$ (i.e., all consumers getting the best possible deal).[20] In our view, however,

That is, product market exit by the leading retailer is prone to reduce the intensity of competition even when there are additional third parties. Furthermore, note that our copying prohibition results do not hinge on the inelastic demand assumption. In the presence of elastic demand, we expect a fee increase to drive up prices and generate additional welfare losses.

[19]The EU Commission has issued a Statement of Objections to Amazon noting: "The Buy Box is essential. It prominently shows the offer of one single seller for the chosen product, with the possibility for the consumer to purchase it directly. So, winning the Buy Box is crucial for the marketplace sellers, as it seems that more than 80% of all transactions on Amazon are channelled through it." See Statement of Objections about Amazon Data case, November 10 2020, https://ec.europa.eu/commission/presscorner/detail/en/statement_20_2082. Reports have also emerged about sellers being excluded from the buy box. BuyBoxer, an agency managing thousands of product listings on Amazon for large brands, has reported instances where their listings were suspended from the buy box without explanation for several days. See 'Amazon is not their friend: Amazon sellers are organizing against the retail giant as the FTC and DOJ continues their anti-trust probe,' Business Insider, August 17th 2019, https://www.businessinsider.com/amazon-sellers-organizing-anti-trust-doj-ftc-2019-8.

[20]In this case M chooses not to enter marketplace products, which leads to a marketplace composed of SBM

full transparency is unlikely to be achieved; as long as the monopolist retains some degree of control over the storefront, his storefront design and management choices will remain aligned with his profit maximization goal.

Proposition 6. *A pro-consumer policy that reduces consumer inattentiveness λ results in i) an increase in ad valorem fee f^*; ii) an ambiguous effect on consumer surplus; iii) a reduction in total welfare except, possibly, in Mode II.*

Proof. See Appendix A. □

A pro-consumer policy increases the intensity of competition on the storefront. The monopolist's response is twofold. First, he raises the marketplace fee, which serves to counteract the impact of lower inattentiveness (recall that f and λ are substitutes for the monopolist). And second, because *SBMT* product markets become comparatively less profitable, he reallocates capacity away from them if good alternatives are available (which is the case under Mode II, where he reallocates from *SBMT* towards *SBM* products). This reallocation increases the average valuation of *SBT* product markets, providing further incentive for the monopolist to raise the fee.

The pro-consumer policy's impact on consumer surplus is ambiguous. More consumers purchase at the lowest available price, which is beneficial, but prices may raise (p_T is increasing in f) and the monopolist's capacity reallocation is detrimental. In general, consumers stand to benefit when the monopolist's responses are muted. The impact on third party profits Π_T is also ambiguous. Some third parties can benefit if the monopolist no longer competes with them after reallocating capacity, but higher competition intensity and a higher fee reduce profits, with some third parties exiting the marketplace. The monopolist is always worse off. As a result, total welfare is generally lower, with the possible exception of a Mode II marketplace if there is a large enough increase in product variety due to capacity reallocation.[21]

We conclude that a pro-consumer policy can fail to deliver the expected benefits for consumers. As in the case of a copying prohibition, the intended goal of the policy is undermined by the monopolist's response across the remaining strategy levers he controls. Both policies lead to higher marketplace fees and a possible reduction in the number of product markets in which the monopolist competes, with potentially negative welfare consequences.

and *SBT* product markets (a mode not present in Proposition 2). All product markets are monopolized and thus consumer surplus falls to zero. Comparison of the optimal fee between the case where $\lambda = 0$ and our baseline model is challenging given that there are various possible modes before and after the policy (three before and two after depending on whether k is binding or not). Nevertheless, one can show that if k is sufficiently low or sufficiently high, then such a policy results in a higher marketplace fee as is the case in Proposition 6.

[21]Our inelastic demand assumption moderates the impact of a pro-consumer policy in our model. In the presence of elastic demand, prices in *SBMT* product markets will adjust further, as the monopolist's price p_M also reacts to lower inattentiveness λ and higher fee f. However, the direction of these price changes is ambiguous, so we cannot conclude a priori how this would affect the policy's effectiveness. Furthermore, the impact of the monopolist's capacity reallocation is stark in our model because his exit from an *SBMT* product market enables the third party to monopolize it. As discussed in the preceding section, this can affect the intensity of the welfare effects we identify but is unlikely to reverse them.

6.4 Marketplace closure

Our policy analysis suggests that fee regulation is the most promising avenue for intervention. Fee regulation overcomes the downsides of other targeted interventions because it does not distort the monopolist's choices across the remaining strategy levers he controls. Before drawing conclusions, however, we need to examine the monopolist's long-term decision about whether to operate the marketplace when the fee is regulated. We study this marketplace closure decision by focusing on the case of drastic fee regulation where the fee is eliminated $f = 0$, as this generates the most desirable welfare outcome (see Proposition 4) and provides clear insight into the mechanisms at play in the closure decision. Our findings are reported in the proposition below and extend naturally to less drastic interventions.

Proposition 7. *The monopolist accepts drastic fee regulation $f = 0$ and continues to operate the marketplace if his information is low relative to capacity $\theta \leq \theta^{Accept}(k)$, and otherwise closes the marketplace and operates as a pure retailer. Marketplace closure drives consumer surplus down to zero and reduces total welfare.*

Proof. See Appendix A. □

The monopolist's decision to close the marketplace when subject to drastic fee regulation hinges on his level of information relative to his capacity. If the monopolist closes the marketplace, he must rely on his own information to allocate all his available capacity. If he continues to operate the marketplace, however, he can learn from third party sellers about the whole product space (given that $v_T = c$ when $f = 0$) and allocate capacity accordingly. Thus, it only pays off to operate the marketplace if the value of this learning is high compared to the alternative, because the marketplace exposes the monopolist to competition and does not generate any fee revenues. This sets a high bar for the marketplace to operate, and our analysis reveals that this bar is met across a large region of the parameter space.

The left panel in Figure 3 identifies the marketplace closure region under drastic fee regulation $f = 0$ on the monopolist's information and capacity parameter space (θ, k). The closure decision is characterized by frontier $\theta^{Accept}(k)$, which is increasing in k given the trade-offs described above. When $\theta > \theta^{Accept}(k)$, corresponding to the region on the top-left above the frontier, the monopolist closes down the marketplace. In this region, his information about the product space is high relative to his capacity, so the value of learning from the marketplace does not offset the downsides of competition. And to the contrary, in the region on the bottom-right below the frontier $\theta < \theta^{Accept}(k)$, his information is low relative to his capacity. He is then willing to keep the marketplace open even in the absence of fee revenues because learning about the full product space pays off despite competition. An implication of the above is that when the monopolist is severely capacity constrained, with very low k (leftmost side of the panel), he will close the marketplace because the value of learning is low when he lacks the capacity to exploit it.

We established in Proposition 4 the positive welfare impact of drastic fee regulation when the marketplace remains open. When the monopolist closes down the marketplace, however, fee regulation backfires and there is significant negative welfare impact. Product variety falls and all products are monopolized. Consumer surplus and third party profits fall to zero, and total welfare is reduced. We conclude that fee regulation has strong potential to improve welfare only if the marketplace remains open. Note that we have examined the most aggressive implementation of fee regulation where the fee is eliminated in full. Interventions that simply cap the fee and reduce it below the profit-maximizing level f^* set by the monopolist will shift the $\theta^{Accept}(k)$ frontier and expand the region in Figure 3 where fee regulation is accepted without marketplace closure. Our analysis suggests that regulators should aim to cap marketplace fees without pushing the monopolist to close the marketplace, that is, they should approximate the closure frontier but not cross it.

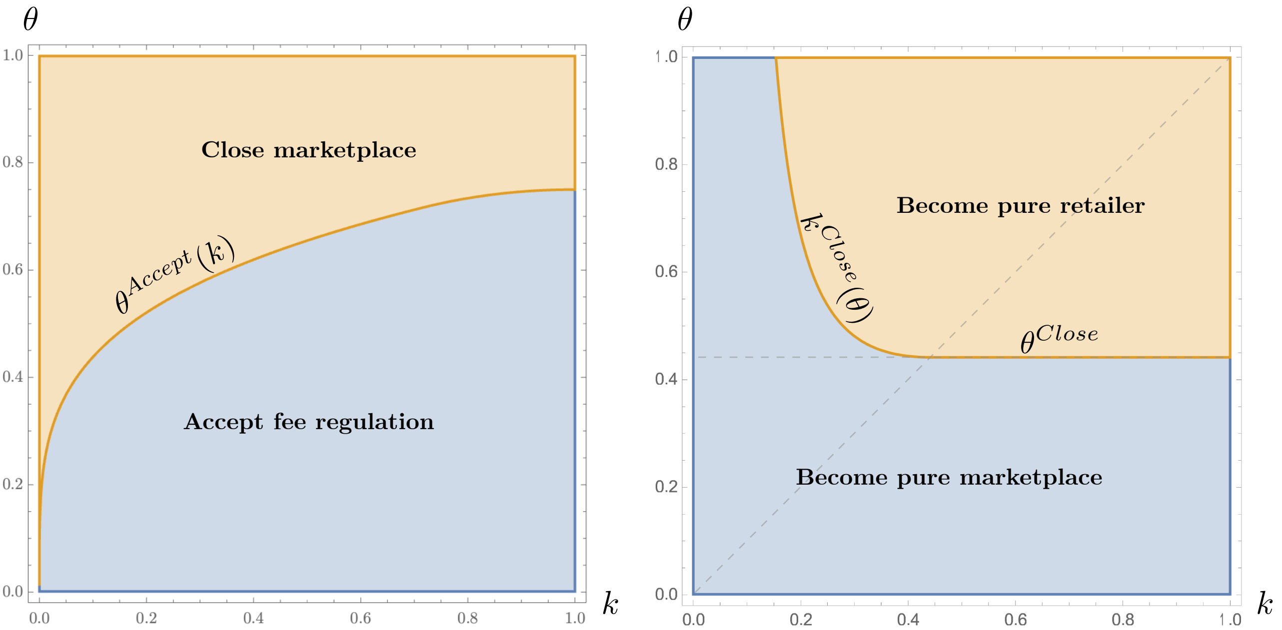

Figure 3: On the left panel, the monopolist's marketplace closure response to drastic fee regulation $f = 0$. The monopolist will close the marketplace if his information is high relative to his capacity $\theta > \theta^{Accept}(k)$, and otherwise will continue to operate the marketplace without fee revenues. On the right panel, response to a prohibition on the hybrid model that forces the monopolist to choose between becoming a pure retailer or a pure marketplace. The monopolist chooses to become a pure retailer if his constraints are not stringent, $\theta > \theta^{Close}$ and $k > k^{Close}(\theta)$, and is otherwise better off becoming a pure marketplace. Plotted for $G(v) = 1 - e^{(v-c)\gamma}$, $\gamma = 2$, $c = 2$, and $\lambda = 0.75$.

6.5 Prohibition of the hybrid model

We close our policy analysis by examining the effectiveness of structural remedies imposed by the regulator. These remedies aim to improve market outcomes by altering the structure of the market to modify the monopolist's incentives. We consider a hybrid model prohibition that forces the monopolist to choose between operating as a pure retailer (closing down the marketplace) or as a pure marketplace (closing down his retail activity). Note that this differs from the monopolist's choice in the preceding section about whether to close or not the marketplace as a response to fee regulation; in this case the status quo is no longer a feasible option.

Proposition 8. *A prohibition of the hybrid model drives the monopolist to become a pure marketplace if his information ($\theta \leq \theta^{Close}$) or capacity constraint ($k \leq k^{Close}(\theta)$) is stringent, which reduces consumer surplus and has an ambiguous effect on total welfare. Otherwise the monopolist becomes a pure retailer, which reduces consumer surplus and total welfare.*

Proof. See Appendix A. □

Consider the two options available to the monopolist. If he becomes a pure retailer, he no longer faces competition from the marketplace but his profitability depends exclusively on his own information and capacity constraints. Instead, if he becomes a pure marketplace, he no longer faces his own constraints but cannot fully appropriate the surplus generated by third party sellers. He controls the marketplace fee, but faces a trade-off between third party participation and surplus extraction. The right panel in Figure 3 identifies the profit-maximizing response to the prohibition over the information and capacity parameter space (θ, k). The solution is characterized by threshold θ^{Close} and frontier $k^{Close}(\theta)$. The monopolist is better off becoming a pure retailer when $\theta > \theta^{Close}$ and $k > k^{Close}(\theta)$, because he benefits from high information and capacity. Otherwise, the pure marketplace solution dominates.

The welfare consequences of a prohibition of the hybrid model are mostly negative. Consumer surplus falls down to zero in all cases given that product markets become monopolized. If the monopolist becomes a pure retailer, total welfare is also reduced given that third party profits are wiped out and product variety falls. If the monopolist becomes a pure marketplace, the impact on total welfare hinges on the direction of the fee change. Due to the complexity of the optimal fee problem, however, we are unable to pin down the sign of the change. There are opposing forces at play given the fee setting trade-off identified above. We have evaluated the problem numerically for the case of an exponential distribution of product valuations and found that total welfare decreases. In this case at least, we find that the retailer is better off increasing the fee when he chooses to become a pure marketplace and this reduces third party profits and product variety.

Our findings provide grounds for caution against a hybrid model prohibition. There are two core mechanisms at play that make the hybrid model desirable from a welfare perspective. First, it fosters competition in many product markets, and some degree of competition for the monopolist (even if imperfect) is preferable to none. And second, it increases the variety of products supplied on the storefront compared to the alternatives, as it combines the monopolist's own capacity with that of third party sellers. In short, a hybrid model prohibition sacrifices the welfare benefits of increased competition and expanded product variety.[22]

[22] We have also examined structural remedies based on divestment, which separates the monopolist's retail and marketplace operations into two separate and independent units. The precise impact of divestment depends on a larger set of assumptions about how it affects the new units and their interaction. In the base scenario, the retail unit inherits the monopolist's information and capacity constraints (and is able to copy third party sellers) while the marketplace unit controls the buy box and sets fees to maximize its fee revenues. We find that the marketplace unit charges the same fee as in the pure marketplace outcome in Proposition 8 and favors high prices when assigning the buy box. Compared to the hybrid model, this increases product prices under competition

Contemporary papers have reported similar findings regarding the benefits of the hybrid model. Etro (2021a) finds that the marketplace owner enters insufficient markets from a consumer surplus perspective, which provides support for the hybrid model even though the impact of a prohibition is not examined. In Hagiu, Teh and Wright (2020), a hybrid model prohibition drives the platform to become a pure marketplace if its quality disadvantage is high and to become a pure retailer otherwise. Their results and welfare implications are largely in line with ours, but the reasons differ substantially given that the mechanisms at play in their model rely on consumer preferences for third party products ("convenience benefits") and the existence of a direct sales channel for third party sellers. Anderson and Bedre-Defolie (2021) also examine a prohibition and find that consumers are worse off if this drives the platform to become a pure retailer, for reasons similar to those in our model. However, if the platform becomes a pure marketplace, the prohibition drives down the marketplace fee and this benefits consumers. Etro (2021b) shows that the marketplace fee may go up (rather than down) using a similar model to Anderson and Bedre-Defolie (2021) with a non-Logit demand structure.[23]

7 Concluding remarks

Reflecting on the benefits of globalization in 1920, John Maynard Keynes wrote that "the inhabitant of London could order by telephone, sipping his morning tea in bed, the various products of the whole Earth, in such quantity as he might see fit, and reasonably expect their early delivery upon his doorstep."[24] A century later, the rise of online marketplaces is delivering these benefits to millions of consumers beyond those residing in wealthy urban areas. In this paper, we set out to analyze this development by asking the following question: what can leading retailers achieve with a marketplace that they cannot do without? Our analysis has been driven by the insight that the retailer can exploit the marketplace to overcome his own limitations, namely the information and capacity constraints that are fundamental to retail.

A leading retailer benefits from hosting a marketplace by learning about products he was uninformed about and by using third party sellers to complement his own capacity allocation choices. In this way, the marketplace enables the retailer to participate in the supply of the most profitable products and to expand the product assortment on the storefront. The main downside of the marketplace is increased competition, which can be particularly intense as firms compete to supply the same products on the storefront, i.e., perfect substitutes. Nonetheless, the retailer has several tools to soften the impact of competition. He observes the product entry choices of third party sellers and adjusts his own entry choices accordingly, implements marketplace fees to control the size of the marketplace and profit from the sales of third party

and lowers product variety. Consumer surplus falls and the impact on third party profits is ambiguous, as is the net effect on total welfare. The joint profits of the divested units are always lower than those of the monopolist before divestment. In summary, we do not find divestment to fare much better welfare-wise than the hybrid model prohibition.

[23]Shopova (2021) finds that with vertical differentiation the same is true for a class of demand functions.

[24]Keynes, John Maynard (1920), '*The Economic Consequences of the Peace*,' Harcourt, Brace and Howe, p. 11.

sellers, and deploys mechanisms such as the buy box to steer inattentive consumers to higher-priced offers (often his own offers). As a result, we find that the hybrid model combining the retailer's own operations with a marketplace is very profitable.

Regulators aiming to curb the market power of a dominant retailer-led marketplace face a complex challenge given the many strategy levers controlled by the monopolist. On the one hand, interventions targeting one of these levers such as a prohibition on copying successful third party products or pro-consumer policies regulating the buy box, backfire by triggering undesired responses across the remaining levers. On the other hand, the hybrid model combining the joint operation of the retailer and the marketplace fosters some degree of competition and expands product variety for consumers, both of which have desirable welfare properties. Our analysis suggests that the marketplace fee constitutes the most effective target for intervention. Because of the non-fee benefits the retailer derives from the marketplace, fee regulation can preserve his incentives to operate it while weakening the retailer's market power vis-a-vis third party sellers.

Our present work has focused on retail marketplaces, which constitute some of the earlier and most widespread examples of the mechanisms we study. Similar hybrid models have gained prominence in other sectors, such as software stores (Apple's App Store, Google Play, Valve's Steam) and more recently inside popular applications and video games (Unity Asset Store, Snapchat Lenses, Minecraft Marketplace). These trends suggest that the hybrid model pioneered in online retail will play an important role in the wider digital economy. Like the retailer we have studied, these new marketplace owners are likely constrained by information about consumer demand for the items traded on their marketplaces as well as their own capacity to supply them. We hope that our work provides a foundation to deepen our understanding of these marketplaces and the economic forces at play within them.

Appendices

A Proofs

Proof of Proposition 1. We characterize the outcome of the price competition game under duopoly. First, consider M's buy box assignment choice under duopoly given prices p_M and p_T. If one of the firms has priced above consumer's willingness to pay, $p_M > v$ or $p_T > v$, the problem is trivial as M will assign the buy box to the firm pricing no higher than v to ensure inattentive consumers purchase. If both firms price above v, no consumer in the product market will purchase so M is indifferent when assigning the buy box. In what follows, consider prices that do not exceed v.

Who should M assign the buy box to? For each inattentive consumer who purchases from the buy box, if M assigns himself the buy box ($B = M$) he earns $p_M - c$ and if he assigns it to the third party ($B = T$) he earns $p_T f$. Thus M will prefer to assign himself the buy box whenever

$$p_M - c \geq p_T f, \tag{9}$$

and otherwise will assign the buy box to T. Note that M's profit-maximization logic when assigning the buy box favors high prices, as T will only get the buy box when $p_T > \frac{p_M - c}{f}$. Also note that when both firms set the same price $p_M = p_T = p$ and T is viable, M assigns himself the buy box. This follows from the fact that $p(1 - f) \geq c$ (T's viability) ensures that (9) is satisfied.

We turn to pricing decisions given these buy box assignment choices. Consider M's pricing problem given p_T. First, note that undercutting T is not optimal as it is dominated by the option of matching T's price $p_M = p_T$ and serving all demand given buy box assignment for inattentive consumers and tie-breaking for attentive consumers. Second, pricing above p_T and below v such that $p_M \in (p_T, v)$ cannot be optimal either. This follows from the fact that M would only serve inattentive demand when (9) is satisfied and profits π_M^{SBMT} are then increasing in price p_M attaining a maximum at $p_M = v$ (which ensures M obtains the buy box).

The above implies that there are two candidate best-responses for M, either $p_M = p_T$ or $p_M = v$. In the first case, equation (9) must be satisfied because T is viable, so M chooses to assign himself the buy box $B = M$. The monopolist serves all demand and derives profits

$$\pi_M^{SBMT}(p_M = p_T) = p_T - c.$$

In the second case where $p_M = v$, equation (9) is satisfied because $p_T \leq v$ and T is viable $p_T \geq c/(1 - f)$, so M assigns himself the buy box $B = M$. The monopolist serves inattentive demand and T serves attentive demand. M's profits are given by

$$\pi_M^{SBMT}(p_M = v, p_T < v) = \lambda(v - c) + (1 - \lambda) f p_T.$$

Inspection of both profit expressions reveals that M will choose to match T's price by setting $p_M = p_T$ when

$$p_T > \bar{p}_T \equiv \frac{\lambda v + c(1-\lambda)}{1 - f(1-\lambda)},$$

and will otherwise set monopoly price $p_M = v$. To summarize, if $T's$ price is sufficiently high ($p_T > \bar{p}_T$) M prefers to serve all demand ($p_M = p_T$) and otherwise M is better off targeting inattentive demand ($p_M = v$) and letting the third party cater to attentive consumers.

We can now solve T's pricing decision under duopoly. M's pricing strategy imposes an upper bound on T's price, given that pricing above $\bar{p}_T$ results in zero profits. Thus T prefers to price in the range $p_T \leq \bar{p}_T$ and serve only attentive consumers. T's profits in this price range are

$$\pi_T^{SBMT}(p_T \leq \bar{p}_T) = (1-\lambda)[(1-f)p_T - c)].$$

Because T's profits are increasing in p_T, T will set $p_T = \bar{p}_T$ if viable $\pi_T^{SBMT}(p_T = \bar{p}_T) \geq 0$, and otherwise will set $p_T > v$ and sell to no one.

Proof of Proposition 2. We pin down M's entry choices in the case of intermediate capacity $k \in (\underline{k}, \bar{k})$. This is enough capacity to enter the most profitable marketplace products $v \geq v^*$ and still have excess capacity, but insufficient to enter all product markets M is informed about.

We define thresholds v_L and v_H such that M enters observed products with $v \in [v_L, v_T)$ as well as all products $v \in [v_H, \infty]$. For M to allocate capacity across both product pools, it must be the case that the marginal profitability of entry in non-marketplace product v_L equals that of entry into marketplace product v_H. Given profit equalization across both product pools and full capacity utilization, M's entry strategy is characterized by the following equations

$$\begin{aligned} \pi_M^{SBM}(v_L) &= \Delta\pi_M^{SBMT-SBT}(v_H) \\ \theta(G(v_T) - G(v_L)) + (1 - G(v_H)) &= k. \end{aligned} \tag{10}$$

These equations identify a unique solution for v_L and v_H. To see this, note that at $v_H = v_T$ we have $v_L = \Delta\pi_M^{SBMT-SBT}(v_T) + c$, which plugged into the second equation provides $1 - G(v_H) + \theta(G(v_T) - G(v_L)) = 1 - G(v_T) > k$ given that $k < (1 - G(v_T)) + \theta G(v_T)$. At $v_H = v^*$ such that $v_L = v_T$ we have $1 - G(v_H) + \theta(G(v_T) - G(v_L)) = 1 - G(v^*) = \underline{k} < k$. Furthermore, $1 - G(v_H) + \theta(G(v_T) - G(\Delta(v_H) + c))$ is decreasing in v_H, so a unique solution for v_H must exist. A unique solution $v_L \in [c, v_T]$ then exists because the definition of v^* implies $\Delta\pi_M^{SBMT-SBT}(v^*) + c = v_T$.

We conclude that M will enter and monopolize products in the valuation interval $v \in [v_L, v_T)$ as well as enter and compete in $v \in [v_H, v^*)$ such that $\Delta\pi_M^{SBMT-SBT}(v_H) = v_L - c$ and all capacity is used, as per definition of v_L and v_H. Reallocating capacity to product markets with $v < v_L$ or $v \in [v_T, v_H)$ cannot be profitable because both π_M^{SBM} and $\Delta\pi_M^{SBMT-SBT}$ are increasing in v.

Proof of Proposition 3. For each $f \in [0,1]$ the marketplace is in one of the three modes. At $f = 0$ the marketplace is in Mode I because $v_T = v^* = c$, such that M enters all markets with $v \geq v_K \geq c$ where $v_K > c$ if $k < 1$.

Increasing f from 0 to 1 has the effect of increasing v^* and v_T from c to ∞. There exists a unique $\underline{f} \in [0,1]$ such that $v^*(\underline{f}) = v_K$, so that for $f \leq \underline{f}$ the marketplace is in Mode I. For $k < 1$ and f just above $\underline{f}$ the marketplace is in Mode II. If $k < \theta$ then the marketplace is in Mode II for all $f > \underline{f}$ because M does not have enough capacity to enter all products he is informed about, which includes products with $v \in [c, v_T]$ and $v > v_T$.

For $k > \theta$ define $\bar{f}$ as the solution to

$$1 - G(v_T(\bar{f})) + \theta G(v_T(\bar{f})) = k,$$

where $\bar{f}$ exists and is unique because the LHS is decreasing in f, equals 1 (and thus exceeds k) for $f = 0$, and equals θ (and thus is lower than k) for $f = 1$. Therefore, for $f \in (\underline{f}, \bar{f})$ the marketplace operates in Mode II and for $f > \bar{f}$ it operates in Mode III. Further, $\bar{f} > \underline{f}$ because $v^*(f) > v_T(f)$.

Marketplace profits are continuous in f and differentiable everywhere on $f \in [0,1]$ (including at $\underline{f}$ and $\bar{f}$ where the right and the left derivative exist and are equal). By Assumption 2 the optimal fee is always given by the smallest solution to the FOC, of which there are at most two (in which case the largest one is $f = 1$, where we can exclude corner solution $f = 0$ by Lemma 3). If the optimal fee is $f^* = 1$, the marketplace is closed and products are sold only under market configuration SBM. The marketplace will operate in Mode II if $k < \theta$ and in Mode III if $k \geq \theta$, the difference being that in the first case M is only able to enter products with $v > v_0$ while in the second case he enters all products he is informed about.

If $k < \underline{k}^*$ assuming Mode I is in play, the FOC gives the optimal fee f_1^*, at which in turn Mode I is in play. Similarly, if $k > \bar{k}^*$ then assuming Mode III is in play, the optimal fee has to be f_3^* and in turn at this fee Mode III is in play, by the definition of $\bar{k}^*$. Note that $\underline{k}^* = \bar{k}^*$ cannot hold for $f > \bar{f}$ and thus given that the profit function is differentiable in f, the optimum cannot jump from Mode I and to Mode III without passing through Mode II, because the profit is strictly quasi-concave by assumption and is continuous in k. The rest of the proof follows from the arguments in the main text.

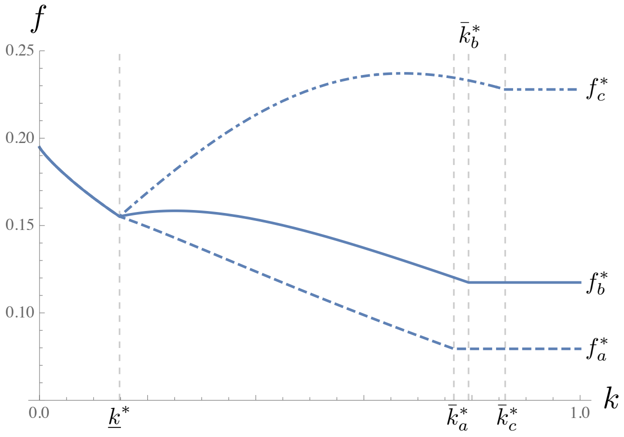

Figure 4: Equilibrium ad valorem fee as a function of capacity k plotted for three different values of θ. The impact of capacity k on the optimal fee varies across the three modes and, within Mode II, can go in either direction depending on θ. For low θ the fee decreases with k across Mode II, but for intermediate and high θ the relationship is hump-shaped (exhibiting a maximum in the middle of the k range when θ is high). Plotted for $G(v) = 1 - e^{(v-c)\gamma}$, $c = 2$, $\gamma = 2$, $\lambda = 0.75$, $\theta_a = 0.2$, $\theta_b = 0.5$, and $\theta_c = 0.8$. The impact of information θ on the optimal fee (not plotted above) is ambiguous in Mode II due to the countervailing forces at play, so we cannot draw general conclusions about its trajectory. Nonetheless, we have examined the problem in the case where the distribution of product valuations is exponential and found that, for this case at least, f^* is weakly increasing in θ.

Proof of Proposition 4. We analyze the impact of fee regulation that reduces f. Consider first a marketplace operating in Mode I. A reduction in f will reduce third party entry threshold v_T and prices p_T in *SBMT* product markets. Prices in *SBT* markets and M's entry choices are unaffected. Clearly, consumer surplus goes up. Third party profits also increase with the lower fee, and so does total welfare due to increased product variety. Only M is worse off.

Consider next a marketplace operating in Mode II. A change in f will shift v_T, v_H and v_L. From $\partial\Delta\pi_M^{SBMT-SBT}/\partial f < 0$ and $\partial\Delta\pi_M^{SBMT-SBT}/\partial v_H > 0$ and the definition of v_H one can show that $\partial v_H/\partial f > 0$. To see this use $1 - G(v_H) + \theta(G(v_T) - G(v_L)) = k$ and $\Delta\pi_M^{SBMT-SBT}(v_H) = v_L - c$ to obtain

$$\frac{\partial v_H}{\partial f} = \frac{\theta\left(g(v_T)\frac{\partial v_T}{\partial f} - \frac{\partial\Delta\pi_M^{SBMT-SBT}}{\partial f}g(\Delta\pi_M^{SBMT-SBT})\right)}{\theta\frac{\partial\Delta\pi_M^{SBMT-SBT}}{\partial v_H}g(v_L) + g(v_H)} > 0,$$

which is clearly positive. However, $\partial v_L/\partial f$ cannot be readily signed, except for the case of low θ in which it is negative. For this we use $\partial v_H/\partial f$ and the definition of v_L to derive

$$\frac{\partial v_L}{\partial f} = \frac{g(v_H)\frac{\partial\Delta\pi_M^{SBMT-SBT}}{\partial f} + \theta g(v_T)\frac{\partial v_T}{\partial f}\frac{\partial\Delta\pi_M^{SBMT-SBT}}{\partial v_H}}{\theta\frac{\partial\Delta\pi_M^{SBMT-SBT}}{\partial v_H}g(v_L) + g(v_H)}$$

which is negative for $\theta = 0$, but could be positive otherwise. Since v_L determines the size of *SBM* product markets, the effect of a reduction in f on welfare is ambiguous because although third parties enter and thereby increase product variety, a potential reduction in *SBM* could offset this and reduce overall welfare. However, since v_H shrinks, *SBMT* must expand, and further prices in *SBMT* fall, so consumer surplus also increases in Mode II.

Finally, Mode III exhibits similar properties to Mode I. A reduction in f reduces third party entry v_T and prices p_T in *SBMT* product markets, and thus welfare effects go in the same direction as in Mode I.

We next argue that $f = 0$ achieves welfare and consumer surplus maxima because, i) third party sellers enter the full product space $v_T = c$ so product variety and total welfare are maximized; ii) *SBMT* prices are minimized when $f = 0$; iii) M allocates all his capacity to the highest valuation products, which maximizes consumer surplus by maximizing $v - p_T$ across all *SBMT* products.

Proof of Proposition 5. We characterize the impact of a prohibition on copying η. In what follows, we redefine v_L and v_H to solve

$$\theta(G(v_T) - G(v_L)) + (\theta + (1-\theta)\eta)(1 - G(v_H)) = k,$$

and revise M's profit expressions accordingly. If the marketplace operates in Mode I, an increase in η will drive the monopolist to reallocate capacity from high to low valuation products within *SBMT* product markets, from $v \in (v_K, \infty)$ to products close to v_K. The monopolist's FOC for profit maximization becomes

$$\int_{v_T}^{v_K} vg(v)\,dv + (\theta + (1-\theta)(1-\eta)) \int_{v_K}^{\infty} \frac{\partial \pi_M^{SBMT}(f,v)}{\partial f} g(v)\,dv \\ +(1-\theta)\eta \int_{v_K}^{\infty} vg(v)\,dv = (fv_T)g(v_T)\frac{\partial v_T}{\partial f},$$

where the LHS is increasing in η by $v > \partial \pi_M^{SBMT}(f,v)/\partial f$, thus f_1^* is increasing in η.

The prohibition increases the average valuation of *SBT* product markets and reduces the average valuation of *SBMT* markets. This reduces consumer surplus for a given fee f. Furthermore, because f_1^* increases, prices in *SBMT* product markets increase and this reduces consumer surplus further. Total welfare also falls because v_T increases so product variety falls.

In Mode II, an increase in η leads the monopolist to reallocate capacity towards lower valuation *SBMT* and *SBM* markets. We redefine v_L and v_H as

$$\pi_M^{SBM}(v_L) = \Delta\pi_M^{SBMT-SBT}(v_H) \\ \theta(G(v_T) - G(v_L)) + (\theta + (1-\theta)(1-\eta))(1 - G(v_H)) = k.$$

The FOC becomes

$$\int_{v_T}^{v_H} vg(v)\,dv + (\theta + (1-\theta)(1-\eta)) \int_{v_H}^{\infty} \frac{\partial \pi_M^{SBMT}(f,v)}{\partial f} g(v)\,dv$$
$$+(1-\theta)\eta \int_{v_H}^{\infty} vg(v)\,dv = [\theta(v_L - c) + (1-\theta)(fv_T)]\, g(v_T) \frac{\partial v_T}{\partial f},$$

where the LHS is clearly increasing in η, thus f_2^* is also increasing in η.

The direct effect of the prohibition reduces v_L, which for a given f would lead to a welfare gain, but since f_2^* increases so does the third party entry threshold v_T, and thus welfare may increase or fall overall. Consumer surplus falls if v_H increases because $SBMT$ markets simultaneously shrink in total size and shift towards lower valuations, however consumer surplus may increase if v_H falls sufficiently so as to lead to an expansion in $SBMT$ that compensates for higher prices and reallocation toward lower v inside $SBMT$.

Finally in Mode III the modified FOC is

$$\int_{v_T}^{v_K} vg(v)\,dv + (\theta + (1-\theta)(1-\eta)) \int_{v_K}^{\infty} \frac{\partial \pi_M^{SBMT}(f,v)}{\partial f} g(v)\,dv$$
$$+(1-\theta)\eta \int_{v_K}^{\infty} vg(v)\,dv = (fv_T) g(v_T) \frac{\partial v_T}{\partial f},$$

and again the LHS is increasing in η and thus f_3^* is also increasing in η.

An increase in η in Mode III leads the monopolist to exit unobserved markets where it cannot copy. Consumer surplus falls because $SBMT$ product markets shrink in total size, and f_3^* increases, so prices in $SBMT$ also increase. Total welfare also falls because v_T increases, reducing product variety.

Proof of Proposition 6. We analyze the impact of a pro-consumer policy that reduces λ within the range $\lambda > 1/2$, which ensures Assumption 1 is satisfied and our equilibrium characterization holds.

In Mode I, M's entry choices are unaffected by λ. However, fee setting incentives change because $\partial^2 \pi_M^{SBMT}/\partial f \partial \lambda < 0$, which implies that λ and f operate as substitutes for value extraction. If λ falls, then M has incentives to increase f in order to compensate, so f_1^* increases. The impact on consumers surplus is ambiguous because p_T is increasing in both λ and f, so there are two countervailing effects on prices in $SBMT$ markets. Total welfare falls because higher f_1^* reduces third party entry, which reduces product variety.

In Mode II, M's entry patterns will change given that a reduction in λ for a given f reduces v_L and increases v_H. Because M's profits in $SBMT$ product markets are increasing in λ, given that $\partial \Delta \pi_M^{SBMT-SBT}/\partial \lambda > 0$, he reallocates capacity from $SBMT$ to SBM product markets. This increases his incentives to extract value through the fee and reduces the downsides of doing so, because the marginal SBM market is less profitable. Inspection of the Mode II FOC in (8) reveals that higher v_H increases the LHS and lower v_L reduces the RHS, so M increases the fee f_2^*. In summary, a reduction in λ reduces v_L and increases v_H and f_2^*. This reduces the number of *SBMT* product markets, though the impact on consumer surplus is ambiguous because of the countervailing effects of λ and f on p_T. The increase in the fee reduces third party entry, but the impact on product variety is ambiguous given that M reallocates capacity towards *SBM* product markets. Thus the effect on total welfare is also ambiguous.

The analysis of Mode III is similar to that of Mode I, given that M is capacity unconstrained and π_M^{SBMT} exhibits the same properties. M's entry choices are unaffected but he increases the fee f_3^*. This reduces third party entry, which reduces the number of *SBMT* product markets as well as product variety. Nonetheless, the net impact on consumers surplus is ambiguous because of the countervailing effects of λ and f on p_T. Total welfare falls because product variety falls.

Proof of Proposition 7. We examine the monopolist's decision about whether to close or not the marketplace when subject to drastic fee regulation $f = 0$. If the monopolist closes the marketplace he will operate as a pure retailer and monopolize all products he has the information and capacity to supply. Profits are then

$$\Pi_M^{Retailer} = \theta \int_{v_0}^{\infty} (v - c) g(v) dv, \tag{11}$$

where v_0 is defined in (2). Clearly, this option is more attractive when k and θ are high.

The following isoprofit condition identifies when operating the marketplace with $f = 0$, where profits originate exclusive from the monopolist's own sales in *SBMT* product markets, yields the same profit as closing it down,

$$\int_{G^{-1}(1-k)}^{\infty} \pi_M^{SBMT}(v) g(v) dv = \Pi_M^{Retailer}. \tag{12}$$

Inspection reveals that for every k there exists a solution $\theta^{Accept}(k)$. The solution exists and is unique because the LHS is independent of θ, the RHS is increasing in θ (M reallocates capacity to higher valuation products as θ increases), for $\theta = 0$ the LHS is lower than the RHS, and for $\theta = 1$ the opposite holds given that $\pi_M^{SBMT}(v) < \pi_M^{SBM}(v)$. Thus the monopolist will close the marketplace and become a pure retailer when $\theta > \theta^{Accept}(k)$ and will otherwise continue to operate it under drastic fee regulation.

Consider the welfare impact of marketplace closure. All products are monopolized because third party sellers exit. Product variety falls because M only supplies products he is ex-ante informed about. This implies that consumer surplus and third party profits fall to zero. By revealed preference, M's profits (weakly) fall when switching away from the hybrid model. Thus total welfare also falls.

Proof of Proposition 8. We examine the monopolist's decision about whether to become a pure retailer or a pure marketplace when subject to a hybrid model prohibition. Profits when operating as a pure retailer are given by $\Pi_M^{Retailer}$ in (11). Profits when operating as a pure marketplace, to be denoted $\Pi_M^{Marketplace}$, are given by Π_M in (4) for the case where $k = 0$ such that the retailer has no retail footprint,

$$\Pi_M^{Marketplace} = \int_{v_T(f_1^*)}^{\infty} (vf_1^*)g(v)dv.$$

Isoprofit condition $\Pi_M^{Retailer} = \Pi_M^{Marketplace}$ identifies the frontier separating both solutions. There are two cases depending on k and θ. If $k \geq \theta$ then $v_0 = c$ and M can supply all products he is informed about as a pure retailer. The isoprofit frontier is then given by threshold θ^{Close} such that M chooses to become a pure retailer if $\theta > \theta^{Close}$. Note that $\theta^{Close} < 1$ because $\int_c^{\infty}(v-c)g(v)dv$ is the maximum total profit that can be derived under monopoly.

If $k < \theta$ then $v_0 = G^{-1}\left(\frac{\theta-k}{\theta}\right)$, M cannot supply all products he is informed about as a pure retailer and only supplies those with higher valuations. In this case $\Pi_M^{Retailer}$ is increasing in k and θ. The former is trivial to show, the latter follows from inspecting the derivative

$$\frac{\partial \Pi_M^{Retailer}}{\partial \theta} = \int_{G^{-1}\left(\frac{\theta-k}{\theta}\right)}^{\infty} (v-c)g(v)dv - \frac{k}{\theta}(G^{-1}\left(\frac{\theta-k}{\theta}\right) - c),$$

which is positive because the average v above v_0 is greater than v_0. In other words, as θ expands, M reallocates capacity from marginal to average markets. From the isoprofit condition when $k < \theta$ we can thus obtain $k^{Close}(\theta)$, where we define $k^{Close}(\theta) = 1$ if $\Pi_M^{Marketplace} > \Pi_M^{Retailer}$ given v_0. Therefore, if $k > k^{Close}(\theta)$ it is more profitable to become a pure retailer, and if $k < k^{Close}(\theta)$ becoming a pure marketplace is the preferred choice.

Consider next the welfare impact of the hybrid model prohibition. The welfare impact of switching away from the hybrid model to become a pure retailer is characterized in Proposition 7. If M becomes a pure marketplace instead, all products are monopolized so consumer surplus falls to zero. However, the change in the marketplace fee is ambiguous, so third party profits, product variety, and total welfare can either increase or decrease. By revealed preference, M's profits (weakly) fall when switching away from the hybrid model.

B Extensions

B.1 Price competition with multiple third party sellers

Let us consider what happens in our price competition model if there are $n \geq 2$ third party sellers. Consider first the case of an *SBT* product market where n sellers have entered (note that even if there are n *potential* sellers it is not guaranteed that all of them will wish to enter). Clearly, M will assign the buy box to the highest-priced seller whose price does not exceed v. If all n sellers charge the same price v, then each of these sellers will have equal probability $1/n$ of being assigned the buy box. No seller will wish to undercut if $(1-\lambda) < \frac{\lambda}{n}$ or when $\lambda \geq \frac{n}{n+1}$. In this case there is unique pure strategy equilibrium where all third-party sellers charge v. All sellers derive equal (expected) profits in this equilibrium and thus will enter if $v > v_T$, which is the same condition as that of our baseline model. If $\lambda < \frac{n}{n+1}$ there is a mixed strategy equilibrium which is more complicated to characterize. We do not solve for this mixed strategy equilibrium here given that, as stated in the main text, we believe the empirically relevant case to be that of a high λ.

Consider next the case of an *SBMT* product market with n third party sellers. Clearly, M will self-assign the buy box and charge $p_M = v$. Third- party sellers then compete in pure Bertrand fashion and charge $p_T = \frac{c}{1-f}$. M earns $\pi_M^{SBMT}(v) = \lambda(v-c) + (1-\lambda)\frac{cf}{1-f}$. In this case

$$\Delta\pi_M^{SBMT-SBT} = (\lambda - f)\left(v - \frac{c}{1-f}\right)$$

which is non-negative if $\lambda > f$ and negative otherwise. This is similar to our baseline model where the condition read $\lambda \geq \frac{f}{1+f}$. Note that M would not enter marketplace products (*SBMT* after entry) if f is high. Whether such a high f is optimal will depend on the remaining parameters, but for the purpose of this extension let us focus on the case where $\lambda > f$. Under this condition it is easy to verify that this profit function satisfies all key comparative statics we have used to derive our entry, fee setting, and policy results. Namely, $\pi_M^{SBMT}(v)$ is increasing in v, $\frac{\partial \pi_M^{SBT}(v)}{\partial f} > \frac{\partial \pi_M^{SBMT}(v)}{\partial f}$, $\frac{\partial^2 \pi_M^{SBMT}(v)}{\partial f \partial \lambda} < 0$, and $\frac{\partial \Delta\pi_M^{SBMT-SBT}(v)}{\partial f} < 0$, which are the only conditions used in our analysis beyond the pricing section.

B.2 Price competition with simultaneous pricing

In Hervas-Drane and Shelegia (2022) we analyze the simultaneous price competition game with two firms. Based on the model presented there, our baseline analysis in the present paper maps to the case where $\tau_p = f$, $\tau_c = 0$, $L_1 = \lambda$, $L_2 = 0$ and $c_1 = c_2 = c$. This parameter mapping ensures that M steers all inattentive consumers to his own offering (i.e., self-assigns the buy box). We next describe the properties of the unique mixed strategy equilibrium of the game.

Both firms continuously randomize their price over the support $[\underline{p}, v]$ where

$$\underline{p} = (\lambda)^{1-f} \cdot v + \left(1 - (\lambda)^{1-f}\right) \cdot \frac{c}{1-f},$$

with M and T using price distributions

$$G_M(p_M) = \frac{(p_M - \underline{p})}{\left(p_M - \frac{c}{1-f}\right)}$$

$$G_T(p_T) = \frac{1}{1-\lambda} - \frac{\lambda}{1-\lambda}\left(\frac{v - \frac{c}{1-f}}{p_T - \frac{c}{1-f}}\right)^{\frac{1}{1-f}}$$

and M placing a point mass of size $1 - \frac{(v-\underline{p})}{\left(v - \frac{c}{1-f}\right)}$ on v.

Equilibrium profits are $\pi_M^{SBMT} = \underline{p} - c$ and $\pi_T^{SBMT} = (1-\lambda)\left(\underline{p}(1-f) - c\right)$.

We next argue that this equilibrium satisfies the key comparative statics used to derive our entry, fee setting, and policy results. First, clearly $\pi_T^{SBMT}(v) > 0$ iff $v > \frac{c}{1-f}$ because $\underline{p}$ is a weighted average of v and $\frac{c}{1-f}$. Second, $\frac{\partial \pi_M^{SBT}(v)}{\partial f} > \frac{\partial \pi_M^{SBMT}(v)}{\partial f}$, or equivalently $\frac{\partial \Delta_M^{SBMT-SBT}(v)}{\partial f} < 0$. For this, note that taking the relevant derivatives obtains

$$
\begin{aligned}
\frac{\partial \Delta_M^{SBMT-SBT}(v)}{\partial f} &= \frac{c\left(1-\lambda^{1-f}\right)}{(1-f)^2} + \frac{c\lambda^{1-f}\log(\lambda)}{1-f} - v\lambda^{1-f}\log(\lambda) - v \\
&= \frac{c}{1-f}\left(\frac{\left(1-\lambda^{1-f}\right)}{(1-f)} - 1\right) - \left(v - \frac{c}{1-f}\right)\left(\lambda^{1-f}\log(\lambda)+1\right) < 0
\end{aligned}
$$

where the inequality follows because $\left(\lambda^{1-f}\log(\lambda)+1\right) > 0$ and $\left(\frac{\left(1-\lambda^{1-f}\right)}{(1-f)} - 1\right) < 0$ by $f < \lambda$, as assumed previously. Finally, $\frac{\partial^2 \pi_M^{SBMT}(v)}{\partial f \partial \lambda} < 0$ because

$$
\frac{\partial^2 \pi_M^{SBMT}(v)}{\partial f \partial \lambda} = \lambda^{-f}(-\log(\lambda)(v(1-f)-c)-v)
$$

which is decreasing in v and is equal to $-\frac{c}{1-f}$ at $v = \frac{c}{1-f}$.

B.3 Unit fee

We introduce a non-negative unit fee t and show that, provided it cannot be negative (i.e., is not a subsidy), it is dominated by the ad valorem fee f and thus the monopolist will set $t = 0$.

The unit fee does not affect T's price in SBT product markets. In $SBMT$ product markets, the third party's equilibrium price becomes

$$
\bar{p}_T = \frac{\lambda v + (1-\lambda)(c+t)}{1-f(1-\lambda)}. \tag{13}
$$

The remaining properties of the price competition equilibrium derived in our baseline analysis are unaffected. T will only derive positive profits in an SBT market if $v(1-f)-c-t$ or $v > \frac{c+t}{1-f}$. In an $SBMT$ market, T will derive positive profits if $\bar{p}_T(1-f)-c-t > 0$ which is again equivalent to $v > \frac{c+t}{1-f}$. We thus redefine $v_T \equiv \frac{c+t}{1-f}$ and note that all our entry analysis is intact subject to this change. In particular, the monopolist's entry condition 3 will not depend on the per unit fee t because its effect is akin to a marginal cost increase for T and this does not alter marginal profitability of entry for the monopolist.

Lemma B.1 *The monopolist will not charge a per unit fee, $t^* = 0$.*

Proof. We prove this lemma by contradiction. Assume that fees $(f^*, t^* > 0)$ are optimal, and consider an alternative set of fees (f', t') with a lower per unit fee $t' = t^* - \varepsilon > 0$ and a higher ad valorem fee $f' = \frac{\varepsilon + f^*(c+t^*-\varepsilon)}{c+t^*} > f^*$. By construction, (f', t') ensures that $v_T(f', t') = v_T(f^*, t^*)$ so that entry decisions of third parties are equivalent under both sets of fees.

We next compare M's profits when switching from fees (f^*, t^*) to (f', t'). In order to identify a lower bound for the profit change induced by the fee change, assume M does not alter his own entry decisions. Note that only fee revenues from SBT and $SBMT$ product markets are affected, as revenues from M's sales are unaffected. In each SBT product market, M derives higher fee revenues with (f', t') if $vf' + t' > vf^* + t^*$, which is equivalent to $v > v_T(f^*, t^*)$. In each $SBMT$ product market, M derives higher fee revenues with (f', t') if $p_T(f', t') * f' + t' > p_T(f^*, t^*) * f^* + t^*$

where p_T is given by (13), and which is (also) equivalent to $v > v_T(f^*, t^*)$. This condition is satisfied whenever third party sellers participate in the marketplace. Which implies that M's profits are higher with fees (f', t') than with fees (f^*, t^*), a contradiction. $\square$

The ad valorem fee is more effective than the per unit fee as a taxation device. The monopolist can implement the same level of marketplace participation v_T by using the ad valorem fee f instead of the per unit fee t, and also extract higher fee revenues from supramarginal sellers. In other words, total fee revenues are determined both at the extensive and the intensive margin, and by using f instead t the monopolist can achieve the same level of marketplace participation v_T (extensive margin) while increasing the fee revenues from supramarginal sellers supplying high valuation products (intensive margin). This logic also applies when $t = 0$; i.e., the monopolist would benefit from setting a negative per unit fee $t < 0$ (a subsidy) and further increasing ad valorem fee f. The monopolist's optimal fee structure is $t^* = -c$ and $f^* = 1$ so that all third parties enter and their surplus is fully extracted. However, we interpret $t^* = 0$ as a corner solution because the implementation of a blanket subsidization scheme in marketplaces with thousands of third party sellers (millions in the case of the largest marketplaces) appears unfeasible and prone to opportunism.

The result relates to the literature on taxation and fees, starting with Suits and Musgrave (1953) who showed that taxing a monopoly with an ad valorem sales tax generates higher revenues than a unit sales tax for the same final price. We have derived the result with inelastic demand, as is the case in their paper, though the result also extends to the case of elastic demand (where the monopolist also sets a per unit fee $t = 0$ in equilibrium). Recent contributions including Gaudin and White (2014), Llobet and Padilla (2016), and Wang and Wright (2017) have examined the comparative impact of ad valorem and per unit schemes in the context of taxation and fee collection. Johnson (2017) provides a detailed discussion of this literature. Similarly to Wang and Wright (2017), the ad valorem fee in our model enables a two-sided platform to extract different amounts based on the value of the good, and our analysis shows that the argument holds even if the platform competes with agents participating on one of the sides.

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