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Product Selection in Online Marketplaces

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by Federico Etro[1]

Abstract

A marketplace such as Amazon hosts many products by third party sellers and acts as a first party or private label retailer. Assuming an advantage of Amazon in logistics and of sellers in marketing, we investigate whether entry by Amazon is excessive from the point of view of consumers. With competitive sellers, entry may be either overprovided or underprovided, but the incentives of Amazon and consumers are correctly aligned for a family of power surplus functions (generating for instance linear, isoelastic and loglinear demands). Competition for customers with other retailers reduces commissions and prices preserving the efficiency result. Market power by sellers increases (reduces) the incentives to retail private label (first party) products, and generates a bias toward underprovision of entry. Similar results apply after extending the analysis to delivery fulfilment by the marketplace, product differentiation with direct price competition on the platform, and dynamic incentives to invest and launch copycat products.

Key words: Entry, product selection, platform competition, business models, intermediaries.
JEL Code: L1, L4.

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1 Introduction

During the pandemic age online marketplaces such as Amazon, eBay, Rakuten, Alibaba, JD.com, Flipkart and others have played an important role in our economies, and the process of selection and pricing of their products has attracted a lot of attenton. In particular, Amazon has been at the center of antitrust and regulatory debate, and much of the criticism in the public discourse has revolved around its role as both “umpire and player”: i.e. both a platform for third party vendors, and a seller in its own right (Khan, 2016). The prevailing narrative describes this “dual role” as creating an inherent conflict of interest in which Amazon cannot possibly resist the incentive to “self preference” products it retails directly (through *Amazon Retail*), or its own versions (through *Amazon Basics* or other private labels) with a variety of channels (as assigning to its products the *Featured Offer* position or the advantage of being *Amazon's Choice*).[2] Relatedly, there is significant focus on the extent to which Amazon is making use of data gathered from seller interactions on its platform to motivate its product launch decisions and depress investment by sellers.

Building on recent works on intermediation platforms (Jiang *et al.*, 2011; Hagiu and Wright, 2015; Anderson and Bedre-Defolie, 2020; Hagiu *et al.*, 2020), we analyze these issues in a model where a marketplace such as Amazon provides a variety of products, and can decide, for each product, whether to monetize sales by *third party* (3P) sellers through a commission or become a seller on its platform, either by commercializing a *private label* (PL) version or by purchasing from a vendor and resell as a *first party* (1P) retailer. These alternatives are used also by traditional intermediaries (such as grocery stores, department stores or hypermarkets), but they are crucial for an online marketplace such as Amazon because customers often concentrate purchases on the products that are promoted by the platform, and there is a critical trade off between the comparative advantage of Amazon in logistics and 3P sellers in marketing their own products. Intuitively, Amazon would act as a direct seller when its advantage in shipping cost and other dimensions is large relative to the advantage of sellers in customer reach, generating more profits from direct sales than commissions on 3P sellers. Our main question is whether the profit-maximizing choices on entry by the marketplace are aligned or not with the interest of consumers, whose preferences depend on the expected surplus obtained from different products (and are assumed quasi-linear and additive). We analyze the two extreme cases

[2] *Amazon Retail* is the channel through which Amazon resells products purchased from independent vendors as a first party retailer (the original business model of Amazon before opening up the store to other sellers), *Amazon Basics* is a line of private label products by Amazon, focused on home goods, office supplies and tech accessories, but there are others for other product categories (as typical of offline and online marketplaces). The *Featured Offer* is the most prominent offer displayed by Amazon for a particular product in the *Buy Box*, where users immediately find the best option, and is associated with *Add to Basket* and *Buy Now* buttons that facilitate purchases: for these reasons, it captures the large majority of sales of each particular product. *Amazon's Choice* is a feature that identifies the best fit product for a customer' search query, which attracts a large portion of the sales induced by a generic search.

of perfectly competitive 3P sellers and monopolistic 3P sellers.

Given the highly competitive environment hosted on a marketplace such as Amazon, our benchmark is based on competitive sellers (ready to sell at marginal cost to become the first option offered to consumers). With general demand functions we find that entry of each product could be either overprovided or underprovided, depending on the relative shapes of the elasticities of demand and utility of the given product. However, we show that the entry choice by Amazon is the one that maximizes aggregate consumer welfare for a family of power surplus preferences generating standard demands, including linear, isoelastic and loglinear demand functions as well as further generalizations. This efficiency result relies on the fact that entry by Amazon reduces prices for consumers and affects conversion rates with a proportionate impact on Amazon profits and aggregate consumer welfare, which aligns choices based on comparisons of profit and welfare. Under power surplus preferences, the marginal benefits for the marketplace from direct entry, over those from commissions, are the same as the marginal benefits of consumers.

Competition for customers with other marketplaces and retailers induces Amazon to reduce commissions and prices (or to introduce a subscription-based service as *Amazon Prime*) to attract more customers, but preserves the conditions for efficient entry. It is exactly the business model of Amazon based on hosting sellers and charging commissions that prevents Amazon from gaining through systematic self-preferencing for its PL and 1P products.[3] To proceed further, we adopt a translated power preference specification and show that Amazon is more likely to directly retail goods when the value added of the products is limited so that efficient shipping is more important, and demand is highly elastic so that there is a potentially large demand at low prices. The platform should leave "long tail" expensive and niche products to distribution by 3P sellers, which is in line with the evidence of Hagiu and Wright (2015) and especially Zhu and Liu (2018) on Amazon.

Introducing market power of 3P sellers tends to incentivize PL products by the platform, as in the typical case of batteries provided by Amazon in competition with manufacturers of highly concentrated sectors, and to disincentivize 1P retail by Amazon, as in the case of brands for luxury, beauty and apparel that are directly distributed by their manufacturers and often not even available on Amazon. The intuition is that PL products avoid the double marginalization created by commissions and high markups of 3P sellers, while 1P retail is less profitable when manufacturers with high market power exploit the advantage of the platform in logistics by increasing their wholesale prices. In both cases, however, we find a bias toward underprovision of entry of Amazon, in the sense that PL or 1P retailing may not occur even when they would be desirable from the point of view of consumers: the more subtle reason is that consumers gain an additional surplus from the price reduction implemented by the platform which is larger than the additional profits this platform can appropriate.

[3] On the concept of business model see Casadesus-Masanell and Ricart (2010) and for application to related antitrust issues see Caffarra (2019) and Etro (2020).

We discuss a number of extensions. Amazon makes its logistics capabilities available to sellers through the so-called *Fulfilment by Amazon* service, which creates further efficiencies, but preserves the incentives of the marketplace to enter with private labels when sellers have market power and limited customer reach. Introducing imperfect substitutability and direct competition on the platform between 3P varieties and a PL variety (see also Anderson and Bedre-Defolie, 2020), we show that the marketplace has an incentive to host all varieties setting a commission that allocates sales to equalize marginal profits on direct sales and marginal revenues on commissions, but for high substitutability only one variety is purchased to consumers. Our linear demand example confirms that, under competitive sellers the marketplace decision on product selection is aligned with the interest of consumers in creating gains from variety. Under market power of 3P sellers entry by the marketplace reduces their prices, but the double marginalization problem generates again overprovision of their varieties from the point of view of consumers. As a cautionary note, our efficiency results are based on a consumer welfare standard and rely on linear commissions optimally set for each product, but imperfect monetization on 3P sales, due for instance to uniform commissions across products or bargaining on two-part tariffs, can generate a bias toward excess entry.

Our last investigation concerns the impact of Amazon's entry on the incentives to create new products for the platform (see also Jiang *et al.*, 2011). Adopting a dynamic extension of our model where the launch of imitative products by Amazon reduces the incentives of sellers to invest in innovation, we argue that the marketplace can internalize this effect in its entry decisions for the exact reason that it monetizes on all the products made available in the future on the platform. Moreover, the marketplace can have incentives to commit to provide less imitative products than optimal from the point of view of consumers, because it takes into account fully the negative dynamic effects on investment but only in part the positive static effects on price reductions. In the absence of such a commitment, the optimal policy can be still sustainable in a repeated interaction with infinite rounds of sellers investing in new products.

This work is related to the wide literature on platforms (Armstrong, 2006; Belleflamme and Toulemonde, 2016; Dubois and Jullien, 2016; De Corniere and Taylor, 2019; Hagiu, Jullien and Wright, 2020; Zennyo, 2020) and in particular to important recent works on the choice of marketplaces to act as retailers. Hagiu and Wright (2015) consider the choice between functioning as a pure marketplace or a reseller under the assumptions of a perfectly rigid demand and optimal access fees for all products, in which case the platform extracts all consumers surplus by adopting the efficient mode of distribution. We consider a similar analysis with general downward sloping demands for each product and linear commissions set by Amazon, which allows us to evaluate welfare effects in a distorsive environment. Hagiu *et al.* (2020) ask whether Amazon should be allowed to sell on its marketplace, and conclude that consumers benefit from the dual role through intensified competition on the platform (which we confirm under imperfect substitutability), but emphasize also possible inefficiencies due to self-preferencing and copycat products. Jiang *et al.* (2011) study dynamic entry decisions by Amazon and focus on asymmetric information on demand and effort of sellers, showing (in line with our results) that Amazon can have an incentive to commit not to imitate 3P products to foster investment while monetizing on commission revenues. Finally, Anderson and Bedre-Defolie (2020) analyze the optimal number of products offered by a marketplace (or equivalently the optimal commissions and listing fees set on 3P sellers), and compare it with the socially optimal one. In the same spirit, we contribute to the broader literature on entry and product selection, started with the classic works of Spence (1976), Dixit and Stiglitz (1977) and Mankiw and Whinston (1986).[4] An interesting and related empirical investigation on entry and pricing on the Amazon platform is in Zhu and Liu (2018).

The rest of the work is organized as follows. Section 2 presents the general model with competitive sellers. Section 3 analyzes market power by sellers. Section 4 extends the analysis to a dynamic environment. Section 5 concludes. All proofs are in the Appendix.

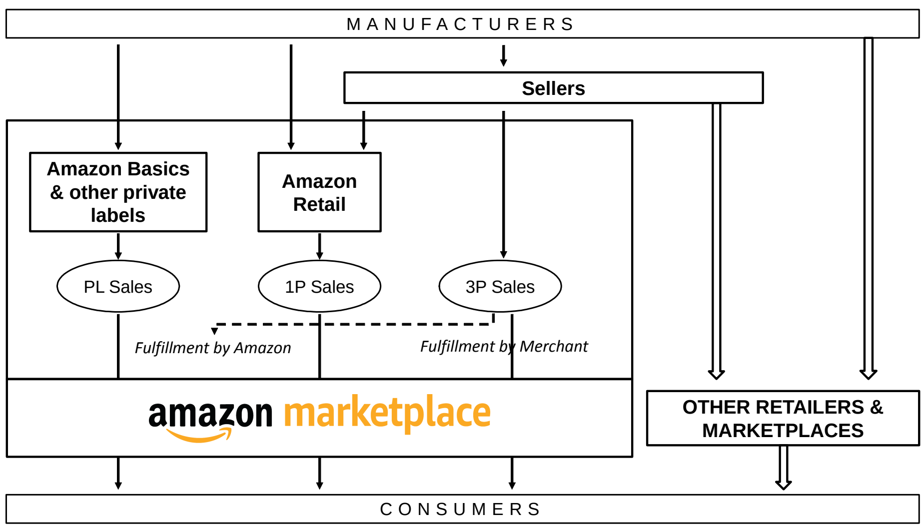

Fig. 1. Description of different selling options on Amazon.

2 The model

We develop a simple model of a marketplace, say Amazon, which hosts third party (3P) sellers of a variety of products and can decide to enter and provide some of these products either as a first party (1P) retailer, purchasing from manufacturers and reselling directly on the platform, or as a product label (PL)

[4]On more recent advances see for instance d'Aspremont and Dos Santos Ferreira (2016) and Bertoletti and Etro (2016, 2017).

producer and retailer of equivalent products (see Fig. 1 for a description of the options). Depending on the choice, the marketplace monetizes through commissions on 3P sales, margins between retail and wholesale prices for 1P sales, or margins between retail prices and marginal costs for PL sales. For each product, we allow the marketplace to redirect consumers toward the single option that is most profitable. In pratice, when consumers select a specific product (say, a particular book), Amazon shows one *Featured Offer* displayed in the *Buy Box* as the most convenient between all the available offers of that product by 3P sellers and Amazon as 1P seller,[5] while when consumers search for a generic product (say, diapers), Amazon shows a suggested option as the *Amazon's choice* or simply the best ranked option in the search results alongside other substitutes by 3P sellers and Amazon as a PL seller: these recommendations capture a large part of sales for each product search on Amazon.

We allow for differences in both shipping costs and customer reach between 3P sellers and the marketplace, but we initially abstract from further product differentiation: the purpose is to verify if an when the marketplace makes entry choices that depart from those that maximize consumer welfare by imitating external sellers and steering consumers toward its own products. The baseline analysis considers a single platform hosting homogeneous competitive sellers. We will later discuss how competition with other platforms, imperfect substitutability between products competing on the platform, market power of sellers and other extensions can affect the basic results.

Let us consider a given set Ω of products available on the marketplace and a unit mass of consumers accessing it and deciding what to purchase. Consumers have quasi-linear preferences represented by an additive indirect utility with surplus (net of income):

$$V(\mathbf{p}) = \sum_{k \in \Omega} z_k v_k(p_k) \tag{1}$$

where p_k is the purchase price of product k, $v_k(p_k)$ is a positive, decreasing and convex function of the price and $z_k \in (0, 1)$ is the probability that the consumer purchases good k on the platform. By Roy's identity, the expected demand for good k is $q_k = z_k \left| v_k'(p_k) \right|$. One interpretation is that consumers have a probabilistic impulse to purchase a product on the platform (say, diapers) and, depending on the price, they decide how many units to purchase.[6] An alternative intepretation, valid when the demand is in the unit interval for any price, is that consumers purchase at most one unit of a product (say a given book), but they do so with a probability depending on its price.[7] In either case, the demand of product k increases in z_k and decreases in the price p_k.

[5] Each specific product is associated with a unique *Amazon Standard Identification Number* (ASIN), and can be provided by various sellers at different prices and conditions on Amazon. Only one offer is chosen by Amazon as the *Featured Offer* with full display of its details.

[6] While the probabilities of purchase are taken as given here, they could be endogenized depending on the characteristics and qualities of products or on the marketing activity of the seller based on differential information (as in Hagiu and Wright, 2015).

[7] The typical case emerges when the willingness to pay for the product is drawn from a known distribution, and the purchase takes place only if this is above the posted price. I am thankful to Benno Buehler for useful insights on this interpretation.

In this environment, each product can be provided either by 3P sellers or by Amazon, which depending on the product can act either as a 1P retailer or a PL seller,[8] and it is the same marketplace that decides which option will be proposed to consumers (as in Jiang *et al.*, 2011). The timing of the game is the following: Amazon selects for each product k which one of the selling modes will be adopted, Amazon decides the commission on each product offered by 3P sellers, then prices are chosen for each product available on the platform, and finally consumers make their purchasing decisions. The trade-off for product selection depends on differences in costs and probability of purchases. In particular, we assume that the marginal cost of production of good k is c_k for any competitive manufacturer or seller, but there are differences in delivery fulfilment costs and in conversion rates for the marketplace and other sellers. Amazon has a comparative advantage in logistics, which allows it to have a lower marginal cost of shipping s_A compared to the shipping cost of 3P sellers, say $s_k \geqslant s_A$ for product k. Instead, 3P sellers have a comparative advantage in the probability of sale due to know-how on the market and the product, superior data on consumers (especially if they are active across multiple distribution channels) and higher incentives to promote their own product, and consequently Amazon has a lower probability of sale at the same price, say $z_k^A \leqslant z_k$ for product k.[9]

2.1 Competitive 3P sellers

Our benchmark case is the one with competitive sellers for each product, so that their prices are driven down to the effective marginal cost. Under competitive sellers a fixed commission on units solds and a percentage commission are equivalent (Suits and Musgrave, 1953), therefore without loss of generality we adopt the former. For each good, we define t_k as the specific commission on 3P sales set by Amazon.[10] Accordingly, sellers of product j set the final price:

$$p_j^S = c_j + t_j + s_j \tag{2}$$

When Amazon acts as a PL retailer, it directly bears the marginal cost of production c_j. When Amazon acts as a 1P retailer, it purchases from sellers (or manufacturers) at the wholesale price w_k, and competitive sellers set the wholesale price at marginal cost, $w_j = c_j$ generating an equivalent situation (this will

[8] The 1P option is the relevant one for branded goods and the PL option for standardized goods. For instance, branded sneakers can be offered through the 1P option by Amazon, but not as PL products. Instead, batteries can be offered as PL products outsourced from the same competitive manufacturers that can produce for *Duracell* or *Energizer*.

[9] Jiang *et al.* (2011) obtain a similar trade-off by assuming that sellers have lower fixed costs and also better information on demand. Also Hagiu and Wright (2015) assume that sellers have a higher probability of sale and shipping costs, but they consider a perfectly rigid unit demand and fixed access fees extracting all the profits of 3P sellers. One can think of products such that $v_k(c_k + s_k) = 0$ as not provided by 3P sellers, but potentially provided by the marketplace to fill the gap if $v_k(c_k + s_A) > 0$.

[10] In practice, Amazon adopts commissions differentiated by product category and not product by product. It also differentiates referral fees from closing fees for media products and charges monthly high-volume listing fees. We will later discuss the implications.

not be the case when we will introduce market power of sellers). Accordingly, Amazon adopts the same price rule for 1P or PL products, maximizing profits $\pi_j^A(p_j) = z_j^A |v_j(p_j)| (p_j - c_j - s_A)$ for product j. The solution is:

$$p_j^A = \frac{c_j + s_A}{1 - \frac{1}{\varepsilon_j(p_j^A)}} \tag{3}$$

where we defined the demand elasticity $\varepsilon_j(p) \equiv -v_j''(p)p/v_j'(p)$, assumed larger than unity at the equilibrium prices.

When Amazon sets the commission on product j sold by 3P sellers, it maximizes commission revenues $\pi_j^{3P}(t_j) = z_j \left|v_j'(c_j + t_j + s_j)\right| t_j$. The solution is:

$$t_j^* = \frac{p_j^S}{\varepsilon_j(p_j^S)} \tag{4}$$

which combined with (2) delivers a final price $p_j^S = (c_j + s_j)/[1 - 1/\varepsilon_j(p_j^S)]$. It is immediate to verify that $s_j \geqslant s_A$ implies that $p_j^A \leqslant p_j^S$, and Amazon exploits its advantage in logistics to price its goods below the price of 3P sellers.

We can now verify which option is the most profitable for Amazon and therefore is promoted to consumers. For a given product j Amazon finds it profitable to either introduce a PL product or act as 1P retailer rather than relying on the 3P seller when $\pi_j^{3P}(t_j^*) \geq \pi_j^A(p_j^A)$, or:

$$z_j^A \left|v_j'(p_j^A)\right| \left(p_j^A - c_j - s_A\right) \geq z_j \left|v_j'(c_j + t_j^* + s_j)\right| t_j^* \tag{5}$$

which suggests that entry takes place when Amazon has an advantage in logistics large enough to compensate the demand advantage of the seller. Otherwise this is a product where it cannot realize any profits above commission revenues. The trade-off depends on relative profitability, therefore entry occurs if the gains in margins more than compensate the losses in customer reach.

Our main objective is to compare this equilibrium entry decision with the socially optimal decision constrained by the same equilibrium prices. Aggregate surplus is maximized when entry by Amazon takes place for each product j if:

$$z_j^A v_j(p_j^A) \geq z_j v_j(c_j + t_j^* + s_j) \tag{6}$$

which delivers a trade off in terms of relative utility. Entry is optimal when the cost advantage of Amazon is translated into gains in surplus that more than compensate the reduction of the fraction of consumers obtaining these gains. The increase in surplus depends on how utility changes with price changes, which is driven by the elasticity of sub-utility $\eta_j(p) \equiv -v_j'(p)p/v_j(p) > 0$ rather than by the demand elasticity.

In general, there can be a mismatch between equilibrium and optimal entry. We refer to overprovision of entry by Amazon when a product is directly provided by Amazon at a lower conversion rate than the one that justifies its entry to maximize aggregate consumer welfare, and underprovision when the opposite occurs. The next result identifies conditions under which entry is optimal as well as conditions under which it is overprovided or underprovided:

PROPOSITION 1. *Under competitive sellers, entry by the marketplace with PL products or as a 1P retailer is always socially efficient for a product j if* $\eta_j(p)/\varepsilon_j(p)$ *is constant, where* $\varepsilon_j(p)$ *and* $\eta_j(p)$ *are the elasticities of demand and subutility, while entry is overprovided when* $\eta_j(p)/\varepsilon_j(p)$ *is always decreasing and underprovided when* $\eta_j(p)/\varepsilon_j(p)$ *is always increasing in the price.*

In practice, there can be products for which a price reduction by Amazon is more valuable for consumers than for the platform and those products tend to be underprovided by the platform and overprovided by high price sellers. Instead, for other products, reaching a larger number of consumers can be a more effective way to expand aggregate welfare than to expand profits, and those products tend to be overprovided by the platform and underprovided by sellers.[11] However, product selection by the marketplace is always efficient for any product whose demand belongs to common specifications, as: 1) the linear demand $q_j = z_j(a - p_j)$ with $a > 0$, generated by a quadratic surplus with $\eta_j/\varepsilon_j = 2$; 2) the isoelastic demand $q_j = z_j p_j^{-\varepsilon}$ with $\varepsilon > 1$, generated by a power function with $\eta_j/\varepsilon_j = 1 - 1/\varepsilon$; and 3) the log-linear demand $\log q_j = \log z_j - p_j$, generated by an exponential surplus with $\eta_j/\varepsilon_j = 1$. These are not the only cases. The next result fully characterizes the family of surplus (and demand) functions that generate efficient entry decisions:

COROLLARY 2. *Under competitive sellers, entry by the marketplace for a product j is socially efficient if and only if its surplus function is a power surplus function, i.e. it can be expressed as either:*

$$v_j(p) = \lambda \left(\frac{\kappa - 1}{\kappa} (a - bp) \right)^{\frac{\kappa}{\kappa - 1}} \tag{7}$$

for $\kappa \neq 1$ *or:*

$$v_j(p) = \lambda e^{-bp} \tag{8}$$

where a *and* $b, \lambda, \kappa > 0$ *are arbitrary constants.*

One can verify that, after selecting the appropriate multiplicative constant λ, the functional form (7) nests the linear demand case above when $\kappa = 2$ and the isoelastic demand case when $a = 0$ and $\kappa = 1 - 1/\varepsilon$, and the functional

[11] The opposite case in which Amazon has a marketing advantage but 3P sellers have a cost advantage can be analyzed in the same way, resulting in a lower final price on 3P products. The condition for efficient entry remains the same as in Proposition 1 and Corollary 2 below, but now entry by the marketplace is overprovided for goods with $\eta_j(p)/\varepsilon_j(p)$ always increasing and underprovided for goods with $\eta_j(p)/\varepsilon_j(p)$ always decreasing (see the Appendix). I am thankful to a referee for noticing that this case can be relevant when specialized sellers enjoy relevant scale economies (even after accounting for the platform's logistic advantage), and the marketplace has higher conversion rates because, for instance, it has earned users' trust.

form (8) provides the log-linear demand example for $b = 1$. Beyond these examples, efficiency applies to the full family of translated power demand functions generated by these preferences. In these cases the marginal benefits for the marketplace from direct entry (over those from commissions) are the same as the marginal benefits of consumers. It is important to remark that the same results would hold if Amazon could decide which product to promote after prices were simultaneously set by Amazon and 3P sellers: the reason is that Amazon would promote the most profitable option anyway, the price of competitive sellers would be driven to the effective marginal cost and the price of Amazon, as well as its commission, would be set to maximize profits as above.[12]

While these results are related to classic works by Spence (1976) and Dixit and Stiglitz (1977) on optimum product diversity and Mankiw and Whinston (1986) on excess entry, they differ for the focus on entry by one firm rather than variety provision under monopolistic or imperfect competition. The optimality of entry in traditional contexts depends on the trade off between limited appropriability of consumer surplus and excessive business stealing, leading to efficiency only under isoelastic demand in the monopolistic competition framework (Dixit and Stiglitz, 1977) and to excess entry in oligopolistic frameworks (Mankiw and Whinston, 1986).[13] Instead, entry by a marketplace that can monetize either through its own products or through commissions on others' products generates efficiency for an entire family of preferences which nests empirically relevant demand functions.

2.2 Competition for customers

The business model of a marketplace such as Amazon is based on its reputation in providing competitive solutions for most products compared to other retailers to attract customers through a flywheel effect. Taking in consideration this dynamic form of competition with other retailers can modify incentives on pricing and entry and here we verify how.

In practice, consumers can and do purchase different products online and offline. However, there are a variety of reasons for which they tend to repeat over time purchases on a platform that is expected to provide lower prices on average and wider coverage of products. To extend the model in this direction, we now assume that customers visit the Amazon platform only if this provides higher expected utility than alternative options (see Fig. 1). We define $V(\theta) = \theta\bar{V}$ as the expected surplus from alternative options for a consumer of type θ, with $\bar{V}$ as the maximum value associated with these options, determined by exogenous factors (as the competitiveness of other marketplaces or the access to offline shopping). We assume that θ is uniformly distributed in the unit interval,

[12] Empirical evidence on biased recommendations by marketplaces funded through commissions is limited, but the results of Ursu (2018) on an online travel agency such as *Expedia* suggest that rankings affect search (and not purchases conditional on search), but are not systematically biased to increase profits at the cost of reducing consumer welfare.

[13] On the recent literature on equilibrium and optimal entry see Mukherjee (2012), Bertoletti and Etro (2016, 2017) and Anderson and Bedre-Defolie (2020). On the empirical front see for instance Berry and Waldfogel (1999) and Dutta (2011).

representing the relative evaluation of other outlets as shopping environments. Then, the cut-off customer $\hat{\theta} = V(\mathbf{p})/\bar{V}$ determines the fraction of Amazon customers. Accordingly, the effective profits of Amazon become:[14]

$$\Pi_A = \frac{\sum_{k\in\Omega} z_k v_k(p_k)\Pi(\mathbf{p})}{\bar{V}} \tag{9}$$

where the profits per visiting customer are:

$$\Pi(\mathbf{p}) = \sum_{k\in 3P} z_k \left|v_k'(c_k + t_k + s_k)\right| t_k + \sum_{k\notin 3P} z_k^A \left|v_k'(p_k^A)\right| (p_k^A - c_k - s_A)$$

and we assume the regularity condition $V(\mathbf{p}) > \Pi(\mathbf{p})$.

In this way, any decision is taken to maximize the product of welfare and profits per customer, implying prices and commissions that satisfy the FOCs:

$$p_j^A = \frac{c_j + s_A}{1 - \frac{V(\mathbf{p})-\Pi(\mathbf{p})}{\varepsilon_j(p_j^A)V(\mathbf{p})}} \quad \text{and} \quad t_j^* = \frac{p_j^S[V(\mathbf{p}) - \Pi(\mathbf{p})]}{\varepsilon_j(p_j^S)V(\mathbf{p})} \tag{10}$$

Higher effective elasticities compared to (3) and (4) imply lower commissions and prices aimed at attracting more customers to the platform. Notice that in this model the prices do not depend on the external factors affecting $\bar{V}$ (for instance the increase in demand of online products in the current pandemic age), which have an impact on profits only through the number of customers. The equilibrium prices allow us to rewrite the effective profits as follows:

$$\Pi_A = \frac{\left(\sum_{k\in\Omega} z_k v_k(p_k)\right)^2 \sum_{k\in\Omega} z_k v_k(p_k)\frac{\eta_k(p_k)}{\varepsilon_k(p_k)}}{\bar{V}\sum_{k\in\Omega} z_k v_k(p_k)\left(1 + \frac{\eta_k(p_k)}{\varepsilon_k(p_k)}\right)} \tag{11}$$

on which basis the platform can make its entry decisions product by product. Whether entry becomes more or less likely under platform competition is not obvious, since now the profitability of entry for a product can depend on the profitability of all the other products as well as on the aggregate surplus. Nevertheless, we can confirm the neutrality result found in the benchmark case:

Proposition 3. *Under competition for customers and competitive sellers, entry by the marketplace for a product j is socially efficient if its surplus function is given by a power surplus function.*

A related microfoundation of platform profits has been analyzed by Anderson and Bedre-Defolie (2020), who consider both a commission and a listing fee optimally set by the marketplace and endogenize the number of sellers under free entry: they show that the equilibrium reproduces the choices of a multiproduct

[14] Similar results could be obtained through models of spatial differentiation and considering network externalities for the marketplace possibly in competiton with rivals (Economides, 1996). See Anderson and Bedre-Defolie (2020) for an analogous foundation.

monopolist, and can imply either excess or insufficient entry of sellers depending on the underlying preferences. Zennyo (2020) analyzes the same issue in a search model showing that a hybrid marketplace can benefit both consumers and 3P sellers by promoting its products and simultaneously reduce commissions to attract more customers.

In our model with a given set of products, efficient pricing can be restored if consumers can be charged a subscription fee.[15] *Amazon Prime*, which involves customers paying a low monthly or annual subscription fee in return for price discounts in form of free delivery (for eligible products) and other promotions, may be viewed as a step in this direction. On the top of this, Amazon obtains also an additional instrument to monetize its online marketplace, changing in part its business model from one entirely based on sales and commissions to one that monetizes also on subscription fees.

As a last remark, the analysis of competition for customers suggests why a marketplace owner has stronger incentives to make investments that attract more customers to the platform, for instance to increase the conversion rates of its products, while 3P sellers have typically lower incentives to invest (or no incentives at all) since they tend to neglect the impact on the demand of the platform and of the other sellers.

2.3 Translated power consumer surplus

We exemplify our analysis through a flexible specification of preferences. From now on, we drop product subscripts and consider the translated power (TP) surplus function:

$$v(p) = \frac{(a-p)^{1+\gamma}}{1+\gamma} \tag{12}$$

where $\gamma \geq 0$ parametrizes the elasticities of demand $\varepsilon(p) = \frac{\gamma p}{a-p}$ and utility $\eta(p) = \frac{(1+\gamma)p}{a-p}$. The condition for efficiency under competitive sellers is clearly satisfied. Since the demand becomes $q = z(a-p)^\gamma$, we can nest the cases of a perfectly rigid demand for $\gamma \to 0$, a linear demand for $\gamma = 1$ and a perfectly elastic demand for $\gamma \to \infty$ (see Bertoletti *et al.*, 2018, for applications).

Given the price of 3P sellers (2), we can directly compute the commission that maximizes Amazon's revenues $\pi^{3P}(t) = z(a-c-t-s)^\gamma t$ as:

$$t^* = \frac{a-c-s}{1+\gamma} \tag{13}$$

implying the following commission revenues for Amazon:

$$\pi^{3P}(t^*) = \frac{z\gamma^\gamma \left(a-c-s\right)^{1+\gamma}}{(1+\gamma)^{1+\gamma}} \tag{14}$$

[15] Consider a fee P for access to the platform. Then, its profits become $\Pi_A = (V-P)(\Pi + P)/\bar{V}$. When the fee is optimally chosen as $P = (V-\Pi)/2$, we obtain $\Pi_A = (V+\Pi)^2/4\bar{V}$, and any decision is taken to maximize the sum of profits and welfare, which is also in the interest of the average consumer. Under competitive sellers, this would lead to marginal cost pricing and efficient product selection. Related results are in Anderson and Bedre-Defolie (2020) and Etro (2020).

Instead, the optimal prices of Amazon's products maximize the profits $\pi^A(p) = z^A(a-p)^\gamma(p-c-s_A)$ where the marginal cost takes into account the cost of products and shipping for Amazon. The solution is:

$$p^A = \frac{a+\gamma(c+s_A)}{1+\gamma} \tag{15}$$

which is below the price of 3P sellers subject to the commission and generates the following profits:

$$\pi^A(p^A) = \frac{z^A\gamma^\gamma\left(a-c-s_A\right)^{1+\gamma}}{(1+\gamma)^{1+\gamma}} \tag{16}$$

Then, the condition for entry can be obtained comparing the commission revenues from 3P sales (14) and the profits from entry (16). This allows one to compute the maximum shipping cost of the 3P seller above which entry by Amazon becomes profitable:

$$s^* \equiv s_A\psi^* + (a-c)(1-\psi^*) \quad \text{with } \psi^* \equiv \left(\frac{z^A}{z}\right)^{\frac{1}{1+\gamma}} \in (0,1) \tag{17}$$

The cut-off for the shipping cost of the seller is a weighted average of the shipping cost of Amazon s_A and the maximum value added generated by the product $a-c$, with a weight on the former ψ^* that increases in the relative conversion rate of Amazon compared to the seller z^A/z and in the substitutability parameter γ: since s^* decreases in ψ^*, a more elastic demand favours entry because it amplifies the comparative advantage associated with a lower shipping cost. Accordingly, Amazon is more likely to directly sell goods when competitive sellers are inefficient at shipping, when the value added of the product is limited so that efficient shipping is more important, and when there is a potentially large demand at low prices. The platform should instead leave expensive products and "long tail" niche products to distribution by 3P sellers, which resonates well with the empirical evidence presented by Hagiu and Wright (2015) and Zhu and Liu (2018) on Amazon.

As mentioned, entry by Amazon is efficient: in the trivial case where $z = z_A$, Amazon enters as long as $s > s_A$ and is indifferent if $s = s_A$, but more generally entry takes place if and only if it increases consumer welfare. Intuitively, whether the products on sale have a more or less elastic demand affects the prices that sellers and Amazon will set, and affects the profitability of those goods and the surplus they create for consumers, but the price reduction induced by Amazon's entry increases the surplus of Amazon and consumers in the same proportion, aligning the equilibrium and efficient decisions on entry. We summarize our findings as follows:

Proposition 4. *Under competitive sellers and translated power surplus, entry by the marketplace with PL products or as a 1P retailer is socially efficient and more likely when sellers have lower conversion rates or higher shipping costs, when products provide lower value added and when their demand is more elastic.*

By our earlier results, efficiency extends to the case with competition with other retailers. However, as we will see in the next section, it will not extend to the case where sellers have market power. Before that, however, we discuss other extensions and point out limitations of our results.

2.4 Extensions and limitations

In this section we explore the role of delivery fulfilment by the marketplace, product differentiation with direct competition on the platform and imperfect monetization of 3P sales in affecting our results.

2.4.1 Fulfilment by the marketplace

Our analysis allows Amazon to face a binary choice between a retail model in which it takes advantage of its efficient logistics, and a marketplace model, where 3P sellers rely on in-house fulfilment for storage and shipping. In reality, Amazon makes its logistics capabilities available to 3P sellers via the *Fulfilment by Amazon* (FBA) service (as an alternative to fulfilment by the merchant; see Fig. 1). This may include not only storage and delivery but also packaging, IT services, product return management and complaints handling, with separate fees from the commissions per product sold.

Assuming that FBA reduces the shipping cost of 3P sellers from s to s_A, sellers should adopt it always in our model combining the comparative advantage of Amazon in shipping with their own advantage in marketing. Amazon can then increase its commission revenues on FBA sellers to monetize its cost advantage, and does not need to enter either as PL or 1P retailer, generating additional gains for consumers.[16] These straightforward implications will not hold when sellers have market power, as we will see in the next section.

2.4.2 Product differentiation and competition on the platform

Until now we have assumed that consumers can only consider the option promoted on the marketplace for each product because this was endogenously the most profitable for the platform. This appears the relevant modeling assumption for standardized products sold by external sellers and by Amazon replicating their offers as a first party retailer or with equivalent private label products, in which case differences in profitability depend only on shipping costs and customer reach. However, Amazon can also provide products that are perceived as differentiated from those of sellers, and in practice consumers have the ability and the interest to purchase both products, generating direct competition on the platform. This is typically the case for PL products that are qualitatively different from those of other sellers, but in principle also 1P products can be perceived as differentiated in terms of delivery speed and customer services.

[16] It is worth mentioning that in the presence of both FBA sellers and sellers adopting in-house fulfilment, it would be profit-maximizing to assign priority to the FBA seller if and only if the gap in conversion rates is compensated by the gap in margins.

As a primary consequence of product differentiation, the marketplace has an extra incentive to enter because it can monetize simultaneously through profits on its own sales and commission revenues on 3P sellers. The marketplace should actually set the commission to allocate sales in a way that equalizes the marginal profits on its products to the marginal revenues from commissions on products of other sellers. Such entry may not exert downward pressure on the prices of sellers when these are already competitive, but it can create gains from variety expanding total sales, which tends to benefit consumers.

To exemplify this case, we depart from our baseline model considering a symmetric quadratic utility depending on consumption q^S of a variety produced by 3P sellers and consumption q^A of a PL variety produced by Amazon:

$$u(q^S, q^A) = q^S \left(a - \frac{q^S}{2}\right) + q^A \left(a - \frac{q^A}{2}\right) - bq^S q^A - p^S q^S - p^A q^A \qquad (18)$$

where $b \in (0, 1)$ parametrizes substitutability in a range between independent varieties ($b \to 0$) and homogeneous ones ($b \to 1$). This delivers the demand $q^j(p^j, \bar{p}) = a - p^j$ if only variety $j = A, S$ is provided at price p^j below the choke off price $\bar{p}$, and $q^j(p^j, p^k) = \frac{a(1-b)-p^j+bp^k}{1-b^2}$ if also variety $k = S, A$ is provided at price p^k, which generates a quadratic indirect utility $v(p^S, p^A) = u(q^S(p^S, p^A), q^A(p^A, p^S))$ in either case.[17]

As before, marketplace and sellers differ in the size of shipping costs, with $s \geqslant s_A$. And as before, the marketplace can either steer consumers toward its PL product alone priced $p^A = \frac{a+c+s_A}{2}$ according to (15), or toward the products of the 3P sellers priced $p^S = c + t + s$ under the optimal commission $t^* = \frac{a-c-s}{2}$ according to (13). Under our assumptions, the PL option generates higher profits:

$$\pi^A = \frac{(a - c - s_A)^2}{4}$$

as well as higher consumer welfare when $s > s_A$, and generates the same profits and welfare when $s = s_A$. However, imperfect substitutability implies that there can be a more profitable strategy where the platform hosts both varieties and purchases are mixed. In this case the prices are set under direct competition for a given commission, and the commission is initially set to maximize profits. Under competitive sellers, this amounts to find the price and the commission of the marketplace that maximize total profits:

$$\pi^A = q^S(c + t + s, p^A)t + q^A(p^A, c + t + s)(p^A - c - s_A)$$

where the first term represents revenues from commissions and the second represents profits from direct sales. It is easy to verify that, under our demand specification, this delivers an equilibrium with the same prices and commission

[17] Since the limit case of perfect substitutability ($b \to 1$) is equivalent to (12) in the quadratic version ($\gamma \to 1$), we are effectively generalizing the earlier linear demand model to imperfect substitutability.

as above:

$$p^S = \frac{a+c+s}{2} \geqslant p^A = \frac{a+c+s_A}{2} \quad \text{and} \quad t^* = \frac{a-c-s}{2}$$

but now the PL variety attracts larger sales at a low price due to its cost advantage, and the 3P variety is also purchased in positive quantity at a high price as long as there is a large enough differentiation. More precisely, the profits of the marketplace are:

$$\pi^A = \frac{2(a-c-s_A)(a-c-s)(1-b) + (s-s_A)^2}{4(1-b^2)}$$

and they are above the profits from its standalone product if $b < \frac{a-c-s}{a-c-s_A}$. Solving the inequality with respect to the shipping cost of the sellers, the provision of both varieties is profitable if s is below the cut-off:

$$s^* \equiv s_A\psi^* + (a-c)(1-\psi^*) \;\; \text{with } \psi^* \equiv b \in (0,1) \tag{19}$$

where we emphasized the parallel with the cut-off (17) where the weight is now given by the substitutability parameter $b \in (0,1)$. Only for high substitutability or a large cost difference, the marketplace sells only the private label variety. More important for our purposes, in this environment with competitive sellers, the equilibrium cut-off rule is the same that maximizes consumer welfare: since the prices are the same as for standalone provision, consumers must be better off from the provision of both varieties if they purchase both of them, and indeed we have $q^S(p^S, p^A) > 0$ if and only if $s < s^*$.[18] A characterization of the family of preferences that generate such an alignment of interests is beyond our scope, but, as in the baseline model, a bias in product selection can emerge under more general demand systems (due to different equilibrium prices under standalone and simultaneous provision of the products).

Intuitively, under efficient pricing of the sellers, the marketplace extracts the monopolistic profits from both varieties through the commission and its price, and provides the efficient number of varieties on the platform under standard demand functions. Adding competition for customers with other retail outlets would tend to limit prices and foster variety. As shown by Anderson and Bedre-Defolie (2020), the ability of the marketplace to replicate the choices of a multiproduct monopolist holds under more general conditions with free entry of sellers (whose profits can be extracted through a listing fee), and also in that case the number of sellers can be either optimal or not depending on the nature of preferences. A separate concern, absent in our environment, emerges if the platform can manipulate preferences, for instance hiding rivals' products that

[18] For instance, with zero costs for both varieties, the provision of one variety only generates profits $\pi^A = a^2/4$ and surplus $v = a^2/8$, while the provision of both varieties increases profits to $\pi = a^2/2(1+b)$ and surplus to $v = a^2/4(1+b)$, and only in the limit case of perfect substitutability the platform would be indifferent between options, as in our benchmark model. Analogous results would emerge adding differences in willingness to pay, but the standalone 3P variety could be the one provided in equilibrium.

are also sold on other retail channels, in which case Hagiu *et al.* (2020) have shown examples where harmful forms of self-preferencing can emerge.[19]

2.4.3 Imperfect monetization

A limitation of our model, including the latest extension to product differentiation, is that we have assumed that the marketplace can set the profit-maximizing commission on each product. If this is not the case, 3P sales would be imperfectly monetized, which would increase the relative profitability of entry. This would generate a bias toward excess entry (on the top of the other possible biases mentioned above).[20] Such a concern can be relevant because marketplaces do not set commissions product by product, but actually differentiate commission rates only by product category. Nevertheless, a limited differentiation of commission rates can be part of an optimal policy taking into account uncertainty on demand and administrative costs of differentiated commissions that are not explicitly considered here. Moroever, the losses from not differentiating commission rates across products of the same category are likely to be of second-order importance compared to the losses from setting wrong commission rates on average, and adjusting suboptimal commissions would be not only feasible, but also much easier compared to introducing new products. The fact that these adjustments do not take place suggests that the bias due to imperfect monetization is likely to be small.

3 Market power of sellers

In our baseline model the sellers active on the platform were competitive. In practice, some 3P sellers have market power on their products, either because they have found new or differentiatied products that can be profitably sold on the platform or because they are exclusive sellers of some products on the platform (as when the original manufacturers of protected brands control their distribution). We now verify how such market power affects prices, commissions and the entry decisions by Amazon.[21]

To isolate the impact of market power, we adopt the translated power specification (12) which under competitive sellers induced efficient entry. We should remark that a fixed commission on 3P sales is not anymore equivalent to a

[19] Hagiu *et al.* (2020) assume differentiated products with perfectly rigid demands, which leads to mixed strategies in prices, and to equilibria where the marketplace offers products that are not purchased.

[20] The possibility of recommendation biases by platforms that do not fully monetize on sales of third party players has been emphasized also by De Cornière and Taylor (2019), and applies typically to ad-funded platforms. Padilla *et al.*(2020) show that excess entry may also occur for device-funded platforms, but their result holds only in the absence of commissions on third party players.

[21] The theory of the introduction of private labels to inject competition with national brands goes back to Mills (1995). Other interesting effects of market power of sellers on competing digital platforms are studied by Karle *et al.* (2020).

percentage commission under monopolistic sellers, but they both generate similar double marginalization problems (Suits and Musgrave, 1953): since the percentage commission leads to more analytical complexity but does not yield additional qualitative insights we keep assuming a specific commission (as in Jiang *et al.* 2011). A monopolistic 3P seller facing the commission t sets the price to maximize unitary profits $(a-p)^\gamma(p-c-t-s)$ implying $p^S = \frac{a+\gamma(c+t+s)}{1+\gamma}$. Expecting this, Amazon sets the commission to maximize the revenues obtained from the product, which is the same as under competitive sellers:

$$t^* = \frac{a-c-s}{1+\gamma} \tag{20}$$

and delivers the final price:

$$p^S = \frac{(1+2\gamma)a+\gamma^2(c+s)}{(1+\gamma)^2} \tag{21}$$

Under this demand specification the platform does not adjust the commission depending on the market power of the sellers (which, by the way, resonates well with the limited variability of Amazon's commissions seen in practice). However, the platform suffers from a double marginalization problem, since both the commission and the markup of the seller are applied to the same demand, reducing joint profits and also the surplus per purchasing customer. The final revenues obtained by Amazon with this mode of distribution can be computed as:

$$\pi^{3P} = \frac{z\gamma^{2\gamma}\left(a-c-s\right)^{1+\gamma}}{(1+\gamma)^{1+2\gamma}} \tag{22}$$

and one can verify that 3P sellers obtain:

$$\pi^{S} = \frac{z\gamma^{1+2\gamma}\left(a-c-s\right)^{1+\gamma}}{(1+\gamma)^{2(1+\gamma)}} \tag{23}$$

which corresponds to $(\frac{\gamma}{1+\gamma})\pi^{3P}$, that is less than the profits of the marketplace. The more elastic is demand, the more equal is the allocation of profits between Amazon and 3P sellers.

3.1 Private Label products

We first consider the case where Amazon can directly provide a PL product which is equivalent to the one of the 3P seller. However, the analysis applies also to the situation where Amazon can bypass a seller (with some temporary market power that is not protected by IP), purchase the same product from the original manufacturer, and retail it directly at a lower price (in this case as a 1P sale). Amazon sets the price (15) reproduced here as:

$$p^{PL} = \frac{a+\gamma(c+s_A)}{1+\gamma} \tag{24}$$

which is clearly lower than the price set by 3P sellers (21) due to the lack of double marginalization and to a lower shipping cost, and even lower than their marginal cost augmented by the commission. However, the conversion rate is also changed. The product-specific profits account for that and are still given by (16), which we reproduce as:

$$\pi^{PL} = \frac{z^A \gamma^\gamma (a - c - s_A)^{1+\gamma}}{(1+\gamma)^{1+\gamma}} \tag{25}$$

Accordingly, entry with a PL product is profitable if $\pi^{PL} > \pi^{3P}$, that is if the conversion rate of the 3P seller is low enough and its shipping cost is above the cut-off:

$$\hat{s}^{PL} \equiv s_A \hat{\psi}^{PL} + (a-c)(1-\hat{\psi}^{PL}) \text{ with } \hat{\psi}^{PL} \equiv \psi^* \left(1 + \frac{1}{\gamma}\right)^{\frac{\gamma}{1+\gamma}} \tag{26}$$

This cut-off cost is lower compared to (17) for the case of competitive sellers ($\hat{\psi}^{PL} > \psi^*$) therefore entry is more likely.[22] Intuitively, when the sellers have market power, entry by Amazon is more profitable because it avoids the double marginalization associated with the commission and the markup of the seller.[23] This result resonates well with the most prominent examples of successful Amazon PL offers (e.g. batteries) being in highly-concentrated product categories, and with the empirical literature on the use of store brands (for instance, in Scott Morton and Zettelmeyer, 2004).

Moreover, the following proposition shows that entry by Amazon is more desirable from the point of view of consumers under sellers' market power because it contributes to reduce prices when this is more needed, but also that it is inefficient in a precise direction:

Proposition 5. *Under translated power surplus, entry by the marketplace with PL products is more likely when sellers have market power, but is under-provided relative to the optimum for consumers.*

Intuitively, the double marginalization generated by 3P sellers reduces both profits of Amazon and consumer surplus but in different ways: the deadweight loss of consumers is larger than the profit loss of Amazon. Accordingly, the gains of consumers from price reductions on PL products are larger than the additional profits of Amazon, which makes entry more attractive for consumers than for Amazon. This implies that entry occurs always when it is efficient, but may not occur in spite of being desirable from the point of view of consumers.[24]

[22] One can verify that entry occurs always if $z \leqslant z^A (1 + 1/\gamma)^\gamma$.

[23] Notice that $\hat{\psi}^{PL} \to \psi^*$ for $\gamma \to 0$ and for $\gamma \to \infty$ because the inefficiency of double marginalization vanishes with a highly rigid or a highly elastic demand. Therefore, entry is made more likely by market power for intermediate elasticities.

[24] Allowing Amazon to decide which product to promote after prices are set can induce sellers to reduce their prices to make sure it is in the interest of the marketplace to promote their products. This generates an additional competitive effect on the price of 3P sellers: in other words, competition on the platform acts as a discipline device toward sellers with monopolistic power (as in Hagiu *et al.*, 2020).

3.2 First Party products

We finally consider the case where Amazon can purchase a product from a vendor with exclusive market power on it, for instance due to control of the supply chain. Such a vendor can either sell the product directly on the platform or set the wholesale price w for resale by Amazon. Since the marketplace would resell at a price chosen to maximize unitary profits $(a-p)^{\gamma}(p-w-s_A)$, its demand of products from the vendor can be obtained as a decreasing function of the wholesale price:

$$q(w) = z^A \left(\frac{\gamma}{1+\gamma}\right)^{\gamma} (a-w-s_A)^{\gamma}$$

Accordingly, the manufacturer sets the wholesale price to maximize $q(w)(w-c)$, that is at the level:

$$w = \frac{a - s_A + \gamma c}{1+\gamma}$$

which is higher when the shipping cost of Amazon is lower: in this way the vendor extracts some of the rents generated by the cost advantage of Amazon.

Amazon ends up selling the product on its platform at the price:

$$p^{1P} = \frac{(1+2\gamma)a + \gamma^2(c+s_A)}{(1+\gamma)^2} \quad (27)$$

which is again lower than the price that would be set by the manufacturer as an independent seller on the platform, but only due to the cost advantage in logistics. The product-specific profits of Amazon can be computed as:

$$\pi^{1P} = \frac{z^A \gamma^{1+2\gamma} (a-c-s_A)^{1+\gamma}}{(1+\gamma)^{2(1+\gamma)}} \quad (28)$$

and the manufacturer obtains the larger profits $(\frac{1+\gamma}{\gamma})\pi^{1P}$ due to its first mover advantage in setting wholesale prices. An immediate comparison with (25) shows that, when feasible, the PL option is always preferred to the 1P option in front of sellers with market power to avoid the double marginalization.

Entry of Amazon as a 1P retailer is more profitable than relying on 3P sales if $\pi^{1P} > \pi^{3P}$, that is if the shipping cost of the seller is above the cut-off:

$$\hat{s}^{1P} \equiv s_A \hat{\psi}^{1P} + (a-c)(1-\hat{\psi}^{1P}) \text{ with } \hat{\psi}^{1P} \equiv \psi^* \left(\frac{\gamma}{1+\gamma}\right)^{\frac{1}{1+\gamma}} < 1 \quad (29)$$

A fortiori the manufacturer gains from outsourcing the distribution to Amazon rather than selling it as a 3P seller subject to a commission.[25]

The relevant cut-off cost is now higher compared to the case of competitive sellers ($\hat{\psi}^{1P} < \psi^*$) therefore entry is less likely, which is the opposite of what

[25] Also in the extreme case without marketing advantage, namely for $z = z^A$, entry does not take place unless Amazon has a large enough cost advantage (since $s^* > s_A$).

we found for PL products.[26] The change is due to the fact that when Amazon acts as a 1P retailer, a manufacturer with market power can extract part of the cost efficiencies generated by Amazon in logistics by asking a relatively high wholesale price, which then leads to higher prices for final consumers and makes the option of operating as a 1P retailer less profitable for Amazon. This is consistent with the fact that many of the brands Amazon tries to source from exploit their market power on various other distribution channels to ask high wholesale prices (as in case of brands for luxury, beauty and apparel, which typically have their own online stores). Often Amazon cannot get good terms of supply or the selection of products that customers desire, and its best option is to simply rely on these manufacturers as 3P sellers on its platform.

Considering the welfare implications of entry as a 1P retailer, we can determine again a precise direction of the inefficiency of entry:

PROPOSITION 6. *Under translated power surplus, entry by the marketplace as a 1P retailer is less likely when sellers have market power, but is underprovided relative to the optimum for consumers.*

Market power makes entry more desirable for consumers than for the platform because, once again, consumers gain more from the price reduction made possible by Amazon. In practice, the non-appropriability of consumer surplus by Amazon leads to suboptimal entry as 1P retailer.

Putting together our results, the empirical predictions of the model are that Amazon should rely on 3P sellers when they have high enough conversion rates and efficient shipping, and otherwise should act as a PL retailer when facing 3P sellers with some market power on standardized commodities, or as a 1P retailer when facing competitive manufacturers of established brands. Moreover, our model suggests that Amazon has an interest in allowing entry of 3P sellers and foster competition, because its commission revenues under competitive sellers (14) are higher than those under market power of the seller (22): when feasible, opening up the marketplace to competing sellers is in the interest of both the platforms and consumers since it reduces prices and restores efficient entry decisions.

Finally, notice that the welfare considerations of this section are based on a consumer welfare standard. Under a total welfare standard entry can be overprovided in this framework with market power of the sellers because Amazon does not take into account the shift of profits from these sellers (a classic business stealing effect *à la* Mankiw and Whinston, 1986).

3.3 Extensions and limitations

We conclude this section reconsidering earlier extensions. As a preliminary comment, our analysis of competition with other retailers can be extended to

[26] Notice that $\hat{\psi}^{1P} = 0$ for $\gamma \to 0$ and 1P retailing never takes place, since Amazon can better extract profits from the vendor facing a rigid demand through a commission, and $\hat{\psi}^{1P} = \psi^*$ for $\gamma \to \infty$, since double marginalization vanishes under a highly elastic demand.

the case of sellers with market power. Taking the outside channel into account forces the online marketplace to internalize the impact of its choices on the number of consumers attracted to the platform, which tends to reduce both its commissions and the prices of PL and 1P products compared to 3P sellers and to invest more in cost reductions. The reason is that 3P sellers do not take into account the positive impact of a price reduction on the platform demand, either because this is negligible on their profits or because it simply diverts demand from other platforms where they are also active. Instead, the marketplace tends to internalize platform-related externalities between products that the sellers do not consider.

3.3.1 Fulfilment by the marketplace

As mentioned before, Amazon makes available its logistics to sellers through the *Fulfilment by Amazon* (FBA) service. In the Appendix we examine the issue under seller market power. Reducing the shipping cost of sellers from s to s_A, FBA allows Amazon to increase the combined charge for shipping service and commission on a monopolistic seller, obtaining higher revenues compared to those without FBA. The 3P seller obtains always the same fraction of these augmented profits, therefore both the platform and the 3P seller gain.

Amazon does not profit from entering as a 1P retailer, but it may still prefer to provide its own PL products instead of relying on 3P sellers adopting FBA. This happens when:

$$z < z^A \left(1 + \frac{1}{\gamma}\right)^{\gamma} \tag{30}$$

that is if the marketing advantage of the seller is small enough. The reason is that, in spite of lower shipping costs, the external provision still suffers from a double marginalization problem that is not present under direct provision by Amazon. Notice that the coefficient on the right hand side of (30) is unitary for a perfectly rigid demand, but the 3P seller must reach twice as customers as Amazon to access them in case of a linear demand and up to almost three times with higher elasticity (since $\lim_{\gamma \to \infty}(1 + 1/\gamma)^{\gamma} = e$). A more elastic demand makes entry harder for independent sellers because they can obtain larger rents compared to Amazon.[27] Finally, a comparison with the socially efficient adoption of FBA allows us to show that, when sellers have market power, entry by Amazon with PL products is still underprovided relative to the optimum for consumers.

[27] There are instances in which a seller can only avoid entry of Amazon by adopting FBA, because otherwise its shipping inefficiency would make it profitable for Amazon to provide its PL products (and the seller's advantage in marketing is large enough to insure market access under FBA). Notice that FBA allows Amazon to internalize the impact of investments in logistics on the marketplace compared to the case of external fulfilment.

3.3.2 Product differentiation and competition on the platform

The introduction of product differentiation between a variety provided by a seller and a private label variety generates additional incentives for the marketplace to enter, host all varieties and allow direct competition on the platform.

Let us reconsider the example based on the quadratic utility (18), when there is a duopolistic provision of a PL variety and one by a 3P seller. The marketplace can either steer consumers toward its PL variety alone priced $p^A = \frac{a+c+s_A}{2}$ according to (24), or toward the variety of the 3P seller priced $p^S = \frac{3a+c+s}{4}$ under the commission $t^* = \frac{a-c-s}{2}$, according to (20) and (21). Under our assumptions the PL option generates higher profits and welfare by avoiding double marginalization. Alternatively, the marketplace can host both varieties allowing direct price competition on the platform. The profits of the 3P seller and the total profits of the marketplace offering the PL variety are:

$$\pi^S = q^S(p^S, p^A)(p^S - c - t - s) \quad \text{and} \quad \pi^A = q^S(p^S, p^A)t + q^A(p^A, p^S)(p^A - c - s_A)$$

For a given commission t, the Bertrand equilibrium prices can be derived as:

$$p^S(t) = \frac{a(1-b)+c}{2-b} + \frac{(2+b^2)t + 2s + bs_A}{4-b^2} \geqslant p^A(t) = \frac{a(1-b)+c}{2-b} + \frac{3bt + 2s_A + bs}{4-b^2}$$

and they are consistent with a positive purchases of the 3P variety only for a low commission. Expecting competition on the platform, the marketplace sets the profit-maximizing commission as:

$$t^* = \frac{8(a-c-s) + b^3(a-c-s_A)}{2(8+b^2)} < \frac{a-c-s}{2}$$

which is actually compatible with purchases of both varieties under the same conditions found with competitive sellers, namely for low substitutability or for a shipping cost of the seller $s < s^*$ with cut-off (19). Interestingly, the entry of the PL product reduces the commission and exerts competitive pressure on the price of the 3P seller $p^S(t^*) < \frac{3a+c+s}{4}$ compared to the hypothetical case where there was no entry (i.e.: Amazon was acting as a pure marketplace), as in Hagiu *et al.* (2020). The difference compared to the case of competitive sellers is that the double marginalization problem increases the price of the 3P product and, by strategic complementarity, also the price of the PL product $p^A(t^*) > \frac{a+c+s_A}{2}$, pushing for larger sales of the same PL product.[28] This limits the profitability of the marketplace compared to the case of competitive sellers, but even more the gains from variety obtained by consumers.

Consumers benefit from the provision of both products (through gains from variety and low prices) for very low substitutability or cost asymmetries, and

[28] Numerical simulations show that increasing the substitutability parameter b initially decreases and then increses the optimal commission t^* and has the opposite impact on p^A, but reduces always p^S, the production levels of both varieties q^A and q^S and also the profits, with those of the seller decreasing toward zero and those of the marketplace toward the standalone profits for b approaching its upperbound.

they are actually worse off when this takes place for intermediate levels of substitutability or cost asymmetries: in such a case, they would be better off if the marketplace was presenting only its own product on the platform, and would do so at a lower price to expand its sales. In other words, product selection by the marketplace is the efficient one except for cases where it overprovides varieties by 3P sellers. This replicates the insights of our baseline model.[29]

The analysis of the welfare consequences of product selection in a more general environment is beyond the scope of this section, but recent results by Anderson and Brede-Defolie (2020) suggest that one could find either too many or too few sellers depending on the nature of the underlying preferences.

3.3.3 Imperfect monetization

We have already discussed the impact of a constraint on the monetization through commissions, which in the presence of sellers with market power may actually limit the bias toward insufficient entry by the marketplace. This bias originates from the double marginalization problem due to the linear commissions. It is easy to verify that such a bias could be eliminated if the platform could use a two-part tariff to extract all the profits of the 3P sellers and avoid the double marginalization. A more realistic assumption, at least in case of large sellers, would involve bargaining on a two-part tariff: this would avoid double marginalization, but it would again limit the monetization of 3P sales. In such a case, entry with a PL product would tend to be overprovided because the access fee on 3P sellers would only extract a fraction of their monopolistic profits. Instead, entry with a 1P product could be still efficient as long as the marketplace has the same bargaining power when facing the vendor in setting a two-part tariff for the provision of the product.[30]

4 Investments and copycat products

One of the key concerns around Amazon's entry is that this might undermine incentives to invest by third parties. These investments are about product

[29] For instance, with zero costs for both varieties, the marketplaces hosts both of them for any $b \in (0,1)$, but this increases consumer welfare only for $b < 0.43$ and decreases it for $b > 0.43$ compared to the provision of the standalone PL product at a lower price. Numerical simulations available from the author show that the same qualitative outcome emerges with differences in shipping costs and maximum willingness to pay for the products. Also the case of differentiation between 1P and 3P products (with commission and wholesale price set before price competition) can deliver overprovision of 3P sales.

[30] A source of monetization that we did not explore here is related to sponsored search listings, which tend to redistribute sales between different sellers with ambiguous consequences on the incentive to enter by the marketplace. To the extent that sellers are available to spend in ads to increase their customer reach compared to the marketplace, this additional source of monetization may disincentivize entry. However, entry by the marketplace may also foster competition on the platform (as in our extension with product differentiation) and increase the willingness to pay for ads, which may actually incentivize entry. The issue would deserve further investigation in a model with oligopolistic sellers.

development but can also include improvements in storage and shipping technology, and allow a 3P seller to introduce new products for sale on the Amazon platform. Some of these investments can be partially protected, for instance through an integrated supply chain which avoids that the same products can be commercialized by imitators, as well as through IP and trade secrets. Nevertheless, in the absence of full protection, such products can be copied by rivals (as in any retail environment), which creates static efficiencies by increasing short-run competition, but may harm investment and possibly welfare over the longer run.[31] The issue becomes a policy concern to the extent that the platform hosting innovative sellers is engaged in this copycat activity, typically through private label products (or by retailing products of original manufacturers after bypassing the sellers), and especially if this is done using privileged access to non-public sellers' data.

To investigate these issues, we now consider investment by a perspective seller to create a generic new product for the Amazon platform. Suppose that the probability $\rho \in [0, 1)$ of developing a new product can be obtained with an investment increasing and convex in ρ: just to exemplify, let us assume an investment $\frac{1+r}{1+\sigma}\rho^{1+\sigma}$, with $r > 0$ parametrizing the marginal cost of investment and with $\sigma > 0$ as its elasticity. In practice a low value of σ implies a probability of successful innovation that is extremely sensitive to investment and a high value of σ implies a probability of success that is relatively flat in the investment, as typical of many minor innovations. The innovation provides expected profits π^S to the seller (for instance, the expectation of (23) in our main example) leaving commission revenues π^{3P} to the platform (as (22) in our example). However, if Amazon develops its own version, we assume that the seller does not obtain any profits and Amazon obtains π^{PL} (as (25) in our example) consistently with our baseline model.[32] We now examine the dynamically optimal commitment for Amazon, and we will later study the case without commitment.

4.1 Dynamically optimal policy with commitment

Assume that Amazon can commit to a stable rate of copycat activity by setting a constant probability of imitation $f \in [0, 1)$. Then, the expected profits of the perspective seller are:

$$\mathbb{E}\left[\pi^S\right] = \rho(1-f)\pi^S - (1+r)\frac{\rho^{1+\sigma}}{1+\sigma} \tag{31}$$

[31] We neglect positive effects that competition can have on investment through the "escape competition" effect (Aghion *et al.*, 2005) or through shifts toward investment in alternative products (Wen and Zhu, 2019).

[32] In the Appendix we allow the seller to retain positive profits after imitation (for instance due to product differentiation considered in the last section), showing that this increases the investment of the seller and has an ambiguous impact on the copycat activity. As in Jiang *et al.* (2011), we also ignore costs of imitation for Amazon, 3P sales through other platforms and imitation by other sellers: all these factors would all reduce the potential harm of the copycat activity.

because positive profits materialize only with probability $1-f$, and we assume $1+r>\pi^S$. The optimal investment implies the probability of innovation:

$$\rho(f)=\left[\frac{(1-f)\pi^S}{1+r}\right]^{\frac{1}{\sigma}}\in[0,1) \tag{32}$$

The higher is the expected profitability of the product the higher the investment, but the more likely is the copycat activity by Amazon the lower is the probability of developing the new product.

The additional expected profits of Amazon can be expressed as:

$$\mathbb{E}[\Delta\pi(f)]=\rho(f)\left[(1-f)\pi^{3P}+f\pi^{PL}\right] \tag{33}$$

which is the product of the probability that the new offer is created and a weighted average of Amazon's profits through commissions on the seller and through the copycat activity. The first term is decreasing in the copycat probability because this has a negative incentive effect, but the second term is increasing in it as long as $\pi^{PL}>\pi^{3P}$. Assuming that this is the case, there is a probability of copycat activity that maximizes the expected profits of Amazon, and it can be derived as follows:

$$f^A=\max\left[\frac{1}{1+\sigma}\left(\sigma-\frac{\pi^{3P}}{\pi^{PL}-\pi^{3P}}\right),0\right] \tag{34}$$

which is in $[0,1)$ for $\sigma\in[0,\infty)$. The copycat activity is undertaken by Amazon with positive probability only if $\pi^{PL}>(1+1/\sigma)\pi^{3P}$, that is if the profitability from its products is not only larger than the profitability from 3P sales, but larger enough. Even when this is the relevant scenario, Amazon has an interest in restraining its copycat activity to foster innovation of products that can be monetized indirectly through commissions. In this case the endogenous probability of innovation becomes:

$$\rho(f^A)=\left[\frac{\pi^S\pi^{PL}}{(1+r)(1+\sigma)(\pi^{PL}-\pi^{3P})}\right]^{\frac{1}{\sigma}}$$

Notice that $\sigma\to 0$ implies $f^A,\rho\to 0$ (both investment and imitation vanish when innovations are hard and the probability of success is extremely sensible to investment), while $\sigma\to\infty$ implies $f^A,\rho\to 1$ (if the probability of success is flat in the level of investment, the scope for disincentive effects is small, and innovation and imitation should go hand in hand).

In the Appendix we show that, in our model, the incentive of the marketplace to be engaged in copycat activity is even weaker than the ideal one for consumers, whose interest balances the innovation effect due to product creation with a price effect due to the price cut implemented by Amazon. The innovation effect is internalized by the platform to the extent that this earns and maximizes profits on the creation of new products. Since we have seen that from a static perspective consumers have more to gain from these price cuts than Amazon has to profit, the socially optimal probability of copycat activity is higher than the one that Amazon would choose.

A corollary of this result is that a ban on the copycat activity would foster innovation by increasing the probability of innovation to $\rho(0) = [\pi^S/(1+r)]^{1/\sigma}$, but it would ultimately harm consumers, because it would eliminate the chances of a price reducing entry, and the second effect dominates the first one because it enlarges the gap between equilibrium and socially optimal probability of entry. In a similar spirit, Jiang *et al.* (2011) have explored signaling equilibria where sellers with private information on demand and effort hide their market potential to avoid imitation, showing that Amazon can have an incentive to commit not to imitate 3P products to foster effort and commission revenues. The same principle is implicit also in Hagiu *et al.* (2020), though their main analysis assumes lack of such a commitment generating harmful effects of copycat activity.

4.2 Sellers' data

The policy debate on the double role of Amazon as a marketplace and a retailer has been centred around its alleged privileged access to sellers's data. To the extent that some of this information is not publicly available, for instance on advertising expenditures needed to increase revenues or stocking decisions needed to serve future demand, it could provide an advantage to identify products whose demand is growing and optimize marketing activity and logistics to quickly launch new products (although there is evidence of decreasing marginal returns in the use of data; see Bajari *et al.*, 2019).[33]

In our framework Amazon has already access to the information of sellers on demand and costs, but one could model access to additional information as the ability to increase the potential conversion rate of Amazon z^A toward the conversion rate of sellers z, which makes entry by Amazon more profitable and reduces the expected profitability of sellers. This creates static efficiencies by making price reductions more likely, but shifts the business risk on sellers reducing their incentives to invest: indeed, the optimal probability of copycat activity f^A would increase and the rate of innovation $\rho(f^A)$ would decrease. Nevertheless, in our model the increase of z^A is beneficial to consumers because it increases the static gains from lower prices for more consumers and reduces the gap between equilibrium and optimal copycat probability (see the Appendix).[34] Notice that similar mechanisms would not be operative if sellers's data on new products were made available to rival sellers to retail imitative products, because

[33] Amazon's internal policy prohibits its retail business units to access and use sellers' data (except for aggregate data). This goes in the direction of limiting the problem, but requires external verification. Related commitment issues have been formalized in Farrell and Katz (2000).

[34] The case of investment in branded products subject to the threat of 1P retailing by Amazon does not generate any trade-off between static and dynamic effects. Entry by the marketplace is going to benefit manufacturers through larger sales, which fosters their investment in new products. It would be interesting to extend our model with imperfect substitutability to information sharing affecting the strategic interactions.

they would not internalize the impact of copycat activity on rivals' sales and future investments.

Alternatively, one could consider data generated from the interaction of sellers on the marketplace and potentially useful to improve stocking decisions or reduce production costs. Also in this case, one should evaluate the impact of data usage on consumer welfare trading off static benefits from lower prices and dynamic costs from lower investments, but notice that it may be in the interest of the marketplace to share part of the data with sellers, internalizing the impact on their sales (as a source of commission revenues) and investments, especially when the marketplace is constrained by competition for customers with other retailers.

4.3 Sustainable policy without commitment

The dynamically optimal policy (34) is time-inconsistent, in the sense that, once a new product is developed by a seller, there is always an incentive to copy it if this is profitable. Since $\rho(1) = 0$, this would eliminate any incentive to invest by the sellers. However, even in the absence of a commitment, the repeated nature of this interaction between sellers as short run players and Amazon as a long run player can provide the latter with the motivation to follow its optimal policy (Fudenberg *et al.*, 1990).

To verify this, let us consider a stylized version of the supergame in which Amazon is involved. In each period a large group of new and identical sellers invests for an innovation that can materialize in the next period generating profits only in that period: given the expected probability of copycat activity f by Amazon, and the same expected profits (31) as above, their investment follows the same rule as in (32) after reinterpreting r as the interest rate used to discount future profits. Accordingly, $\rho(f)$ is also the fraction of sellers that successfully create new goods for the platform available in the next period. Amazon obtains in each period the expected profits $\mathbb{E}[\Delta\pi(f)]$ in (33), which, discounting with a factor $\delta \in (0, 1)$ over an infinite horizon provides $\mathbb{E}[\Delta\pi(f)]/(1-\delta)$. However, in each period Amazon can change policy and its best deviation is to copy all the new products available in that period and earn $\rho(f)\pi^{PL}$, which multiplies the fraction of new products $\rho(f)$ for the profits from the imitation of each single product π^{PL}. Since the copycat activity is immediately verifiable by the sellers, such a deviation eliminates all subsequent investments and profits. Clearly, the deviation is not profitable for Amazon if $\mathbb{E}[\Delta\pi(f)]/(1-\delta) > \rho(f)\pi^{PL}$ or:

$$\delta > \frac{(1-f)(\pi^{PL} - \pi^{3P})}{\pi^{PL}} \tag{35}$$

This requires high discounting of future profitability, with a cut-off decreasing in the target rate of copycat activity f and increasing in the relative profitability of imitation π^{PL}/π^{3P}: it is easier to implement the policy when it implies more imitation and when imitation is relatively less profitable.

For a given target policy f, sustainability appears independent from the incentive effects because the probability of innovation does not affect the above condition. However, we can use the dynamically optimal copycat rate f^A to obtain the condition for this to be sustainable. Focusing on the interesting case of a positive probability in (34), the optimal policy of the marketplace is sustainable if:

$$\delta > \frac{1}{1+\sigma} \in (0,1) \tag{36}$$

All what matters for sustainability of the optimal policy is the elasticity of the cost function. When the probability of innovation becomes less sensitive to investment (σ increases) it is easier to implement the optimal policy. Most important, even if the optimal imitation rate is not sustainable, one can find for every discount factor the best sustainable rate $f > f^A$, which may even generate higher expected welfare for consumers. The analysis could be extended taking into account more sophisticated policies in the presence of heterogeneous profitability of innovations across investors, in which case imitation may affect sellers differently.

Overall, if there is a serious negative impact that the development of online marketplaces can exert on aggregate investment, it does not appear to be related to business that is intermediated on these marketplaces. It is instead related to investment in traditional offline business whose services are substitutes for online ones: this is a well known consequence of the online revolution, and a quite evident one during the current pandemic age, but it is independent from competition on the platform.

5 Conclusions

In this work we have analyzed some aspects of the economics of an online marketplace such as Amazon. Building on its business model mainly based on commissions set on sales by other firms active on its platform, we have evaluated its incentives to enter with private label products and as a retailer of others' products. While entry may be over-provided or under-provided in general, in this model product selection by Amazon tends to be efficient under competitive sellers and standard demand conditions, and market power by sellers tends to generate a bias toward underprovision of entry of Amazon. Of course, our setting can only capture some aspects of the interaction between marketplaces and third-party sellers, and it would be important to verify whether similar results would apply in alternative frameworks.

There are other issues that deserve further theoretical research, including more general forms of product differentiation and competition with other retailers, the role of advertising on the platform and investments in logistics, information sharing and more. Moreover, there is little empirical literature on the dynamics of competition on and among platforms and further work would be useful on this. Finally, some of our results on the alignment of incentives between a marketplace and its sellers apply to a variety of traditional marketplaces, and further applications could be studied both theoretically and empirically.

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Appendix

Proof of Proposition 1. Using (4) and (3) we can rewrite the entry condition (5) as:

$$\frac{z_j^A}{z_j} \geq \frac{v_j'(p_j^S)^2/v_j''(p_j^S)}{v_j'(p_j^A)^2/v_j''(p_j^A)}$$

while (6) can be rewritten as:

$$\frac{z_j^A}{z_j} \geq \frac{v_j(p_j^S)}{v_j(p_j^A)}$$

Then, for any cost configuration and equilibrium prices, equilibrium entry is optimal if and only if the right hand sides are equal. Likewise, entry is over- (under-) provided if:

$$\frac{v_j'(p_j^S)p_j^S}{v_j(p_j^S)} \frac{v_j'(p_j^S)}{v_j''(p_j^S)p_j^S} < (>) \frac{v_j'(p_j^A)p_j^A}{v_j(p_j^A)} \frac{v_j'(p_j^A)}{v_j''(p_j^A)p_j^A}$$

Defining the elasticities of demand and subutility as:

$$\varepsilon_j(p) \equiv \frac{-v_j''(p)p}{v_j'(p)} > 0 \quad \text{and} \quad \eta_j(p) \equiv \frac{-v_j'(p)p}{v_j(p)} > 0$$

we have efficient entry if $\eta_j(p)/\varepsilon_j(p)$ is a constant. Otherwise over- (under-) provision of entry occurs if:

$$\frac{\eta_j(p_j^S)}{\varepsilon_j(p_j^S)} < (>) \frac{\eta_j(p_j^A)}{\varepsilon_j(p_j^A)}$$

Since $p_j^S > p_j^A$, a sufficient condition for over- (under-) provision to occur is that $\eta_j(p)/\varepsilon_j(p)$ is always decreasing (increasing) in p.

Remark 1. Under the opposite assumption that $z_j^A > z_j$ and $s_A < s_j$, we would have $p_j^S < p_j^A$, and a sufficient condition for over- (under-) provision to occur would be that $\eta_j(p)/\varepsilon_j(p)$ is always increasing (decreasing) in p.

Proof of Corollary 2. A constant ratio $\eta_j(p)/\varepsilon_j(p)$, which is required by efficiency according to Proposition 1, implies a surplus function $v_j(p) = \lambda\tilde{v}(p)$, for an arbitrary constant $\lambda > 0$ and a positive, decreasing and convex $\tilde{v}(p)$, such that:

$$\frac{\tilde{v}'(p)}{\tilde{v}(p)} = \kappa \frac{\tilde{v}''(p)}{\tilde{v}'(p)}$$

for a constant $\kappa > 0$. Integrating, we have:

$$\ln \tilde{v}(p) = \kappa \ln(-\tilde{v}'(p)) - \kappa \ln b$$

where the last term is an arbitrary constant for a given parameter $b > 0$, or:

$$\tilde{v}'(p)\tilde{v}(p)^{\frac{-1}{\kappa}} = -b$$

Integrating again for $\kappa \neq 1$ we have:

$$\frac{\kappa}{\kappa - 1}\tilde{v}(p)^{\frac{\kappa-1}{\kappa}} = a - bp$$

for an arbitrary constant a. This provides the functional form for the surplus:

$$v_j(p) = \lambda \left(\frac{\kappa - 1}{\kappa} (a - bp) \right)^{\frac{\kappa}{\kappa-1}}$$

which is positive, decreasing and convex in the price (with the latter below the choke-off price) either for $\kappa > 1$ and $a > bp$, generating the demand:

$$q_j = z_j \lambda b \left(\frac{(\kappa - 1)(a - bp)}{\kappa} \right)^{\frac{1}{\kappa-1}}$$

or for $\kappa \in (0, 1)$ and $a < bp$, generating the demand:

$$q_j = z_j \lambda b \left(\frac{\kappa}{(1 - \kappa)(bp - a)} \right)^{\frac{1}{1-\kappa}}$$

Integrating for the residual case with $\kappa = 1$ we have:

$$v_j(p) = \lambda e^{-bp}$$

where we consolidated the arbitrary positive constant insuring that the function is positive, decreasing and convex. This generates the demand function:

$$q_j = z_j \lambda b e^{-bp}$$

Efficiency implies surplus functions that belong to this family.

Remark 2. An alternative interpretation of the model implies that a representative consumer purchases one unit of product j at price $p \in [0, \bar{p}]$ with probability $z_j |v'(p)| \in [0, 1]$ under the restrictions that $|v'(\bar{p})| = 0$, $|v'(0)| = 1$ and $z_j \leqslant 1$. The efficiency result of Corollary 2 applies when parameters deliver the demands $q_j = z_j \left(\frac{a-p}{a}\right)^{\frac{1}{\kappa-1}}$ with finite choke price $\bar{p} = a$, or $q_j = z_j (\frac{1}{1+p})^{\frac{1}{1-\kappa}}$ and the log-linar demand without a finite choke price.

Proof of Proposition 3. In the model with heterogeneous consumers and competition for customers, the aggregate consumer welfare can be expressed as the weighted average of the surplus of consumers on the platform and outside of it:

$$W = \hat{\theta} V(\mathbf{p}) + \int_{\hat{\theta}}^{1} \theta \bar{V} d\theta = \frac{\bar{V}^2 + V(\mathbf{p})^2}{2\bar{V}}$$

where we used $\hat{\theta} = V(\mathbf{p})/\bar{V}$. This expression is increasing in $V(\mathbf{p})$, so the socially efficient entry of a product is always associated with (6).

The profits of the platform conditional on reaching the customers are:

$$\Pi(\mathbf{p}) = \sum_{k\in 3P} z_k \left|v_k'(p_k^S)\right| t_k^* + \sum_{k\notin 3P} z_k^A \left|v_k'(p_k^A)\right| (p_k^A - c_k - s_A)$$

or, after using the optimality conditions (10):

$$\Pi(\mathbf{p}) = \sum_{k\in\Omega} z_k \frac{v_k(p_k)\eta_k(p_k)}{\varepsilon_k(p_k)} \frac{V(\mathbf{p}) - \Pi(\mathbf{p})}{V(\mathbf{p})}$$

and solving explicitly:

$$\Pi(\mathbf{p}) = \frac{\sum_{k\in\Omega} z_k v_k(p_k) \sum_{k\in\Omega} z_k \frac{v_k(p_k)\eta_k(p_k)}{\varepsilon_k(p_k)}}{\sum_{k\in\Omega} z_k v_k(p_k) \left(1 + \frac{\eta_k(p_k)}{\varepsilon_k(p_k)}\right)}$$

This allows one to express the expected profits $\Pi_A = V(\mathbf{p})\Pi(\mathbf{p})/\bar{V}$ as in (11). It is now immediate that when $\eta_j(p_j)/\varepsilon_j(p_j)$ is a constant, the expected profits are a monotonic increasing function of $z_j v_j(p_j)$ and entry for good j must be efficient from the point of view of consumers.

Proof of Proposition 4. The comparative statics is immediate. To verify the optimality of entry notice that the incremental surplus generated by 3P provision of a product under the commission (13) can be computed as:

$$\Delta W^{3P} = \frac{z\gamma^{1+\gamma}(a - c - s)^{1+\gamma}}{(1+\gamma)^{2+\gamma}}$$

and the incremental surplus generated by provision by Amazon under the price (15) can be computed as:

$$\Delta W^{A} = \frac{z^A\gamma^{1+\gamma}(a - c - s_A)^{1+\gamma}}{(1+\gamma)^{2+\gamma}}$$

whose comparison provides the cut-off (17).

Proof of Proposition 5. Under provision by 3P sellers, the incremental surplus generated by a product can be computed as:

$$\Delta W^{3P} = \frac{z\gamma^{1+\gamma}(a - c - s)^{1+\gamma}}{(1+\gamma)^{2+\gamma}} \left(\frac{\gamma}{1+\gamma}\right)^{1+\gamma}$$

It can be verified that the last term $(\gamma/(1+\gamma))^{1+\gamma} < 1$ represents the loss of incremental surplus due to the double marginalization (that is, compared to the incremental surplus obtained when Amazon could set optimal access fees that extract all the profits of 3P sellers).

Under provision by Amazon with a PL product the incremental aggregate surplus is:

$$\Delta W^{PL} = \frac{z^A \gamma^{1+\gamma} (a - c - s_A)^{1+\gamma}}{(1+\gamma)^{2+\gamma}}$$

Entry with PL is efficient if $\Delta W^{PL} > \Delta W^{3P}$, that is if the shipping cost of the seller is above the cut-off:

$$\tilde{s}^{PL} \equiv s_A \psi^{*PL} + (a-c)(1-\psi^{*PL}) \text{ with } \psi^{*PL} \equiv \psi^* \left(1 + \frac{1}{\gamma}\right)$$

The cut-off cost is lower compared to the one for equilibrium entry by Amazon ($\psi^{*PL} > \hat{\psi}^{PL}$) therefore the condition for optimal entry is less demanding.

Proof of Proposition 6. Under provision by Amazon acting as a 1P retailer the incremental surplus is:

$$\Delta W^{1P} = \frac{z^A \gamma^{1+\gamma} (a - c - s_A)^{1+\gamma}}{(1+\gamma)^{2+\gamma}} \left(\frac{\gamma}{1+\gamma}\right)^{1+\gamma}$$

so entry is efficient if $\Delta W^{1P} > \Delta W^{3P}$, that is if the shipping cost of the seller is above the same cut-off s^* as in the baseline model with competitive sellers. Since (29) implies $\hat{s}^{1P} > s^*$, the condition for optimal entry is less demanding than in equilibrium.

Fulfilment By Amazon. Under a 3P seller with market power adopting FBA, Amazon can increase the combined charge for shipping services and commission to obtain the profits:

$$\pi^{FBA} = \frac{z\gamma^{2\gamma} (a - c - s_A)^{1+\gamma}}{(1+\gamma)^{1+2\gamma}} \tag{37}$$

which are above the profits without FBA (22) due to the lower shipping cost. The 3P seller obtains always the same fraction of these augmented profits, therefore both the platform and the 3P seller gain from adopting FBA.

When the FBA option is available, Amazon does not profit from entering as a 1P retailer since $\pi^{FBA} > \pi^{1P}$ from (28), and manufacturers should adopt FBA to the extent that they cannot rely on equally efficient logistics.

However, Amazon may still prefer to provide its own PL products instead of relying on 3P sellers with market power on unprotected brands. The comparison with (25) shows that $\pi^{PL} > \pi^{FBA}$, and therefore Amazon prioritizes its own production if and only if:

$$z < z^A \left(1 + \frac{1}{\gamma}\right)^{\gamma}$$

The incremental surplus generated by a product can be computed as:

$$\Delta W^{FBA} = \frac{z\gamma^{1+\gamma} (a - c - s_A)^{1+\gamma}}{(1+\gamma)^{2+\gamma}} \left(\frac{\gamma}{1+\gamma}\right)^{1+\gamma}$$

and entry with PL is efficient if $\Delta W^{PL} > \Delta W^{FBA}$ which requires:

$$z < z^A \left(1 + \frac{1}{\gamma}\right)^{1+\gamma}$$

which is a less demanding condition than the one in equilibrium.

Dynamic incentives. In this Appendix we verify the impact of the copycat activity through private label products on consumers. Let us consider the additional aggregate surplus generated by the investment activity with rate of imitation f:

$$\mathbb{E}[\Delta W] = \left[\frac{(1-f)\pi^S}{1+r}\right]^{\frac{1}{\sigma}} \left[(1-f)\Delta W^{3P} + f\Delta W^{PL}\right]$$

where the first term is the probability of innovation and is decreasing in the copycat probability while the second term is the weighted average of the incremental surplus under provision by the innovator and by Amazon and is increasing in the copycat probabilty since the PL product is welfare enhancing when introduced. The probability of copycat activity that maximizes the incremental surplus can be derived as follows:

$$f^* = \max\left[\frac{1}{1+\sigma}\left(\sigma - \frac{\Delta W^{3P}}{\Delta W^{PL} - \Delta W^{3P}}\right), 0\right]$$

In our model this is weakly higher than the probability that maximizes expected profits of Amazon:

$$f^A = \max\left[\frac{1}{1+\sigma}\left(\sigma - \frac{\pi^{3P}}{\pi^{PL} - \pi^{3P}}\right), 0\right]$$

because:

$$\frac{\Delta W^{PL}}{\Delta W^{3P}} = \frac{\pi^{PL}}{\pi^{3P}}\left(\frac{1+\gamma}{\gamma}\right) > \frac{\pi^{PL}}{\pi^{3P}}$$

A ban on the copycat activity has a positive effect on the probability of innovation $\rho(0) = (\pi^S/(1+r))^{\frac{1}{\sigma}}$ and generates the additional aggregate surplus:

$$\Delta W^{ban} = \left(\frac{\pi^S}{1+r}\right)^{\frac{1}{\sigma}} \Delta W^{3P}$$

which is always lower than $\mathbb{E}[\Delta W]$.

Finally, the welfare impact of an increase of z^A is positive in our model because:

$$\frac{\partial \mathbb{E}[\Delta W]}{\partial z^A} = \frac{\partial \mathbb{E}[\Delta W]}{\partial f^A}\frac{\partial f^A}{\partial z^A} + \left[\frac{(1-f^A)\pi^S}{1+r}\right]^{\frac{1}{\sigma}} f^A \frac{\partial \Delta W^{PL}}{\partial z^A}$$

and the first term is positive for $f^A < f^*$ since $\partial f^A/\partial z^A > 0$, while the second is positive since $\partial \Delta W^{PL}/\partial z^A > 0$.

Remark 4. We can amend the model assuming that the seller retains positive profits after imitation, for instance due to product differentiation from the private label product. Let us assume that the seller preserves a fraction $\phi \in [0, 1)$ of the standalone profits π^S. The optimal probability of innovation becomes:

$$\rho(f) = \left[\frac{[1 - f(1-\phi)]\pi^S}{1+r}\right]^{\frac{1}{\sigma}} \in [0, 1)$$

which is clearly increasing in the fraction of retained profits ϕ. However, the impact on the optimal probability of copycat activity depends on the profitability of imitation. Assuming that the copycat product obtains the fraction $1 - \phi$ of π^S (there is no profit dissipation), the optimal probability of copycat activity becomes:

$$f^A = \max\left[\frac{1}{1+\sigma}\left(\frac{\sigma}{1-\phi} - \frac{\pi^{3P}}{(1-\phi)\pi^S - \pi^{3P}}\right), 0\right]$$

which is ambiguously dependend on ϕ: a higher share of profits for the seller reduces the static gains of imitation but also the dynamic costs of lost investment. Nevertheless, in this case one can verify that $d \ln \rho(f^A)/d \ln \phi > 0$, so that a higher fraction of profits retained by the imitated seller generates more innovation with an ambiguous impact on the copycat activity.