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DIGITAL PLATFORMS' STRATEGIES: PARITY CLAUSES, INFORMATION PROVISION AND DATA SHARING

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Overview

Digital technology is transforming much of the economy. The combination of computing power, big data, networked processing and cloud-based systems have created entirely new markets and opened up an array of opportunities across existing industries. Most of these new markets are based on digital platforms.
Digital platforms are applications that serve multiple groups of users at once, providing value to each group based on the presence of other users. The economic concept of 'multi-sided platforms' is used to describe and explain how digital platforms function. The multiple sides of these platforms consist of groups of individuals who use the platforms for different reasons.
For example, one side of a platform may consist of individuals who use its search services to find content or products, while another side may consist of businesses wanting to advertise to targeted groups of those individuals. Using different types of digital platforms, a user can communicate with other users, find and access content or services, transact with merchant businesses, or produce and publish their own user-generated content. At the same time, content publishers and advertisers can use digital platforms to easily reach online audiences.
Digital markets have shown throughout the years a propensity to concentration, creating major challenges for competition policy. In market based societies, competition has been the favoured model to ensure that the economy serves the needs of the citizen, and competition has traditionally been understood as the presence of a large enough number of firms producing similar products. In order to increase their profits, firms compete to acquire market share through lower prices and innovation, both in product design and in production technology. When such competition is not possible, governments have traditionally intervened through regulation or public ownership. When such competition is possible, governments use the instruments of competition policy to ensure that private entities do not hinder competition for their own interests, through cartel agreements, monopolisation strategies or mergers.
Fostering competition—with a large number of firms competing—is not always feasible in the digital economy. In these very fast moving and diversified markets, regulations organising the whole sector—akin to the type of regulation used for traditional utilities— could be inappropriate. Rather, the tools of competition policy should be adapted to the new environment.
In order to do this, one must take into account the forms that competition takes in this sector. Indeed, competition in digital markets is strongly characterized by three key elements of the digital economy.

First, digital platforms show very strong "returns to scale": the cost of production is much less than proportional to the number of customers served. While this has always been true to some extent, as bigger factories or retailers are often more efficient than smaller ones, the digital world pushes this phenomenon to the extreme. Once created, information can be transmitted to a large number of people at very low cost. Once a search engine or mapping service has been developed and is running, it can usually serve fairly cheaply hundreds of thousands of users. This is not to say that servicing these users is not costly but rather

that the costs rise much more slowly than the number of users.
With increasing returns to scale, competition between two firms producing the same product will not allow them to cover their costs. Indeed, were they to cover their (total) costs, they would have to price above the cost of serving an additional consumer (the marginal cost) and each of them would find it profitable to lower their price to steal the other's clients. As a consequence, no firm, unless armed with a much superior and cheaper technology, would want to enter a market dominated by an incumbent, even when this incumbent is making large profits.

Second, digital platforms are often subject to network externalities: the usefulness for each user of using a technology or a service increases as the number of users increases.
A special case of network externalities has gained lots of attention since the beginning of the century: two-sidedness. A platform exhibits two-sidedness when it connects two different and well-identified groups of users. For instance, a platform such as Steam connects publishers of video games to players, the publishers are one side of the platform and the players another side. Similarly, Booking.com connects owners of properties with renters and Amazon.com buyers with sellers. For two-sided platforms, the benefit that one side derives from the platform depends on who participates on the other side: their number, but also on their identity.
The strategies of two-sided platforms have specific features which influence the way in which competition policy plays out. Each side of the market is both a consumer of the platform, and the "product" which is being sold to the other side of the market. It is perfectly natural and can be pro-competitive for a platform to subsidise one side of the market when its presence on the platform is very valuable to the other side.
For instance, platforms which rely on advertising revenues will often provide content for a very low price, or even for free, to consumers in order to attract them.

Third, digital platforms are characterized by the important role of data in their business strategy. The evolution of technology has made it possible for companies to collect, store, and use large amounts of data. This has and will continue to enable considerable changes to the way markets function.
Data is one of the key ingredients of AI and smart online services, and a crucial input to production processes, logistics and targeted marketing. The ability to use data and to develop new, innovative applications and products is a competitive parameter whose relevance will continue to increase. Furthermore, because data is sometimes accumulated as a by-product of the normal functioning of a platform, incumbents will have access to much more and more recent data than other firms, and this will be a source of competitive advantage.
The competitiveness of firms will increasingly depend on timely access to relevant data and the ability to use that data to develop new, innovative applications and products. Against this background, an important debate has emerged on whether, and if so under which conditions and on which legal basis, public intervention is needed to ensure sufficient and timely access.

Purpose of the Thesis

Economies of scale, network effects and big data have favoured a significant concentration in all digital markets, defining new important challenges for competition policy. This doctoral research is an attempt to improve the understanding of the ongoing digital market dynamics and to provide effective and viable policy recommendations based on the outcomes of our theoretical models.

Most of the platforms under scrutiny are likely to abuse their dominant position or, generally, to adopt practices that limit competition. This is usually the case of vertical restraints imposed by platforms on retailers hosted on their online marketplaces. In the first chapter of the thesis we investigate the effects of one particular type of vertical restraints, namely price-parity clauses (PPCs), on the surplus and profit of the different agents involved.

PPCs are vertical agreements that require retailers hosted by a given platform to not offer the same service/product at better conditions on other sales channels (either other platforms or retailers' direct channel, e.g. their websites). PPCs pose substantial threats to competition since they remove the incentive for platforms to compete in fees, thus softening inter-platform (more generally, inter-channel) competition.[1]

The adoption of such contracts is justified though by the presence of a form of consumer free-riding known as *showrooming*. This phenomenon occurs when consumers identify/discover what product they want to buy on a given sales channel but eventually switch channel for finalizing the purchase, not paying any fee to the initial intermediary (usually, a digital platform) for its service. PPCs are then meant to remove the incentive for consumers to showroom.

In the first chapter of the thesis, we show that platforms are always better off after PPC adoption. Nevertheless the direct sales channel constrains platform pricing strategies such that PPCs have ambiguous effects on consumers. From the social welfare perspective, imposing PPCs is desirable when platforms are perceived as highly substitutable. We also show that both platforms imposing price parity is always a Nash equilibrium but under certain conditions it can also arise another Nash equilibrium in which both platforms select an unrestricted pricing regime.

Not only platforms are likely to set anti-competitive agreements, they have also the ability to control users' access to essential inputs/facilities. One relevant instance of this is the market information extracted from data gathered from users' interactions on the marketplace.

Given their greater ability to collect and process data, platforms enjoy a significant information advantage with respect to their users, which are then forced to rely on the hosting platform in order to better estimate market demand and consumer preferences. In particular, information can be provided to users by the platform in the form of free *analytics*, derived from the gathered data.

Given that providing information is a platform arbitrary choice, we do not know whether platforms are willing to share market information with retailers or, in case we observe available *analytics* for users, whether information provision is either informative or truthful.

This has recently raised the awareness of policymakers and academics alike, especially in the case of *hybrid platforms*. These platforms are those which adopt a dual role: they own and manage a platform — possibly with a large market share — and, at the same time, they compete with third-party firms operating within the same platform. For example, Apple hosts on its App Store third-party streaming services (such as Spotify and Tidal) and, at the same time, offers a competing service (Apple Music). Similarly, Amazon is both a marketplace and a reseller, directly competing with third-party sellers; in many instances, the same products can be sold simultaneously by both Amazon and other sellers.

In the second chapter, we show that, when information provision is costless and information is verifiable, full-information sharing occurs in equilibrium despite platform duality. This result is explained by what we define as *coordination effect* which allows both the the platform and the seller to make higher expected gains, showing how information provision results, in expected terms, in consumer surplus extraction and

[1] Considering two platforms A and B, if firms which are active on both A and B have to set the same price on both marketplaces, both platforms A and B will have less incentive to reduce the fee charged on these firms since it will not result in lower prices, namely lower fees will not attract more users if the price is the same across platforms/sales channels.

lower total welfare. Interestingly, we also find that platform's incentives to share information are strongest for intermediate degrees of product differentiation.

We may observe instances in which platforms do not provide market information to downstream retailers because making analytics available is costly or cases where platforms may not provide a truthful description of the market because information is not ex-post verifiable. In these cases, retailers do not have access to more precise market information and may not be able to properly compete neither among themselves nor against the platform when it acts as a first-party seller. For this reason, the European Commission has proposed in the recent Digital Markets Act that those platforms which enjoy a significant market share and provide a core service (defined as *gatekeepers*) share with sellers and rival companies all or part of the consumers' data they possess. In this case, the European Commission refers to *raw data*, from which is possible to extract valuable market information. We refer to this policy as "mandated data sharing", which is one of the pillars of the European strategy for data.

Data is a complex concept that subsumes a multiplicity of information, uses, and functions. Indeed, when discussing data access, one has to consider the nature of data. A list of consumers may be used to send out discounts, tailored ads, and prices. Information about the production process of a specific good may be used to improve the efficiency of firms in producing it. Searches and reviews by consumers may be used to assess the size of the demand for a specific good and potential fallacies that bother consumers, limiting retail risks. Hence, from an anti-trust perspective, the data's importance strongly depends on analysing the specificities of a given market and available data. Investigating an overall impact on market outcomes without explicitly accounting for the data type may limit the breadth of policy implications and provide little guidance to policy makers.

In the third chapter, we investigate the effects of mandated data sharing on market outcomes and social welfare when data can be used for different purposes (price discrimination or cost reduction). In particular, mandated data sharing has no effects on welfare if data can be used to price discriminate consumers and competition is in prices of homogeneous goods. Hence, with or without data, the sellers can only set a price equal to their marginal costs and cannot exploit consumers' data. The platform may also decide to operate as intermediary in some markets, letting some sellers without competitive pressure and free to perfectly price-discriminate consumers.

Instead, mandated sharing of cost-reducing data improves welfare by lowering the average price in the market. Sellers are unaffected, as price competition drives profits to zero, but the platform is better off as more markets are covered and revenues from intermediation increase. When goods are horizontally differentiated, data sharing may negatively affect consumers (price discrimination) and some sellers (cost reduction). In the former case, access to data enables sellers to price more efficiently and extract more surplus from the consumers. In the latter case, efficient sellers have little gains from the cost-reducing data but suffer from the generalized increase in transaction fees. However, the aggregate effect is positive.

Hence, we argue that in markets where competition is softer, mandatory data sharing may damage the very agents it is intended to protect, namely consumers and (efficient) sellers.

Chapter 1

Platform pricing strategies when consumers web/showroom

1.1 Introduction

Today, a growing number of firms sells their products to consumers through on-line marketplaces. Companies like Amazon, Ebay, Airbnb, Booking.com, Deliveroo and Just Eat are just few examples of the most popular of such intermediaries. In many cases, in order to expand their sales, firms offer their products both online, possibly on multiple marketplaces, and directly in their physical points of sale, acting as multi-channel retailers. Consumers, therefore, find themselves in front of a multiplicity of places, physical and virtual, where to search for their favorite product and can switch swiftly from one channel to another. While this allows consumers to find the best deal, it may also result in free-riding behaviour: consumers can use presale services of brick and mortar shops before purchasing the product online; alternatively, consumers can search and compare products online before purchasing in brick and mortar shops.

Empirical evidence reveals that in many cases the channel chosen to make the purchase differs from the one in which consumers have searched. According to KPMG (2017), when willing to buy a given product consumers are often involved in the so called "path to purchase journey" made of two distinct phases: the "awareness and consideration phase", in which customers search for their preferred brand, and the "conversion phase", in which they decide where to buy the selected product. Interestingly for our scopes, these two phases often take place in different channels. More specifically, Nielsen (2016) reports that in 2015 about 20% of individuals that in the US made a purchase, searched for which product to buy by visiting retailers' physical stores but then, most of the times, finalized the transaction over an on-line marketplace. This practice is known as *showrooming*. At the same time, more and more frequently, things go the other way and consumers identify their favorite product on a virtual marketplace, prompted by the greater ease with which they can conduct search online, and then buy the product in the physical store or through sellers' websites, a practice known as *webrooming* (Chandler, 2020). According to Nielsen (2016), in 2015 80% of the consumers in the US used to search products online, and half of them then purchased the product in person in the physical store. As reported by the European Commission (2017), 72% of the manufacturers acknowledge the existence of free-riding by online sales on offline services. 62% acknowledge the existence of free-riding by offline retail on services (information) offered online. Approximately 40% of retailers also acknowledge the existence of free-riding behaviour both way.

Webrooming and showrooming are posing complex challenges for the platforms hosting the online marketplaces. In order to prevent such risk, many online marketplaces impose the so-called price parity clauses (PPCs) according to which retailers, if they want to post their offers on a given platform, cannot charge lower prices on the other channels in which they operate for the same product/service.

The aim of this paper is to shed light on the intricate relationships between multi-channel retailers and platforms in a context characterized by PPCs and web/showrooming.

PPCs have long been the subject of heated debate. On the one hand, in fact, by preventing retailers from being able to freely choose the prices of their products on the various channels, PPCs represent a clear restriction to competition with likely negative effects on consumer welfare. For instance, Hunold et al. (2018) show that when online travel agencies do not adopt PPCs hotels publish their offers more often and their prices in the direct channel are more likely to be the lowest ones. Also Boik and Corts (2016) shed light over the anti-competitive effects of PPCs showing that these clauses typically raise platform fees and retail prices and curtail entry or skew positioning decisions by potential entrants pursuing low-end business models.
On the other hand, however, it has been highlighted by many that this kind of agreement can have positive effects on markets efficiency. Buccirossi (2015) emphasizes the positive effects of PPC on dynamic efficiency and, in particular, when such a restriction is in place, platforms would be able to protect their investments by preventing other platforms from free-riding on them. Despite free-riding could have positive effects on consumers, it may harm platforms reducing their incentives to invest in innovation. Another argument in favour of PPCs is that, by restricting suppliers' ability to price-differentiate between sales channels, they reduce consumer search and negotiation costs, thus promoting inter-brand competition.
Price parity clauses have been imposed by several large platforms in the past. This includes hotel booking platforms such as Booking.com, which has led to abuse cases in several jurisdictions in the 2010s. It also includes Amazon with its general pricing rule[1] and Apple, which obliged publishers to set ebooks prices in Apple's iBookstore at the lowest retail price available in the market.
Competition authorities and courts in Europe and beyond intervened by prohibiting wide-PPC (where sellers are forced by an intermediary to not offer better conditions for a given product in any other sales channel) and sometimes narrow-PPC (where the constraint imposed by the intermediary applies to sellers' direct channel only) as for the case of Austria, Belgium, France and Italy in case of hotel booking platforms. The prohibition of PPCs, both wide and narrow, is also included in the Digital Markets Act (DMA) since PPCs when used by gatekeeper platforms and applied in the context of core platform services are seen as harmful to consumers (and businesses). Nevertheless this is not the end of the story since platforms may have alternative tools to discipline sellers. One of these practices is known as *dimming*, which consists in reducing the prominence on a given marketplace of the sellers that offer lower prices on other sales channels. Therefore, when price parity clauses are not available to gatekeeper platforms, other practices that may be seen as substitutes raise important questions about how regulation will affect the overall quality of the platform services that are provided.

Focusing on full-participation equilibria, we will establish a relationship between agents' pricing strategies and the distribution of initial consumers across sales channels. These dynamics will be investigated under both unrestricted pricing scenario (UP) and PPC.

The objectives of our analysis are manifold. On the one hand, we investigate how multi-channel retailers behave when show/webrooming takes place; on the other hand, we want to discuss the benefits for platforms to impose PPCs and, more importantly, under which conditions this kind of contract arises as an equilibrium

[1] After the competition authorities initiated investigations, Amazon removed price parity clauses in Europe in 2013, but continued to impose the clause in the U.S. In 2019, it then apparently removed the clause also in the U.S.; however, the clause was replaced by a similar "fair pricing policy."

outcome. Finally, we will devote a specific section to analyze the welfare effects of PPC and to discuss whether a ban on PPC adoption is socially desirable.

Our results show that (i) platforms benefit from adopting PPC while the effect on consumers is ambiguous. In particular, the model predicts that sectors in which few consumers exploit the direct channel are the ones in which a PPC adoption harms consumers the most; (ii) all platforms imposing PPCs is an equilibrium outcome, although in some instances another equilibrium without PPC may emerge; (iii) banning PPCs can be, under certain conditions, welfare reducing.

Our baseline model assumes two competing platforms and a direct sales channel. In order to assess the desirability of more inter-channel competition, we extend the model by including three competing platforms. Interestingly, (iv) we find that stimulating competition is welfare improving under both price regimes as the reduction in platform profit due to stronger competition is always compensated by the gain in consumer surplus.

The paper is organized as follows. Section 2, is devoted to review the related literature and how this paper contributes to it; Section 3 presents the basic model, while Sections 4 and 5 characterize the equilibrium outcomes with unrestricted pricing and with PPC, respectively. In Section 6 the outcomes obtained in the two regimes are compared. In section 7, we investigate which regime platforms choose in equilibrium and Section 8 discusses the effect of stimulating platform competition. Section 9 concludes with some policy implications.

1.2 Related literature

This paper contributes to the streams of literature on showrooming and PPCs. Although the existing literature has addressed several questions regarding the effects of PPCs, rarely web/showrooming plays a crucial role.

Boik and Corts (2016) and Johnson (2017) assume consumers must use one of two differentiated platforms, and focus on how wide-PPCs result in each platform's demand becoming less responsive to its fees, resulting in higher equilibrium fees and prices. Carlton and Winter (2018) extend these works by allowing for a direct channel. They focus on the case with perfectly competitive firms that must list on the platform, applying their theory of a PPC to show the harm caused by the no-surcharge rule of credit card platforms. Edelman and Wright (2015), in a similar setting, show that when consumers can buy directly from the supplier or through one or more platforms, price parity clauses lead to higher prices and excessive investment by the platform (offering additional benefits to consumers to attract them away from the direct sales channel). Johansen and Vergé (2017) also allow for a direct channel, they focus on the effects of allowing firms to delist from platforms. Authors find that the harm from price parity depends critically on the degree of competition between the suppliers and on their ability to sell directly. In particular, when the suppliers compete fiercely, they find that price parity clauses are unlikely to cause any harm and may actually increase platforms' and suppliers' profits as well as consumer surplus.

Our model differs from these works in many aspects. A key difference in our analysis is precisely the showrooming behaviour (which is not investigated in the aforementioned works) which determines buyers' endogenous split-up across sales channels. In our model indeed, buyers apply sequential purchase decisions which allows them to switch sales channel from the starting one. This characterizes our results by defining how the direct channel constrains platforms' pricing strategies. Platforms and firms, in fact, take shares of initial consumers into account for setting their prices. The larger is the share of consumers that start choosing his product in a channel, the fiercer firm competition in that channel (fiercer intra-channel competition).

In the case in which many consumers start their "path to purchase journey" directly among sellers' stores or websites, platforms are induced to reduce their fees since attracting consumers is harder. This novel result explains how the direct channel constrains platform pricing strategies and why consumers could be better off in the presence of PPCs.

Also Wang and Wright (2020) focus on buyers' showrooming behavior and the effects of PPCs. In particular, they stress the difference between applying a wide-PPC and a narrow-PPC. Their findings support banning wide-PPCs, but whether narrow-PPCs should be banned as well depends on whether platforms would remain viable without them.

Unlike Wang and Wright (2020), we consider a different setting for capturing the showrooming behavior such that buyers' purchase decisions are determined by a more realistic multi-dimensional consumer heterogeneity (i.e. with respect to both sales channels and products). This allows us to determine the main contribution of our work, namely that all kind of PPCs (not only narrow-PPCs) can be welfare improving.

In the work of Wismer (2013), both showrooming and the direct sales channel are investigated. In particular, the author shows that the platform operator imposes a PPC if he faces high transaction costs, if seller competition is weak, and if the initial distribution of consumers on channels is strongly skewed.

The key difference between this work and ours is considering two competing platforms (instead of a monopolistic one) and a direct channel. This allows us to investigate three cases that are out of the scope of Wismer (2013) and that provide a substantial contribution to the existing literature, namely: i) analyzing the effects of wide PPCs ii) understanding which platforms' pricing regime arises in equilibrium when PPCs are strategically adopted by multiple platforms simultaneously and iii) investigating the effects of platform entry on market outcomes.

1.3 Baseline framework

The market is populated by three firms producing differentiated products. Firms reach customers either directly, through a direct sales channel (d), or via two intermediaries/platforms (A, B).[2] The direct channel represents the physical market where firms compete by means of their brick and mortar shops (or, equivalently, via their own websites). All through the paper we focus on the full-participation scenario, namely the case in which firms are active in all the three channels. This may represent a strong restriction as firms can decide to distribute their products only in a subset of the available channels (Calzada et al., 2021). In the appendix we show that under realistic parameters values, firms do not have incentive to do so and full-participation is actually an equilibrium outcome. Hence, our restriction occurs without great loss of generality but it allows us to greatly simplify the analysis.

There is a continuum of consumers of unitary mass who search products across sales channels and then finalize the purchase on one channel. A key feature of the model is that the purchase decision is taken following a two-step process: in the first stage, consumers choose their preferred product within a certain channel (*selection* stage), either an online marketplace or the direct channel, and then, once identified the product, they compare the prices through the various channels, buying on the channel which entitles higher net utility (*purchase* stage). This in line with the aforementioned presence of show/webroomers, namely consumers that search on a channel and then buy elsewhere. Consumers are assumed to have heterogeneous preferences towards the various channels of distribution; this heterogeneity determines also which is the

[2] As it will be shown in the next sections, employing two platforms instead of one allows us to i) investigate market outcomes when only some of the platforms adopt PPCs (asymmetric scenario) and ii) analyze whether PPC adoption emerges as an equilibrium outcome. When a platform impose PPC it affects the gains that other platform have from the same strategy (see Section 1.7), thus by considering only one platform we will not be able to capture these interesting dynamics.

channel on which consumers conduct the selection stage. Formally, we assume that a share M_j of consumers search on channel $j \in \{A, B, d\}$, with $M_A + M_B + M_d = 1$; to simplify the setting, we also assume a within platform symmetry: $M_A = M_B$.

The timing of the game is the following:

1. intermediaries set per-transaction fees to firms and consumers, f_i and c_i respectively, with $i = A, B$;
2. firms simultaneously set prices;
3. consumers make their "choose then purchase" sequential decision;

As indicated, f_i and c_i are platform per-transaction fees; throughout the document, we will refer to "fee level" in order to indicate the sum of the two fees charged by platform i, $f_i + c_i$, and to the "fee structure" to indicate how the fee level is split among firms and consumers. Platforms bear no cost for the transactions conducted over their marketplaces.

Firms offer their products in each of the three available channels and, if permitted, they can charge different prices on the sales channels. In the case platforms impose price parity, firms must set a unique price on all the channels. We discuss this scenario in Section 5. Firms produce horizontally differentiated products and face linear production costs; without loss of generality, we normalize this cost to zero. We model products differentiation using a circular city model with firms competing *à la Salop* in each sales channel; consumers differ in their attitude towards horizontal product characteristics: the mass M_j of consumers selecting the product on channel j, $j \in \{A, B, d\}$, is uniformly distributed on the unit length circumference; the three firms are equidistantly located on the circle.[3] A consumer located in x buying from a firm which is located at y incurs linear transportation costs of running across the distance between x and y, which is defined as: $min\{|x - y|, 1 - |x - y|\}$.

For simplicity, the parameter measuring transportation costs is normalized to 1. We are also assuming, in line with the empirical literature on e-commerce (Duch-Brown et al. 2017 and Cavallo 2017), that the degree of firm differentiation is the same in each sales channel.

Consumers' purchase decision follows a two-step procedure: in the first step consumers search for their preferred product within a given channel and then, once identified the product, they decide in which channel to buy it. As explained above, consumers have heterogeneous preferences towards which channel to conduct their search: they are either *shoppers*, i.e. they select their favourite product in the direct channel, or *web-shoppers*, if they do the same in one of the online marketplaces. Once selected the product, consumers decide where to buy it. Also in the purchase stage, we assume that consumers have, at least partially, heterogeneous preferences towards sales channels. In particular, we assume that while consumers have homogeneous preferences towards the direct sales channel, they perceive the two platforms as horizontally differentiated. Borrowing the setting developed in Bouckaert (2000), we assume that in deciding where to purchase, either on platforms A or B or on the direct channel, consumers are uniformly distributed over a circumference of unitary length with the two platforms that are symmetrically located over the circumference, and with the direct channel that is placed at the centre of the circle. Figure 1 provides a visual representation of the competition between channels.

Heterogeneity among consumers is captured by their different location over the circle; when purchasing on a given platform, consumers face a unitary transportation cost w, which can be interpreted also as the degree of platform differentiation[4]. When buying through the direct channel, consumers face a fixed cost

[3] We choose three sellers to allow for a tractable analysis of asymmetric scenarios with one seller specializing on a single sales channel

[4] Alternatively, it can be describe as the disutility arising from the mismatch between consumer preferences and a given platform design.

s, which is not proportional to the length of the ray of the circle in Figure 1. s parametrizes the disutility from buying in the physical store like the physical distance from the store and the time spent for reaching it; clearly, if s is sufficiently high, all consumers may prefer to buy on a platform, leading to a standard Salop model, while if s is too low with respect to w firms may find profitable to sell products without intermediaries. We think that investigating these cases is less interesting than analyzing a framework where all the sales channels are used in equilibrium by both firms and consumers. In order to ensure this, all throughout the paper we will assume $s \in (w/16, w/2)$. Moreover, in order to set a realistic upper-bound for the cost of using the direct channel, we assume that s is lower than the maximum transportation cost a consumer can bear within each sales channel, namely $s < 1$.

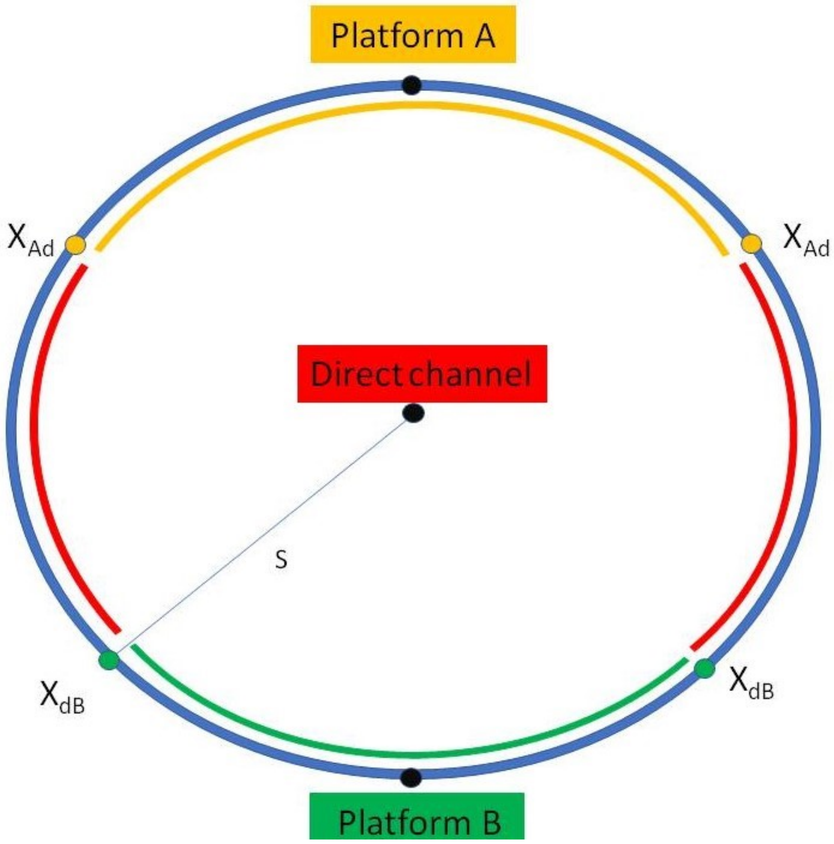

Figure 1.1: Consumers are distributed over a circle and choose their favourite sales channel for purchasing the selected product.

The game is solved by backward induction for the case of symmetric Nash equilibria within the full-participation sub-game (every firm is active in each sales channel).

1.4 Two platforms with unrestricted pricing

This section is devoted to the analysis of the model when firms are free to set different prices in different sales channels.

1.4.1 Stage 3.b: sales channel selection by consumers

In the last stage, consumers, who have selected which product to buy, let's say product $k \in \{1, 2, 3\}$, must decide on which channel to complete the purchase. Consumers select the channel that yields the higher net utility.

Channels compete according to the Salop circular model with the outside option described in Figure 1. A consumer located in $x \in [0, 1]$ on the unitary circumference enjoys a net utility of

$$U_{d,k} = v - p_{d,k} - s,$$

if he buys product k in the direct channel d, where v is the baseline utility from the consumption of the good, $p_{d,k}$ is the price firm k charges on the direct channel and s is the fixed cost borne for not using any intermediary. Alternatively, if the consumer buys the product through the marketplace i, with $i \in \{A, B\}$, the net utility is

$$U_{i,k} = v - p_{i,k} - c_i - w\,|x_i - x|\,,$$

where c_i is the per transaction fee paid to the platform and w is the degree of platform differentiation.

Let's define with x_{Ad} and x_{dB} the consumer who is indifferent between platform A and the direct channel and the one who is indifferent between the direct channel and platform B, respectively. Formally (for consumers located between 0 and 1/2):

$$v - p_{i,k} - c_i - w \min\left\{x, \frac{1}{2} - x\right\} = v - p_{d,k} - s.$$

From these expressions, by exploiting the symmetry assumption, we obtain the shares of consumers purchasing product k on each channel:

$$m_i = 2 \min\left\{x_{id}, \frac{1}{2} - x_{id}\right\} = \frac{2(p_{d,k} + s - p_{i,k} - c_i)}{w}, \qquad \text{with} \quad i \in \{A, B\} \tag{1.1}$$

and

$$m_d = 2(x_{dB} - x_{Ad}) = \frac{2(c_A + c_B + p_{A,k} + p_{B,k} - 2p_{d,k} - 2s) + w}{w}. \tag{1.2}$$

It is worth to notice that an increase in the platforms' differentiation parameter w leads to a reduction of platforms' demands as more consumers will prefer to buy through the direct channel.

1.4.2 Stage 3.a: consumers search for their favorite product

A mass of M_d consumers selects the product in the direct channel, while a mass $M_m/2$ searches within each platform. Firms participate to all channels and on each channel they compete *à la Salop.* The demand faced by firm k on channel i is therefore given by:[5]

$$q_{i,k} = \frac{1}{3} + \frac{p_{i,j} + p_{i,g} - 2p_{i,k}}{2}, \qquad \forall k, j, g \in \{1, 2, 3\}, i \in \{A, B, d\} \quad \text{with} \quad k \neq j \neq g.$$

[5] Given our symmetric setting, consumers decide which product to buy according to prices posted in the channel that corresponds to their respective group M_i. Indeed, equilibrium firm prices are the same in each channel (and potentially different across channels) while consumer preferences over products are the same across sales channels such that if a consumer prefers product j to product k in channel i, it cannot prefer product k over product j in channel $-i$. Therefore, consumers' expectations on the price they would pay at the next stage do not affect equilibrium outcomes.

1.4.3 Stage 2: firms' pricing decision

Using our previous results, the mass of consumers buying from firm k on all the three channels is

$$Q_k(\mathbf{p_d}, \mathbf{p_A}, \mathbf{p_B}) = M_d q_{d,k}(p_d) + \frac{M_m}{2}\left(q_{A,k}(p_A) + q_{B,k}(p_B)\right),$$

where $\mathbf{p_i} \equiv (p_{i,1}, p_{i,2}, p_{i,3})$, $i \in \{d, A, B\}$, is the firms' price vector in channel i.

Using this expression, firm k 's expected profits are therefore:

$$\pi_k = Q_k(\mathbf{p_d}, \mathbf{p_A}, \mathbf{p_B})\left(m_d p_{d,k} + m_A(p_{A,k} - f_A) + m_B(p_{B,k} - f_B)\right).$$

Firm k maximizes its profit by setting $p_{d,k}$, $p_{A,k}$ and $p_{B,k}$. At the symmetric equilibrium, firms charge the same prices; imposing the symmetry condition $p_{i,k} = p_i$ on the first order conditions and solving the system, we obtain the equilibrium prices p_d^* , p_A^* and p_B^*.[6]

We can use firms' first order conditions for profit maximization to discuss some interesting properties of equilibrium prices; in particular, it is easy to show that equilibrium prices satisfy the following condition:

$$p_i^* - p_d^* = \frac{f_i - c_i}{2} - w\left(\frac{1 - M_d}{8}\right) + \frac{s}{2} \qquad \text{with} \quad i \in \{A, B\}. \tag{1.3}$$

From this expression an interesting observation follows. Given the price in the direct sales channel, p_d^*, the prices firms set on a given platform i are *a*) increasing in the fee they pay to the platform, f_i, and *b*) decreasing in the fee consumers pay to the platform, c_i. Why this occurs can be intuitively explained. On the one hand, firms internalize the fee they have to pay, so they include the fee in their price in order to preserve their margins; on the other hand, an increase in c_i may induce some consumers not to purchase from the platform, and this allows firms to raise prices in their physical stores (while they have to decrease prices online).

Plugging p_d^*, p_A^* and p_B^* into m_d, m_A and m_B defined into expressions (1.1) and (1.2), gives us back the number of transactions conducted in each sales channel, as function of the transaction fees:

$$m_i^*(f_i, c_i) = \frac{(1 - M_d)}{4} - \frac{(f_i + c_i - s)}{w}, \qquad \text{with} \quad i \in \{A, B\} \tag{1.4}$$

and

$$m_d^*(f_A, c_A, f_B, c_B) = \frac{(f_B + c_B + f_A + c_A - 2s)}{w} + \frac{(1 + M_d)}{2}. \tag{1.5}$$

Demand of platform i is decreasing in its fee level, in the share of shoppers M_d and in the platform differentiation parameter w, while it is increasing with s.

On the contrary, the share of consumers purchasing from the direct channel is increasing in M_d as well as in both platforms' fees. Indeed, an increase in the fee level always increases the demand in the direct channel, either directly, through an increase in the fee on consumers, or indirectly, through an increase in the fee on firms which, in turn, raises firms' online prices.

1.4.4 Stage 1: platform pricing stage

The profit of each platform i can be written as the product of the fee level $(f_i + c_i)$ times the demand faced by platform i. Using (1.4), platform i's profit is therefore:

[6] See appendix 1.A.1 for the formal details.

$$\Pi^i(f_i + c_i) = \left(\frac{(1 - M_d)}{4} - \frac{(f_i + c_i - s)}{w}\right)(f_i + c_i), \quad i \in \{A, B\}.$$

From this expression an interesting observation follows: platform i maximizes profits by choosing the optimal fee level $f_i + c_i$; how the fee level is then shared across firms and consumers is irrelevant. In other words the fee structure neutrality holds.[7] This property of the equilibrium is due to the fact that the demand faced by a platform does not change when the fee on one side is raised and the one on the other side is reduced by the same amount. What matters for profit maximization is the fee level $f_i + c_i$.

Taking the derivative of $\Pi_i(f_i + c_i)$ with respect to fee $f_i + c_i$, it is immediate to obtain the equilibrium fee level with unrestricted pricing:

$$f_i^* + c_i^* = \frac{s}{2} + \frac{w(1 - M_d)}{8}, \quad i = A, B. \tag{1.6}$$

The equilibrium fee level is increasing in the platform differentiation parameter w, while it is decreasing in the share of shoppers M_d. This latter effect occurs because the larger is the mass of consumers searching for their favourite product in the direct channel, the more firms compete in the direct channel and, ultimately, the harder is for platforms to attract consumers.[8] On top of this, under a very mild condition ($w/16 < s$), firms do not profitably deviate from full-participation.[9]

Plugging the optimal fees into equation (1.4) allows us to get the equilibrium share of consumers that buy through a given platform:

$$m_A^{**} = m_B^{**} = \frac{4s + w(1 - M^d)}{8w}.$$

Similarly, using expression (1.5), the equilibrium share of consumers who purchase products directly in the physical stores is

$$m_d^{**} = \frac{w(3 + M_d) - 4s}{4w}.$$

The shares of showroomers and webroomers are therefore given by $M_d(m_A^{**} + m_B^{**})$ and $(1 - M_d)m_d^{**}$, respectively, while platforms' equilibrium profits are equal to:

$$\Pi_A^* = \Pi_B^* = \frac{(4s + w(1 - M^d))^2}{64w}. \tag{1.7}$$

As the fee levels, platforms' profits increase in w and decrease in M_d.

Finally, we can use the optimal transaction fee level, to investigate firm pricing strategies. Plugging the equilibrium transaction fee level into expression (1.3), we can determine the difference in the price firms charge on one platform and the one they charge in the direct channel:[10]

$$p_i^{**} - p_d^{**} = \frac{3s}{4} - \frac{w(1 - M_d)}{16} \qquad \text{with} \quad i \in \{A, B\}.$$

The difference can be used in order to assess the relative degree of firm competition between one platform and the physical stores. This difference is increasing in the disutility consumers incur when purchasing in the physical store; as a matter of fact, as s gets larger, firms may increase prices in the marketplace without loosing customers. With the same logic, when platforms are more differentiated (w gets larger), more

[7] The proof of this statement is in appendix 1.A.1

[8] As shown before (as well as in the next section), a larger share of shoppers (M_d) pushes firms to reduce their prices in the direct channel, thus attracting more consumers from platforms as well.

[9] See appendix 1.A.1 for the proof.

[10] See appendix 1.A.1 for the technical details.

consumers find that physical stores fit them better and this provides firms with the possibility of raising prices in the direct channel with respect to prices in the two marketplaces. The larger the share of shoppers, the larger the difference between the two equilibrium prices, meaning that the degree of competition in the direct channel relatively increases with M_d.

1.5 Two platforms with price parity clause

We are now ready to analyze the model when platforms impose a PPC according to which firms cannot charge different prices on different channels. In line with the literature, the PPC softens inter-channel competition and makes the consumer decision about where to purchase to depend on platforms' fees and on transportation costs related to the selected purchasing channel. The timing of the game is unchanged.

1.5.1 Stage 3.b: sales channel selection by consumers

Once consumers have selected which product to buy, let's say product $k \in \{1, 2, 3\}$, they choose the sales channel where to finalize the purchase. Just like in the previous section, we employ a centred Salop circular model to capture consumers sales channel selection, as shown in Figure 1.

Let's indicate with x_{Ad} the consumer who is indifferent between platform A and the direct channel and with x_{dB} the consumer who is indifferent between the direct channel and platform B; formally (for consumers located between 0 and 1/2):

$$v - p_k - c_A - w x_{Ad} = v - p_k - s, \quad \text{and} \quad v - p_k - c_B - w\left(\frac{1}{2} - x_{dB}\right) = v - p_k - s,$$

where p_k is the (unique) price set by firms across sales channels, c_i is the fee imposed by platform $i = A, B$ on consumers and w and s are the purchasing costs. Using the above expressions, the two indifferent consumers are:

$$x_{Ad} = \frac{s - c_A}{w},$$

and

$$x_{dB} = \frac{c_B - s}{w} + \frac{1}{2}.$$

Channels' demands, as function of platforms' fees, are therefore defined as:

$$m_i = 2\min\left\{x_{id}, \frac{1}{2} - x_{id}\right\} = \frac{2(s - c_i)}{w} \qquad \text{with} \quad i \in \{A, B\}.$$

and

$$m_d = 2(x_{dB} - x_{Ad}) = \frac{2(c_B + c_A - 2s)}{w} + 1.$$

1.5.2 Stage 3.a: consumers select their favorite product

Going backward to the product selection stage, under full participation firms compete in each sales channel according to a standard Salop circular model; firm k's demand in each channel is:

$$q_k = \frac{1}{3} + \frac{p_j + p_g - 2p_k}{2}, \qquad \forall k, j, g \in \{1, 2, 3\} \quad with \quad k \neq j \neq g.$$

1.5.3 Stage 2: firms' pricing decision

As firms are active in every channel, the overall mass of consumers who buy from firm k equals

$$Q_k(p_1, p_2, p_3) = q_k(p_1, p_2, p_3)(M_d + M_m) = q_k(p_1, p_2, p_3),$$

and firm k 's expected profit is therefore

$$\pi_k = Q_k(p_1, p_2, p_3)\left(m_d p_k + m_A(p_k - f_A) + m_B(p_k - f_B)\right).$$

Firm k maximizes its profit by setting p_k. Solving the system of first order conditions leads to the symmetric equilibrium price given platforms fees:

$$p^* = \frac{1}{3} + \frac{2\left(f_A(s - c_A) + f_B(s - c_B)\right)}{w}.$$

Firms' prices increase with the fees they have to pay to the platforms, f_i and decrease with the fee levied on consumers, c_i. This last effect is due to the fact that the higher c_i, the more consumers switch to the direct channel and the smaller the number of transactions on which firms pay the fee f_i. Analogously, firms prices decrease as s gets smaller; a reduction in s reduces the amount of transactions finalized on the platforms and, therefore, the costs faced by the firms. Finally, firms prices decrease in w, since the higher is the transportation cost the less consumers use the platforms and the smaller is the number of transactions on which they have to pay a fee. It is easy to see that at this equilibrium pricing, firms' profits are equal to 1/9, as in standard Salop model.

1.5.4 Stage 1: platform pricing stage

As before, platform i's sets its fees in order to maximize profits:

$$\Pi^i(f_i, c_i) = (M_d + M_A + M_B)\left(\frac{2(s - c_i)}{w}\right)(f_i + c_i), \quad i \in \{A, B\}.$$

Looking at this expression, two observations follow. First of all, it is immediate to see that under PPC the fee structure neutrality does not longer hold. As a matter of fact, the marginal profitability of a change in c_i and in f_i are now different, hence the fee structure matters. Moreover, first order derivative of platform i's profits w.r.t f_i is always positive, meaning that platforms find it optimal to increase f_i as much as possible. Note that, as stated in the previous section, raising the fee on firm side may induce firms to abandon the online marketplace, to the detriment of the platform. Hence, we focus on the maximum fee the platforms can charge provided that firms keep posting their prices on the marketplaces (so called full-participation constraint); formally, platforms set the highest possible fee such that the full-participation constraint is binding. [11]The constraint is defined as the difference between the full participation profit and the profit that a firm would make by abandoning the marketplaces, formally:

$$\frac{1}{9} \geq M_d\left(\frac{12(f_A(s - c_A) + f_B(s - c_B)) + 5w}{3w(M_d + 4)}\right)^2 \tag{1.8}$$

where the rhs represents the profits from deviation. When this constraint is binding, the profit maximizing

[11] Note that platforms find optimal to keep all firms on-board since a lower number of firms on a given platform would result into higher prices on the marketplace and a lower platform's demand. This is also in line with many platforms' business strategies which, especially in the presence of network effects, aim to have as many firms joining their marketplace as possible.

fee structure is the following:

$$c_A^* = c_B^* = \frac{s}{2},$$

and

$$f_A^* = f_B^* = \frac{w\left(4 - 5\sqrt{M_d} + M_d\right)}{12s\sqrt{M_d}}.$$

As already observed, with price parity the fee structure's neutrality does not hold and, consequently, the optimal fee structure is unique. Furthermore, it turns out that under PPC, platforms find optimal to set a fee on consumers which is half of the consumers' disutility of purchasing in a brick and mortar store. This result turns out to be very interesting because other relevant works in the platform literature either assume the fee on consumers' side to be equal to zero (Wang and Wright, 2020) or claim, like in Edelman and Wright (2015), that platforms find optimal to reward consumers, namely setting a negative fee, in order to attract the largest share of customers possible.[12] In our model instead, by considering both showrooming and a positive cost for purchasing directly, there is a trade-off faced by platforms when they set the fee on consumers' side. Indeed reducing c_i implies that, on the one hand, platforms attract more consumers but, on the other hand, they also increase the profit that one firm would make by deviating to the direct channel, thus making full-participation harder to sustain. Although setting $c_i = 0$[13] brings the largest share of consumers on the e-marketplaces, it would also force platforms to reduce f_i as well in order to keep all firms on board[14] and this would further lower their profits. Setting $c_i = s$ would instead completely erase platforms' advantage of having lower purchasing costs than the direct sales channel, while platforms' profits would shrink to zero. Setting $c_i = \frac{s}{2}$ is therefore optimal since it maximizes revenues from consumers' side, then platforms set f_i in order to make full-participation constraint binding.

Using these fees, the equilibrium share of consumers who purchase through the platform is equal to:

$$m_A^{**} = m_B^{**} = \frac{s}{w},$$

and platforms equilibrium profits are

$$\Pi_A^* = \Pi_B^* = \left(\frac{s}{2} + \frac{w\left(4 - 5\sqrt{M_d} + M_d\right)}{s12\sqrt{M_d}}\right)\frac{s}{w}. \tag{1.9}$$

Note that equilibrium profits decrease with the mass of shoppers M_d. This is due to the fact that the profits a firm obtains in case of deviation from full-participation increase in both f_i and M_d; when M_d increases, the deviation becomes more profitable and, in order to ensure firm full-participation, platforms must reduce f_i, thus obtaining lower profits. It follows that this model exists only for shares of direct shoppers that are high enough to ensure that prices do not exceed the average willingness to pay (net of transportation costs). According to this model, when the share of direct shoppers is too low the average consumer prefers to not buy since he would receive a negative surplus from the purchase. As we will show in the following section, we can define the lower-bound $\underline{M_d}$ of the share of direct shoppers such that $CS(\underline{M_d}) = 0$ and $CS(M_d) > 0$ for $M_d > \underline{M_d}$.

The equilibrium share of consumers who purchase through the direct channel is

$$m_d^{**} = \frac{w - 2s}{w},$$

[12] The fact that consumers do not have to pay does not necessarily imply that their activity on the platform is cost less (e.g., consumers are usually required to share their private data with the platform).

[13] The same result applies also when considering negative fees on consumers' side.

[14] The deviation profit in 1.8 is indeed decreasing in c_i whenever $c_i < s$.

which is positive for any $s < w/2$.[15]

1.6 Unrestricted pricing *vs* price parity clause

Once determined the equilibrium prices, fees and profits with UP and with PPC, it is now interesting to compare the two regimes. A first interesting result regards platforms' profits. Comparing expressions (1.7) and (1.9) it is possible to prove the following:[16]

Proposition 1.1. *If $w < 2$ platform profits under price parity are larger than with unrestricted pricing.*

As explained in the previous section, the condition $w < 2$ is very mild and it is reasonably verified in most instances since it ensures that all sales channels have positive equilibrium demands. In line with the literature, this remark shows that, as firms cannot price-discriminate sales channels, platforms benefit from imposing a PPC; in this case, consumer channel decisions depend only on c_i and transportation costs. Therefore, platforms set the revenue maximizing fee on consumer side, namely $c_i = s/2$, and fees on firm side are set such that the full-participation constraint binds. A PPC makes platform competition softer and allows platforms to extract more consumer surplus.

Conversely, when firms can charge different prices in different channels, they are able to entirely pass-through the fee f_i to consumers, thus making platform competition more intense. Suppose a platform increases its fee f_i; firms can pass it through to consumers via larger prices and, in turn, this encourages more consumers to abandon the marketplace and to finalize the purchase in the direct channel, thus hurting the platform. [17]

Platforms' profits are always decreasing in M_d. In the unrestricted pricing scenario, a larger mass of shoppers makes the competition in the direct sales channel relatively fiercer than the one in the two marketplaces,[18] therefore platforms have to lower the fee level, and so their profits, in order to make their marketplaces more competitive. When platforms impose a PPC instead, platforms' profits are decreasing in the share of shoppers because the higher M_d the harder is to prevent firms from deviating to the direct channel. When this happens, in order to satisfy the full-participation constraint, platforms react by further reducing f_i together with their profits.

In order to provide policy relevant conclusions on which scenario could be more desirable from a social standpoint it is useful to compare the social welfare in the two regimes. Social welfare is defined as the sum of the profits made by firms and platforms and the consumer surplus, as follows:

$$W = \sum_j \Pi_j + \sum_i \pi_i + CS, \quad j = A, B \quad \text{and} \quad i =, 1, 2, 3.$$

The consumer surplus is defined as the average utility from purchasing the good net of all transportation costs incurred by consumers both when they search for the best product and when they effectively purchase;

[15] Note that, because of the upper-bound set for the cost of using the direct channel ($s < 1$), this condition requires that $w < 2$.

[16] The proof of this and of all the results in the paper are in the technical appendix.

[17] Note that throughout the article we are assuming full market coverage within each sales channel. If we relax this condition we will allow firms to serve only part of their potential demand as some consumers may prefer to not purchase at all. This implies that: i) higher fees due to PPC adoption may not pass-through to final prices since this may be suboptimal for firms and ii) higher fees translate into lower firms' demand and then lower platforms' profit from per-transaction fees, meaning that allowing for partial market coverage may further constrain platforms' pricing strategies. Indeed, platforms would have a smaller incentive to adopt PPCs and consumers may be less harmed by these clauses. Nevertheless, firms may see a reduction in profits due to fee increase after PPC adoption.

[18] This fact has also been discussed previously when we showed that the price difference $p_i - p_d$, with $i \in \{A, B\}$, increases in M_d)

formally:

$$CS = m_d(v - p_d - s) + \sum_i m_i(v - p_i - c_i) - 4\int_0^{x^*} wx\,dx - 6\int_0^{\frac{1}{6}} y\,dy, \quad i = A, B, \tag{1.10}$$

where the last and the last but one element are the total transportation costs in the product decision stage and in the sales channel decision stage, respectively.[19] Clearly, the less sales channels are substitutes between each other (w and s large), the higher the cost borne by consumers and the lower their surplus.

As platforms' fees are strictly decreasing in M_d, consumer surplus is increasing in the share of shoppers. Since consumer surplus cannot be negative, it is possible to define the lower-bound $\underline{M_d}$ of the share of shoppers such that $CS(\underline{M_d}) = 0$.[20] This means also that platforms' profits are bounded from above by the profit value $\Pi^{Max} = \Pi(\underline{M_d})$.

Given that consumer surplus under PPC increases faster with M_d than consumer surplus under UP, it is possible to prove the following:

Proposition 1.2. *The larger the share of shoppers, the less consumers are harmed by platforms adopting PPC.*

Proposition 1.2 can be easily interpreted. We know, from Proposition 1.1, that platforms are able to increase their fees by adopting PPCs which relax inter-channel competition. Since fees are a marginal cost for the firms, higher fees translate into higher products prices. Nevertheless, if platforms set very high fees firms may have the incentive to delist from the marketplaces because the profit they would make by selling in the direct channel could be higher than when they sell via the marketplaces. Since the deviation profit is increasing in the share of shoppers in the direct channel, platforms reduce their fees when M_d increases in order to keep every firm on board. It follows that PPCs are harmful for consumers only when the share of direct shoppers is small enough because firms' incentives to delist are not strong enough for constraining platforms' pricing strategies. In this case prices are much higher than what they would be without PPCs.

Proposition 1.1 shows that platforms always benefit from the imposition of a PPC, while Proposition 1.2 that consumers benefit only when M_d is sufficiently large. It is therefore interesting to look at the overall welfare effect of such clause. This is done in the following proposition:

Proposition 1.3. *The larger the share of shoppers, the higher the total welfare under PPC adoption.*[21]

Proposition 1.3 follows immediately from the previous Propositions 1.1 and 1.2. When the share of shoppers is sufficiently large, the adoption of the PPC makes both platforms' profits and the consumer surplus larger than in the unrestricted pricing regime. Therefore also total welfare is unambiguously higher under PPC since total firm profit is constant across the two pricing regimes. When the share of shoppers is lower, the total welfare effects of the PPC are more blurred since PPCs affect consumer surplus and platform profit in opposite ways. Nevertheless, the negative effect on the former is outweighed by the positive effect on the latter. Unlike in Wang and Wright (2020), wide and narrow PPCs coincide in a full-participation equilibrium and both of them can be welfare improving whenever the mass of initial consumers in the direct channel is large enough to constrain platform pricing strategies. Also Johansen and Vergé (2017) emphasize

[19] The last term represents the aggregate transportation costs borne by consumers when moving along the Salop circle for purchasing a given product; the last but one term is the aggregate transportation costs in the centered Salop circular model borne by consumers who buy the selected product through one of the two platforms. In particular, x^* is the equilibrium distance between each platform and the indifferent consumers, namely x^*_{Ad}. Those who buy through the direct sales channel generate a total cost $m_d s$.

[20] Consumer surplus gets to $-\infty$ as $M_d \to 0^+$ only under the price parity regime. While, under the unrestricted pricing regime, consumer surplus is always positive $\forall M_d \in [0, 1]$

[21] When $M_d > 1 - 4s/w$, total welfare is higher under PPC, otherwise it is higher under the unrestricted pricing regime.

the ability of the retailers to sell directly as a factor which mitigates the effects of PPCs on prices, nevertheless we depart from their approach by considering showrooming which provides different mechanisms that may exert a downward pressure on prices.

One may interpret Proposition 1.3 also through the degree of platform competition. Indeed for a given share of shoppers, PPCs are more likely to be welfare improving when platforms are not very differentiated (fierce platform competition) relatively to the consumer cost of exploiting the direct channel. On top of this, the condition in Proposition 1.3 is the same that ensures that platforms' equilibrium demands with PPCs are greater than the ones without PPCs[22]. In other words, whenever imposing PPCs expands platforms' demands we can consider PPCs to be welfare improving.

1.7 Platform regime decision

In the previous sections we have studied how the two regimes, UP and PPC, impact on market equilibrium, on firms and platforms profits and on social welfare. In particular, we have seen that under mild conditions platforms benefit from adopting a PPC regime. It is now interesting to ask what could be the choice of platforms with respect to the contractual regime to be adopted in the event that, simultaneously, they were to decide between PPC and UP. This is clearly a strategic choice, given that the decision of a platform influences the rival's payoff. In order to do so, we introduce an additional preliminary stage where the two platforms decide whether to impose a PPC or not; once they have taken this decision, platforms compete as in the previous sections. The game is solved by backward induction.

In order to solve the preliminary stage, we need to determine platforms payoffs in the three possible scenarios: *i*) both platforms adopt PPC, *ii*) both platforms adopt UP and *iii*) one platform adopts PPC and one platform adopts UP.[23] Subgames *i*) and *ii*) have already being solved in the previous sections; therefore, indicating with $\Pi_i^{\alpha,\beta}$ the profits of platform i when platform i adopts the contractual regime α and platform j the contractual regime β, with $\alpha, \beta \in \{PPC, UP\}$, we already know that:

$$\Pi_i^{UP,UP} = \frac{(4s + w - M_d w)^2}{64w},$$

and

$$\Pi_i^{PPC,PPC} = \left(\frac{s}{2} + \frac{w\left(4 - 5\sqrt{M_d} + M_d\right)}{s12\sqrt{M_d}} \right).$$

In Appendix 1.A.4, we solve for the mixed case whereby platform i adopts a PPC but not platform j; formally, platforms payoffs in this case are:

$$\Pi_i^{UP,PPC} = \frac{(4s + w - M_d w)^2}{72w},$$

and

$$\Pi_i^{PPC,UP} = \frac{1}{72} \left(4(M_d - 1)s + \frac{40s^2}{w} - \Phi(w, M_d) \right),$$

where

$$\Phi(w, M_d) = \frac{\left(1 - \frac{2}{M_d}\right) 24\sqrt{M_d} + M_d^2 w(M_d - 3) - 6M_d(4 + w) + 8(12 + w)}{1 - M_d}.$$

[22]From previous results on equilibrium demands we know that $\frac{4s+w(1-M_d)}{8w} < \frac{s}{w} \leftrightarrow M_d > 1 - 4s/w$.

[23]From a regulation standpoint, this scenario represents the case in which the platform that adopts a PPC is imposing to the subscribing firms to set the same price in the direct channel only, namely a narrow PPC.

we also define the threshold $\tilde{M}_d$ as the share of shoppers that makes one platform indifferent on which pricing regime to choose when the other platform chooses the unrestricted pricing regime, formally $\Pi_i^{PPC,UP}(\tilde{M}_d) = \Pi_i^{UP,UP}(\tilde{M}_d)$.

Lemma 1.1. *$\tilde{M}_d$ always uniquely exists in the unit interval such that when $M_d > \tilde{M}_d$ (resp. $M_d < \tilde{M}_d$) we have that $\Pi_i^{PPC,UP} > \Pi_i^{UP,UP}$ (resp. $\Pi_i^{PPC,UP} < \Pi_i^{UP,UP}$).*

It is then possible to prove the following result:

Proposition 1.4. *Both platforms imposing price parity is a Nash equilibrium. When $M_d > \tilde{M}_d$, both platforms choosing unrestricted pricing is also Nash equilibrium.*

Interestingly, given Proposition 1.1, Proposition 1.4 shows that our game resembles a standard prisoner's dilemma where a sub-optimal Nash equilibrium may arise. The strategy combination $\{PPC, PPC\}$ is always an equilibrium. It turns out that for large share of direct shoppers ($M_d > \tilde{M}_d$), the strategy combination $\{UP, UP\}$ can be an equilibrium as well.
When only platform i imposes a PPC, firms set equal prices in both marketplace i and the direct channel. Platform i benefits from the softer inter-channel competition against the direct channel, but now the direct channel is more competitive (and the participation constraint more binding) than in strategy combination $\{PPC, PPC\}$. Indeed, more consumers are induced to switch from platform j to the direct channel since platform j, which does not impose price parity, results to be relatively more expensive compared to the direct channel because of its fees. This makes delisting from platform i more appealing for firms than with the strategy combination $\{PPC, PPC\}$ such that platform i must reduce its fees.
When the share of direct shoppers is large enough, platform i is better off by removing the PPC since its gains from relaxing competition with the direct channel are outweighed by the losses from the reduction in fees. It follows that imposing a PPC does not represent a profitable deviation from the strategy combination $\{UP, UP\}$ which is a Nash equilibrium for $M_d > \tilde{M}_d$.

1.8 Three-platforms competition

Whenever platform two-sidedness is involved, an increase in the number of online marketplaces affects the surplus of the two types of users in different ways according to the assumptions on user behavior (e.g. single-homing vs multi-homing). We know from the established literature on two-sided platforms that if a group of users single-homes and the other one multi-homes competition is fiercer on the single-homing side since those users are exclusive for the platforms. In our case we have multi-homing on firm side and showrooming on consumer side. In this case platforms' incentive to compete for consumers may be outbalanced by consumers' ability to switch sales channel. Moreover, the possibility for firms to sell directly to consumers may further constrain platforms' strategies, leading to ambiguous outcomes. We are therefore interested in investigating how agents' surplus changes when we consider a larger number of online marketplaces in this largely unexplored setting. In order to do so, we extend our baseline model by considering three (instead of two) platforms (A, B, C) in the same market. We also assume that one extra platform does not have any impact in the expansion of the total mass of consumers, considering only a diversion effect[24] The structure of the model is the same, in the full-participation case there are four sales channels hosting all of the three firms each. There is a mass of shoppers M_d, who search for the product to buy in the direct channel, and

[24]This assumption fits pretty well digital markets in highly developed countries since it is reasonable to think consumers' firm awareness to have little to no correlation with the number of digital intermediaries. The opposite can be thought about digital markets in developing countries where internet penetration is weaker (Duch-Brown et al., 2017).

there is a mass M_m who search on-line. The latter share of consumers (web-shoppers) is equally distributed across marketplaces, such that a share of $\frac{M_m}{3}$ consumers search in each.[25]
Following exactly the same procedure as above, it is possible to show that platform fees and profits with unrestricted pricing regime are [26]:

$$f_i + c_i = \frac{6s + w(1 - M_d)}{12} \qquad \text{with} \quad i \in \{A, B, C\},$$

and

$$\Pi^*_A = \Pi^*_B = \Pi^*_C = \frac{(6s + w(1 - M_d))^2}{144w}, \tag{1.11}$$

while with price parity clauses are:

$$c^*_A = c^*_B = c^*_C = \frac{s}{2}, \qquad f^*_A = f^*_B = f^*_C = \frac{w\left[4 - 5\sqrt{M_d} + M_d\right]}{18s\sqrt{M_d}},$$

and

$$\Pi^*_A = \Pi^*_B = \Pi^*_C = \left(\frac{s}{2} + \frac{w\left[4 - 5\sqrt{M_d} + M_d\right]}{s18\sqrt{M_d}}\right)\frac{s}{w}. \tag{1.12}$$

Looking at these expressions, the following proposition holds:

Proposition 1.5. *In both regimes, increasing competition reduces platforms' profits and increases both consumers surplus and total welfare.*

Under full-participation and per-transaction fees, firm profit is independent of the number of sales channels. Although firms multi-home and consumers do not, platform competition is more intense on firm side. In particular, under the price parity regime platforms still charge a fee on consumers equal to the half of the cost of purchasing directly but reduce the fee on firms since they have a greater incentive to deviate from full-participation for selling through the direct channel only compared to the case with two platforms.[27] Lower fees translate into lower prices which make consumers better off. On top of this, given consumers' possibility to showroom, a larger number of marketplaces makes purchasing through the direct channel relatively more costly[28]. It follows that a smaller share of final consumers buys directly and in equilibrium the total cost of purchasing (cost of the direct channel plus transportation costs) faced by consumers is lower.

The gains in consumer surplus after an increase in the number of platforms always outweighs the relative loss in platform profits. This result is also in line with the empirical evidences in Duch-Brown et al. (2017), namely we find that consumers benefit from competition more than firms mainly because of the appearance of an additional distribution channel. Furthermore, it is worth to notice that the absence of expansion effects coming with more intermediaries could affect the magnitude of competition effects on total welfare. If the mass of consumers increased with number of platforms, we would probably observe ambiguous effects on total welfare.

[25]Note that with N platforms the necessary and sufficient condition for the existence of the full-participation equilibrium is $s < \frac{w}{N}$; hence, in this triopolistic environment, we assume $s < \frac{w}{3}$. See Appendix 1.A.5

[26]Consumer surplus for both pricing regimes is reported in appendix

[27]The intuition for this relies on the fact that with 3 platforms the direct channel represents a larger share of the market compared to the case with 2 platforms. Hence, the share of potential transactions without fees is larger as well, making the incentive to abandon platforms stronger.

[28]Increasing the number of platforms reduces the average distance from the consumer to the closest platform while the cost s stays constant. Therefore more consumers will prefer buying online.

1.9 Conclusions

Within the last decade we have witnessed to a hyper-fast growth of e-commerce activities. In 2020, about 15% of the yearly gross merchandise value of the retail sector comes from e-commerce activities and an important share (about 70%) of these trades takes place through on-line marketplaces (Cramer-Flood, 2020). This paradigm shift has gone hand in hand with the efforts of the national regulation authorities to prevent any abuse or competitive harm. One of the main concerns for competition authorities comes from the fact that, on the one hand, consumers have the chance to free-ride platforms' fees through their showrooming behaviour by exploiting firms' multi-channel sales strategies and, on the other hand, platforms may harm consumers by imposing price parity clauses which soften inter-channel competition.

We have developed a theoretical model in order to contribute to the ongoing literature on showrooming and PPC and for providing policy relevant conclusions. With our work, we have determined firms pricing strategies within a multi-channel sales strategy context. We have defined how an increase in the share of initial consumers (shoppers/web-shoppers) in a given channel makes competition relatively fiercer in that channel. The distribution of initial consumers across channels affects platforms' pricing strategies. In particular, we have found that the larger is the share of initial consumers in the direct channel (shoppers), the harder is for platforms to attract users. Therefore platforms' fees and profits are decreasing in the mass of shoppers M_d. This result holds also when platforms impose a PPC but it occurs through a different mechanism. A price parity clause makes platforms better off. In fact, in line with the literature, a PPC reduces the inter-channel competition so platform can raise their fee level and profits. Nevertheless, platforms' pricing strategy is constrained by the possibility of the firms to delist and sell exclusively in the direct sales channel. The profit that a firm makes by selling its product in its store is increasing in the share of shoppers. Hence, platforms set lower fees in order to prevent firms from delisting, their profits then decrease with the share of shoppers also when they impose a PPC. Platforms' profits actually decrease faster in M_d with PPC than without.

Firms instead, under full-participation, make always the same profit because their prices are proportional to their marginal and average costs in the UP and in the PPC case respectively. Consumers are always better off in the unrestricted pricing scenario but when the share of shoppers is very large. This leads to an overall ambiguous effect on total welfare. Indeed when platforms are not very differentiated, and the cost of buying in the direct channel is high, price parity clauses generate higher total welfare. These interesting results help understanding why banning price parity clauses is not always welfare-improving and indicate what authorities should analyze in order to evaluate the effects of a PPC ban. In particular, observing the degree of inter-channel competition is not enough for assessing the goodness of the PPC ban, it is indeed important to take into account both the degree of platform competition and the consumers' opportunity cost of exploiting the direct sales channel for purchasing products. Moreover, our model provides useful tools for predicting in which markets a PPC adoption is detrimental for consumers and requires the intervention of the authorities. According to our model, those sectors in which the share of initial consumers is very low are the ones in which a PPC adoption would harm consumers the most and are therefore the ones in which a PPC ban would be the most effective from a consumer surplus standpoint.

We have extended the extensive-form game in the model in order to understand which contractual choices occur in a competitive equilibrium. It always exists an equilibrium in which both platforms impose a PPC and it never occurs an equilibrium in which platforms adopt different pricing regimes (asymmetric equilibrium). Nevertheless, we have found that for a sufficiently large share of shoppers there exists another symmetric equilibrium in which both platforms adopt the unrestricted pricing regime. Interestingly enough, this strategy combination always provides lower platform profit than the first equilibrium. The reason for this outcome is that imposing a PPC, while the competitor is not, means trading-off the gain from the reduced inter-channel competition against the direct channel with the reduction in fees caused by a greater firms' incentive to delist; therefore when the share of shoppers is large, the losses from the latter effect outweigh the gains from the former one.

We have developed another extension with three intermediaries in order to find out whether increasing the competition between digital platforms is, also in this particular and not very explored setting, welfare improving. Propositions show that increasing the number of platforms reduces both platforms' average profits and platforms' total profits while it always increases consumer surplus, mainly because of: i) a reduction in the total costs borne for exploiting the direct channel and ii) lower fees and prices resulting by firms' greater incentives to delist from platforms. Although competition effects on platforms' profits and consumer surplus take opposite sign, fiercer competition among intermediaries is always welfare improving. Whenever increasing the number of platforms does not increase the total mass of users (absence of expansion effects), consumers are those who benefit from inter-channel competition the most given that firms' full-participation profit does not change with the number of distribution channels.

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1.A Appendix

1.A.1 Technical appendix for Section 4(Unrestricted Pricing)

Equilibrium prices in the UP regime

Firms' prices resulting from the standard Salop competition, under the unrestricted pricing regime, are:

$$p_i^* = (3M_d^2w^2 - 24c_i^2 - 48c_Af_i + 48c_is - 24c_iw - 24c_j^2 - 48c_jf_j + 48c_js - 24f_i^2 + 48f_is + 24f_iw - 24f_j^2 + 48f_js - 48s^2 + 24sw - 3w^2 + 16w)/48w \qquad i,j \in \{A,B\}, i \neq j$$

$$p_d^* = (3M_d^2w^2 - 6M_dw^2 - 24c_A^2 - 48c_Af_A + 48c_As - 24c_B^2 - 48c_Bf_B + 48c_Bs - 24f_A^2 + 48f_As - 24f_B^2 + 48f_Bs - 48s^2 + 3w^2 + 16w)/48w.$$

After having computed platforms' equilibrium fees, I can get firms' equilibrium prices by plugging the equilibrium fees into the previous equations.

$$p_A^{**} = p_B^{**} = \frac{9M_d^2w^2 - 24M_dsw - 6M_dw^2 - 48s^2 + 168sw - 3w^2 + 64w}{192w},$$

$$p_d^{**} = \frac{9M_d^2w^2 - 24M_dsw - 18M_dw^2 - 48s^2 + 24sw + 9w^2 + 64w}{192w}.$$

Fee structure's neutrality under UP

In order to check for the neutrality of the fee structure under unrestricted pricing regime I differentiate the mass of consumers that buy from a certain platform, as function of the fees only and taking the other platform's fees as given, with respect to the fees for both firms and consumers.

$$\frac{\partial m_A^*}{\partial f_A} = \frac{\partial m_A^*}{\partial c_A} = -\frac{1}{w},$$
$$\frac{\partial m_B^*}{\partial f_B} = \frac{\partial m_B^*}{\partial c_B} = -\frac{1}{w}.$$

The fee structure is actually neutral since one platform's demand is affected in the same way regardless of the side on which the fee has been raised.

$$\frac{\partial m_B^*}{\partial f_A} = \frac{\partial m_B^*}{\partial c_A} = 0,$$

$$\frac{\partial m_A^*}{\partial f_B^f} = \frac{\partial m_A^*}{\partial f_B^c} = 0.$$

Since the profit of each platform depends on its own demand only, this result is sufficient for claiming that the structure of the fee is irrelevant with respect to the equilibrium profit of the platforms. When a price parity clause is imposed instead, the fee structure is no longer neutral:

$$\frac{\partial m_A^*}{\partial c_A} = \frac{\partial m_B^*}{\partial c_B} = -\frac{1}{w},$$

$$\frac{\partial m_A^*}{\partial f_A} = \frac{\partial m_B^*}{\partial f_B} = 0.$$

Indeed, platforms' demand is affected only by changes in the fee on consumers' side.
Cross elasticities are still null, namely one platform's fees do not affect the other platform's demand.

$$\frac{\partial m_B^*}{\partial f_A} = \frac{\partial m_B^*}{\partial c_A} = 0,$$

$$\frac{\partial m_A^*}{\partial f_B} = \frac{\partial m_A^*}{\partial c_B} = 0.$$

The full-participation equilibrium under UP

I will show that, by assuming $\frac{w}{16} < s < \frac{w}{2}$, a unilateral deviation from the full-participation strategy to the specialization in the direct sales channel is never profitable. When a firm specializes in the direct sales channel, it maximizes, by setting p_{dev}, the following profit

$$\pi^{dev} = p_{dev}\left(\frac{p_{d,1} + p_{d,2} - 2p_{dev}}{2} + \frac{1}{3}\right) M_d. \tag{1.13}$$

Each of the two non-deviating firms k maximize instead:

$$\pi_k^{Nd} = p_{d,k}\left(\frac{p_{d,-k} + p_{dev} - 2p_{d,k}}{2} + \frac{1}{3}\right) m_d M_d + \sum_i p_{i,k}\left(p_{i,-k} - p_{i,k} + \frac{1}{2}\right) m_i M_i,$$

with $i \in \{A, B\}, k \in \{1, 2\}$, where $m_i = \frac{2(p_{d,k}+s-p_{i,k}-c_i)}{w}$ and $m_d = \frac{2(c_A+c_B+p_{A,k}+p_{B,k}-2p_{d,k}-2s)+w}{w}$
After applying the symmetry assumption, I can solve the system of the three F.O.C.s. By plugging the solution prices and the optimal fee level in expression (1.6) into equation (1.13) I get that the deviation profit, when platforms set the optimal fee level, is:

$$\pi^{dev} = \frac{M_d(48M_d s^2 + 24s(2 + M_d(2 - 3w) + w + 2M_d^2 w) + \Psi(w, M_d))^2}{144(1 + M_d)^2(4M_d s - 8w - 13M_d w + M_d^2 w)^2}, \tag{1.14}$$

where

$$\Psi(w, M_d) = w(9M_d^3 w + 5M_d(-16 + 9w) - 4M_d^2(1 + 9w) - 2(38 + 9w)).$$

The necessary and sufficient condition for the full-participation strategy to be on the equilibrium path is $\frac{1}{9} \geq \pi^{dev}$. Since for $\frac{w}{16} < s < \frac{w}{2}$, and $M_d \in [0, 1]$, π^{dev} is decreasing in s, I plug $s = \frac{w}{16}$ into equation (1.14) because if $\frac{1}{9} \geq \pi^{dev}$ is true for $s = \frac{w}{16}$ it will be also true for $s \in (\frac{w}{16}, \frac{w}{2})$. If $s = \frac{w}{16}$, equation (1.14) becomes:

$$\pi^{dev} = \frac{M_d(144M_d^3 w - 16M_d^2(4 + 33w) - 8(146 + 33w) + 7M_d(-176 + 93w))^2}{2304(1 + M_d)^2(32 + 51M_d - 4M_d^2)^2}. \tag{1.15}$$

Equation (1.15) is (i) increasing in w if $M_d \in (0, \frac{11}{12})$, while it is (ii) decreasing in w if $M_d \in (\frac{11}{12}, 1]$. Hence, I plug $w = 0$ and $w = 2$ into equation (1.15) and I get

$$\pi^{dev}(w = 0) = \frac{M_d(73 + 4M_d)^2}{9(32 + 51M_d - 4M_d^2)^2} \tag{1.16}$$

and

$$\pi^{dev}(w = 2) = \frac{M_d(848 - 35M_d + 560M_d^2 - 144M_d^3)^2}{576(1 + M_d)^2(32 + 51M_d - 4M_d^2)^2}. \tag{1.17}$$

Equation (1.16) is (i) smaller than $\frac{1}{9}$ also for $M_d \in [0, \frac{11}{12}]$ and equation (1.17) is (ii) smaller than $\frac{1}{9}$ also for $M_d \in (\frac{11}{12}, 1]$. Therefore equation (1.15) is smaller than $\frac{1}{9}$ for all the values of $M_d \in [0, 1]$. This proves that the condition $\frac{w}{16} < s < \frac{w}{2}$ guarantees that a full-participation equilibrium always occurs[29].

[29] Under both pricing regimes, also a deviation from the full-participation to the direct channel and one of the two platforms (single-homing deviation) is never profitable. Propositions available upon request.

1.A.2 Technical appendix for Section 6

Platform profits

Proof. of Proposition 1.1 Let Π^{Δ} be the difference between Π^{PPC} (equation (1.9)) and Π^{UP} (equation (1.7)). The derivative of Π^{Δ} with respect to M_d is:

$$\frac{\partial \Pi^{\Delta}}{\partial M_d} = \frac{4}{96M_d^{\frac{1}{2}}} + \frac{4s + w(1 - M_d)}{32} - \frac{1}{6M_d^{\frac{3}{2}}}. \tag{1.18}$$

Equation (1.18) is negative for $s \in (0, w/2)$ and $M_d \in [0, 1]$. Given that $\Pi^{PPC}(M_d = 1) = \frac{s^2}{2w}$ and $\Pi^{UP}(M_d = 1) = \frac{s^2}{4w}$, we have that $\Pi^{PPC} > \Pi^{UP}$ $\forall M_d \in (0, 1)$. □

Platform profit function's upper-bound under PPC

Consumer surplus, under PPC, goes to $-\infty$ as $M_d \to 0$. So I have set the lower-bound for consumer surplus to 0 and I have found the relative share of shoppers $\underline{M_d} \in (0, 1)$, below which the consumer surplus is negative. $\underline{M_d}$ is defined as:

$$\underline{M_d} = \left(\frac{5w - \sqrt{3((6s^2 - 12ws + 12vw + 13w)(2s^2 - 4ws - w + 4vw)) + 12vw - 12sw + 6s^2}}{4w} \right)^2.$$

This establishes the upper-bounds for both fees and profits of the platforms as functions of $\underline{M_d}$.

1.A.3 Consumer surplus

Proof. of Proposition 1.2

The consumer surplus, under the two pricing regimes, is:

$$CS^{UP} = \frac{348vw - 160w - 408sw + 24sM_d w + 48s^2 - 15w^2(1 - 2M_d + M_d^2)}{348w},$$

$$CS^{PPC} = \frac{5 - 2\sqrt{M_d} + 12v - 12s - 2s\sqrt{M_d}}{12} + \frac{s^2}{2w} + \frac{2s}{3\sqrt{M_d}}.$$

The difference $CS^{UP} - CS^{PPC}$ is

$$\frac{1}{384w} \left(24sw(M_d - 1) + \frac{64(M_d + 4)}{\sqrt{M_d}} - 48s^2 - 5w(64 + 3w(M_d - 1)^2) \right);$$

it is possible to see that for $M_d \in [0, 1]$ this expression is *i*) monotone and decreasing in M_d, *ii*) negative for $M_d = 1$ and *iii*) it goes to infinity for M_d approaching zero. This is enough to prove that $CS^{PPC} > CS^{UP}$. □

Total welfare

Proof. of Proposition 1.3

The equilibrium welfare levels are defined as follows:

$$W^{UP} = \frac{336s^2 - 32w + 384vw - 312sw - 72M_d sw - 3w^2 + 6M_d w^2 - 3M_d^2 w^2}{384w}$$

$$W^{PPC} = \frac{18s^2 - w + 12vw - 12sw}{12w}.$$

The difference $W^{PPC} - W^{UP}$ is

$$\frac{1}{128} \left(24s(M_d - 1) + 80\frac{s^2}{w} + w(1 - M_d)^2 \right). \tag{1.19}$$

Since from the restrictions on parameters, made for ensuring full-participation, we have $\frac{1}{16} < \frac{s}{w} < \frac{1}{2}$, within this setting $\frac{s}{w} > \frac{1-M_d}{4}$ is necessary and sufficient for having $W^{PPC} > W^{UP}$. □

1.A.4 Technical appendix for Section 7

Profits when platforms choose different pricing regimes

Suppose that platform B decides to impose a PPC while platform A does not. In order for both pricing regimes to coexist, in a full-participation scenario, I must consider the PPC to be a *narrow* one such that firms have to set the same price in both the direct channel and in platform B while they can set prices in platform A freely. Formally, prices set by firm k will be set such that $p_{B,k} = p_{d,k} = p_k \ \forall k \in \{1, 2, 3\}$. Each firm sets $p_{A,k}$ and p_k in order to maximize the following profit:

$$\pi_k = p_{A,k}\left(p_{A,-k} - p_{A,k} + \frac{1}{3}\right) m_A M_A + \sum_i p_k \left(p_{-k} - p_k + \frac{1}{3}\right) m_i M_i,$$

with $i \in \{d, B\}, k \in \{1, 2, 3\}$, where $m_A = \frac{2(p_k+s-p_{A,k}-c_A)}{w}$, $m_B = \frac{2(s-c_B)}{w}$ and $m_d = \frac{2(c_A+c_B+p_{A,k}-p_k-2s)+w}{w}$. Since the fee structure's neutrality holds for the platform that chooses the unrestricted pricing regime, platform A sets the fee level $l = f_A + c_A$ in order to maximize its profit, which is defined as:

$$\Pi^A = \left(\frac{s-l}{w} + \frac{1-M_d}{4}\right) l.$$

While the fee structure's neutrality does not hold for platform B meaning that the fee f_B does not affect platform's own demand but the possibility for firms to deviate from full-participation to the direct sales channel must then be taken into account. Therefore Platform B sets c_B and f_B in order to maximize the following profit:

$$\Pi^B = \left(\frac{2(s-c_B)}{w}\right)(c_B + f_B),$$

under the following participation constraint:

$$PC = \frac{1}{9} - \frac{M_d((M_d-1)(48(l^2 - ls + c_B f_B) - f_B) + 12s^2 - 32w + 24M_d w - 3w^2)^2}{576(M_d-2)^2 w^2} \geq 0.$$

After computing the F.O.C.s of the two platforms' profit functions with respect to the relative fees, it is possible to solve the system of equations that provides the optimal fees. Following the notation used in this work:

$$\Pi^A = \Pi^{UP,PPC} = \frac{(4s + w - Mdw)^2}{72w}$$

$$\Pi^B = \Pi^{PPC,UP} = \frac{1}{72}\left(4(M_d-1)s + \frac{40s^2}{w} - \Phi(w, M_d)\right),$$

where

$$\Phi(w, M_d) = \frac{\frac{48}{\sqrt{M_d}} - 24\sqrt{M_d} + 3M_d^2 w - M_d^3 w + 6M_d(4+w) - 8(12+w)}{M_d - 1}.$$

Uniqueness of the threshold $\tilde{M_d}$

We want to show that $\tilde{M_d} \in (0, 1)$ is always true for one value of M_d only. In order to do so, we define the difference between the profit $\Pi^{PPC,UP}$ and the profit $\Pi^{UP,UP}$ as:

$$\frac{1}{576}\left(104(M_d-1)s + \frac{176s^2}{w} - \Gamma(w, M_d)\right), \tag{1.20}$$

where

$$\Gamma(w, M_d) = \frac{\frac{384}{\sqrt{M_d}} - 192\sqrt{M_d} - 768 - 73w - 3M_d^2 w + M_d^3 w + 3M_d(64 + 25w)}{M_d - 1},$$

$\tilde{M_d}$ is therefore the value of the share of shoppers for which equation (1.20) is equal to zero.

Proof. of Lemma 1.1
Consider that:

1. Given the initial assumptions on parameters, equation (1.20) is monotonically decreasing in M_d.

2. Equation (1.20) is always positive (negative) for low (high) values of M_d . Indeed we have that: $\lim_{M_d \to 0^+} \Pi^{diff} = +\infty$ and $\lim_{M_d \to 1^-} \Pi^{diff} = -\infty$

By putting together 1 and 2, we conclude that the function in equation (1.20) always crosses the $x - axis$ and it does that only once for $M_d \in (0,1)$. This implies that the threshold $\tilde{M_d}$ is always inside the unit interval and it is unique in that interval. □

Platform regime choice

Proof. of Proposition 1.4.

Considering platform's possibility to choose which of the two regimes to impose, there are 4 possible outcomes for each platform. Defining $\Pi^{\alpha\beta}$, with $\alpha, \beta \in \{PPC, UP\}$, as the profit made by one platform when it imposes the regime α and the other platform imposes the regime β, the 4 possible payoffs for each platform are:

$$\Pi^{UP,UP} = \frac{(4s + w - M_d w)^2}{64w},$$

$$\Pi^{UP,PPC} = \frac{(4s + w - Mdw)^2}{72w},$$

$$\Pi^{PPC,PPC} = \left(\frac{s}{2} + \frac{w\left[4 - 5\sqrt{M_d} + M_d\right]}{s12\sqrt{M_d}}\right)\frac{s}{w},$$

and

$$\Pi^{PPC,UP} = \frac{1}{72}\left(4(Md - 1)s + \frac{40s^2}{w} - \Phi(w, M_d)\right),$$

where

$$\Phi(w, M_d) = \frac{\frac{48}{\sqrt{Md}} - 24\sqrt{Md} + 3Md^2 w - Md^3 w + 6Md(4 + w) - 8(12 + w)}{M_d - 1}.$$

In order to prove Proposition 1.4 it is sufficient to show that: (a) $\Pi^{PPC,PPC} > \Pi^{UP,PPC}$and (b) that when $M_d > \tilde{M_d}$ ($M_d < \tilde{M_d}$) we have that $\Pi_i^{PPC,UP} < \Pi_i^{UP,UP}$ ($\Pi_i^{PPC,UP} > \Pi_i^{UP,UP}$). Condition (b) represents Lemma 2 and it has already been proved in Appendix 1.A.4. Condition (a) can be easily proved by looking at the fact that $\Pi^{UP,UP} > \Pi^{UP,PPC}$ always holds for $w > 0$, in fact:

$$\Pi^{UP,UP} - \Pi^{UP,PPC} = \frac{(4s + w - Mdw)^2}{576w}.$$

Since we have already shown that $\Pi^{UP,UP} < \Pi^{PPC,PPC}$ (namely, Proposition 1.1), condition (a) is then immediately verified by transitivity. This concludes the proof of Proposition 1.4. □

1.A.5 Proofs relating to Section 8

Necessary and sufficient condition for all the sales channels being active

The share of consumers that, under PPC, buy through a given platform i is always represented as $m_i = \frac{2(s-c_i)}{w}$. Moreover, platforms always maximize $\Pi^i = m_i(f_i + c_i)$. Therefore, regardless of the number of platforms, the optimal value for the fee on consumers is $c_i^* = \frac{s}{2}$. Hence, the equilibrium mass of consumers within a marketplace is always $m_i = \frac{s}{w}$. Since platforms are assumed to be identical, each platform can serve, in equilibrium, a share of consumers smaller than $\frac{1}{N}$ (where N is the number of platforms). It follows that the necessary and sufficient condition for all the sales channels to be active is $s < \frac{w}{N}$.

Platform triopoly

Proof. of Proposition 1.5.

The variation of platform average profit under the unrestricted pricing regime given by the difference $\Pi^{UP} - \Pi^{3UP}$ is:

$$\frac{4 - 5\sqrt{M_d} + M_d}{36w\sqrt{M_d}}$$

which is equal to 0 if $M_d = 1$ and greater than zero for $M_d \in (0, 1)$.
The variation of platform average profit under the price parity regime given by the difference $\Pi^{PPC} - \Pi^{3PPC}$ is:

$$\frac{24s + 5w(1 - M_d)}{576w}$$

which is always positive.

Consumer surplus under PPC in the duopoly case and in the triopoly case is:

$$CS^{PPC} = \frac{5 - 2\sqrt{M_d} + 12v - 12s - 2s\sqrt{M_d}}{12} + \frac{s^2}{2w} + \frac{2s}{3\sqrt{M_d}}, \tag{1.21}$$

$$CS^{3PPC} = \frac{5 - 2\sqrt{M_d} + 12v - 12s - 2s\sqrt{M_d}}{12} + \frac{3s^2}{4w} + \frac{2s}{3\sqrt{M_d}}. \tag{1.22}$$

The difference $CS^{3PPC} - CS^{PPC}$ is

$$\frac{s^2}{4w},$$

which is always positive since $w > 0$.
Consumer surplus under the unrestricted pricing regime in the duopoly case and in the triopoly case is:

$$CS^{UP} = \frac{348vw - 160w - 408sw + 24sM_dw + 144s^2 - 15w^2(1 - 2M_d + M_d^2)}{348w}, \tag{1.23}$$

$$CS^{3UP} = \frac{348vw - 160w - 408sw + 24sM_dw + 216s^2 - 10w^2(1 - 2M_d + M_d^2)}{348w}. \tag{1.24}$$

The difference $CS^{3UP} - CS^{UP}$ is

$$\frac{72s^2 + 5w^2(M_d - 1)^2}{348w}, \tag{1.25}$$

which, since $w > 0$, is always positive.

The total welfare under PPC is

$$W^{PPC} = \frac{3s^2}{w} - \frac{1}{12} + v - s, \tag{1.26}$$

while the total welfare in the triopoly case is:

$$W^{3PPC} = \frac{9s^2}{2w} - \frac{1}{12} + v - s. \tag{1.27}$$

The difference between equation 1.26 and equation 1.27 is:

$$W^{3PPC} - W^{PPC} = \frac{3s^2}{4w},$$

which is always positive because $w > 0$.
The total welfare in the unrestricted pricing scenario is

$$W^{UP} = \frac{336s^2 - 32w + 384vw - 312sw - 72M_dsw - 3w^2 + 6M_dw^2 - 3M_d^2w^2}{384w} \tag{1.28}$$

and in the triopoly case it is equal to

$$W^{3UP} = \frac{504s^2 - 32w + 384vw - 312sw - 72M_d sw - 2w^2 + 4M_d w^2 - 2M_d^2 w^2}{384w}. \tag{1.29}$$

The difference between equation 1.28 and equation 1.29 is:

$$W^{3UP} - W^{UP} = \frac{168s^2 + w^2(M_d - 1)^2}{384w},$$

which is always positive because $w > 0$. □

Chapter 2

Information provision in hybrid platforms (coauthored by Marco Magnani)

2.1 Introduction

The behavior of online platforms have recently raised the awareness of policymakers and academics alike. A main concern is their hybrid nature: they own and manage a platform — possibly with a large market share — and, at the same time, they compete with third-party firms operating within the same platform. For example, Apple hosts on its App Store third-party streaming services (such as Spotify and Tidal) and, at the same time, offers a competing service (Apple Music). Similarly, Amazon is both a marketplace and a reseller, directly competing with third-party sellers; in many instances, the same products can be sold simultaneously by both Amazon and other sellers.[1] In 2020, although Amazon private labels represented less than 1% of the listings in each product category they were generating up to 9% of the total sales volume in the clothing department and up to 29% in the book department.[2]

In many instances, online platforms act as *gatekeepers*. According to Regulation (EU) 2022/1925 (Digital Markets Act or DMA, hereafter),[3] gatekeepers are platforms that have a significant impact on the internal market, providing a core platform service which is an important gateway for business users to reach end users and enjoy (or might enjoy) an entrenched and durable position[4] Gatekeepers, therefore, provide a *de facto* essential input, that is a digital infrastructure to which a third-party needs access to be able to have a presence in the market. For instance, advertisers cannot avoid to rely on advertising services provided by Google as more than 90% of searches are made on its search engine[5]. Similarly, in the retail industry, Amazon owns around 60% of total e-commerce sales,[6] which pressures sellers to use Amazon's Marketplace as a way to grow their business and gain visibility. Providing an essential input, gatekeepers have the ability to foreclose third-party firms. Considering their dual nature, might they also have an incentive to do so and under what circumstances? As stressed by the DMA, thanks to extreme scale economies, strong network effects, lock-in effects, the lack of multi-homing and data driven-advantages, the action of gatekeepers in

[1]As of 2022, Amazon operates as first party seller (with and without private-label products) in the following product categories: consumer electronics, beauty, home&kitchen, softlines, consumables, books and toys.

[2]Data were reported by Amazon's founder Jeff Bezos in response to House Antitrust Subcommittee questions following the July 29, 2020 hearing.

[3]DMA, which was signed into law by the European Parliament and the Council of the European Union in September 2022 and will become applicable, for the most part, on 2 May 2023, aims at increasing competition in the European digital markets avoiding abuse of market power by large companies.

[4]Article 3.1, DMA.

[5]Nasdaq: https://www.nasdaq.com/articles/2-growth-stocks-to-buy-and-hold-forever-3

[6]PYMNTS: https://www.pymnts.com/news/retail/2022/amazons-share-of-us-ecommerce-sales-hits-all-time-high-of-56-7-in-2021/

digital markets may substantially impact the fairness of market functioning and firms relationships.
In this paper our aim is to study the extent to which online platforms might facilitate the business of third-party seller providing useful information about market demand. Hybrid platforms, indeed, enjoy a privileged position in several dimensions with respect to the sellers they host. One of these dimensions is the information about market demand which is derived from the data collected on the marketplace. In practice, due to the lack of detailed data, sellers (including both manufacturers and resellers) cannot adequately observe demand information. In contrast, platforms — as the owners of the digital infrastructure — can more easily acquire high-quality and detailed information on demand than sellers, especially when the former serves as an online marketplace. Unlike brick-and-mortar stores, online marketplaces can observe more efficiently detailed information about the market, such as consumer online browsing histories, consumer purchase histories and sales data. These data play an essential role in forecasting demand potential or trends. Furthermore, online marketplaces are more proficient at information analysis because they are usually equipped with advanced information technology and data analytic tools. Hence, sellers may have to rely on online marketplaces for demand information.
Thus, crucial questions arise: what are a platform's incentives to share market information with independent sellers when they compete with each other on the marketplace? How does platform information sharing policy affect firm and consumer surpluses? Anecdotal evidence suggests that sellers massively rely on the hosting platform analytics and recommendations tools for setting their pricing strategies, regardless of the fact that the platform is operating in the same product market (Li and Zheng, Forthcoming). This is the case of small and medium retailers using Amazon's Marketplace, which can access broad market information related to their products through insights provided by Amazon itself. Moreover, brand owners may also subscribe for free to *Amazon Analytics*, an advanced market information provider that the platform offers to its third-party sellers. Other platforms as well (e.g., Google and Apple) provide sophisticated data analytic tools through which sellers can monitor their performance in addition to learning information about competitors and forecasting market trends. Several information provision strategies have been implemented over time. In 2012, Alibaba (i.e., the owner of Tmall) set up Ali Index, an open access data platform to provide all market sellers with detailed research reports on market trends or demand forecasts for many product categories. The emergence of Ali Index indicated that Tmall decided to fully share its demand information with all sellers. Moreover, in 2017, the Tmall Innovation Center (TMIC) was established. As a market-research division of Tmall, the TMIC's goal is to enable sellers to make more informed decisions by providing them with the most accurate demand information. By designing these ancillary services and by controlling the accuracy of the information provided through analytics, platforms actually affect sellers' strategies as well as market outcomes. Hence, understanding under which conditions hybrid platforms provide accurate information about market demand is essential for regulators and policymakers to better tailor pro-competitive measures.
The DMA has established rules that only gatekeepers will have to comply with.[7] Among these rules, gatekeepers must allow their business users to access the data that they generate in their use of the gatekeeper's platform. In this paper, instead of raw data, we focus on information, namely the content extracted from data and provided to third-party sellers through free analytics tools. As mentioned before, this kind of practice has been widely adopted by platforms way before the DMA proposal. Although this may seem to be aligned with the DMA, our results suggest that sharing market information may have highly undesirable welfare effects.
In our model, a platform hosts the sale of two horizontally differentiated products. One product is always

[7]See Chapter III of the DMA related to practices of gatekeepers that limit contestability or are unfair.

sold by a third-party seller while the other product is either sold by the platform itself (*dual mode*) or sold by a second independent seller (*agency mode*). In addition of deciding which type of business mode to implement, the platform is also in charge of choosing the amount of information to provide to the seller(s). When the platform adopts an agency business mode, the incentives to share market information with third-party sellers are clearly strong, as both agents can achieve higher profits and the platform extracts — through a fee — a portion of them. Under a dual mode, instead, one may think that the intrinsic conflict of interests of such business model prevents the platform from providing good quality information to third-party sellers. It would be reasonable to think that, since the platform is also competing against a third-party seller within its own marketplace, it has incentive to preserve the existing information asymmetry such that it can steal consumers from sellers and *win* the pricing competition game. Surprisingly, full-information sharing occurs in equilibrium despite platform duality because of what we call the *information effect*, which allows both the the platform and the seller to make higher expected gains. We find that platform incentives to share information are strongest for intermediate degrees of product differentiation. Information provision results in consumer surplus extraction such that the total welfare is reduced.
The remaining sections are organized as follows: Section 2.2 discusses the literature this paper contributes to. Section 2.3 presents the theoretical setting. Section 2.4 illustrates the results of our baseline model. In Section 2.5 we carry out the welfare analyses while in Section 2.6 we compare the dual mode with a more traditional agency model. 2.7 presents an extension where the platform decides whether to operate as a dual or a pure agency platform. Finally, Section 3.5 concludes and indicates directions for future research.

2.2 Related literature

Our work is related to three main strands of literature. The first one comprises studies of information asymmetry and information sharing. Many papers examine information sharing in traditional supply chains where information is vertically exchanged between the upstream and the downstream market. The seminal paper by Gal-Or (1985) investigates the incentives for information sharing among firms in an industry by considering an oligopolistic market where firms face an uncertain demand for their product. Each firm observes a private signal for the state of demand and decides whether to reveal it to other firms and how complete this revelation will be. As a result, no information sharing occurs in equilibrium regardless of the correlation of private signals.
Vives (1984) extends the work of Gal-Or (1985) by: i) allowing for differentiated goods and ii) introducing also Bertrand competition. The author studies a duopoly model where firms have private information about an uncertain linear demand, it is shown that if the goods are substitutes (not) to share information is a dominant strategy for each firm in Bertrand (Cournot) competition. If the goods are complements the result is reversed. Furthermore the market outcome with respect to information sharing may be optimal in Bertrand competition if the products are good substitutes. With complements the market outcome is always optimal.
Zhang, 2002 instead considers a supply chain with one manufacturer in the upstream and two competing retailers with private demand information in the downstream. The paper shows that the manufacturer's optimal strategy is independent of the type of downstream competition, Cournot or Bertrand, and that no information will be shared with the manufacturer on a voluntary basis.
First, we show that some of the results in Vives (1984) can be obtained also in the case of one of the two firm to be vertically integrated (i.e. the hybrid platform), thus taking into account also the case of price competition with asymmetric firms. Second, we depart from this work by highlighting how product differentiation affects the incentives to share market information with downstream sellers and by showing how

market outcomes can be sub-optimal from a total welfare point of view, regardless of the degree of product differentiation.

More recently, authors have investigated information sharing in the case in which a platform act as intermediary between firms and consumers. In these papers, the platform has superior information about market demand. Tsunoda and Zennyo, 2021 examine a model in which a supplier sells products through an online platform and an offline retailer under conditions of demand uncertainty. The actual demand potential can be observed by the platform and retailer, but not by the supplier. However, the platform can commit to sharing its demand information with the supplier. Results show that the platform charges its commission rate so that the supplier chooses the agency model rather than the wholesale one, unless the consumer demand is sufficiently uncertain. Nevertheless, information transparency arising from the platform's voluntary information disclosure can be unfavorable to the retailer.

Liu et al., 2021 find that a platform that operates in agency mode has incentives to share the information, and such sharing is beneficial both to the platform and to all sellers. Under the asymmetric information sharing format, the optimal strategy for the platform is to select a subgroup of sellers and truthfully share information with them. Under the symmetric sharing format, the platform must share the same information with all sellers and thus has incentives to reduce the accuracy of the shared information. With our work we will show that some of the results in Liu et al. (2021) hold also when the platform operates in dual mode.

Li and Zheng (Forthcoming) instead consider co-opetition between a manufacturer and a retailer on an online marketplace. Their analysis shows that when the intensity of competition between the manufacturer and reseller is relatively low and demand variability is moderate, the online marketplace prefers full information sharing; otherwise, it prefers to share its demand information only with the manufacturer. Moreover, they find that the manufacturer always prefers the scenario with full information sharing to the scenario that endows her with an informational advantage over the reseller. When, as in Kirpalani and Philippon (2020), consumers are the ones sharing data with the platform (which then sells them to firms), data sharing increases gains from trade by improving match quality but gives more market power to the platform relative to the merchants which can reduce entry and consequently consumer welfare. This leads to an externality not internalized by consumers thus leading to more data sharing than is efficient.

We depart from these works by investigating the hybrid role of the platform which adds a layer of complexity in understanding the effects of information sharing. Indeed the information value affects profits from direct sales and from intermediation in different ways such that the overall effect can be hard to predict. Our model allows us also to investigate the platform entry in a given product market and the optimal information policy before and after the entry.

A second strand of literature is the one on hybrid platforms and platform duality. Both the empirical and theoretical literature have not found conclusive evidence of the effects of platform entry in competition with third parties on economic outcomes. For example, Wen and Zhu (2019) studied how Android app developers which are more vulnerable to the entry threat of Google reduced their innovation effort, increased their app prices, and eventually shifted their effort to new or unaffected markets. Zhu and Liu (2018) studied the entry of Amazon into the product space of third-party sellers, finding that sellers pull their products from the marketplace.

Other empirical studies have, instead, highlighted some positive effects. For example, Foerderer et al. (2018) found that the decision of Google to release Google Photos in 2015 and enter the market of all-purpose apps for organizing, editing, and sharing digital photographs, spurred major updates from existing apps.

The theoretical literature found an ambiguous response too. Some studies found that platform entry in competition with third parties have pro-competitive effects. For example, Hagiu et al. (Forthcoming) found that platform duality might be welfare-enhancing because of its pro-competitive effect, helping consumers to save shopping costs and limiting third parties' pricing. In turn, an outright ban on platform duality could be harmful to consumers. Similar pro-competitive effects are documented by Dryden et al. (2020) and Etro (2021), but the entry decision depends on its category-specific cost-advantage compared to third-party sellers and the type of fee strategy implemented. These positive effects should be balanced against the negative effects, such as foreclosure or reduction in product variety. For example, Padilla et al. (2020) considered a dynamic framework to understand the incentive of a platform to abuse its gatekeeper role by privileging its own products. They found that the incentive to foreclose third parties arise when the gatekeepers face saturated demand and this may be detrimental to consumers.

Anderson and Bedre-Defolie (2021) focused on the decision of a platform to act as a reseller or be "hybrid", competing therefore with third-party sellers. They found that a hybrid model might lead to a reduction in consumer surplus when the platform's quality increases. This effect arises because the platform increases commission fees, so reducing seller participation and, hence, hurting consumers. Firms may also face a hold-up problem when dealing with a hybrid platforms as sellers fear that they cannot recoup their sunk costs of entry, they do not join the platform. Muthers and Wismer (2013) find that a proportional fee may mitigate the problem, unlike classical two-part tariffs.

Our work complements this strand of literature by focusing also on the role of the platform as information gatekeeper such that it is able to provide or restrict the access to an essential input as market information. We show how information provision policies heavily affect pricing strategies and final outcomes. The existing literature has shown how gatekeeping platforms can use limited access to the marketplace and the fee imposed on sales and revenues as tools for reducing the competitive pressure on the platform itself intended as a selling agent. We show that information provision, even when it is verifiable (hence truthful), can be just another option for relaxing competition despite being profitable also for 3P sellers.

The third stream of literature which connects to our work is the one on vertical integration, access pricing and sabotage. The question of how a monopolist owner of a bottleneck facility should set the quality of the facility and the price for access to the facility by an entrant or rival supplier of a complementary component continues to be an interesting question for theory and policy. This question is often framed in the antitrust context of an unregulated "essential facility" monopolist that is vertically integrated into a complementary upstream or downstream activity in which one or more other producers are present (or may enter). In our case, the essential facility is the marketplace which is necessary to the third-party seller for reaching customers. The level of market information provided to sellers by the platform can be considered instead as the "quality" of the essential facility. We can then talk about "sabotage" anytime the platform decides to not disclose market information to third-party sellers.

Economides (1998) finds that a monopolist in the essential input market has an incentive to practice non-price discrimination against its downstream rivals, sabotaging the monopolized product until they are driven out of business. Beard (2001) argue strongly in favor of this point of view, and present a model demonstrating the incentive of a regulated dominant firm to engage in anti-competitive "sabotage" against downstream rivals.

Contrary to these works, we find that the essential input monopolist does not have incentives in sabotaging the facility provided to third-party sellers as the expected gains from information provision are positive.

2.3 Baseline framework

We consider a platform operating as a monopolist, P, and a representative consumer. The platform operates in dual mode, namely it provides a marketplace to third-party sellers for reaching consumers while it operates at the same time as first-party seller competing in price against other firms. For tractability we consider in our analysis a single representative third-party seller, S, hosted on the marketplace.

2.3.1 Market demand

The seller and the platform compete in prices on the retail market offering differentiated products. We model competition using the demand specification used by Shubik and Levitan (1980) which is derived by considering the following consumer utility function:

$$U = v(q_i + q_j) - \frac{1}{2}(q_i + q_j)^2 - \frac{(q_i - q_j)^2}{2(1+\mu)} - p_i q_i - p_j q_j \quad \forall i, j \in S, P.$$

where v indicates the maximum willingness-to-pay and $\mu \in [0, +\infty)$ is a parameter representing product differentiation. When the representative consumer maximizes his utility with respect to quantities it is possible to rearrange the solution in terms of own direct market demand:

$$q_i = \frac{1}{2}\left[v - \left(1 + \frac{\mu}{2}\right) p_i + \frac{\mu}{2} p_j\right] \quad \forall i, j \in S, P$$

In order to simplify the analysis we apply the reparametrization $\mu \to \frac{2\gamma}{1-\gamma}$ with $\gamma \in [0, 1)$ such that the higher γ the greater the substitutability between products. In this way we obtain the following demand specification:

$$q_i = \frac{1}{2}\left(v - p_i + \frac{\gamma}{1-\gamma}(p_j - p_i)\right) \quad \forall i, j \in S, P.$$

v, can be either high or low. In particular, $v = \bar{v}$ when a high demand state is realized and $v = \underline{v}$ for a low demand state, with $\bar{v} > \underline{v} > 0$. This parameter determines the maximum willingness to pay of the consumer and consequently the demand function. We indicate with $\delta \in (0, 1)$ the probability that high demand is realized; this information is common knowledge. The platform always observes the true state of demand once realized while the seller does not. As illustrated in section 2.2 or in the case of Tmall and its choice to create a market-research division (i.e., Tmall Innovation Center), providing information is a long-term investment which characterizes the business of the platform for future periods, thus we assume that the platform decides whether to share information with the seller before demand potential is realized. When the platform decides to not share market information, seller's posterior distribution coincides with the prior one. It follows that when information is not shared, the seller decides the price of its product on the expected demand potential $v^e = \delta\bar{v} + (1-\delta)\underline{v}$. Demand is ex-post verifiable by the seller, hence the platform cannot provide false information.

Finally, it is worth noticing that this demand specification does not make the intercept to vary with product differentiation. In other words, changes in the differentiation parameter do not lead to any variety effect, namely there is no market expansion.

2.3.2 Firms

We consider a representative seller which sets its price for maximizing the following objective function:

$$\pi = \frac{1}{2}[p_s(1-f) - c_s]\left[v - p_s + \frac{\gamma}{1-\gamma}(p_p - p_s)\right]$$

which depends on the information about the demand potential v. If information is shared, the seller perfectly knows market demand and correctly sets its price. All things equal, a higher demand potential pushes the seller to set higher prices. When the degree of product differentiation decreases (i.e. γ increases) the elasticity of demand with respect to the price difference $(p_p - p_s)$ increases as well as price competition. In case the platform does not share information, the seller maximizes its expected profit according to the expected demand potential v^e.[8] The seller has to pay a share f of its revenues to the platform on every transaction it makes and its marginal cost of production is c_s and it take values in the unit interval.

2.3.3 Platform

The platform instead always observes the actual demand state and competes in prices with the seller for maximizing:

$$\Pi = \frac{f}{2} p_s \left[v - p_s + \frac{\gamma}{1-\gamma}(p_p - p_s) \right] + \frac{1}{2}(p_p - c_p) \left[v - p_p + \frac{\gamma}{1-\gamma}(p_s - p_p) \right]$$

where the first term is the share f of the seller's revenues earned by hosting the third-party seller and while the second term is the stream of profits generated by selling directly the product as a reseller. The platform has a marginal cost of production is c_p and it take values in the unit interval. For tractability purposes, we consider marginal costs to be lower than the consumer willingness-to-pay. We are also assuming that providing information has not extra costs. In line with most of the existing literature, the platform imposes an ad-valorem revenue sharing fee f which is exogenously determined.[9]

2.3.4 Timing

The timing of the extensive-form game is the following:

1. The platform decides whether to share information.

2. Market demand potential is realized and observed by the platform.

3. The seller receives information, if any, then price competition takes place and profits are realized.

2.4 Analysis

2.4.1 Price competition

Whenever information is not shared, the seller sets its price according to the expected demand potential v^e. Since the seller's price is proportional to the demand potential, the uninformed seller always sets a sub-optimal price $p_s(v^e) \in (p_s(\underline{v}), p_s(\bar{v}))$. Indeed, when the realized demand potential is high (low) the uninformed seller sets a price lower (higher) than optimal such that it earns a sub-optimal profit.

Lemma 2.1. *When the platform does not share information, the seller sets a different price from the profit-maximizing one.*

[8] When information is not shared, the seller incorporates into its response function the expected price of the platform, namely the price that the platform would set considering $v = v^e$. It is then impossible for the seller to infer the actual demand state through the price of the platform without information provision.

[9] The profit of the platform with information provision dominates the profit without information for every value of the revenue sharing fee. Moreover, simulations points to the fact that the optimal revenue sharing fee is the same with and without information provision. These facts allow us to claim that our results would hold also in the case of an endogenously determined fee.

Sharing market information does not only affect the profit of the seller but it changes the price competition outcome in its entirety, including the platform's expected profit. In order to see how pricing strategies are affected by the information sharing policies. Consider the difference between the price of the seller and the one of the platform when information is shared, that is when $v^e \in (\underline{v}, \bar{v})$:

$$\Delta P^I = p_s^I - p_p^I = \frac{c_p(1-f)(2-\gamma) + (1-f)fv(1-\gamma)\gamma + c_s(\gamma + f\gamma - 2)}{(1-f)((1+f)\gamma^2 - 4)}$$

with $v \in \{\underline{v}, \bar{v}\}$.[10] This price difference is increasing in c_s and f while it decreases with c_p. Indeed in line with the literature, an increase in one firm's marginal cost makes other firms in the same market relatively more competitive. The price difference when information is not shared can be rewritten in terms of the price difference under information sharing

$$\Delta P^N = p_s^N - p_p^N = \Delta P^I - \frac{(v - v^e)(2-\gamma-\gamma^2)(2-\gamma-f\gamma)}{8 - 2(1+f)\gamma^2}, \tag{2.1}$$

Since both f and γ lie in the unit interval, the sign of the second element in equation 2.1 depends entirely on $v - v^e$, namely the difference between the realized demand state and the expected one. When the demand state is high, $v - v^e > 0$, the price difference is lower than the information sharing case ($\Delta P^N < \Delta P^I$) since the seller expects a lower demand and sets a lower price. The opposite occurs when the realized demand state is low. Notice that price differences cancel out the more we move towards the homogeneous goods case: $\Delta P^N = \Delta P^I$ as $\gamma \to 1$, prices do not depend on demand potential and are set in relation of marginal costs only.

Following Lemma 2.1, the profit of the platform coming from intermediation is always maximized when information is shared given that: i) the seller earns higher profit and revenues with information sharing and ii) the platform is imposing a revenue sharing fee.

The profit of the platform coming from sales instead increases with the price difference ΔP and the other way around. For instance, if the realized demand is low the uninformed seller sets a higher price than the optimal one (increasing the difference between the price of the seller and the price of the platform), this relaxes competition such that the platform makes higher margins on each transaction. On the contrary, if the realized demand is high, the uninformed seller sets a lower price than the optimal one (reducing ΔP) and results to be too aggressive for the platform which is forced to set lower prices thus losing profits.

2.4.2 Information sharing policy

When the platform decides to share market information with the seller, it earns a profit of $\Pi^I(\overline{\mathbf{p}}^I(\bar{v}, \bar{v}))$ when the demand is high and a profit of $\Pi^I(\underline{\mathbf{p}}^I(\underline{v}, \underline{v}))$ when the realized demand is low. When information is not shared instead, the platform earns $\Pi^N(\overline{\mathbf{p}}^N(\bar{v}, v^e))$ and $\Pi^N(\underline{\mathbf{p}}^N(\underline{v}, v^e))$ when market demand is high and low, respectively. [11] Notice that $\overline{\mathbf{p}}^N(\bar{v}, v^e)$ is the price vector given that market demand is high ($\bar{v}$) and the seller does not have demand information such that it bases its strategies on v^e; the other three price vectors are defined accordingly.

In this part of the paper, we consider the case in which the platform is not able to promptly adjust its information sharing policy to market demand shocks. Hence, it is like assuming that the platform commits to its information sharing policy without having the possibility to report false information. In line with Li and Zheng (Forthcoming), the information sharing policy is determined before market demand is realized,

[10] Equilibrium prices for both the platform and the seller, with and without information sharing, are shown in appendix 2.A.1.
[11] Platform's profits in each of the four demand-information combination are shown in appendix 2.A.3.

thus the platform has to weigh the gains and losses from information sharing for the probability that a given demand state is realized. Information sharing occurs in equilibrium if the expected profit with information sharing is larger or equal than the expected profit without information sharing, formally:

$$\delta\Pi^I(\overline{\mathbf{p}}^I(\bar{v},\bar{v})) + (1-\delta)\Pi^I(\underline{\mathbf{p}}^I(\underline{v},\underline{v})) \geq \delta\Pi^N(\overline{\mathbf{p}}^N(\bar{v},v^e)) + (1-\delta)\Pi^N(\underline{\mathbf{p}}^N(\underline{v},v^e)) \tag{2.2}$$

In order to understand what this choice entails, let us first consider the difference between the expected profits of the seller with information sharing and the expected profits of the seller without information sharing, formally defined as:

$$\Delta\pi^e = \pi_I^e - \pi_N^e = \frac{2(\bar{v}-\underline{v})^2(1-f)(1-\gamma)((2+\gamma)^2)(1-\delta)\delta}{2((1+f)\gamma^2-4)^2} \geq 0$$

The seller's expected profit difference $\Delta\pi^e$ is non-negative and strictly decreasing in the product differentiation when $\gamma \in (0,1)$. This means that the third-party seller always benefit in expected terms from information sharing and that this expected gain shrinks as product differentiation decreases. When products are homogeneous, the platform and the seller set prices equal to marginal costs regardless of the information-sharing policy such that $\Delta\pi^e(\gamma \to 1) = 0$.

Lemma 2.2. *The expected variation of the third-party seller's profit after information sharing is always non-negative.*

Part of the expected additional profit of the platform when information is shared consists in the seller's additional revenue that the platform is able to extract through its revenue sharing fee. Given Lemma 2.2, the expected intermediation profit of the platform is always non-negative as well.

Lemma 2.3. *Information sharing always weakly increases the profits of the platform as intermediary.*

As stated in Lemma 2.3, intermediation profits clearly increase with information sharing; it is then interesting to understand why expected sales profits increase as well even though the platform loses its information advantage.
Since we are investigating the case of a hybrid platform, the platform and the seller may also compete in prices for customer sales against each other. When this occurs (i.e., products are not independent), the platform and the seller's pricing strategies are influencing each other, such that if the seller sets prices inefficiently, the platform on average sets an inefficient price as well. This implies that also the price of the platform changes according to the information-sharing policy.
Indeed, as mentioned in Lemma 2.1, the uninformed seller sets a higher (lower) price than optimal if realized market demand is low (high); when this occurs, the platform's best response is to increase (decrease) its price as well. In particular, when the uninformed seller sets a higher then optimal price, competition is relaxed and the platform has the opportunity to make higher profits by increasing its price as well. In the opposite scenario, instead, the uninformed seller is more aggressive, forcing the platform to set a lower price in order to not lose customer sales and to minimize its loss.

Lemma 2.4. *The information-sharing gains of the platform made with a high realized demand outweigh information-sharing losses with a low realized demand.*[12]

By taking the difference between the left-hand side and the right-hand-side in expression 2.2, we obtain the platform expected profit difference between the two information sharing policies (sharing and not sharing),

[12]See proof in Appendix 2.A.4

formally defined as:

$$\Delta\Pi^e = \frac{2(\bar{v} - \underline{v})^2(1-f)(1-\gamma)(\gamma(4+\gamma) + f(f\gamma^2 - 4))(1-\delta)\delta}{2((1+f)\gamma^2 - 4)^2} \geq 0$$

The function $\Delta\Pi^e$ does not depend on marginal costs, it is increasing in the variation of potential demand $(\bar{v} - \underline{v})$ and it is concave in the degree of product differentiation. The expected profit difference can be interpreted as a measure of the platform's incentives to share information with the seller. Given Lemmas 2.3 and 2.4, this difference is always non-negative, hence the hybrid platform has, in expected terms, always incentive to share information.

Proposition 2.1. *A hybrid platform, which commits to its information sharing policy before market demand is realized, has always the incentive to share market information with downstream sellers hosted on its marketplace.*[13]

Contrarily to results in Economides (1998), Proposition 2.1 states that an input provider monopolist has not the incentive to *sabotage* its downstream competitor. This also shows that some of the results obtained in the seminal work of Vives (1984) hold when one of the two downstream firms is vertically integrated upstream.

The net expected variation in platform's profits can be explained as the result of an *information effect* taking place between the pricing strategies of the platform and the ones of the seller. When strategies are substitutes, reducing uncertainty on the common market demand increase (decreases) the price level in high (low) demand state, hence increasing the expected market power of both parties. The more the strategies are substitutable (higher γ) the more information-sharing affects pricing strategies and the price level.

The net expected variation is concave in γ such that it takes the maximum value when products are mildly differentiated.

Proposition 2.2. *The hybrid platform's incentive to share information with the third-party seller is strongest for intermediate degrees of product differentiation.*

Proposition 2.2 is based on the concavity of the function $\Delta\Pi^e$ with respect to γ. This concavity is the result of the co-existence of an *information effect* and of a *competition effect.* As shown in Figure 2.1, the former dominates the latter when products are still sufficiently differentiated such that $\Delta\Pi^e$ increases with γ. Nevertheless, when γ is higher than a certain threshold the *competition effect* gets stronger and outweighs the *information effect* such that the extra profits from information are dissipated by fiercer price competition as product differentiation reduces.[14] An intermediate value of γ allows the platform to balance the two effects, maximizing the expected gains from information sharing.

2.5 Welfare analysis

We compute consumer surplus by plugging equilibrium quantities into consumer net utility function:

$$U = v(q_s + q_p) - \frac{1}{2}(q_s + q_p)^2 - \frac{(1-\gamma)(q_s - q_p)^2}{2(1+\gamma)} - p_s q_s - p_p q_p$$

[13] Given that the platform has incentives to share market information, this proposition holds also in the case in which we allow seller free entry on the platform's marketplace.

[14] If we consider an endogenous fee, the platform may prefer increasing the fee in order to relax price competition when γ approaches 1. In other words, when goods are similar, the platform may replace its information sharing strategy with an increase in the revenue sharing fee for increasing the average price of the downstream competitor.

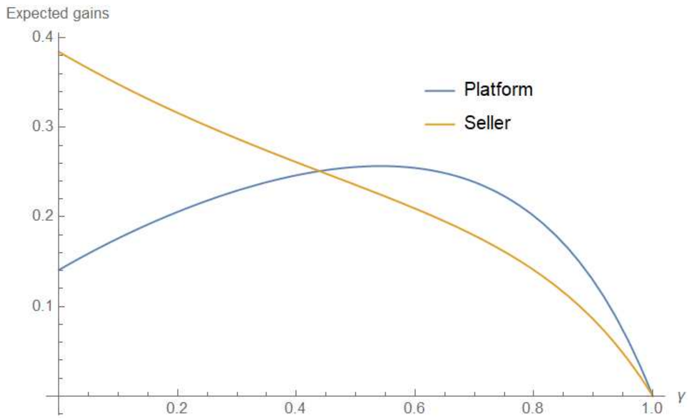

Figure 2.1: Platform expected gains on degrees of product differentiation

We compute the difference in terms of expected consumer surplus between the two information sharing policies:

$$\Delta CS^e = CS_I^e - CS_N^e = \frac{(\bar{v}-\underline{v})^2(1-\gamma)(2+\gamma)(2+\gamma+f\gamma)(-12+2(f-2)\gamma+3(1+f)\gamma^2)(1-\delta)\delta}{16((1+f)\gamma^2-4)^2} \quad (2.3)$$

which is increasing and convex in γ within the unit interval and it is always negative. As we have shown in Lemmas 2.2 and 2.4, after information sharing the profits of both the platform and the seller in a high demand state increase more (in absolute value) than profit losses in a low demand state. We can say then that information sharing leads to a negative expected consumer surplus.

Market information sharing has ambiguous effects on total welfare; in our total welfare analysis we employ an utilitarian welfare function defined as the sum of consumer surplus and the profit of both platform and seller. The difference between the two expected policy outcomes is:

$$\Delta TW^e = TW_I^e - TW_N^e = \frac{(\bar{v}-\underline{v})^2(1-\gamma)(2+\gamma)(2+\gamma+f\gamma)(-4+\gamma(4+f(-2+\gamma)+\gamma))(1-\delta)\delta}{16((1+f)\gamma^2-4)^2} \quad (2.4)$$

Proposition 2.3. *Information sharing always makes consumers weakly worse off and the utilitarian total welfare decreases unless goods are close substitutes.*

Although information sharing makes both the platform and the seller better off, consumer surplus extraction is large enough to drive total welfare down. Only for very high values of γ the effect of information provision on total welfare is positive. Nevertheless, when $\gamma \to 1$ prices equal marginal costs regardless of the realized demand and $\Delta TW^e = 0$.

Market information can be a tool for foreclosing competitors, the fear is that by not providing market information the platform increases its market power and harms both sellers and consumers. Contrary to what one may think, we show that the platform's information provision policy makes sellers (i.e., platform's competitors) better off, yet it harms consumers. When the platform shares market information with the seller, it enjoys an *information effect* that on average increases the price level and reduces consumer surplus. This result suggests that policymakers, before pressuring gatekeepers to share information, should take into account undesirable effects as well. According to our model, as long as information helps sellers in adjusting their pricing strategies, information sharing is detrimental for both consumer surplus and total welfare and should be prevented.

2.6 Agency vs Dual mode

Platform duality has raised several concerns over the years especially because of the pervasiveness and the extreme network effects enjoyed by online platforms. Vertical integration between upstream and downstream activities (marketplaces and resellers) may be concerning from a policy standpoint as stressed in popular streams of literature about *access pricing* and *vertical mergers*. In these contexts, anti-competitive practices such as raising costs (in this framework, the revenue sharing fee) or non-price discrimination, as sabotaging an essential input for the downstream rival, may occur. In our case, the latter takes place by not sharing market information, thus providing a lower quality service to third-party sellers such that competition is hampered and consumers are harmed.
One of the proposed remedies is to prevent vertical integration (i.e., dual mode) to occur, thus pushing for either an agency or a wholesale business model. For these reasons we think it is extremely interesting and useful to compare the incentives to share information, and the related effects on major aggregate values, across different business models.
In this part of the paper, we consider a platform that operates as intermediary only (agency mode) and study the optimal information policy and its impact on agents. Under agency mode, there are two third-party sellers in the marketplace, namely s_1 and s_2, competing in prices over a horizontally differentiated good. The timing of the extensive-form game is unchanged: the platform sets its information-sharing policy and the revenue-sharing fee f before market demand is realized, then price competition between third-party sellers takes place.
Coherently with the previous model, we consider a representative consumer with a utility function in the vein of Shubik and Levitan (1980). Therefore, seller s_i sets the price p_{s_i} in order to maximize the following profit function:

$$\pi_{s_i} = \frac{1}{2}[p_{s_i}(1-f) - c_{s_i}]\left[v - p_{s_i} + \frac{\gamma}{1-\gamma}(p_{s_{-i}} - p_{s_i})\right]$$

where retailers' prices are function of the demand state $v \in \{\underline{v}, v^e, \bar{v}\}$; while the profit of the platform when it adopts the agency business model has the following form:

$$\Pi^A = \frac{f}{2}\left[v - p_{s_1} + \frac{\gamma}{1-\gamma}(p_{s_2} - p_{s_1})\right] + \frac{f}{2}\left[v - p_{s_2} + \frac{\gamma}{1-\gamma}(p_{s_1} - p_{s_2})\right]$$

Now, differently with respect to the hybrid model, there is a symmetric competition between sellers since, under agency mode, both are either informed or not about market demand. Sellers' equilibrium prices without information sharing are:

$$p_A^N = \frac{(\underline{v}(1-\delta) + \bar{v}\delta)(1-f)(1-\gamma) - c_s}{(1-f)(2-\gamma)}$$

while sellers' prices with information sharing are:

$$p_A^I = v - \frac{v(1-f) - c_s}{(1-f)(2-\gamma)}$$

Given equilibrium outcomes of the pricing stage, we can compute the expected increase in each seller's profit due to information provision, formally:[15]

$$\Delta\pi_A^e = \frac{(1-f)(\bar{v} - \underline{v})^2(1-\gamma)(1-\delta)\delta}{2(2-\gamma)^2} \geq 0$$

[15]See the equilibrium profits of the sellers with and without information in Appendix 2.A.6

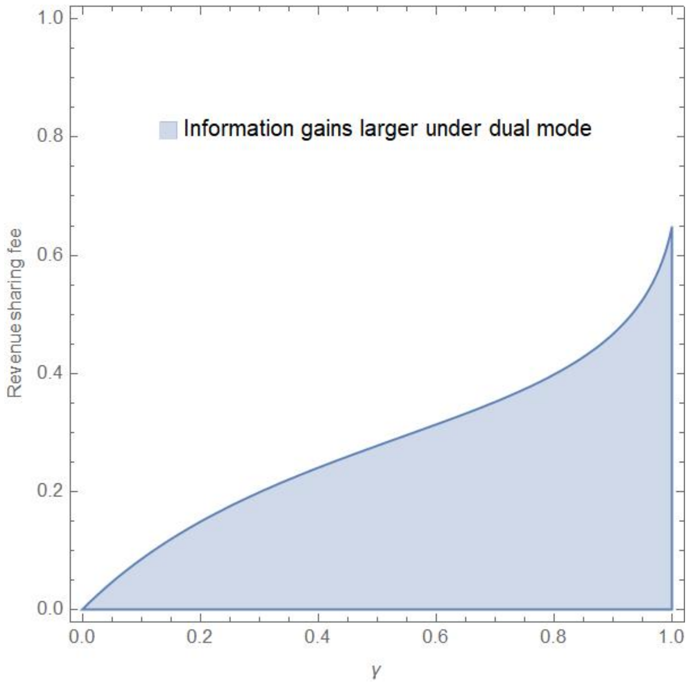

Figure 2.2: Combinations of revenue sharing fee and product differentiation which provide higher gains under dual mode than under agency

Lemma 2.5. *With an agency business model, third-party sellers are always weakly better off in expected terms after information sharing.*

given Lemma 2.5, the platform which intermediates trades between sellers and consumers is better off as well since its expected gains are proportional to the revenue-sharing fee:[16]

$$\Delta\Pi_A^e = \frac{f(\bar{v} - \underline{v})^2(1-\gamma)(1-\delta)\delta}{2(2-\gamma)^2} \geq 0$$

Lemma 2.6. *With an agency business model, the platform is always weakly better off in expected terms after information sharing.*

We combine Proposition 2.1 and Lemma 2.6 in the plot in Figure 2.2, which shows combinations of product differentiation γ and revenue-sharing fee f which ensure that the incentives to share market information with third-party sellers are higher in dual mode than in agency. In other words, the light blue area in Figure 2.2 is the set of $\{\gamma, f\}$ combinations such that $\Delta\Pi_{DM}^e > \Delta\Pi_A^e$.

Proposition 2.4. *Incentives to share market information are larger under agency mode unless goods are close substitutes and the revenue sharing fee is small enough.*

When goods are more independent the platform earns larger expected gains under agency mode because both sellers have more market power and generate higher revenues. When goods are closer substitutes the platform can use the *information effect* of the information sharing under dual mode for relaxing competition; hence if the revenue-sharing fee is small enough (i.e. intermediation profits are low) the expected gains from information provision are larger for a hybrid platform.
Given Proposition 2.4, we observe that consumer surplus shrinks in expected terms after market information

[16]See the equilibrium profits of the platform with and without information in Appendix 2.A.7

is shared with an agency business model. Formally:

$$\Delta CS_A^e = \frac{(\bar{v} - \underline{v})^2(1-\gamma)(3-\gamma)(\delta-1)\delta}{2(2-\gamma)^2} \leq 0 \tag{2.5}$$

consumer willingness-to-pay is better targeted by sellers which can extract more surplus such that also the total utilitarian welfare is always non-positive under agency, formally:

$$\Delta TW_A^e = \frac{(\bar{v} - \underline{v})^2(1-\gamma)^2(\delta-1)\delta}{2(2-\gamma)^2} \leq 0 \tag{2.6}$$

Proposition 2.5. *With platform agency, information provision reduces both consumer surplus and total welfare in expected terms. Nevertheless, both consumer surplus and total welfare are highest under agency without information provision and lowest under dual mode with information provision.*[17]

The intuition for these results is that prices can increase for two reasons: higher fees and platform entry. In particular, as pointed out in Etro (2021), a hybrid platform has more incentives to raise the price since it can recoup part of the lost profit through the revenue-sharing fee.[18] Therefore, prices are already higher with dual mode than with agency; consequently, when market information is shared by a hybrid platform, the effects of platform entry and information sharing sum together, further reducing consumer surplus.

2.7 Platform entry decision

After having compared the two business modes, we want to extend the analysis to a more dynamic framework, thus we want to investigate the platform decision to enter in the product space of one of the sellers hosted on its marketplace. As highlighted in several reports, one of the main concerns of competition authorities deals with the possibility of the platform of exploiting its superior market demand information for entering in product markets and hampering competition within the marketplace. Once inside the product space, the platform may have a strong incentives to foreclose its rival by raising the fee, which would also lead to higher retail prices.

We investigate this case study by introducing an additional stage to the extensive-form game employed in the previous sections in which the platform, after setting its information-sharing policy, decides whether to enter the market, adopting a dual mode. This new timing captures the fact that when platforms decide whether and how to provide market information they incur in investments that may be more or less binding compared to their ability to enter a given product market. As in the case of Tmall and its choice to create a market-research division (i.e., Tmall Innovation Center), providing information is a long-term investment which constrains the business of the platform for future periods. [19]

In our model, entering the product space consists in the platform acquiring one of the two retailers and competing with the other one. The cost of the acquisition is equal to the profit that the firm makes under agency. The platform makes a *take-it-or-leave-it* offer to one of the firms when entering the market.

The timing of the new extensive-form game is the following:

1. The platform sets the information-sharing policy.

2. The platform decides whether to enter or not.

[17]See consumer surplus with an agency business model in Appendix 2.A.8
[18]See equilibrium prices with platform entry in Appendix 2.A.1.
[19]We investigate market outcomes with an alternative timing in Appendix 2.A.9.

3. Market demand potential is realized and observed by the platform.

4. The seller receives information if any, then price competition takes place and profits are realized.

In this game, the platform decides the information policy first and then its business model (entry decision). Entry is profitable if the expected dual mode profit, net of the acquisition cost, is larger than the expected profit under agency, formally:

$$\Pi^e - \pi^e > \Pi^e_A$$

When the platform shares market information, the expected dual mode profit of the platform is higher ($\Pi^e_I > \Pi^e_N$) but the expected profit of the seller is higher as well ($\pi^e_I > \pi^e_N$). In other words, information provision increases also the cost of the acquisition and makes, all things equal, entry less profitable.
We know from Lemma 2.6 that the platform will always share market information if entry is not profitable (i.e. with the platform operating in agency).
Hence, entry takes place if:

$$max\{\Pi^e_I - \pi^e_I, \Pi^e_N - \pi^e_N\} > \Pi^e_{I_A}$$

while information is not shared in equilibrium if

$$\Pi^e_N - \pi^e_N > max\{\Pi^e_I - \pi^e_I, \Pi^e_{I_A}\}$$

it follows that if $\Pi^e_I - \pi^e_I$ is the highest profit level in the subgame, both entry and information sharing occur in equilibrium.[20]

Proposition 2.6. *In the unique equilibrium of the game, the platform enters the market either when it is very cost efficient with respect to the seller or when products are very similar. With the agency mode, the platform finds optimal to provide market information while platform entry always occurs without information provision.*

Although the platform is always better off by providing market information, this increases also the profit of the seller thus making the acquisition more costly for the platform. Entry occurs either when the platform is more efficient than the third-party seller in producing and selling the product ($c_p < c_s$) or when products are perceived as close substitutes (low values of γ). In the latter case, the competitive advantage of the platform lies in the presence of the fee, which increases seller's price, such that the platform is able to make profits from sales despite the little product differentiation.
According to our model, when the platform operates under agency it also provides market information while when it operates in dual mode it does not. Therefore in this game, the platform earns $max\{\Pi^e_N - \pi^e_N, \Pi^e_{I_A}\}$ in equilibrium; which of the two outcomes occurs depends on parameters' values. This shows that the platform can share market information in equilibrium also when entry is taken into account. As we have seen, information sharing results, in expected terms, in higher profits for both the platform and the seller but lower consumer surplus and total welfare. Contrary to Vives, 1984, we show that the market outcome can be always detrimental from a total welfare standpoint, regardless of the degree of competition.

2.8 Conclusion

Nowadays, online platforms often adopt a so-called dual mode, namely a business model where they act both as intermediaries (owning the platform itself) and resellers within their own marketplace, directly competing

[20]See profit functions for both the platform and the seller in Appendix.

with third-party sellers. This has raised concerns of competition authorities all around the world since platforms may use their position to favour their sales, thus hampering competition — especially when they act as gatekeepers, enjoying a sizable market share and large network effects. Online platforms can achieve this by deciding how much information about market demand share with sellers. In other words, platforms' decision on whether or not sharing superior market information affects pricing strategies of all the sellers that consider this information relevant for their business.

In this paper we investigate the incentive of a hybrid platform to commit in information sharing when information is verifiable by sellers in order to understand the impact of this strategy on consumer surplus and total welfare. Surprisingly, we find that platforms have strong incentives to share full information with sellers despite the dual mode because of the *information effect* it generates. The *information effect* increases when interactions between the platform and the firm are stronger (i.e., goods are closer substitutes) but starts decreasing when product differentiation is too small, thus incentives to share information are strongest for intermediate degrees of product differentiation. Information provision results on average in more surplus extraction by firms and platforms, thus it lowers both consumer surplus and total welfare.

We also find that the agency mode without information provision is the best scenario for consumers while dual mode with informed sellers is the worst one. Nevertheless, both the expected consumer surplus and total welfare decrease after information provision more under agency than in the dual mode case.

When the platform's entry decision is taken into account, the platform decides the information policy first and then its business model. According to our model, the platform enters the product space of the third-party seller either when its cost is very low or when products are very similar. Since information provision increases the cost of the acquisition, when the platform decides to enter, it finds optimal not to provide market information before the acquisition stage. Generally, platform entry tends to increase the average price level either through information provision or through higher fees, thus reducing consumer surplus.

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2.A Appendix

2.A.1 Equilibrium prices

Equilibrium prices are obtained by solving the system of first order conditions. When the seller is not informed, it takes into its nest response the platform price given the the expected market demand, namely $p_p(v = v^e)$. Prices of the seller and the platform without information sharing are:

$$p_s^N = \frac{2c - (-1+f)(a\gamma + 2\underline{v}(-1+\gamma)(-1+\delta) - (-1+\gamma)(v\,\gamma + 2\bar{v}\delta))}{(-1+f)(-4+(1+f)\gamma^2)}$$

$$p_p^N = \frac{-2a(-1+f) + 2(-1+f)v(-1+\gamma) + (1+f)\gamma(c - (-1+f)(-1+\gamma)(\underline{v}(-1+\delta) - \bar{v}\delta))}{(-1+f)(-4+(1+f)\gamma^2)}$$

Prices of the seller and the platform with information sharing are:

$$p_s^I = \frac{2c + (-1+f)(-a\gamma + v(-2+\gamma+\gamma^2))}{(-1+f)(-4+(1+f)\gamma^2)}$$

$$p_p^I = \frac{-2a(-1+f) + c(1+f)\gamma + (-1+f)v(-1+\gamma)(2+\gamma+f\gamma)}{(-1+f)(-4+(1+f)\gamma^2)}$$

2.A.2 Firm profit

The profit of the firm under information sharing is

$$\pi_I^e = \Gamma(\frac{c^2(-2+(1+f)\gamma^2)^2}{f-1} + 2c(-2+(1+f)\gamma^2)(-a\gamma - \underline{v}(-2+\gamma+\gamma^2)(\delta-1)+ \bar{v}(\gamma+\gamma^2-2)\delta) + (f-1)((a\gamma - \underline{v}(-2+\gamma+\gamma^2))^2 + (\bar{v}-\underline{v})(-2+\gamma+\gamma^2)(-2(\bar{v}+\underline{v}) + (-2a+\bar{v}+\underline{v})\gamma + (\bar{v}+\underline{v})\gamma^2)\delta)) \tag{2.7}$$

where $\Gamma = \frac{1}{2(-1+\gamma)(-4+(1+f)\gamma^2)^2}$

while the profit of the firm without information sharing is:

$$\pi_N^e = \pi_I^e - \frac{2(\bar{v}-\underline{v})^2(1-f)(1-\gamma)((2+\gamma)^2)(1-\delta)\delta}{2((1+f)\gamma^2-4)^2}$$

2.A.3 Platform profit

The profit of the platform when the seller is not informed is:
$\Pi_N^e = \eta(\Lambda - (\gamma-1)^2(2\bar{v}\underline{v}(-\gamma(4+\gamma) + f(f\gamma^2-4))(-1+\delta)\delta - \bar{v}^2\delta(-4+f\gamma(\gamma+\gamma^2-4) - 4f\delta - \gamma(4+\gamma)\delta + f^2\gamma^2(\gamma+\delta)) + \underline{v}^2(\delta-1)(-4+f^2\gamma^2(1+\gamma-\delta) + \gamma(4+\gamma)(\delta-1) + f(-4-4\gamma+\gamma^2+\gamma^3+4\delta))))$

where

$$\eta = \frac{1}{2(-1+\gamma)(-4+(1+f)\gamma^2)^2}$$

and

$$\Lambda = \frac{c^2(4f-(1+f)^2\gamma^2)}{(-1+f)^2} - a^2(4-(4+f)\gamma^2+(1+f)\gamma^4) + a\underline{v}(\gamma-1)(8+\gamma(4+f^2\gamma^2(1+\gamma) - 2\gamma(2+\gamma)+f(1+\gamma)(-4+(\gamma-2)\gamma)))(-1+\delta) - a\bar{v}(-1+\gamma)(8+\gamma(4+f^2\gamma^2(1+\gamma) - 2\gamma(2+\gamma)+f(1+\gamma)(-4+(\gamma-2)\gamma)))\delta + \frac{2c\gamma(a(-2+(1+f)\gamma^2)+(\gamma-1)(2+\gamma+f\gamma)(\underline{v}(\delta-1)-\bar{v}\delta))}{f-1}$$

while platform profit under information sharing is

$$\Pi_I^e = \Pi_N^e + (-1+\gamma)^2(f^2\gamma^2(1+\gamma)+f(-2+\gamma)(1+\gamma)(2+\gamma)-(2+\gamma)^2)(\underline{v}^2(-1+\delta)-\bar{v}^2\delta)$$

2.A.4 Information sharing gains in price competition

We want to show the platform's gains of sharing information in price competition. Results are reported assuming a revenue sharing fee f equal to zero in order to isolate pricing strategies from any intermediation effect.
Platform's profit variation after information is shared when the realized demand is high:

$$\Delta\Pi(v=\bar{v}) = \frac{(\bar{v}-\underline{v})(-1+\delta)(-2c_s\gamma^2-2c_p\gamma(-2+\gamma^2)+(-1+\gamma)\gamma(-\underline{v}\,\gamma(-1+\delta)+\bar{v}(4+\gamma+\gamma\delta)))}{2(-4+\gamma^2)^2} \tag{2.8}$$

Platform's profit variation after information is shared when the realized demand is low:

$$\Delta\Pi(v=\underline{v}) = -\frac{(\bar{v}-\underline{v})\delta(-4c_p\gamma+2c_s\gamma^2+2c_p\gamma^3+(1-\gamma)(2\underline{v}\gamma(2+\gamma)+(\bar{v}-\underline{v})\gamma^2\delta))}{2(-4+\gamma^2)^2} \tag{2.9}$$

By taking the difference between equation 2.8 and equation 2.9, assuming marginal costs equal to zero for tractability we get:

$$\frac{(\bar{v}-\underline{v})\gamma((1-\gamma)(\bar{v}(4+\gamma-4\delta)+\underline{v}(\gamma+4\delta)))}{2(-4+\gamma^2)^2} \geq 0$$

which is the platform's net absolute gain from information sharing with its competitor, this gain is always non-negative

2.A.5 Consumer surplus

Consumer surplus with information sharing

$$\mathrm{CS}_I^e = \frac{1}{4(-1+\gamma)(-4+(1+f)\gamma^2)^2}(a^2(-4+3\gamma^2)+\frac{c^2(-4-(-3+f)(1+f)\gamma^2)}{(-1+f)^2} - 2a\underline{v}(-1+\gamma)(-4+\gamma(-4-\gamma+2f(1+\gamma)))(-1+\delta)+2a\bar{v}(-1+\gamma)(-4+\gamma(-4-\gamma+2f(1+\gamma)))\delta - (-1+\gamma)(8+2\gamma(4+\gamma)+f\gamma(1+\gamma)(-4+(-2+f)\gamma))(\underline{v}^2(-1+\delta)-\bar{v}^2\delta)+\Omega)$$

where

$$\Omega = \frac{2c(2af\gamma-a(1+f)\gamma^3+(-1+\gamma)(-4+\gamma(-4-\gamma+f(-2+\gamma(f+\gamma+f\gamma))))(\underline{v}(-1+\delta)-\bar{v}\delta))}{f-1}$$

Consumer surplus with information sharing is:

$$CS_N^e = CS_I^e - \frac{(\bar{v}-\underline{v})^2(1-\gamma)(2+\gamma)(2+\gamma+f\gamma)(-12+2(f-2)\gamma+3(1+f)\gamma^2)(1-\delta)\delta}{16((1+f)\gamma^2-4)^2}$$

2.A.6 Firm profit under agency

The agency profit of the firm under information sharing is

$$\pi^e_{I_A} = \frac{(-1+\gamma)((c+(-1+f)\underline{v})^2(1-\delta)+(c+(-1+f)\bar{v})^2\delta)}{2(-1+f)(-2+\gamma)^2}$$

While the agency profit of the seller when it is not informed is:

$$\pi^e_{N_A} = -\frac{f(c-(-1+f)(\underline{v}(-1+\delta)-\bar{v}\delta))(c-(-1+f)(-1+\gamma)(\underline{v}(-1+\delta)-\bar{v}\delta))}{2(-1+f)(-2+\gamma)^2}$$

2.A.7 Platform profit under agency

The profit of the platform when the seller is not informed is:

$$\Pi^e_{N_A} = -\frac{f(c-(-1+f)(\underline{v}(-1+\delta)-\bar{v}\delta))(c-(-1+f)(-1+\gamma)(\underline{v}(-1+\delta)-\bar{v}\delta))}{(-1+f)(-2+\gamma)}$$

while platform profit under information sharing is

$$\Pi^e_{I_A} = \frac{f(-c^2+c(-1+f)\gamma(\underline{v}(-1+\delta)-\bar{v}\delta)+(-1+f)^2(-1+\gamma)(\underline{v}^2(-1+\delta)-\bar{v}^2\delta))}{(-1+f)(-2+\gamma)}$$

2.A.8 Consumer surplus under agency

Consumer surplus with information sharing is:

$$\mathrm{CS}^e_{I_A} = \alpha(a^2(-4+3\gamma^2)+\tfrac{c^2(-4-(-3+f)(1+f)\gamma^2)}{(-1+f)^2}-2a\underline{v}(-1+\gamma)(-4+\gamma(-4-\gamma+2f(1+\gamma)))(-1+\delta)+2a\bar{v}(-1+\gamma)(-4+\gamma(-4-\gamma+2f(1+\gamma)))\delta-(-1+\gamma)(8+2\gamma(4+\gamma)+f\gamma(1+\gamma)(-4+(-2+f)\gamma))(\underline{v}^2(-1+\delta)-\bar{v}^2\delta)+\Omega)$$

where

$$\alpha = \frac{1}{4(-1+\gamma)(-4+(1+f)\gamma^2)^2}$$

and

$$\Omega = \frac{2c(2af\gamma-a(1+f)\gamma^3+(-1+\gamma)(-4+\gamma(-4-\ \gamma+f(-2+\gamma(f+\gamma+f\gamma)))))(\underline{v}(-1+\delta)-\bar{v}\delta))}{f-1}$$

Consumer surplus without information sharing is:

$$\mathrm{CS}^e_{N_A} = \beta(1-\delta)(c+(f-1)(\underline{v}+(\bar{v}-\underline{v})(\gamma-1)\delta))^2+\delta(c-(f-1)(\underline{v}(\gamma-1)(\delta-1)+\bar{v}(\gamma+\delta-\gamma\delta-2)))^2$$

where

$$\beta = \frac{1}{2(f-1)^2(-2+\gamma)^2}$$

2.A.9 Platform entry decision: alternative timing

We are interested in investigating an alternative timing in which the platform decides the business mode first and then the information policy. As before, entering the product space consists in the platform acquiring one of the two retailers by paying a price equal to the profit that the firm makes under agency. Since the platform decides the business mode first and then the information policy, the cost of the acquisition is the same in every sub-game, namely the profit of the seller without information provision (π^e_N). From

Proposition 2.1 and Lemma 2.6, we know that in both business modes the platform has incentives to share market information. Therefore, the equilibrium profit of the platform is the highest profit between agency with information sharing and dual mode with information sharing, net of the acquisition of the uninformed seller; formally:

$$max\{\Pi_I^e - \pi_N^e, \Pi_{I_A}^e\}$$

In the unique equilibrium of the game, the platform always enters the market and then provides market information unless it is less cost efficient than the seller, in this case it prefers to stay out of the market but still providing market information. The most profitable strategy for the platform is to acquire one of the sellers and then provide market information to the other one unless it faces a selling cost that is too high with respect to the seller's one. In this latter case it is better for the platform to not acquire any of the sellers and to keep operating under agency. Nevertheless, it still provides market information.

Chapter 3

Mandated data sharing in hybrid marketplaces (coauthored by Flavio Pino & Luca Sandrini)

3.1 Introduction

The relevance of data in modern economies has constantly been increasing during the past years, primarily due to the importance of digital markets. Every interaction on digital platforms and websites is tracked and registered by companies, and large amounts of data are traded every moment. Recent estimates from the European Commission show that:

> "The value of the data economy for the EU27 has been estimated to have reached almost €400 billion in 2019 and €440 billion in 2021, with a year-on-year growth rate of 4.9% in 2021. The estimated share of overall impacts on GDP in the EU27 ranges from 3.1% in 2019 to 3.6% in 2021" (DATA Market Study 2021–2023, pg. 116)."[1]

Data is a core input factor for production processes, logistics, targeted marketing, smart products, and services. Also, they are fundamental to training Artificial Intelligence and refining algorithms. On top of that, data drive interoperability in interconnected environments and are expected to impact specific sectors such as mobility and healthcare drastically.

Data owners have a large competitive advantage over their market rivals. Hence, data are very relevant to competition and privacy authorities. Digital platforms may have the incentive to adopt potential anti-competitive practices, such as self-preferencing (Padilla et al., 2022) and bias-recommendation (Bourreau and Gaudin, 2022), or, more generally, they may abuse their dominant position.

To stay competitive, firms competing against digital platforms increasingly depend on timely access to relevant data and their ability to use those to develop new, innovative applications, services, and products. For these reasons, a widespread debate has emerged on whether – and under which conditions and legal bases – public intervention is required to ensure adequate and timely access to data. One of the proposed remedies is to mandate platforms to share with sellers and rival companies all or part of the consumers' data they possess. Data sharing is one of the pillars of the European strategy for data.[2] It is at the core of the Digital Market Act (DMA hereafter), the recently introduced EU competition law regulating large digital platforms' (gatekeepers) business conduct.[3]

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[1] Available at `https://digital-strategy.ec.europa.eu/en/library/results-new-european-data-market-study-2021-2023`.

[2] Available at `https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0066&from=EN`.

[3] In particular, article 6 of the DMA states that: *"The gatekeeper shall provide business users and third parties authorized by a business user, at their request, free of charge, with effective, high-quality, continuous and real-time access to, and use of,*

Table 3.1: Effect of data sharing on main market outcomes.

	Homogeneous Goods		**Differentiated Goods**	
	Price Disc.	Cost Red.	Price Disc.	Cost Red.
CS	= or ↓	↑	↓	↑
TW	=	↑	↑	↑

This paper analyses the strategic interactions between a monopolistic platform and the many sellers operating within the digital marketplace. Moreover, we investigate the effects of mandated data sharing on market outcomes and social welfare when data can be used for different purposes (price discrimination or cost reduction). We focus on a setting where a digital platform mediates between many sellers and consumers. Sellers must pay a per-transaction fee to the platform to be included in the marketplace, whereas consumers do not pay any admission fee. The platform decides, in order, i) the size of the fee, ii) whether or not to directly produce some (or all) final goods and compete against the sellers, and iii), in case of entry, the price of each good it produces. This setup is consistent, as an example, with Amazon's product groups' referral fees. Amazon subdivides its marketplace into broad product groups such as "baby products" or "clothing and accessories". While these categories contain many sub-markets, Amazon sets a single per-transaction fee for every product group.[4] Moreover, we assume the platform has an ex-ante data advantage against the sellers, meaning that it can use the data it owns exclusively. Mandated data sharing alters the interaction between the platform and sellers depending on the competition structure (homogeneous or differentiated goods).

Our main result is summarized in Table 3.1. Mandated data sharing has no effects on welfare if data can be used to price discriminate consumers and competition is in prices of homogeneous goods. Indeed, we show that the platform sets a per-transaction fee that makes all sellers less efficient than the platform itself. Hence, with or without data, the sellers can only set a price equal to their marginal costs and cannot exploit consumers' data. The platform may also decide to operate as anintermediary in some markets, letting some sellers without competitive pressure and free to perfectly price-discriminate consumers.
Instead, mandated sharing of cost-reducing data improves welfare by lowering the average price in the market. Sellers are unaffected, as price competition drives profits to zero, but the platform is better off as more markets are covered and revenues from intermediation increase. When goods are horizontally differentiated, data sharing may negatively affect consumers (price discrimination) and some sellers (cost reduction). In the former case, access to data enables sellers to price more efficiently and extract more surplus from the consumers, and the platform sets the per-transaction fee to temper competition with the sellers. In the latter case, efficient sellers have little gains from the cost-reducing data but suffer from the generalized increase in transaction fees. However, the aggregate effect is positive.

Our second result pertains to the pricing strategies adopted by the platforms and the sellers. We identify conditions under which the platform has the incentives to either *strategically lose* price competition (homogeneous goods) or to give up competing in some market segments (data sharing with differentiated goods). In the former case, the platform's strategy is to set a price the rival can undercut. In particular, the platform sets its price just above the rival's marginal costs. It does so because winning the price competition yields

aggregated and non-aggregated data, including personal data, that is provided for or generated in the context of the use of the relevant core platform services or services provided together with, or in support of, the relevant core platform services by those business users and the end users engaging with the products or services provided by those business users". (DMA, Art. 6.10), available at `https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32022R1925&from=EN`.

[4]The case of fee discrimination in online marketplaces is beyond the scope of our analysis.

lower revenues than collecting the transaction fees. Similarly, in the latter case, the platform decides not to send any offer to some consumers as it would be less profitable than collecting the fee from the sellers. This result stems from the vertically integrated (i.e., hybrid) nature of the platform, which operates as an intermediary and a rival in the market. Earning revenues in both cases, the platform exploits its advantage and sets a per-transaction fee to lower the efficiency of rival sellers. Then, depending on whether the competitive price guarantees higher or lower net revenues than the transaction fee, the platform decides whether to win or to lose the competition.

Data is a complex concept that subsumes a multiplicity of information, uses, and functions. Indeed, when discussing data access, one has to consider the nature of data. A list of consumers may be used to send out discounts, tailored ads, and prices. Information about the production process of a specific good may be used to improve the efficiency of firms in producing it. Searches and reviews by consumers may be used to assess the size of the demand for a specific good and potential fallacies that bother consumers, limiting retail risks.

Hence, from an anti-trust perspective, the data's importance strongly depends on analysing the specificities of a given market and available data. Investigating an overall impact on market outcomes without explicitly accounting for the data type may limit the breadth of policy implications and provide little guidance to policy makers.

In recent years, many authors have investigated the effects of data on various aspects, such as market structure, competition, welfare, and privacy. However, most of these works have focused on a specific data effect in particular settings. This, in turn, has created a conundrum. While the impact of data is widely analyzed, the specificity of most studies makes it difficult to compare models and abstract more general insights.

In this paper, we compare different usages of data in different market structures, and we provide some guidance from a regulatory perspective about what one should expect from mandating data sharing. As mentioned earlier, we argue that in markets where competition is softer, mandatory data sharing may damage the very agents it is intended to protect, namely consumers and (efficient) sellers.

The paper is organized as follows: in the next section, we provide an overview of the existing literature on the topic and illustrate our main contributions. Section 3.3 presents the model with homogeneous goods. We analyze the effects of mandated data sharing when data allow firms to either price discriminate consumers 3.3.1 or to reduce their costs 3.3.2. In Section 3.4, we introduce horizontal differentiation: we repeat the analysis of the effects of mandated data sharing in sections 3.4.1 and 3.4.2. Finally, in Section 3.5 we compare our results with those of the related literature and draw concluding remarks.

3.2 Related literature

This paper contributes to four main strands of literature. The first one focuses on the effect of consumer data in digital economics. The use of data is widespread across every sector, thanks to their versatility; typical uses include improving products or services quality and efficiency, personalisation, matching, and discriminating between different consumers groups or individuals. Recent surveys (Goldfarb and Tucker, 2019; Bergemann and Bonatti, 2019; Pino, 2022) have thus focused on categorizing both the types and uses of data, trying to extract broader insights that hold across different models. Two typical data functions are those of allowing price discrimination on consumers and of increasing the vertical differentiation between firms (either allowing for an improvement of the products or a reduction in their marginal cost of production).

Price discrimination has been observed in various markets: a typical example involves the use of geolocalization to tailor prices to different consumers (Mikians et al., 2012; Aparicio et al., 2021). The literature has mostly focused on competition between informed firms, stemming from Thisse and Vives (1988) seminal work, and on the vertical relations between firms and a data seller (Montes et al., 2019; Bounie et al., 2021; Delbono et al., 2021; Abrardi et al., 2022). The common insight of these models is that allowing all firms to obtain data benefits consumers while it harms both the firms and the data seller. Our main contribution highlights how, when vertical integration is introduced, mandating data sharing can benefit all actors, as firms can retain more profits due to their increase in competitiveness while the platform benefits from the overall increase in market efficiency.

Data can also help firms increase their products' value or decrease the associated costs. An example of the former is using consumer data to optimize product offerings (Campbell et al., 2015) and versioning (Bhargava and Choudhary, 2008), while the latter can be due, among others, to a reduction in search, replication, and transportation costs (Goldfarb and Tucker, 2019). All these effects point towards an increase in the vertical differentiation between firms if one has more data than the other. Our analysis shows that mandating data sharing reduces vertical differentiation, increasing competition and benefiting consumers. Sellers are better off as the gap between them and the platform is reduced, and platform profits increases as it can charge a higher fee.

The second strand of literature focuses instead on information sharing. Information sharing has been extensively studied in the literature: Raith (1996) describes a general model that summarizes many existing models, to show the determinants of when and how firms are incentivized to disclose private information. The recent literature on digital economics is also gaining interest with regard to information sharing, with particular attention on consumer data. Krämer and Schnurr (2022) focus on market contestability with regard to data-rich incumbents, and explore the possible effects of policy interventions such as data siloing, data sharing and data portability. Regarding to e-commerce, they stress the importance of sellers' data portability, as this policy would allow sellers to grow without having to lock-in on a specific platform. Prüfer and Schottmüller (2021) study competition in data-driven market where data reduce the cost of quality production. Their model shows how mandated data sharing does not reduce the dominant firm's incentive to innovate and also eliminates the risk of market tipping. Krämer and Shekhar (2022) expand on this topic by analyzing how the aforementioned policy interventions impact competition between platforms, modeling the effect of data as an improvement in the user experience on the platforms and allowing platforms to compete as well as set their investment levels. In particular, they show that mandated data sharing can reduce innovation investment by platforms, which in turn can hurt consumers when data externalities are large. De Corniere and Taylor (2020) analyze the effects of data sharing by using a competition in utilities approach, finding sufficient conditions under which data sharing would be unambiguously pro-competitive. Liu et al. (2021) focus instead on a retail platform that hosts sellers and can strategically disclose information to them: they find that the platform has the incentive to disclose information only to a subgroup of sellers. While our work focuses on an exogenous shock that mandates complete information sharing instead of allowing for a strategic decision by the platform, as far as we know we are the first to allow the platform to vertically integrate, entering the downstream market and competing with sellers.

Related to the vertical integration aspect of our model, the third strand of literature concerns the classical questions regarding access pricing and sabotage. Indeed, our model resembles the typical setup of an upstream monopolist that controls an infrastructure and can choose to integrate downstream. Economides (1998) shows how an integrated monopolist has the incentive to degrade the quality of the downstream input, as to raise the costs of its rivals until they are driven out of the market. Beard et al. (2001) expand on this topic by showing that the upstream monopolist is always willing to expand downstream, but has the incentive to sabotage only when input price regulation is introduced. Our model presents a similar result: the platform can strategically use the per-transaction fee to increase downstream costs, allowing it to better compete against sellers. Moreover, in the case of price discrimination with heterogeneous goods, the platform sets the fee such that sellers opt to price as monopolists, increasing surplus extraction from consumers and, in turn, the platform's profits.

Finally, the third strand of literature concerns hybrid marketplaces – platforms that allow transactions between sellers and buyers and where the platform can become a seller's competitor. This literature is becoming pivotal in policy discussion, as tech giants such as Amazon and Apple are themselves hybrid marketplaces. Empirical evidence suggests that the downstream entry of the platform, sometimes referred to as *dual mode*, usually takes place in successful markets and leads sellers to reduce their growth efforts in the platform (Zhu and Liu, 2018). Moreover, sellers tend to increase the prices in the markets where the platform enters, while shifting their innovation investments elsewhere (Wen and Zhu, 2019). In particular, evidence suggests that complementary goods become the focus of innovation, as the platform entry usually expands the demand for that good (Foerderer et al., 2018). From a theoretical perspective, the effects of a platform operating in dual mode are ambiguous. On the one hand, platform downstream entry could reduce sellers' market power and increase competition, benefiting consumers (Dryden et al., 2020; Etro, 2021a). Platform entry could also induce it to reduce its commission fees to further expand the market's reach (Etro, 2021b). On the other hand, a higher quality (or lower cost) of the platform's goods can incentivize it to increase its commission fees, ultimately harming consumers (Anderson and Bedre-Defolie, 2021). While our model assumes the presence of a hybrid marketplace, focusing instead on mandated data sharing, our results show that an increase in vertical differentiation by the platform leads indeed to an increase in the commission fee, which in turn can crowd out sellers.

3.3 Homogeneous goods

We consider a monopolistic platform which operates in dual mode, namely it intermediates between sellers and consumers while selling directly to consumers as well. We consider a mass of independent sellers ranked by their marginal costs of production c_s which we assume uniformly distributed between 0 and ∞. Each technology is allocated to only one seller, and each seller is a monopolist in his market. However, the platform can enter in a market where a seller is present. There is a unitary mass of consumers for every product space (namely for every seller) and consumers are uniformly distributed according to their willingness to pay $v \in [\underline{v}, \bar{v}]$ with $\underline{v} < \bar{v}$. Every consumer buys at most one unit of any given good.
Both the platform and sellers know the distribution of the willingness to pay but sellers cannot always price discriminate consumers. The platform intermediates between sellers and consumers by imposing a per-transaction fee f. Note how the platform sets a unique fee for all markets: our modeling choice is consistent with Amazon's practice of setting a specific fee per product group.[5] Our model thus aptly represents one of Amazon's product groups, which is composed of multiple sub-markets. Our analysis could be easily replicated in any one of Amazon product groups to find the optimal fee for each of them. Moreover, allowing the platform to operate fee discrimination within a product group would give it even more market power: our analysis thus describes a lower bound with respect to the welfare effects of the hybrid platform.

When the platform and a seller operate in the same product space, they compete in prices *à la Bertrand*. We assume that the platform is always able to serve customers with its products, thus it incurs a marginal production cost $c_p \in [0, \underline{v})$ which is equal across product spaces.[6]

[5]This type of fee is labeled by Amazon as a "referral fee": *Amazon charges a referral fee on each item sold. The amount varies depending on the product group.* See `https://sell.amazon.com/pricing#referral-fees`.

[6]The assumption of a single technology that the platform can use to produce every good allows us to generate asymmetries between the platform and the sellers. We are interested in analyzing a situation in which the platform could be more or less efficient than the relevant seller, depending on the sub-market they are operating in. One may argue that, for the model to be

Platform cost c_p is known by the platform and revealed to sellers when the platform enters their markets. In order to capture the fact that the platform exploits its data advantage for avoiding retail risk, we assume that the platform can produce good i only if seller i enters the market (joining the online marketplace).[7] In other words, we never consider the platform to be a monopolist on its marketplace for a given product space.

In line with the measures recently proposed by the Digital Markets Act (DMA), we focus our analysis on mandated data sharing, namely we do not let the platform to decide over its data sharing policy but it rather suffers a third-party decision on whether to share platform data with third-party sellers or not. We then compare the resulting outcomes with and without data sharing. As we observe in reality, data can serve several purposes and can improve seller efficiency in multiple ways, in our analysis we first consider data as a price discriminating tool and later as a cost reducing one.

The timing is the following:

1. The platform sets the per-transaction fee.

2. The platform selects which of the downstream markets to enter.

3. Price competition takes place.

The solution concept is the Sub-game Perfect Nash Equilibrium (SPNE).

3.3.1 Data allow price discrimination

We begin our analysis by considering data as an essential tool for price discrimination. In other words, if sellers can access data they are able to distinguish consumers and their actual willingness to pay, thus setting different prices. Otherwise, sellers set a unique price for all consumers. In our model, the platform always price discriminates since it enjoys all the data gathered on the marketplace. When the platform is forced to share its data, sellers price discriminate as well.

Platform data advantage (no data sharing)

Stage 1: Sellers are initially independent monopolists. After having observed the fee f set by the platform, they set prices in order to maximize their profits. Without data sharing, sellers know the distribution of consumers' willingness to pay but cannot tell what is the willingness to pay of each consumer, hence sellers set a unique price. Seller i sets p_{s_i} in order to maximize $\pi_{s_i} = (p_{s_i} - c_{s_i} - f)d(p_{s_i})$ where $d(p_{s_i}) = 1 - \frac{p_{s_i} - \underline{v}}{\bar{v} - \underline{v}}$. The optimal seller i's price without data sharing is $p^*_{s_i} = \frac{\bar{v} + c_{s_i} + f}{2}$ such that the seller serves a share $d(p^*_{s_i}) = \frac{\bar{v} - c_{s_i} - f}{2(\bar{v} - \underline{v})}$ of market i.

Stage 2: The platform decides for each product market i whether to operate as intermediary (*pure agency*) or to enter the product market, thus acting also as a first-party seller (*dual mode*). In the former case, the platform earns a fee f on every transaction which takes place in market i, thus earning a profit of $\Pi_i = fd(p^*_{s_i})$ in each market in which it operates in pure agency. In the latter one instead, the platform enters the market and sets the price of the final good strategically: we show that the platform has two pricing strategies: i) to compete à la Bertrand against the seller and win the market ii) to strategically lose the price competition by setting a price just above the rival's marginal costs. In what follows, we will refer to

realistic, the platform should face different technologies in each market: this assumption, though, allows us to keep the model as simple and clear as possible.

[7] See https://www.reuters.com/investigates/special-report/amazon-india-rigging/ and Madsen and Vellodi (2022)

the latter strategy as *constrained agency*, meaning that the platform still earns only the per-transaction fee f (platform profit from direct sales is still zero) but on a larger customer base. In fact, its price constrains the third-party seller's price at the competitive level.

Instead, under standard Bertrand competition the platform enjoys two revenue sources: the profit from intermediation and the one from direct sales. Which of the option prevails once the platform enters the market is the outcome that maximizes platform profit, which is formally defined as:

$$\Pi_i^D M = fd(p_{s_i}^{DM}) + (p_{p_i} - c_p)d(p_{p_i})$$

Stage 3: When the platform operates in *constrained agency*, it enters the market and loses the competition strategically. However, by doing so, it exerts competitive pressure on the seller's price. If the seller is more cost-efficient than the platform ($c_{s_i} < c_p$) it sets a price equal to $p_p = c_p$. Otherwise, the platform sets a price just above the marginal costs of the seller, so that the seller can always win the competition by setting a price equal to its own marginal costs $p_{s_i} = c_{s_i} + f$.

In the former case, given that $c_p < \underline{v}$ by assumption, the seller serves the entire market i and the platform earns $\Pi_i = f$, while in the latter case the seller serves $d(f + c_{s_i}) \leq 1$ and the platform earns $\Pi_i = fd(f + c_{s_i})$. Straightforward calculations prove that platform's profit under *constrained agency* is larger than the one under *pure agency* if $fd(p_{s_i}^*) < fd(f + c_{s_i})$ which is equivalent to:

$$f\left(\frac{\bar{v} - c_{s_i} - f}{2(\bar{v} - \underline{v})}\right) < f\left(\frac{\bar{v} - c_{s_i} - f}{(\bar{v} - \underline{v})}\right)$$

which holds as long as $c_{s_i} < \bar{v} - f$.

Notice that those markets in which this condition is satisfied are all the ones in which sellers are profitable. We define those markets as *active*. Indeed, if the maximum willingness to pay $\bar{v}$ was lower than the sellers' marginal cost, they would not make positive profits even as monopolists and they would not join the marketplace in the first place. It follows that in every market the platform prefers to enter rather than to operate as a pure intermediary.

Lemma 3.1. *In every active market, operating in pure agency is a dominated strategy for the platform, as entry allows it to earn strictly higher profits.*

The platform can win the Bertrand competition against the seller i only when it enjoys a lower marginal cost. Keeping in mind that i) the marginal costs of the sellers are endogenously determined by the fee set by the platform, but ii) the fee has already been set at the pricing stage, an efficient platform ($c_p < c_{s_i} + f$) can always set a price p_p equal to the seller's marginal costs and serve all the consumers with a willingness to pay $v \in [f + c_{s_i}, \bar{v} - f]$.[8] On top of this, using its data advantage, the platform can also fully extracts the surplus from those consumers with a low willingness to pay $v \in [\underline{v}, f + c_{s_i})$ and could not be served by the seller. Wrapping everything up, the profit of the platform in market i under Bertrand competition is:

$$\Pi_i^{DM} = (f + c_{s_i} - c_p)d(f + c_{s_i}) + \int_{\underline{v}}^{f + c_{s_i}} v\, dv \tag{3.1}$$

where the first element in equation (3.1) is the profit made by competing for the consumers that have a willingness to pay $v \geq c_{s_i} + f$, while the the second element represents the surplus extracted by the platform through price discrimination from the consumers that the seller in unable to serve.

[8]Note that $\bar{v} - f$ is the upper-bound for sellers' marginal cost given that those with more expensive technologies would never be profitable and do not join the marketplace in the first place.

Alternatively, the platform could potentially operate under *constrained agency*, setting its price just above the seller's marginal cost. As a result, the platform would not earn from selling downstream, but only via collecting per-transaction fees f. Moreover, given its data advantage, the platform could still extract surplus through price discrimination from the consumers that the seller is unable to serve.

One can see that Bertrand competition is superior to *constrained agency* when

$$(f + c_{s_i} - c_p)d(f + c_{s_i}) + \int_{\underline{v}}^{f+c_{s_i}} v\,dv \geq f d(f + c_{s_i}) + \int_{\underline{v}}^{f+c_{s_i}} v\,dv \tag{3.2}$$

which holds true for $c_{s_i} \geq c_p$.

Lemma 3.2. *In every active market i in which $c_{s_i} \geq c_p$, the platform compete à la Bertrand. Otherwise, the platform strategically loses the price competition and the seller sets $p_{s_i} = c_{s_i} + f$, and serves the entire market i.*

Platform total profit is defined as:

$$\Pi = \int_0^{c_p} f\,dc_{s_i} + \int_{c_p}^{\bar{v}-f} \left((f + c_{s_i} - c_p)d(f + c_{s_i}) + \int_{\underline{v}}^{f+c_{s_i}} v\,dv \right) dc_{s_i}, \tag{3.3}$$

where the first term represents the platform's profit from *constrained agency* while the second one captures the platform's profit from Bertrand competition. When sellers' marginal cost exceeds $\bar{v} - f$ they exit the marketplace since they cannot earn positive margins even with a monopoly price. Platform's total profit is concave in f since a fee increase would reduce the extensive margins (demand contraction) and increase the intensive ones (per-transaction revenues expansion), hence an interior solution for the optimal fee may exist.

Proposition 3.1. *The optimal fee is $f^* = c_p$, such that the platform is weakly more cost-efficient than every third-party seller.*

Proof. The result stems from standard profit-maximization of equation (3.3). □

Proposition 3.1 implies that each active seller makes zero profit, while consumer surplus is equal to:

$$CS = \int_0^{\bar{v}-c_p} \int_{c_p+c_{s_i}}^{\bar{v}} v - c_{s_i} - c_p\,dv\,dc_{s_i}$$

One can see that, with $f = f^*$, the marginal costs of the seller in any given market is $c_{s_i} + c_p$, which is always larger than or equal to c_p. This implies:

Proposition 3.2. *When data allow price discrimination, the equilibrium prices under no data sharing are the following. If $c_{s_i} \geq c_p$, the platform sets $p_p = c_p + c_{s_i} - \varepsilon$ and serves the entire market. If $c_{s_i} < c_p$, the platform sets $p_p = c_p + c_{s_i} + \varepsilon$ and strategically loses the price competition. The seller always sets $p_{s_i} = c_p + c_{s_i}$.*

Proof. Proposition 3.2 derives from using the optimal fee f^* in the results stated in Lemma 3.2. □

Propositions 3.1 and 3.2 describe the equilibrium of the game. In fact, i) if the platform is ex-ante more efficient than the seller ($c_p < c_{s_i}$), then $f = f^*$ implies that the platform always wins the price competition by charging $p_p = c_{si} + f^* = c_{si} + c_p$, which allows it to gain a net margin of c_s on every transaction. ii) If the seller is ex-ante more efficient than the platform ($c_p > c_{s_i}$), the latter enters the market and chooses to strategically lose the Bertrand competition, setting a price just above the seller's marginal costs

$p_p = c_{s_i} + c_p + \varepsilon$, with ε arbitrarily small. Hence, the platform loses the competition and earns only from intimidation. Because it faces no costs of production, the available margin is $f^* = c_p > c_{s_i}$. In both cases, the final price is $c_{s_i} + c_p$, meaning that there is no difference between the two strategies on the extensive margin.

Data sharing

When the platform is forced to share the gathered data, third party sellers can perfectly price discriminate consumers, namely they know the exact willingness to pay of each consumer in their market. Nevertheless, the presence of the platform in every market constrains sellers' pricing strategies such that prices are equal to marginal costs with and without data sharing.

Indeed, if sellers were monopolists, thanks to price discrimination they would serve a share $d(f + c_{s_i})$ in market i and the platform would make a *pure agency* profit of $\Pi_i = fd(f + c_{s_i})$.[9] If the platform operates in *constrained agency* instead, it would make at least the same profit; the platform decides to strategically lose and sets the price of its product equal to $p_p = f + c_{s_i} + \varepsilon$. In this way it forces the seller to set $p_{s_i} = f + c_{s_i}$ such that it earns a profit $\Pi_i = fd(f + c_{s_i})$, which is equal to the *pure agency* one.

The platform then does not have strong incentives to adopt *pure agency* and may decide to always enter its own marketplace as first-party seller. In this case, it is easy to see that pricing strategies are the same with or without data sharing. As a result, the number of active firms in the marketplace does not change after data sharing and sellers make zero profit despite their ability to price discriminate consumers. Hence, consumer surplus does not change after the policy.

Lemma 3.3. *When the platform decides to enter as first-party seller in every market after data sharing, equilibrium pricing strategies are identical to the case without data sharing.*

As mentioned before, the platform may also opt to act as intermediary in those markets in which sellers are more cost-efficient. In this case, although the platform makes the same profit of the case without data sharing and with data sharing when it always acts as first-party seller, efficient sellers ($c_{s_i} < c_p$) do not face any competitive pressure in their product market and are free to price discriminate consumers. It follows that: efficient sellers are better off, inefficient sellers are indifferent and consumers are worse off after policy implementation.

Lemma 3.4. *When the platform decides to act as intermediary in markets where it does not enjoy a cost advantage, sellers are able to price discriminate consumers.*

Given that the Platform is indifferent between *pure agency* and *constrained agency*, the condition that determines in which markets the platform operates in *dual mode* stays the same also after data sharing, namely $c_{s_i} > c_p$. The same applies to the cost threshold that determines seller entry in the marketplace which stays equal to $c_{s_i} = \bar{v} - f$.

Proposition 3.3. *When data allows price discrimination, if the platform decides to operate as intermediary in markets where $c_{s_i} < c_p$, data sharing makes: efficient sellers better off, inefficient sellers indifferent and consumers worse off, without affecting total welfare. Otherwise, data sharing is not effective since equilibrium prices and the equilibrium fee are unaltered.*

Proof. Proposition 3.3 derives from the discussion above. □

[9] A monopolist seller with data sharing serves every consumer with a willingness to pay higher than its marginal cost.

Given this result, one can see that a mandatory data sharing policy is unlikely to improve either consumer surplus or total welfare. The only change we observe is the increase in the profit of cost-efficient sellers to the detriment of consumers.
When data allows price discrimination, data sharing does not expand market entry as it does not make sellers more efficient. Therefore, in order to increase total welfare, competition should increase within existing markets but this is not possible given that platform and sellers already compete *à la Bertrand* without data sharing. In other words, data sharing cannot improve total welfare once perfect competition is in place. If any, data sharing tends to reduce the competitive pressure on efficient sellers, being highly detrimental for consumers.

3.3.2 Data allow cost reduction

We now turn to the case when data are used for reducing production costs. To keep the analysis simple, we assume that the platform enjoys a data advantage such that it has a marginal cost $c_p^{CR} = c_p(1-r)$, where $r \in [0,1]$ is exogenous. The data-driven cost advantage can be related to versioning (Bhargava and Choudhary, 2008), or to a reduction in replication and transportation costs (Goldfarb and Tucker, 2019).[10]
When the platform has to share its data, every seller i can lower its marginal cost by lowering their marginal cost from c_{s_i} to $c_{s_i}^{CR} = c_{s_i}(1-r)$.

Platform data advantage (no data sharing)

Stage 1 and **stage 2** of the game stay the same as in the previous price discrimination case and Lemma 3.1 holds also with data for cost reduction, while outcomes and their conditions change in **stage 3**.
The platform can undercut seller i only when it enjoys a lower marginal cost. It follows that in market i the platform prefers competing à la Bertrand than strategically losing the price competition when the following condition holds

$$(f + c_{s_i} - c_p^{CR})d(f + c_{s_i}) \geq f d(f + c_{s_i}). \tag{3.4}$$

Expression (3.4) holds when $c_{s_i} > c_p^{CR}$. Viceversa, keeping in mind that $c_p^{CR} \leq c_p < \underline{v}$, the platform operates in *constrained agency* and the seller serves the entire market.

Lemma 3.5. *In every active market i in which $c_{s_i} \geq c_p^{CR}$, the platform competes à la Bertrand. Otherwise, the platform strategically loses the price competition and the seller sets $p_{s_i} = c_{s_i} + f$, and serves the entire market i.*

Platform profit is defined as

$$\Pi = \int_0^{c_p^{CR}} f \, dc_{s_i} + \int_{c_p^{CR}}^{\bar{v}-f} (f + c_{s_i} - c_p^{CR})d(f + c_{s_i}) \, dc_{s_i} \tag{3.5}$$

Following the same maximization strategy as for price discrimination, we derive the optimal fee:

Proposition 3.4. *The optimal fee is $f^\dagger = c_p^{CR}$, such that the platform is weakly more cost-efficient than every third-party seller.*

Proof. The result stems from standard profit-maximization of equation (3.5). □

[10] To keep the model as simple as possible, we are thus assuming that the platform and the sellers are equally effective in using data to decrease their costs.

Using the optimal fee in the aggregate sellers' profits, one can see that

$$\Sigma\pi = \int_0^{c_p^{CR}} (c_{s_i} + c_p^{CR} - c_{s_i} - c_p^{CR})\, dc_{s_i} = 0 \tag{3.6}$$

and consumer surplus is

$$CS = \int_0^{\bar{v}-c_p^{CR}} \int_{c_p^{CR}+c_{s_i}}^{\bar{v}} (v - c_{s_i} - c_p^{CR})\, dv\, dc_{s_i} \tag{3.7}$$

Proposition 3.5. *When data allow cost reduction, the equilibrium prices under no data sharing are the following. If $c_{s_i} \geq c_p^{CR}$, the platform sets $p_p = c_p + c_{s_i} - \varepsilon$ and serves the entire market. If $c_{s_i} < c_p^{CR}$, the platform sets $p_p = c_p + c_{s_i} + \varepsilon$ and strategically loses the price competition. The seller always sets $p_{s_i} = c_p^{CR} + c_{s_i}$.*

Proof. Proposition 3.5 derives from using the optimal fee $f^\dagger$ in the results stated in Lemma 3.5. □

Data sharing

When data sharing is mandated, sellers reduce their marginal costs to $c_{s_i}^{CR} = c_{s_i}(1-r)$.

By the same logic as under no data sharing, it is trivial to observe that the platform would never operate in *pure agency.* Hence, upon entry, the platform has to decide whether to compete à la Bertrand or to adopt *constrained agency* strategy. The former is superior when

$$(f + c_{s_i}^{CR} - c_p^{CR})d(f + c_{s_i}^{CR}) \geq f d(f + c_{s_i}^{CR}), \tag{3.8}$$

which holds when $c_{s_i} > \frac{c_p^{CR}}{1-r} = c_p$.

Lemma 3.6. *In every active market i, the platform enters the market and operates in dual mode. Moreover, given the fee f, when $c_{s_i} \geq c_p$, the platform compete à la Bertrand. Otherwise, the platform strategically loses the price competition and the seller sets $p_{s_i} = c_{s_i}^{CR} + f$ and serves the entire market i.*

Lemma 3.6 simply states that, when data allow cost reduction, mandatory data sharing makes the platform decide to strategically lose (win) price competition in more (less) markets than in the case without data sharing.

The platform profit becomes

$$\Pi = \int_0^{c_p} f\, dc_{s_i} + \int_{c_p}^{\frac{\bar{v}-f^*}{1-r}} (f + c_{s_i}^{CR} - c_p^{CR})d(f + c_{s_i}^{CR})\, dc_{s_i} \tag{3.9}$$

Proposition 3.6. *The optimal fee is $f^\dagger = c_p^{CR}$, such that the platform is weakly more cost-efficient than every third-party seller.*

Proof. The result stems from standard profit-maximization of equation (3.9). □

Using f^* in the sellers' payoff, one can see that the aggregate sellers' profits are

$$\Sigma\pi = \int_0^{c_p} (c_{s_i}^{CR} + c_p^{CR} - c_{s_i}^{CR} - c_p^{CR})\, dc_{s_i} = 0 \tag{3.10}$$

while consumer surplus is

$$CS = \int_0^{\frac{\bar{v}-c_p^{CR}}{1-r}} \int_{c_p^{CR}+c_{s_i}}^{\bar{v}} (v - c_{s_i}^{CR} - c_p^{CR})\, dv\, dc_{s_i} \tag{3.11}$$

It follows that:

Proposition 3.7. *When data allow cost reduction, the equilibrium prices under mandated data sharing are the following. If $c_{s_i} \geq c_p$, the platform sets $p_p = c_p^{CR} + c_{s_i}^{CR} - \varepsilon$ and serves the entire market. If $c_{s_i} < c_p$, the platform sets $p_p = c_p^{CR} + c_{s_i} + \varepsilon$ and strategically loses the price competition. The seller always sets $p_{s_i} = c_p^{CR} + c_{s_i}^{CR}$.*

Proof. Proposition 3.7 derives from using the optimal fee $f^\dagger$ in the results stated in Lemma 3.6. □

Data sharing expands the cost threshold for seller entry from $\bar{v} - f^*$ to $\frac{\bar{v}-f^*}{1-r}$, which increases with the share of cost reduction r. New sellers that join the marketplace are less efficient than the platform and therefore make zero profits. Nevertheless, sellers' entry also allows consumers that would have stayed out of the market without data sharing to make transactions. Therefore, consumer surplus increases as a result of the increased number of active markets. On top of that, data sharing also implies a generalized reduction of prices. Indeed, one can see that, in the already existing markets i with $c_{s_i} \in [0, \bar{v} - c_p^{CR}]$, the price level decreases by $c_{s_i} r$. This price effect entails a second positive effect of data sharing on consumer surplus
By taking the difference between the consumer surplus with and without data sharing we get:

$$\Delta CS = \frac{(\bar{v} - \underline{v})(\bar{v} - c_p^{CR})(\underline{v} - c_p^{CR})r}{2(1-r)} > 0$$

Although the platform makes smaller profits in every market i with $c_{s_i} \in [0, \bar{v} - c_p^{CR}]$, the demand expansion entailed by data sharing more than compensate the loss in per- transaction margins in each market. Formally, the difference between the platform profits with and without data sharing writes as:

$$\Delta \Pi = \frac{r\bar{v}^2}{2(1-r)} - r^2(\bar{v} + c_p^{CR}) > 0 \quad \forall\ 0 < r \leq 1$$

Define the (utilitarian) social welfare as the sum of aggregate profits and consumer surplus. Because sellers are unaffected by mandated data sharing, while consumers and the platform are strictly better off, it is trivial to observe that the effect of data sharing on social welfare is positive.

Proposition 3.8. *Mandated data sharing is welfare-enhancing and never harms consumers. Moreover, sellers are unaffected by the policy while the platform strictly benefits from it.*

Proof. Results derived from the discussion above. □

3.4 Differentiated goods

The analysis of competition with homogeneous goods captures some interesting features of the platform economy. Indeed, on platforms like Amazon Marketplace, in many product categories, sellers offer the same identical good to many consumers and compete for prominence (e.g., to appear in the Amazon *buy box*). To do so, they engage in Bertrand-like price competition, trying to increase their quality-price ratio (Ciotti and Madio, 2022).

However, digital marketplaces are also populated by sellers and buyers who offer and demand different varieties of given goods. When consumers' demand for variety is high, the substitutability between different producers decreases, and competition softens (Hagiu, 2009).

In this section, we replicate the analysis by adopting a different model specification. By doing so, we aim to further investigate the strategic interaction between the platform and sellers when consumers have heterogeneous valuations of the goods offered in the market.

We show that, in this framework, data-sharing may indeed have anti-competitive effects (it harms consumers) if data allow price discrimination, or it may harm some sellers if data allow cost reduction. In general, data sharing is welfare improving, but not in the sense of Pareto.

Moreover, and noteworthy, we emphasize that data sharing can be harmful to the economic agents it is originally intended to favor (consumers and sellers), whereas it always benefits the platform.

Model set up. Consider a digital marketplace owned by a platform. The marketplace groups together a unit mass of markets denoted by $\mathcal{I}$. In each market $i \in \mathcal{I}$, a seller (s^i) and the platform (p) compete in prices for horizontally differentiated goods. In what follows, we will sometimes refer to the seller and the platform together as to *firms*.

We assume that in each market there is a continuum of consumers uniformly distributed on the $[0-1]$ Hotelling line. They consume at most one unit of either the good sold by the seller or the one sold by the platform. A consumer located in $x \in [0,1]$ derives constant utility $u > 1$ from consuming either of the two goods and pays a price p_k, where $k = s, p$. Also, she suffers a mismatch disutility $t|z_k - x|$ from consuming a variety that is not her favorite one, where $t > 0$ is the transportation cost, and z_k is the location of the variety consumed ($z_s = 0$ and $z_p = 1$). Throughout the model, we assume that t is sufficiently large so that no firm can under any circumstance cover the entire market alone. In each market i, the consumers' utility functions are:

$$\begin{aligned} U_s^i &= u - p_s^i - t\,x \\ U_p^i &= u - p_p^i - t(1-x) \\ U_{no}^i &= 0 \end{aligned}$$

where the subscript $_{no}$ stands for *no consumption*.

In any market $i \in \mathcal{I}$, the seller and the platform compete in prices and sell two varieties of one good. We assume production does not involve any fixed cost, but the seller active in i produces at a marginal cost $c_s^i \in [0,1]$. Instead, the platform produces all final goods at the same constant marginal cost $c_p \in [0,1]$. Similarly to the model with homogeneous goods, we assume that sellers are heterogeneous in their cost of productions ($c_s^i \neq c_s^{-i}$). Moreover, c_s^i is uniformly distributed between 0 and 1, and each technology is allocated to only one seller. In other words, we can map each technology c_s^i to a market i.

In addition to the marginal costs of production, all sellers have to pay the same per-transaction fee $f > 0$ to the platform in order to sell on the marketplace. Consequently, the payoffs of the two firms are:

$$\pi_s^i = D_s^i(p_s^i - c_s^i - f), \qquad \pi_p^i = D_p^i(p_p^i - c_p) + D_s^i\, f$$

where D_k^i indicates the demand of each firm $k = s, p$ in market i and includes all consumers who derive larger utility from consuming the good produced by k than by $-k$ or than not consuming at all. Notice that the platform earns revenues from per-transaction fees paid by the seller.

In each market, the seller must earn net revenues to stay active. It must set a price that is at least as high as the marginal costs of production, which are determined by the cost parameter c_s^i and, crucially, by the fee f set by the platform. By adjusting f, the platform can alter the price of the seller and the market demands, which are determined by the locations of the indifferent consumers.

Market configurations. Three possible market configurations may emerge. First, the locations of the consumers indifferent between buying from either the platform or the seller and not buying at all are such that $\tilde{x}_{s,no} > \tilde{x}_{p,no}$. In this case, keeping in mind that the location of the two firms are $z_s = 0$ and $z_p = 1$, there exists a consumer $\tilde{x}_{s,p} \in (\tilde{x}_{s,no}, \tilde{x}_{p,no})$ who is indifferent between buying from the seller or the platform and derives positive utility in both cases. This is the standard Hotelling duopoly (hd) case with full market coverage. Firms compete in the product market and prices are strategic complements.

Second, the locations of the indifferent consumers are such that $\tilde{x}_{s,no} < \tilde{x}_{p,no}$. In this case, consumers located in $x \in (\tilde{x}_{s,no}, \tilde{x}_{p,no})$ prefers not buying at all and the market is not covered. This is the local monopolies scenario (lm), in which firms do not compete against each other and prices are not set strategically.

Finally, the locations of the consumers indifferent between buying from firm i and not buying at all are such that $\tilde{x}_{s,no} = \tilde{x}_{p,no} = \tilde{x}_{s,p}$. In other words, there exists a range of values of v such that the platform and the seller can achieve higher profits by pricing like monopolists, while the market is fully covered. This scenario is referred in the literature as *monopolistic duopoly* (md) case (Thépot, 2007; Bacchiega et al., 2021). Prices are strategic substitutes and firms adjust them strategically to ensure the market is just covered. Differently from the Hotelling duopoly market configuration, in this one, the indifferent consumer derives zero utility from consuming either goods.

The timing of the game is the following: $t = 0$) the policy maker introduces a data-sharing policy. If there is no data-sharing, the platform uses data exclusively. Otherwise, all sellers can also use data. $t = 1$) the platform sets a single per-unit linear fee which is the same in all markets. All sellers have to pay it to be allowed to sell their goods on the marketplace. $t = 2$) Given the fee f, sellers and the platform set prices simultaneously in each market. If data allow the data owners to price discriminate consumers, as they know their exact locations on the Hotelling line, we model price competition as in Montes et al., 2019, and Bounie et al., 2021, among others.[11] $t = 3$) Consumers observe the prices and decide if and what they consume.[12] The solution concept is Subgame Perfect Nash Equilibrium, and the game is solved by backward induction.

For sake of clarity, in what follows, we will omit the apex ^{i} when doing so does not create confusion.

3.4.1 Data allow price discrimination

Consider any given market i. Data ownership allows the platform to operate first-degree price discrimination to all consumers. The price set by the uninformed seller is uniform for all consumers, while the platform can offer tailored prices to each consumer.

We model tailored prices as the prices that make consumers indifferent between buying from the platform and the best available alternative option (i.e., buying from the seller at a uniform price or not buying at all):

$$p_p^{TC}(x) = p_s - t + 2tx, \qquad p_p^{TM}(x) = u + tx - t,$$

[11] When the platform holds information about consumers' location, but the sellers don't, a well-known problem is the existence of a pure strategy Bertrand-Nash equilibrium (see Rhodes and Zhou, 2022, p.25). In order to ensure equilibrium existence, we assume that personalized price schedules are set only after uniform prices are set. Consistently, Amazon allegedly shows higher prices to Amazon Prime subscribers but compensates them with discounted services such as free shipping. See `https://www.consumeraffairs.com/news/lawsuit-alleges-amazon-charges-prime-members-for-free-shipping-031414.html`

[12] Consistently with the literature, we assume consumers do not observe more than one price per firm. In other words, if a consumer observes personalized price by a firm, she cannot compare it with a uniform price by the same firm.

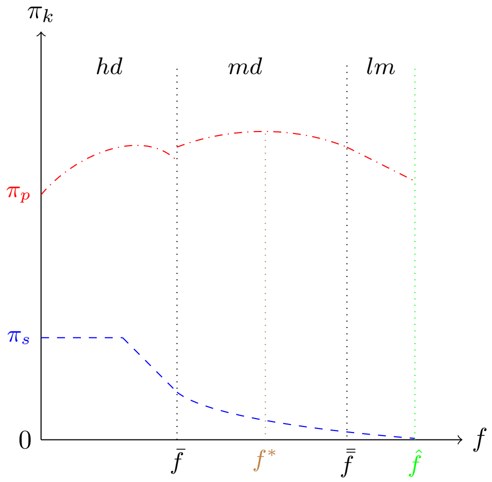

Figure 3.1: The equilibrium market configuration. $\forall\ c_s^i, c_p \in [0,1]$ the optimal platform sets a fee f^* such that firms act as monopolistic duopoly (md). The red dashdotted curve is the profit function of the platform, whereas the blue dashed curve is the profit function of the seller. Thresholds $\bar{f}$ and $\bar{\bar{f}}$ sort between Hotelling duopoly (hd) and monopolistic duopoly, and between monopolistic duopoly and local monopolies (lm), respectively. Above $\hat{f}$ the seller leaves the market.

The apex ^{TC} stands for *Tailored under Competition*, suggesting a price that makes the consumer indifferent between buying from p or s. Instead, the apex ^{TM} indicates a price *Tailored under Monopoly* that makes the consumer indifferent between buying from the platform or not buying at all. We relegate all mathematical steps and proofs to the Appendix.

Platform data advantage (no data sharing)

First, suppose that data sharing is not mandated, and thus only the platform can operate first-degree price discrimination. The platform offers a price schedule $p_p(x)$. Hence, in any given market i its payoff function adjusts as follows:

$$\pi_p^i(f) = \begin{cases} \int_{\tilde{x}_{s,p}}^{\tilde{x}_{s,no}} \ p_p^{TC}(x) - c_p\, dx + \int_{\tilde{x}_{s,no}}^{1} \ p_p^{TM}(x) - c_p\, dx + D_s^i\, f & \text{if} \quad \tilde{x}_{s,p}^i \geq \tilde{x}_{p,no}^i \\ \int_{\tilde{x}_{p,no}}^{1} \ p_p^{TM}(x) - c_p\, dx + D_s^i\, f & \text{if} \quad \tilde{x}_{s,p}^i < \tilde{x}_{p,no}^i \end{cases} \tag{3.12}$$

Equation (3.12) shows that the platform surplus extraction crucially depends on whether the targeted consumer does or does not consider purchasing both goods. Indeed, a consumer located after $\tilde{x}_{s,no}^i$ would never purchase the good from the seller. Hence, the platform sets a tailored price that extracts all of the consumer's surplus. Instead, a consumer who is located before $\tilde{x}_{s,no}^i$, would compare the prices of the two firms and consume accordingly. Thus, the platform's ability to extract surplus is limited by the presence of the rival.

The platform operates in all markets. Hence, its aggregate profit function can be written as

$$\Pi_p = \int_0^1 \pi_p^i(f)\, dc_s^i$$

As mentioned above, depending on the size of f, which is given at the pricing stage, the two firms can be competing in a Hotelling duopoly, a monopolistic duopoly, or they can operate as local monopolies. In the Appendix, we identify the cut-off values of f such that the different market configurations emerge, and solve the game under each configuration them to derive the equilibrium in every market. Moreover, we prove that:

Proposition 3.9. *Assume there is no data sharing. The platform set a fee*

$$f^* = \frac{2(u + 2(t + c_p))) - 3}{10}$$

such that the equilibrium market configuration is monopolistic duopoly (md) in every market i. The prices are:

$$p_s^i = \frac{u + c_s^i + f^*}{2}; \quad p_p^i(x) = \frac{u + c_s^i + f^* + 2t(2x-1)}{2}$$

Proof. See the Appendix. □

The intuition for the result is the following: on the one hand, the platform wants to set a high fee to extract more profits from the seller, while on the other hand, a fee too high would result in some consumers not buying any good. By setting a fee such that all markets fall under the monopolistic duopoly case, the platform achieves three results: i) it extracts all surplus from its captive consumers, ii) it softens competition by charging monopoly pricing, and iii) it ensures that every market is fully covered.

Figure 3.1 illustrates the main result in Proposition 3.9. The cut-off value $\bar{f}$, which is depends on c_p and c_s^i, represents the level of fee such that, if $f = \bar{f}$, the seller is indifferent between reacting competitively to the price schedule of the platform or charging a monopoly price. Noteworthy, this is not the same threshold that makes the platform indifferent between competitive and monopoly pricing. Thus, in equilibrium, platform profits exhibit a discontinuity at $\bar{f}$.

Data sharing

Consider now data sharing is mandated so that sellers can also operate first-degree price discrimination. Depending on the market configuration, we can sort consumers into three groups. The first one includes those consumers that can only be profitably targeted by the seller. Consequently, the seller offers them its tailored price $p_s^{TM}(x)$ end extracts all the surplus from them. Similarly, the second group includes those consumers that can only be profitably targeted by the platform. To them, the platform offers a tailored price $p_p^{TMk}(x)$. Finally, the third group includes those consumers who can be reached by both the seller and the platform, and are thus contested. Since both firms can price discriminate, they can technically compete *à la Bertrand* for each consumer of the third group. To do so, they set a tailored price $p_k^{TC}(x)$.

The intense competition to *conquer* contested consumers generates ambiguous incentives on the platform. Because of the transportation costs, the firms have to offer consumers prices that are decreasing in the preference mismatch (i.e., the distance between consumers and firms' locations). However, the platform earns f from every consumer who purchases the seller's variety. Consequently, the platform may adopt sophisticated pricing strategies to *regulate* competition with the seller for consumers in the third group (i.e., contestable ones). More in detail, the platform may not be able to extract at least $c_p + f$ via personalized pricing from consumers whose preferred variety is sufficiently far from variety p. In this case, allowing the seller to serve those consumers may be the most profitable choice.

To understand this seemingly counterintuitive result, consider a platform with a marginal cost c_p. If there exist some consumers who are contested, then the platform's standard strategy is to offer $p_p^{TC}(x)$ and undercut the rival. However, if $p_p^{TC}(x) < c_p + f$, the net revenues the platform earns from winning the price competition is $p_p^{TC}(x) - c_p < f$. Instead, by giving up those consumers and allowing the seller to serve them, the platform earns f without producing anything (no costs involved). This strategy is similar, but not equal, to the *constrained agency* strategy highlighted in the model for homogeneous goods. In both cases, the platform prefers strategically losing price competition because it is more efficient to let the seller serve

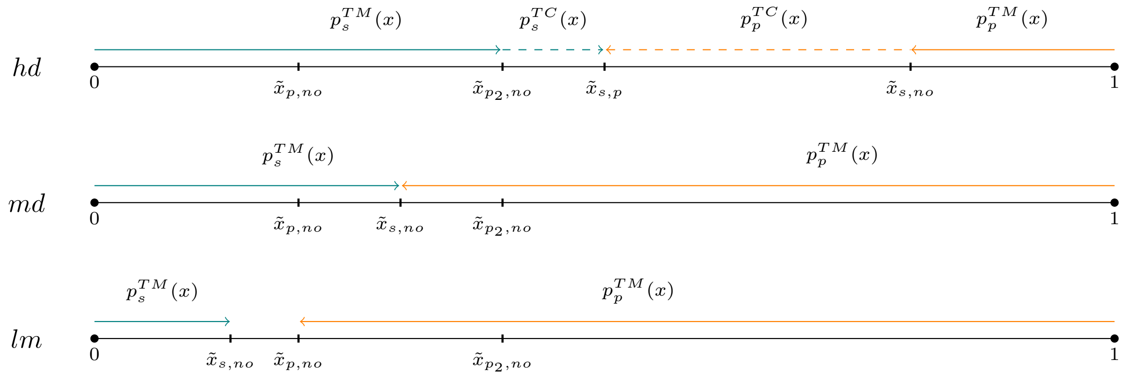

Figure 3.2: Market configuration and pricing strategies. When $f > \bar{\bar{f}}_{ds}$, firms are local monopolies (lm). If $f \in [\bar{f}_{ds}, \bar{\bar{f}}_{ds}]$, firms operate in monopolistic duopoly. Finally, if $f < \bar{f}_{ds}$, firms compete in a Hotelling duopoly. For illustrative reasons, the diagram shows the case $c_p = c_s^i$.

the market. The main difference, however, is that in this case, the platform does not *contrain* the seller's pricing strategy to the marginal cost of production. Instead, by giving up the competition, it allows the seller to fully extract the surplus from those consumers.

Obviously, giving up the price competition is a viable option if and only if those consumers are contested (third group). Otherwise, if they cannot be profitably targeted by the seller, the platform earns nothing from not offering them a tailored price. We define $\tilde{x}_{p_2,no} > \tilde{x}_{p,no}$ the location of the last contested consumer that the platform can conquer with a price $c_p + f$. Figure 3.2 describes graphically the combination of market configuration and pricing strategies of the two firms.

In the Appendix, we identify the cut-off values of f such that the different market configurations emerge, and solve the game under each configuration to derive the equilibrium in every market. Moreover, we prove that:

Proposition 3.10. *Assume there is data sharing. The platform sets a fee*

$$f_{ds}^{*} = \frac{3u - t - c_p - 1}{3}$$

such that the equilibrium market configuration is monopolistic duopoly (md) in every market i. The equilibrium prices are:

$$p_s^{TM}(x) = u - t\,x \qquad p_p^{TM}(x) = u - t(1 - x);$$

Proof. See the Appendix. □

Corollary 1. *The platform strategically gives up competition for consumers located in $x^i \in [\tilde{x}^i_{p,no}, \tilde{x}^i_{s,no}]$. It does so because the transaction fee earned by allowing the seller to serve those consumers is larger than the surplus the platform could directly extract through personalized pricing.*

Proof. The proof of Corollary 1 stems from the following considerations. First, define $\tilde{x}_{p_2,no}$ as the last consumer from whom the platform can extract at least $c_p + f$. This consumer is necessarily closer to the platform than the consumer in $\tilde{x}_{p,no}$, by construction. It follows that, if the consumer indifferent between the seller's good and the zero payoff is located in $\tilde{x}_{s,no} \in [\tilde{x}_{p,no}; \tilde{x}_{p_2,no}]$, then the platform earns $f > p_p^{TC}(x \in [\tilde{x}_{p,no}, \tilde{x}_{s,no}]) - c_p$ by renouncing to compete. □

The intuition behind the results stated in Proposition 3.10 and Corollary 1 resembles the one described for the scenario with no data sharing: the platform can maximize its profits by ensuring full market coverage while simultaneously softening competition with the seller. As to the equilibrium fee, we find that f_{ds}^* can be lower or higher than f^*, depending on the parameters. In particular, when c_p is relatively low, the platform can serve most of the consumers in all markets. If this is the case and given the efficiency of the seller, the platform can strategically set a larger fee to raise its rival costs, without uncovering the market. Instead, if c_p is relatively high, the platform may not be able to cover a large section of the market. Lowering the fee enables the sellers to serve more consumers and allows the platform to keep earning revenues from all consumers in the market. One may also notice that, due to data sharing, the equilibrium fee decreases faster in c_p than without data sharing. Indeed, data allow the sellers to price more efficiently and to cover larger sections of the market.

Finally, from a welfare perspective, we find that:

Proposition 3.11. *Data sharing exerts a negative effect on consumers, who are strictly worse off, and a positive effect on firms' payoffs, which strictly increase. Total welfare increases as the latter effect dominates the former.*

Proof. See the Appendix. □

Proposition 3.11 states that all consumers are worse off under mandated data sharing, whereas firms are better off. On the one hand, the platform can extract more profits through the per-unit fee, while still using it to avoid direct competition with sellers. On the other hand, sellers become more efficient in extracting surplus and thus enjoy higher profits. Instead, all consumers obtain zero surplus in equilibrium. In fact, by controlling the fee, the platform sets up a monopolistic duopoly with the seller, and both of them can perfectly extract surplus through price discrimination, leaving consumers with no residual utility. This result is novel in the literature. Most models stemming from Thisse and Vives (1988) seminal work highlight how allowing both competitors to price discriminate leads to price wars, which largely benefit consumers. Interestingly, we show that, by strategically using the fee, the platform can avoid price wars altogether, leading to a fully covered market under monopolistic pricing.

3.4.2 Data allow cost reduction

Let us now turn to the case where data allow firms to produce the final good more efficiently. We impose the following modification to the model presented in the previous section: 1) The cost of the platform is given by $c_p^{CR} = c_p(1-r)$, where $r \in [0,1]$ indicates the intensity of the cost-reducing effect of data. 2) There is no price discrimination, meaning that both the sellers and the platform, in each market, set a single price for their goods. 3) Data sharing allows the seller to produce the final good at a reduced cost $c_s^{i,CR} = c_s^i(1-r)$ in all markets

Platform data advantage (no data sharing)

First, consider the scenario where the platform does not share its database with sellers. In all markets, it produces the final good at a marginal cost $c_p^{CR} \in [0,1]$. Hence, the platform has a data advantage, as it can exploit the cost-reducing potential of data exclusively. The two strategic variables that the platform chooses are the transaction fee (linear per unit) that applies to all sellers and is the same across all markets, as well as the market-specific price. Instead, sellers only decide the market-specific price of their final goods. We relegate all mathematical steps and proofs to the appendix. The model solves as a standard Hotelling game.

In the appendix we prove the following proposition:

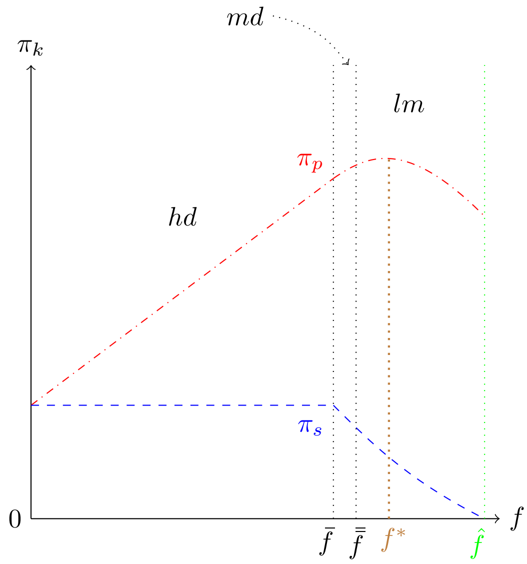

Figure 3.3: The equilibrium market configuration. $\forall\ c_s,\ c_p,\ r \in (0,1)$ the optimal platform sets a fee that is such that firms act as local monopoly (lm). The red dashdotted curve is the profit function of the platform, whereas the blue dashed curve is the profit function of the seller. Thresholds $\bar{f}$ and $\bar{\bar{f}}$ sort between Hotelling duopoly (hd) and monopolistic duopoly, and between monopolistic duopoly and local monopolies (lm), respectively. Above $\hat{f}$ the seller leaves the market. For illustrative reasons, the graph shows the case $c_p(1-r) = c_s$.

Proposition 3.12. *Assume there is no data sharing. The platform set a fee*

$$f^\dagger = \frac{2u-1}{4}$$

such that the equilibrium market configuration is local monopolies (lm) in every market i. The equilibrium prices are:

$$p_s^i = \frac{u + c_s^i + f^\dagger}{2} \qquad p_p^i = \frac{u + c_p^{CR}}{2};$$

Proof. See the Appendix. □

Proposition 3.12 shows that an interior optimal f always exists and it is located in the region where the market is only partially covered and firms are local monopolies. This result is graphically illustrated in Figure 3.3. The intuition behind it is the following: if the market is fully covered (hd), the firms compete in prices and the seller transfers its entire marginal costs to the consumers via pricing. This includes also the per-unit transaction fee that sellers must pay to the platform. Consequently, the platform has the incentive to raise the fee, at least to the point when the market starts uncovering. This is the well-known *increase rival's costs* strategy. Because prices are strategic complements, the platform can increase the fee (hence earning larger revenues from intermediation) as well as its price (hence earning larger profits from direct sales).

However, the seller cannot keep transferring the fee to consumers indefinitely, as they have a limited willingness to pay for the two goods. In particular, median consumers who suffer the highest utility loss from preference mismatch would eventually decide not to purchase any good if the prices go above their consumption value, net of the transportation costs. We define $\bar{f}$ as the value of the fee above which the pricing strategy described here stops working.

Above $\bar{f}$, the platform needs to adjust its price in order to prevent the market from uncovering. As charging a larger fee implies that the seller increases its price, the platform has to lower react strategically by lowering its own price. By doing so, the platform ensures that the consumers left over by the seller due to high prices do not abandon the market. This pricing strategy can be sustained up to the point when the platform finds lowering the price less profitable than allowing some consumers to abandon the market, which occurs when $f > \bar{\bar{f}}$.

Finally, above $\bar{\bar{f}}$, the two firms are local monopolies. In this region, increasing the fee has two opposite effects on the revenues from intermediation: on the one hand, it raises the intensive margin (the platform earns more per transaction); on the other hand, increasing the fee decreases the extensive margin (less consumers purchase from the sellers in each market). There exists a level $f^{\dagger}$ above which the negative effect on the extensive margin dominates the positive effect on the intensive margin.

One may notice that this setting resembles the problem of horizontal licensing of a process innovation (or technology transfer) as illustrated by Kabiraj and Lee (2011), among others. However there is one main difference that is worth mentioning. In the literature on licensing, the size of the royalty (f in our setting) is set so that the market is fully covered. Indeed, because it is impossible to find a royalty rate that simultaneously i) satisfy the conditions of partial market coverage, ii) it is profitable for the licensor, and iii) it is profitable for the licensee, the equilibrium royalty must be the highest one such that, in equilibrium, all consumers purchase a unit of one good.

In our setting, however, the seller pays the fee to be active on the platform, not to get the cost-reducing data. In other words, it is as the platform was licensing a fundamental input, not a non-drastic innovation. Hence, the exit option for the seller is the zero payoff, which strongly relaxes condition iii) above. As a result, a fee that implies local monopolies can be an equilibrium and, in fact, it turns out to be the only equilibrium of the game.

Data sharing

Assume now a policy maker imposes data sharing so that the platform has to hand over its database to all sellers in each market. The marginal cost function of the seller in market i becomes $c_s^{i,CR}$, as it is now able to improve its efficiency using the cost-reducing effect of data. The payoffs of the two firms in each market (dropping ^{k} for simplicity) are:

$$\begin{aligned}\pi_s^{ds} &= D_s(\tilde{x})\,(p_s - c_s(1-r) - f)\\ \pi_p^{ds} &= D_p(\tilde{x})(p_p - c_p(1-r)) + D_s(\tilde{x})\,f\end{aligned}$$

The game solves as in the case with no data sharing with only one main novelty: because sellers are more efficient on average, the platform needs to increase the fee to sustain local monopolies - i.e., it is harder, everything else being equal, to uncover the market if the rival is more efficient. In the appendix we prove that:

Proposition 3.13. *Assume there is data sharing. The platform set a fee*

$$f_{ds}^{\dagger} = \frac{2u - 1 + r}{4}$$

such that the equilibrium market configuration is local monopolies (lm) in every market i. The equilibrium prices are:

$$p_s^i = \frac{u + c_s^{i,CR} + f_{ds}^{\dagger}}{2} \qquad p_p^i = \frac{u + c_p^{CR}}{2};$$

Proof. See the Appendix. □

Both the seller and the platform are better off by sharing cost-reducing data. Intuitively, the sellers obtain a better technology (except for the seller producing at $c_s = 0$), which has a clear positive effect on their payoffs. The platform too benefits from sharing data. In fact, because it is always able to set a fee that ensures each market is never covered, it never suffers from competing against a more efficient rival.

Because sellers are more efficient, the platform has to charge a larger fee to ensure there is no competition between itself and the sellers.

Also, by raising the fee, the platform can increase the rent extraction from the sellers without altering too much the number of goods traded in the market. As a consequence, both the platform and the sellers are better off in aggregate.

From a social perspective, because data sharing lowers the monopoly price set by each seller in all markets, the effect on consumer surplus is positive. Together with the positive effects on aggregate profits, it implies that data sharing is welfare-improving. Not all sellers are better off, however. Those sellers that are ex-ante very efficient (c_s very low) obtain very small benefits from data sharing but have to pay a disproportionately larger fee. Indeed, the larger the cost-reducing effect of data, the more severely efficient sellers are hurt by data sharing. Similarly, if the cost-reducing potential of data is limited, also very inefficient sellers are negatively affected by data-sharing. In their case, the cost-reducing effect may be insufficient to compensate for the increase in the fee.

Their losses are compensated by the benefits of other sellers.

Proposition 3.14. *Data sharing benefits sellers that are ex-ante moderately efficient* ($\min\left\{\frac{4u+2-r}{8-4r}, 1\right\} > c_s^i > \frac{1}{4}$)*. Instead, data sharing always hurts ex-ante efficient sellers* ($c_s^i < \frac{1}{4}$)*. Moreover, if* $r \in \left(0, \frac{6-4u}{3}\right]$*, very inefficient sellers* ($c_s^i \in \left[\frac{4u+2-r}{8-4r}, 1\right]$) *are also hurt by data sharing.*

Proof. See the Appendix. □

3.5 Discussion and conclusions

Consumer data are becoming an essential input in the digital economy. In particular hybrid marketplaces can collect vast amounts of data, transform them into valuable information and then use them to compete against the sellers they host. In this work, we investigate the effect of a mandated data sharing policy on market outcomes across different data functionalities (price discrimination and cost reduction) and different market structures (perfect and imperfect competition).

The previous literature (Prüfer and Schottmüller, 2021; Krämer and Shekhar, 2022) has focused on the effects that mandated data sharing can have on platforms' incentives to innovate, highlighting how the effect on consumer surplus can be either positive or negative depending on the model's characteristics. When data enables price discrimination, allowing all firms to obtain them usually benefits consumers, as firms engage in price wars (see Montes et al. (2019), Bounie et al. (2021), and Abrardi et al. (2022) among others). However, as far as we know, we are the first to analyze the effects of mandated data sharing when the platform can compete with downstream sellers.

We find that mandated data sharing has no effects on welfare if data can be used to price discriminate consumers who buy homogeneous goods. Indeed, we show that the platform sets a per-transaction fee that makes all sellers less efficient than the platform itself. Hence, with or without data, the sellers can only set a price equal to their marginal costs and cannot exploit consumers' data. The platform may also decide to operate as an intermediary in some markets, leaving some sellers without competitive pressure and free to

perfectly price-discriminate consumers.
Instead, mandated sharing of cost-reducing data improves welfare by lowering the average price in the markets. Sellers are unaffected, as price competition drives profits to zero, but the platform is better off as more market coverage, and in turn revenues from intermediation, increase.

When goods are horizontally differentiated, data sharing (with price discrimination) may instead negatively affect consumers. The reason is that the platform can avoid data-induced price wars by setting a high per-transaction fee, which incentivizes sellers to set monopolistic prices, even when a market is fully covered. By avoiding downstream competition, both the sellers and the platform can use data-enabled price discrimination to extract higher surplus from consumers, leaving them worse off.

On the other hand, when data allow cost reduction, consumers are better off and total welfare increases. Interestingly, although the aggregate effect on sellers is positive, sellers are heterogeneously affected by mandated data sharing. In particular, efficient sellers have little gains from the cost-reducing data but suffer from the generalized increase in transaction fees, while inefficient sellers are not able to compensate their high marginal costs in order to have an advantage over the platform. Those sellers which are mildly efficient are the only ones benefiting by a cost-reducing data sharing.
These results highlight the complexity of the effects of a mandated data sharing policy, as they are ambiguous and hard to predict. Indeed, we argue that in markets where competition is softer, mandatory data sharing may damage the very agents it is intended to protect, namely consumers and (efficient) sellers. Similarly, even when perfect competition is in place, mandated data sharing may push the platform to not enter the market, thus removing every competitive constraint from sellers which can then perfectly price discriminate consumers, bringing their net utility to zero.

Turning to platform profits, our analysis shows that they increase under data sharing. Then, a question naturally arises: if platforms unambiguously benefit from data sharing, why should a policymaker mandate it? We interpret this seemingly paradoxical result as the consequences of hidden costs we fail to model. Data sharing does not consist of a mere transfer of a file via email, but it entails investments in interoperability between sellers and buyers. Those costs could be non-negligible and could also entail competitive risks for the platform, as data sharing could stimulate entry by new platforms, exerting potential negative pressure on the incumbent. Indeed, the recitals of the DMA place market contestability among the important goals of the act. Further research is thus needed to better analyze these additional characteristics.

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3.A Appendix

3.A.1 Price discrimination with differentiated goods

Proof of Proposition 3.9. To solve the model, we first focus on a given market k. Depending on the value of f, the market can either be fully or partially covered. Moreover, the seller can choose to either set his price following standard Hotelling competition or to set it as a local monopolist. When useful, the superscript indicates the level of market coverage (hd - hotelling duopoly, dm - duopolistic monopoly lm - local monopoly respectively), while the subscript indicates the seller's pricing strategy (c - competitive and m - monopoly respectively).

First, suppose that the seller sets his price as a local monopolist and that f is so high that the market is partially covered. The platform extracts all surplus from consumers through tailored prices. FOCs of the seller profits with respect to its price leads to

$$p_{s_m}^{lm} = \frac{c_s + f + u}{2}; \qquad p_{p_m}^{lm} = u - t + tx.$$

The seller opts to only pass half of the fee to consumers, as a way to obtain a higher market share. Indifferent consumers' locations are

$$\tilde{x}_{s,no} = \frac{u - c_s - f}{2t}; \qquad \tilde{x}_{p,no} = \frac{c_p + t - u}{t},$$

while profits are

$$\pi_{s_m}^{lm} = \frac{(c_s + f - u)^2}{4t}; \qquad \pi_{p_m}^{lm} = \frac{c_p^2 - f(c_s + f) - 2c_p u + u(f + u)}{2t}.$$

These results hold as long as the seller can make positive profits and market shares do not overlap. The seller obtains positive profits as long as it can at least profitably serve the consumer located in $x = 0$. Thus, if $f > u - c_s$, the seller would not enter the market and the platform could not enter. Instead, by equating the indifferent consumers' locations, we find that if $f \leq 3u - 2t - c_s - 2c_p$, then market shares overlap.

When market shares overlap, the seller's pricing strategy does not change, as he still prices as a local monopolist. On the other hand, the platform adjusts his pricing strategy: while the platform can still extract all surplus from consumers located in $(\tilde{x}_{s,no}, 1]$, he instead must beat the seller's offer for consumers located in $[\tilde{x}_{p,no}, \tilde{x}_{s,no}]$. Thus, on this last segment, the platform sets a tailored price equal to

$$p_{p_m}^{dm} = \frac{c_s + f - 2t + u + 4tx}{2},$$

which results in the indifferent consumer being located in

$$\tilde{x}_{s,p} = \frac{2c_p - c_s - f + 2t - u}{4t}.$$

This results in profit being

$$\pi_{s_m}^{dm} = \frac{(c_s + f - u)(-2c_p + c_s + f - 2t + u)}{8t};$$

$$\pi_{p_m}^{dm} = \frac{4c_p^2 - c_s^2 - 6c_s f - 5f^2 - 4tc_s + 4tf - 4t^2 + 2u(3c_s + f + 6t) - u^2 - 4c_p(c_s - f + 2t + u)}{16t}.$$

Next, suppose instead that the seller adopts competitive pricing, and that f is low enough that we have full market coverage. In this scenario we have standard Hotelling competition, where both the seller and the platform simultaneously set their uniform prices. Then, the platform will set the tailored prices. By standard computations, we obtain equilibrium prices

$$p_{s_c}^{hd} = \frac{c_s + c_p + 2f + t}{2}; \qquad p_{p_c}^{hd} = cp + f.$$

As we can see, the platform sets his uniform price as low as possible, since in equilibrium all the consumers he serves will purchase through tailored prices, which are equal to

$$p_{p_c}^{hd}(x) = \frac{c_s + c_p + 2f - t + 4tx}{2}.$$

These prices lead to the indifferent consumer being located in

$$\tilde{x}_{s,p} = \frac{c_p - c_s + t}{4t},$$

while equilibrium profits are equal to

$$\pi_{s_c}^{hd} = \frac{(c_p - c_s + t)^2}{8t}; \qquad \pi_{p_c}^{hd} = \frac{(c_p - c_s)^2 + 2t(8f + 3(c_s - c_p)) + 9t^2}{16t}.$$

From the platform's profits function, it is clear that his profits are increasing in f. In turn, the fee is directly passed to the consumers, both by the seller and by the platform. By analysing consumer utility, we find that the consumer with the lowest utility after purchase is the one located in $x = 1$, as the platform can extract most of her surplus. Thus, these results hold as long as the net utility of the consumer located in $x = 1$ is ≥ 0, which translates to $f \leq \frac{2u-3t-c_p-c_s}{2}$.

When $f > \frac{2u-3t-c_p-c_s}{2}$, the strategies regarding uniform pricing do not change; however, the platform must change the tailored prices he proposes to consumers located on the segment $[\frac{2u-t-2f-c_p-c_s}{2t}, 1]$ in order to allow consumers to maintain non-negative utility. To those consumers, the platform offers a tailored price equal to

$$p_{p_c}^{hd}(x) = u - t(1-x) - c_p,$$

leading to profits equal to

$$\pi_{p_c}^{hd} = \frac{-c_p^2 - 6c_pc_s - c_s^2 - 8fc_p - 8fc_s - 8f^2 - 18tc_p - 6tc_s - 8ft - 9t^2 + 8u(c_p + c_s + 2f + 3t) - 8u^2}{16t}.$$

As f increases, consumers' net utility decreases. In particular, the next threshold is reached when the indifferent consumer $\tilde{x}_{s,p}$ net utility is equal to 0, which translates to $f = \frac{4u-3t-c_s-3c_p}{4}$. When $f \geq \frac{4u-3t-c_s-3c_p}{4}$, duopolistic monopoly ensues. While the seller loses market share due to the increasing fee, the platform can poach these consumers through tailored prices, leading to profits equal to

$$\pi_{s_c}^{dm} = \frac{(c_p - c_s + t)(2u - t - 2f - c_p - c_s)}{4t}$$

$$\pi_{p_c}^{dm} = \frac{-5c_p^2 - c_s^2 - 8fc_s - 12f^2 - 6tc_s - 16tf - 9t^2 - 2c_p(3c_s + 8f + 9t - 8u) + 8u(c_s + 3f + 3t) - 12u^2)}{8t}$$

Finally, as f increases further, the consumers lost by the seller are too far from the platform to be poached. This happens when $\tilde{x}_{s,no} = \tilde{x}_{p,no}$, which results in $f = \frac{4u-3t-c_s-3c_p}{2}$. Above this threshold, the platform and seller become local monopolists: the platform extracts all available surplus from his consumers, while the seller continues to price competitevely by construction. The seller's profits maintain the same form as above, while platform profits are

$$\pi_{p_c}^{lm} = \frac{c_p^2 - f(c_s + 2f + t) + 2fu + u^2 - c_p(f + 2u)}{2t}$$

Finally, when $f \geq \frac{4u-3t-c_s-3c_p}{2}$, the seller cannot profitably serve any consumer, and thus he does not enter the market, and neither can the platform.

Having analysed all cases, we now focus on the seller's pricing strategy as a function of f. By comparing the profits function, we find that if $f < \bar{f}$ the seller obtains higher profits with competitive pricing, while otherwise he opts for monopolistic pricing. $\bar{f}$ is found by equating the seller's profits function, and is equal to

$$\bar{f} = c_s - c_p - t + \sqrt{2c_s^2 - c_p^2 - 2tc_p - t^2 + 2c_pu - 4c_su + 2tu + u^2}$$

Thus, seller's and platform's profits as a function of f are

$$\pi_s = \begin{cases} \frac{(c_p-c_s+t)^2}{8t} \quad \text{for} \quad 0 \le f < \frac{4u-3t-c_s-3c_p}{4} \\ \frac{(c_p-c_s+t)(2u-t-2f-c_p-c_s)}{4t} \quad \text{for} \quad \frac{4u-3t-c_s-3c_p}{4} \le f < \bar{f} \\ \frac{(c_s+f-u)(-2c_p+c_s+f-2t+u)}{8t} \quad \text{for} \quad \bar{f} \le f < 3u-2t-c_s-2c_p \\ \frac{(c_s+f-u)^2}{4t} \quad \text{for} \quad 3u-2t-c_s-2c_p \le f < u-c_s \\ 0 \quad \text{for} \quad f \ge u-c_s \end{cases}$$

$$\pi_p = \begin{cases} \frac{(c_p-c_s)^2+2t(8f+3(c_s-c_p))+9t^2}{16t} \quad \text{for} \quad 0 \le f < \frac{2u-3t-c_p-c_s}{2} \\ \frac{-c_p^2-6c_pc_s-c_s^2-8fc_p-8fc_s-8f^2-18tc_p-6tc_s-8ft-9t^2+8u(c_p+c_s+2f+3t)-8u^2}{16t} \quad \text{for} \quad \frac{2u-3t-c_p-c_s}{2} \le f < \frac{4u-3t-3c_p-c_s}{4} \\ \frac{-5c_p^2-c_s^2-8fc_s-12f^2-6tc_s-16tf-9t^2-2c_p(3c_s+8f+9t-8u)+8u(c_s+3f+3t)-12u^2)}{8t} \quad \text{for} \quad \le f < \bar{f} \\ \frac{4c_p^2-c_s^2-6c_sf-5f^2-4tc_s+4tf-4t^2+2u(3c_s+f+6t)-u^2-4c_p(c_s-f+2t+u)}{16t} \quad \text{for} \quad \bar{f} \le f < 3u-2t-c_s-2c_p \\ \frac{c_p^2-f(c_s+f)-2c_pu+u(f+u)}{2t} \quad \text{for} \quad 3u-2t-c_s-2c_p \le f < u-c_s \\ 0 \quad \text{for} \quad f \ge u-c_s \end{cases}$$

To find the equilibrium fee, we convert all the thresholds on f to thresholds on c_p, and maximize platform's profits across all markets:

$$\max_f \quad \int_0^1 \pi_p \, dc_s$$

Standard calculations yield to $f^* = \frac{2u+4t+4c_p-3}{10}$, which corresponds to all markets being under duopolistic monopoly with the sellers pricing as a local monopolist. Replacing f^* in firms' prices and profits gives the results described in the Proposition.

Proof of Proposition 3.10. When both the platform and sellers have data, they price discriminate all consumers they serve. Thus, their uniform prices do not influence their strategies.

First, suppose that f is so high that the market is partially covered: then, as no consumer can be reached by both the platform and the seller, each of them will set their tailored prices to extract all surplus from each consumer. This leads to

$$p_s^{TM}(x) = u - tx; \qquad p_p^{TM}(x) = u - t + tx.$$

the location of the last consumer buying from the seller and the platform are respectively

$$\tilde{x}_{s,no} = \frac{u - c_s - f}{t}; \qquad \tilde{x}_{p,no} = \frac{c_p + t - u}{t},$$

which results in profits being

$$\pi_s^{lm} = \frac{(c_s + f - u)^2}{t}; \qquad \pi_p^{lm} = \frac{c_p^2 - 2f(c_s + f) - 2uc_p + 2fu + u^2}{2t}.$$

When $f \ge u - c_s$, the seller cannot profitably serve any consumer and leaves the market, thus also impeding entry to the platform. Instead, when $f < 2u - t - c_p - c_s$ we have $\tilde{x}_{s,no} > \tilde{x}_{p,no}$, and the consumers in $[\tilde{x}_{p,no}, \tilde{x}_{s,no}]$ become contestable.

Let us focus on one of these contestable consumers. If she is served by the seller, the platform obtains profits equal to f. Instead, if she is served by the platform, the platform obtains $p_p^{TM}(x) - c_p$. By standard calculations, we find that the platform is better off by leaving to the seller all the consumers located in $[\tilde{x}_{p,no}, \tilde{x}_{p2,no}]$, where $\tilde{x}_{p2,no} = \frac{c_p+f+t-u}{t}$. Intuitevely, $\tilde{x}_{p2,no}$ is the last consumer from which the platform can extract revenues equal to $c_p + f$. Thus, it is more profitable for the platform to leave consumers in $[\tilde{x}_{p,no}, \tilde{x}_{p2,no}]$ to the seller, as he his more efficient in extracting surplus. Thus, the seller's profits are the integral of the monopolistic tailored price from 0 to $\tilde{x}_{s,no}$, while the platform's profits are the integral of his monopolistic tailored price from $\tilde{x}_{s,no}$ to 1 plus the agency profits $f\tilde{x}_{s,no}$, resulting in

$$\pi_s^{dm} = \frac{(c_s + f - u)^2}{t}$$

$$\pi_p^{dm} = \frac{-c_s^2 - 3f^2 - 2ft - t^2 - 2c_s(2f + t - 2u) - 2c_p(c_s + f + t - u) + 6fu + 4tu - 3u^2}{2t}.$$

Finally, when $\tilde{x}_{s,no} > \tilde{x}_{p2,no}$, the platform starts contesting consumers located in $[\tilde{x}_{p2,no}, \tilde{x}_{s,no}]$ as it can extract from them revenues higher than f. This scenario holds whenever $f < \frac{2u-t-c_p-c_s}{2}$. Price competition follows the following strategies:

- Consumers located in $[0, \tilde{x}_{p2,no})$ are poached by the seller through his monopolistic tailored price $p_s^{TM}(x)$;
- Consumers located in $[\tilde{x}_{p2,no}, \tilde{x}_{s,no})$ are contested;
- Consumers located in $[\tilde{x}_{s,no}, 1]$ are poached by the platform through his monopolistic tailored price $p_p^{TM}(x)$.

Let us focus on the second segment: both the platform and the seller will set their competitive tailored prices to beat the opponent's best offer, as Bertrand competition ensues. The seller will not price any lower than $c_s + f$, while the platform will not price lower than $c_p + f$, leading to

$$p_s^{TC}(x) = c_p + f + t - 2tx; \qquad p_p^{TC}(x) = c_s + f - t + 2tx.$$

The indifferent consumer in the second segment is thus located in

$$\tilde{x}_{s,p} = \frac{c_p - c_s + t}{2t},$$

and profits are equal to

$$\pi_s^{hd} = \frac{-c_p^2 + c_s^2 - 2f^2 - 2c_st - 4ft - t^2 - 2c_p(c_s + 2f + t - 2u) + 4u(f + t) - 2u^2}{4t}$$

$$\pi_p^{hd} = \frac{c_p^2 - c_s^2 - 4c_sf - 2f^2 - 2tc_s - t^2 - 2c_p(c_s + t) + 4u(c_s + f + t) - 2u^2}{4t}.$$

Platform's profits as a function of f are

$$\pi_p = \begin{cases} \frac{c_p^2 - c_s^2 - 4c_sf - 2f^2 - 2tc_s - t^2 - 2c_p(c_s+t) + 4u(c_s+f+t) - 2u^2}{4t} & \text{for } 0 \leq f < \frac{2u-t-c_p-c_s}{2} \\ \frac{-c_s^2 - 3f^2 - 2ft - t^2 - 2c_s(2f+t-2u) - 2c_p(c_s+f+t-u) + 6fu + 4tu - 3u^2}{2t} & \text{for } \frac{2u-t-c_p-c_s}{2} \leq f < 2u - t - c_p - c_s \\ \frac{c_p^2 - 2f(c_s+f) - 2uc_p + 2fu + u^2}{2t} & \text{for } 2u - t - c_p - c_s \leq f < u - c_s \\ 0 & \text{for } f \geq u - c_s \end{cases}$$

Having computed profits for all levels of f, we now find the equilibrium fee by maximizing platform total profits with respect to f. FOC w.r.t. to f result in $f_{ds}^* = \frac{3u-t-c_p-1}{3}$. When plugged in the functions above, we find that this fee results in all markets being under duopolistic monopoly, with both the seller and the platform only pricing through their monopolistic tailored prices.

Proof of Proposition 3.11. With regards to platform and sellers' profits, direct comparisons between the results described in Propositions 3.9 and 3.10 show that all firms' profits increase with data sharing. With regards to consumer surplus, recall that under no data sharing all markets are under duopolistic monopoly with the seller opting for monopolistic pricing. Consumer surplus in a given market k is thus equal to

$$CS^k = \int_0^{\tilde{x}_{p,no}} u - tx - p_{s_m}^{lm}\, dx + \int_{\tilde{x}_{p,no}}^{\tilde{x}_{s,no}} u - t(1-x) - p_{p_m}^{dm}\, dx + \int_{\tilde{x}_{s,no}}^{1} u - t(1-x) - p_{p_m}^{lm}\, dx =$$

$$= \frac{(4c_p - 3 + 10c_s + 4t - 8u)^2}{800t},$$

which, once summed across all markets leads to

$$CS = \frac{(7 + 4c_p + 4t - 8u)^3 - (4c_p - 3 + 4t - 8u)^3}{24000t}.$$

Instead, under data sharing, the seller and the platform never compete head to head for any consumer: thus, they can extract all surplus from consumers, and $CS = 0$.

By adding firms' profits and CS in the two cases, we find that total welfare increases under data sharing.

3.A.2 Cost reduction with differentiated goods

Proof of Proposition 3.12. The platform always sets a fee f such that, in equilibrium, the seller and the platform are local monopolies. To prove this result, assume the firms operate in Hotelling duopoly and the market is fully covered. In any given market k, standard calculation leads to the Hotelling prices

$$p_s^{hd} = \frac{(c_p(1-r) + 2c_s)}{3} + f + t; \qquad p_p^{hd} = \frac{(2c_p(1-r) + c_s)}{3} + f + t$$

The seller is able to pass the fee entirely on consumers, without lowering its margins. Hence, as observable from the profits, conditional on f

$$\pi_s^{hd} = \frac{(c_s - c_p(1-r) - 3t)^2}{18t}$$

$$\pi_p^{hd} = \frac{t}{2} + f - \frac{c_p(1-r)}{3} + \frac{c_s(6t - 2c_p(1-r))}{18t} + \frac{c_p^2(1-r)^2 + c_s^2}{18t}$$

the platform has strict incentives to indefinitely increase the fee. The usual result emerges, with the equilibrium fee in this specific scenario being a corner solution (i.e., $f = \bar{f} \equiv \frac{2u-3t-c_s-c_p(1-r)}{2}$ such that the indifferent consumer gets zero utility, see Figure 3.3).

Second, consider the intermediate case in which the two agents (platform and seller) operate in a monopolistic duopoly. Following Bacchiega et al. (2021), the two firms set the monopolistic prices:

$$p_s^{md} = u - \frac{t}{2} + \varepsilon; \qquad p_p^{md} = u - \frac{t}{2} - \varepsilon$$

with ε sufficiently small. The market is split accordingly and the profits of the two agents are:

$$\pi_s^{md} = \left(\frac{1}{2} - \frac{\varepsilon}{t}\right)\left(u - \frac{t}{2} - c_s - f + \varepsilon\right)$$

$$\pi_p^{md} = \left(\frac{\varepsilon}{t} + \frac{1}{2}\right)\left(u - \frac{t}{2} - c_p(1-r) - \varepsilon\right) + f\left(\frac{1}{2} - \frac{\varepsilon}{t}\right)$$

One can notice immediately that the platform's profits are monotonically increasing in f. Hence, conditional on consumers' willingness to pay for a good, the platform has the incentives to increase the fee indefinitely. Again, we end up with a corner solution such that $f = \bar{\bar{f}} \equiv 2(u-t) - c_s - c_p(1-r)$ (see Figure 3.3), i.e., the fee above which the market is partially not covered.

Finally, let us now turn to the case, where firms operate as local monopolies. In order for this scenario to exist, the consumer indifferent between purchasing the good from the seller or the platform must earn net negative utility from consumption. Hence, she prefers not consuming at all and gets zero utility. When in this scenario, both the platform and the seller set monopoly prices:

$$p_s^{lm} = \frac{c_s + f + u}{2}; \qquad p_p^{lm} = \frac{c_p(1-r) + u}{2}$$

The conditional profits level of the platform is now concave in the fee f, as one can easily observe:

$$\pi_s^{lm} = \frac{u - c_s - f}{4t}, \qquad \pi_p^{lm} = \frac{f(u - c_s) - f^2}{2t} + \frac{(u - c_p(1-r))^2}{4t}$$

Moreover, profits are bell-shaped in f, with a global maximum in $(u - c_s)/2$, which is always lower than $u - c_s$, i.e., the level above which the platform kicks the rival out of the market. The maximum can be either above $\bar{\bar{f}}$, meaning that the solution is interior, or below it, meaning that the solution is a corner. Formally $f^* = \max\{\bar{\bar{f}} + \eta;\ (u - c_s)/2\}$, with η arbitrarily small and positive, is the fee that would be chosen in that specific market.

It is easy to show that the solution is interior if:

$$u > 1 \quad \text{and} \quad t > \frac{3u - c_s - 2c_p(1 - r))}{4}$$

In any case, the optimal fee lies in the region of parameters where the two economic agents (platform and seller) operate as local monopolies.

Hence, in every market i, the two goods operate in local monopolies. we use π_p^{lm} in the platform's aggregate profit function and maximize it w.r.t. f:

$$\max_f \quad \int_0^1 \pi_p^{lm}\, dc_s = \int_0^1 \frac{f(u - c_s) - f^2}{2t} + \frac{(u - c_p(1 - r))^2}{4t}\, dc_s$$

Standard calculations yield to $f = f^\dagger = \frac{2u-1}{4}$. Using $f^\dagger$ in the prices of the firms in all markets allows us to derive the results in Proposition 3.12. □

Proof of Proposition 3.13. The proof unfolds as the one for Proposition 3.12. By the same logic as above, it is easy to show that, in each market, the profit function of the platform exhibits a maximum in the region where $f > \bar{\bar{f}}_{ds} = 2(u - t) - (c_s + c_p)(1 - r)$

The conditional profits level of the platform is now concave in the fee f, as one can easily observe:

$$\pi_{s,ds}^{lm} = \frac{u - c_s(1 - r) - f}{4t}, \qquad \pi_{p,ds}^{lm} = \frac{f(u - c_s(1 - r)) - f^2}{2t} + \frac{(u - c_p(1 - r))^2}{4t}$$

Moreover, profits are bell-shaped in f, with a global maximum in $(u - c_s(1 - r))/2$, which is always lower than $u - c_s(1 - r)$, i.e., the level above which the platform kicks the rival out of the market. The maximum can be either above $\bar{\bar{f}}_{ds}$, meaning that the solution is interior, or below it, meaning that the solution is a corner. Formally $f_{ds}^* = \max\{\bar{\bar{f}} + \eta;\ (u - c_s(1 - r))/2\}$, with η arbitrarily small and positive, is the fee that would be chosen in that specific market.

It is easy to show that the solution is interior if:

$$u > 1 \quad \text{and} \quad t > \frac{3u - (c_s + 2c_p)(1 - r))}{4}$$

In any case, the optimal fee lies in the region of parameters where the two economic agents (platform and seller) operate as local monopolies.

Hence, in every market i, the two goods operate in local monopolies. we use π_p^{lm} in the platform's aggregate profit function and maximize it w.r.t. f:

$$\max_f \quad \int_0^1 \pi_p^{lm}\, dc_s = \int_0^1 \frac{f(u - c_s(1 - r)) - f^2}{2t} + \frac{(u - c_p(1 - r))^2}{4t}\, dc_s$$

Standard calculations yield to $f = f_{ds}^\dagger = \frac{2u-1+r}{4}$. Using $f_{ds}^\dagger$ in the prices of the firms in all markets allows us to derive the results in Proposition 3.13. □

Proof of Proposition 3.14. Using $f^\dagger$ and $f_{ds}^\dagger$ in the profit function of sellers in each market π_s^i and $\pi_{s,ds}^i$, respectively, it is possible to derive their actual payoffs:

$$\pi_s^{i,\dagger} = \frac{(1 + 2u - 4c_s^i)^2}{64t}; \qquad \pi_{s,ds}^{i,\dagger} = \frac{(1 - r + 2u - 4c_s^i(1 - r))^2}{64t};$$

Standard calculations show that:

$$\pi_s^{i,\dagger} - \pi_{s,ds}^{i,\dagger} > 0 \quad \text{if} \quad 0 < c_s^i < \frac{1}{4} \quad \text{or} \quad \frac{1}{4} \leq c_s^i < 1 \quad \text{and} \quad u < \frac{(4c_s(2-r) - 2 + r)}{4}$$

The last condition can be rearranged as $c_s > \frac{4u+2-r}{4(2-r)}$. Moreover, one can see that

$$\frac{4u+2-r}{4(2-r)} < 1 \quad \text{if} \quad \left(0 < u \leq \frac{3}{4} \text{ and } 0 < r < 1\right) \text{ or } \left(\frac{3}{4} < u < \frac{3}{2} \text{ and } 0 < r < \frac{1}{3}(6-4u)\right)$$

Focusing on $u > 1$, the condition above reduces to

$$\frac{4u+2-r}{4(2-r)} < 1 \quad \text{if} \quad \left(1 < u < \frac{3}{2} \text{ and } 0 < r < \frac{1}{3}(6-4u)\right)$$

□

Conclusions

This research aims to investigate the effects of different platform strategies and mandatory policies on main market outcomes. In the first chapter, We have developed a theoretical model in order to contribute to the ongoing literature on showrooming and PPC and for providing policy relevant conclusions. With our work, we have determined firms pricing strategies within a multi-channel sales strategy context. We have defined how an increase in the share of initial consumers (shoppers/web-shoppers) in a given channel makes competition relatively fiercer in that channel. The distribution of initial consumers across channels affects platforms' pricing strategies. In particular, we have found that the larger is the share of initial consumers in the direct channel (shoppers), the harder is for platforms to attract users. In line with the literature, a PPC reduces the inter-channel competition so platform can raise their fee level and profits. Nevertheless, platforms' pricing strategy is constrained by the possibility of the firms to delist and sell exclusively in the direct sales channel. The profit that a firm makes by selling its product in its store is increasing in the share of shoppers. Hence, platforms set lower fees in order to prevent firms from delisting, their profits then decrease with the share of shoppers also when they impose a PPC.
Firms instead, under full-participation, make always the same profit because their prices are proportional to their marginal and average costs in the UP and in the PPC case respectively. Consumers are better off in the unrestricted pricing scenario always but when the share of shoppers is very large. This leads to an overall ambiguous effect on total welfare. Indeed when platforms are not very differentiated, and the cost of buying in the direct channel is high, price parity clauses generate higher total welfare. These interesting results help understanding why banning price parity clauses is not always welfare-improving and indicate what authorities should analyze in order to evaluate the effects of a PPC ban. According to our model, those sectors in which the share of initial consumers is very low are the ones in which a PPC adoption would harm consumers the most and are therefore the ones in which a PPC ban would be the most effective from a consumer surplus standpoint.
We have extended the extensive-form game in the model in order to understand which contractual choices occur in a competitive equilibrium. It always exists an equilibrium in which both platforms impose a PPC and it never occurs an equilibrium in which platforms adopt different pricing regimes (asymmetric equilibrium). Nevertheless, we have found that for a sufficiently large share of shoppers there exists another symmetric equilibrium in which both platforms adopt the unrestricted pricing regime.
In the second chapter, we investigate the incentive of a hybrid platform to commit in information sharing when information is verifiable by sellers in order to understand the impact of this strategy on consumer surplus and total welfare. Surprisingly, we find that platforms have strong incentives to share full information with sellers despite the dual mode because of the *coordination effect* it generates. The *coordination effect* increases when interactions between the platform and the firm are stronger (i.e., goods are closer substitutes) but starts decreasing when product differentiation is too small, thus incentives to share information are strongest for intermediate degrees of product differentiation. Information provision results on average in

more surplus extraction by firms and platforms, thus it lowers both consumer surplus and total welfare. When the platform's entry decision is taken into account, platform entry occurs without information provision given that this would increase the cost that the platform pays for the acquisition. Otherwise, the platform find optimal to act as intermediary only and to share information downstream.

In the third chapter, we investigate the effects of mandated data sharing on market outcomes and social welfare when data can be used for different purposes (price discrimination or cost reduction). In particular, mandated data sharing has no effects on welfare if data can be used to price discriminate consumers and competition is in prices of homogeneous goods. With or without data, sellers can only set a price equal to their marginal costs and cannot exploit consumers' data. Alternatively, the platform may also decide to operate as intermediary in some markets, letting some sellers without competitive pressure and free to perfectly price-discriminate consumers without affecting total welfare.

Instead, mandated sharing of cost-reducing data improves welfare by lowering the average price in the market. Sellers are unaffected, as price competition drives profits to zero, but the platform is better off as more markets are covered and revenues from intermediation increase. When goods are horizontally differentiated, data sharing may negatively affect consumers (price discrimination) and some sellers (cost reduction). In the former case, access to data enables sellers to price more efficiently and extract more surplus from the consumers. In the latter case, efficient sellers have little gains from the cost-reducing data but suffer from the generalized increase in transaction fees.

Although the aggregate effect is usually positive, we argue that under certain conditions, mandatory data sharing may damage the very agents it is intended to protect, namely consumers and (efficient) sellers.