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PLATFORM PRICING STRATEGIES WHEN CONSUMERS WEB/SHOWROOM

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Platform pricing strategies when consumers web/showroom*

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Abstract

This paper studies the effects of price parity clauses (PPC) on consumer surplus and platform profit by investigating the strategic interactions among horizontally differentiated multi-channel retailers selling through online platforms as well as in their the direct channel. Consumers first choose which product to buy and then in which channel (online/direct) to finalize the purchase; platforms can decide about whether or not to impose PPCs. We show that 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. 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.

Keywords: *platform competition, price parity clauses, vertical restraints, showrooming, webrooming.*
JEL codes: *D43, L13, L42.*

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1 Introduction

Today, a growing number of firms sell 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 and Schlütter (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

[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."

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 multichannel 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 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 the PPC can be, under certain conditions, welfare reducing.

Our baseline model assumes duopolistic platform competition. In order to assess the desirability of more competition among platforms, we extend the model to a triopolistic setting. 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.

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. Wang and Wright (2020) 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. 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 the way in which we capture the showrooming behaviour which determines buyers' endogenous split-up across sales channels. Indeed we extend the setting from Wismer (2013) with buyers' sequential purchase decisions, thus considering a more realistic multi-dimensional consumer heterogeneity (i.e. with respect to both sales channels and products). Moreover, we highlight how the shares of consumers that search for products in each channel play a crucial role in determining agents' 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.

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). 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 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 *a' 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. 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. When buying through the direct channel, consumers face a fixed cost s, which in the above figure is represented by 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. In order to prevent this from happening, all throughout the paper we will assume $s \in (w/16, w/2)$ such that at the equilibrium all the sales channels are used by both firms and consumers.

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).

4 Duopoly 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.

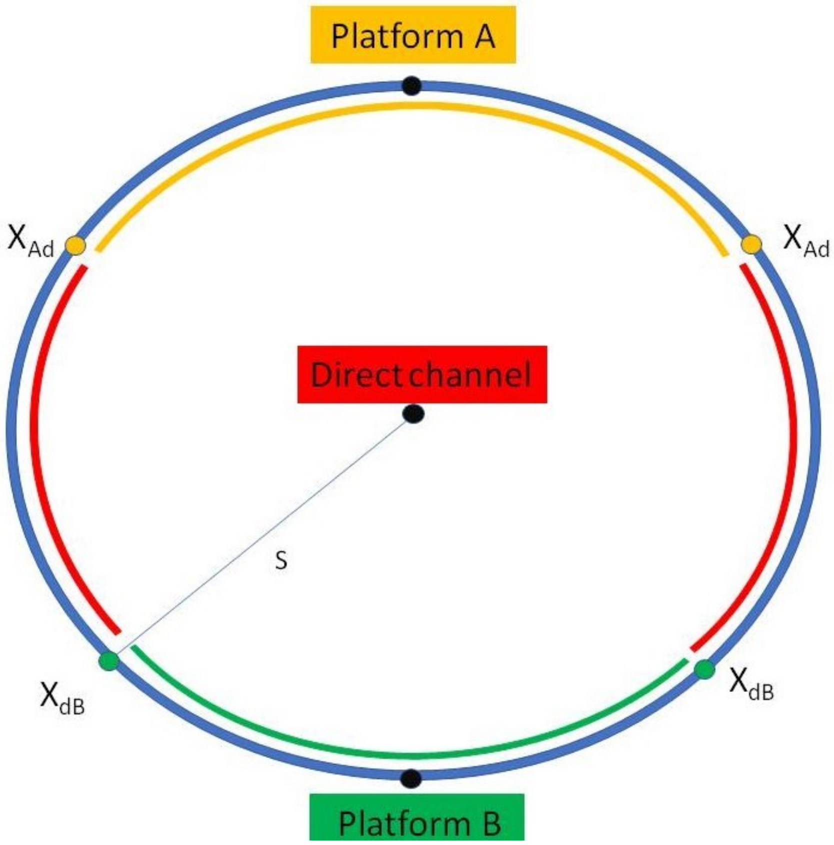

Figure 1: Consumers are distributed over a circle and choose their favourite sales channel for purchasing the selected product.

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

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

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:

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

and

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

It is worth to notice that, unlike in a standard Salop model, 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.

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 *a' la Salop*. The demand faced by firm k on channel i is therefore given by:

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

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^*.[2]

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:

$$p_i^* - p_d^* = \frac{f_i - c_i}{2} - w\left(\frac{1-M_d}{8}\right) + \frac{s}{2} \qquad \text{with} \quad i \in \{A, B\}. \tag{3}$$

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.

Plugging p_d^*, p_A^* and p_B^* into m_d, m_A and m_B defined into expressions (1) and (2), gives us back the number of transactions conducted in each sales channel, as function of the transaction fees:

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

and

$$m_d^*(f_A, c_A, f_B, c_B) = \frac{(f_B + c_B + f_A + c_A - 2s)}{w} + \frac{(1+M_d)}{2}. \tag{5}$$

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.

4.4 Stage 1: platform competition

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 (4), platform i's profit is therefore:

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

From this expression an interesting observation follows: platform i maximizes profits

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

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.[3] 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 that 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:

$$f_i^* + c_i^* = \frac{s}{2} + \frac{w(1 - M_d)}{8}, \quad i = A, B. \tag{6}$$

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. On top of this, under a very mild condition ($w/16 < s$), firms do not profitably deviate from full-participation.[4]

Plugging the optimal fees into equation (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 (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:

$$\Pi_A^* = \Pi_B^* = \frac{(4s + w(1 - M^d))^2}{64w}. \tag{7}$$

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 (3), we can determine the difference in the price firms charge on one platform and the one they charge in the direct

[3]The proof of this statement is in appendix A.2

[4]See appendix A.3 for the proof.

channel:[5]

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

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 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.

5 Duopoly 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.

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):

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

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:

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

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

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

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

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:

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

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.

5.4 Stage 1: platform competition

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. 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:

$$\frac{1}{9} \geq M_d\left(\frac{12(f_A(s-c_A) + f_B(s-c_B)) + 5w}{3w(M_d+4)}\right)^2 \tag{8}$$

where the rhs represents the profits from deviation. When this constraint is binding, the profit maximizing 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. In my 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 $c_i = 0$[6] 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[7] 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

$$\Pi_A^* = \Pi_B^* = \left(\frac{s}{2} + \frac{w\left(4 - 5\sqrt{M_d} + M_d\right)}{s12\sqrt{M_d}} \right) \frac{s}{w}. \tag{9}$$

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

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

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

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

[7]The deviation profit in 8 is indeed decreasing in c_i whenever $c_i < s$.

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 (7) and (9) it is possible to prove the following:[8]

Result 1. *If $w < 2$ platform profits under price parity are larger than with unrestricted pricing.*

The condition $w < 2$ is very mild and it is reasonably verified in most instances. 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 from 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.

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,[9] 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

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

[9]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)

all transportation costs incurred by consumers both when they search for the best product and when they effectively purchase; formally:

$$CS = m_d(v - p_d - s) + \sum_i m_i(v - p_i - c_i) - 4\int_0^{x^*} wx\,dx - 6\int_0^{\frac{1}{6}} y\,dy, \quad i = A, B, \quad (10)$$

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.[10] 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 $CS(\underline{M_d}) = 0$.[11] 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:

Result 2. *The larger the share of shoppers, the less consumers are harmed by platforms adopting PPC.*

Result 2 can be easily interpreted. We know, from Result 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.

Result 1 shows that platforms always benefit from the imposition of a PPC, while Result 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:

[10] 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 $m_d s$.

[11] 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 $\forall M_d \in [0, 1]$

Result 3. *When $M_d > 1 - 4s/w$, total welfare is higher under PPC, otherwise it is higher under the unrestricted pricing regime.*

Result 3 follows immediately from the previous Results 1 and 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 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 Result 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 Result 3 is the same that ensures that platforms' equilibrium demands with PPCs are greater than the ones without PPCs[12]. In other words, whenever imposing PPCs expands platforms' demands we can consider PPCs to be welfare improving.

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.

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

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.[13] 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 C.1, 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

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

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. *$\tilde{M}_d$ 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:

Result 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 Result 1, Result 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

[13]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.

($M_d > \tilde{M_d}$), 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 more consumers are induced to switch from platform j to the direct channel. This makes delisting from platforms more appealing for firms such that the participation constraint is now more binding than with the strategy combination $\{PPC, PPC\}$. 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 $M_d > \tilde{M_d}$.

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[14]
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 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.[15]
Following exactly the same procedure as above, it is possible to show that platform fees and

[14]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).

[15]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 D.1

profits with unrestricted pricing regime are [16]:

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

and

$$\Pi_A^* = \Pi_B^* = \Pi_C^* = \frac{(6s + w(1 - M_d))^2}{144w}, \tag{11}$$

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

$$\Pi_A^* = \Pi_B^* = \Pi_C^* = \left(\frac{s}{2} + \frac{w\left[4 - 5\sqrt{M_d} + M_d\right]}{s18\sqrt{M_d}}\right)\frac{s}{w}. \tag{12}$$

Looking at these expressions, the following proposition holds:

Result 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. 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[17]. 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.

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

[17] 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.

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 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. 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 dynamic 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 with the competitor's advantage in attracting showroomers; 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. Results show that increasing platform competition reduces both platforms' average profits and platforms' total profits while it always increases consumer surplus, mainly because of a reduction in the total costs borne for exploiting the direct channel. 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 platform competition the most given that firms' full-participation profit does not change with the number of distribution channels.

References

Boik, A. and K.S. Corts (2016). "The effects of platform most-favored-nation clauses on competition and entry". In: *The Journal of Law and Economics* 59.1, pp. 105–134.

Bouckaert, J. (2000). "Monopolistic Competition with a Mail Order Business". In: *Economics Letters* 322, pp. 891–921.

Buccirossi, P. (2015). “Vertical restraints on e-commerce and selective distribution”. In: *Journal of Competition Law and Economics* 11.3, pp. 747–773.

Calzada, J., E. Manna, and A. Mantovani (2021). “Platform Price Parity Clauses and Market Segmentation”. In: *Journal of Economics and Management Strategy*, pp. 1–29.

Carlton, D.W. and R.A. Winter (2018). “Vertical MFN’s and the Credit Card No-Surcharge Rule”. In: *SSRN Working Paper* 2982115.

Cavallo, A. (2017). “Are Online and Offline Prices Similar? Evidence from Large Multi-Channel Retailers”. In: *American Economic Review* 107.1, 283–302.

Chandler, S. (2020). “How showrooming and webrooming impact e-commerce”. In: *Pattern.com*. URL: https://pattern.com/blog/how-showrooming-and-webrooming-impact-ecommerce/.

Cramer-Flood, E. (2020). “Global e-commerce 2020”. In: *eMarketer.com*. URL: https://www.emarketer.com/content/global-ecommerce-2020.

Duch-Brown, N. et al. (2017). “The Impact of Online Sales on Consumers and Firms: Evidence from Consumer Electronics”. In: *International Journal of Industrial Organization* 52, 30–62.

Edelman, B. and J. Wright (2015). “Price Coherence and Excessive Intermediation”. In: *Quarterly Journal of Economics* 130.3, 1283–1328.

European Commission (2017). *Report from the Commission to the Council and the European Parliament: Final Report on the E-Commerce Sector Inquiry.*

Hunold M., Kesler R. Laitenberger U. and F. Schlütter (2018). “Evaluation of best price clauses in hotel booking”. In: *International Journal of Industrial Organization* forthcoming.61, pp. 542–571.

Johansen, B.O. and T. Vergé (2017). “Platform Price Parity Clauses with Direct Sales”. In: *CREST working papers* 201745.

Johnson, J.P. (2017). “The Agency Model and MFN Clauses”. In: *The Review of Economic Studies* 84.3, pp. 224–253.

KPMG (2017). “The truth about online consumers”. In: *Global online consumer report.*

Nielsen (2016). “Global connected commerce”. In: *Nielsen annual report* 1062.

Wang, C. and J. Wright (2020). “Search platforms: Showrooming and price parity clauses”. In: *RAND Journal of Economics* 51.1, pp. 32–58.

Wismer, S. (2013). “Intermediated vs. Direct Sales and a No-Discrimination Rule”. In: *Working Papers, Bavarian Graduate Program in Economics, University of Erlangen-Nuremberg* 131.

Appendix

A Technical appendix for Section 4 (Unrestricted Pricing)

A.1 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.

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

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

A.2 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.

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

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

A.3 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

$$\pi^{dev} = p_{dev}\left(\frac{p_{d,1} + p_{d,2} - 2p_{dev}}{2} + \frac{1}{3}\right) M_d. \tag{13}$$

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 (6) into equation (13) I get that the deviation profit, when platforms set the optimal fee level, is:

$$\pi^{dev} = \frac{M_d(48M_ds^2 + 24s(2 + M_d(2 - 3w) + w + 2M_d^2w) + \Psi(w, M_d))^2}{144(1 + M_d)^2(4M_ds - 8w - 13M_dw + M_d^2w)^2}, \tag{14}$$

where

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

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 (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 (14) becomes:

$$\pi^{dev} = \frac{M_d(144M_d^3w - 16M_d^2(4 + 33w) - 8(146 + 33w) + 7M_d(-176 + 93w))^2}{2304(1 + M_d)^2(32 + 51M_d - 4M_d^2)^2}. \tag{15}$$

Equation (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 (15) and I get

$$\pi^{dev}(w = 0) = \frac{M_d(73 + 4M_d)^2}{9(32 + 51M_d - 4M_d^2)^2} \tag{16}$$

and

$$\pi^{dev}(w = 2) = \frac{M_d(848 - 35M_d + 560M_d^2 - 144M_d^3)^2}{576(1 + M_d)^2(32 + 51M_d - 4M_d^2)^2}. \tag{17}$$

Equation (16) is (i) smaller than $\frac{1}{9}$ also for $M_d \in [0, \frac{11}{12}]$ and equation (17) is (ii) smaller than $\frac{1}{9}$ also for $M_d \in (\frac{11}{12}, 1]$. Therefore equation (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[18].

B Technical appendix for Section 6

B.1 Platform profits

Proof. of Result 1 Let Π^{Δ} be the difference between Π^{PPC} (equation (9)) and Π^{UP} (equation (7)). The derivative of Π^{Δ} with respect to M_d is:

$$\frac{\partial \Pi^{\Delta}}{\partial M_d} = \frac{4}{96M_d^{\frac{1}{2}}} + \frac{4s + w(1 - M_d)}{32} - \frac{1}{6M_d^{\frac{3}{2}}}. \tag{18}$$

[18] 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. Results available upon request.

Equation (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 $\Pi^{PPC} > \Pi^{UP}$ $\forall M_d \in (0,1)$. □

B.2 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 $\underline{M_d}$.

B.3 Consumer surplus

Proof. of Result 2

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

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

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

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 $CS^{PPC} > CS^{UP}$. □

B.4 Total welfare

Proof. of Result 3

The equilibrium welfare levels are defined as follows:

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

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

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

$$\frac{1}{128}\left(24s(M_d - 1) + 80\frac{s^2}{w} + w(1 - M_d)^2\right). \tag{19}$$

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 $W^{PPC} > W^{UP}$. □

C Technical appendix for Section 7

C.1 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

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

C.2 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:

$$\frac{1}{576}\left(104(M_d-1)s + \frac{176s^2}{w} - \Gamma(w, M_d)\right), \tag{20}$$

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 (20) is equal to zero.

Proof. of Lemma 1
Consider that:

1. Given the initial assumptions on parameters, equation (20) is monotonically decreasing in M_d.

2. Equation (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 (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. □

C.3 Platform regime choice

Proof. of Result 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 Result 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 C.2. 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, Result 1), condition (a) is then immediately verified by transitivity. This concludes the proof of Result 4. □

D Proofs relating to Section 8

D.1 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 $s < \frac{w}{N}$.

D.2 Platform triopoly

Proof. of Result 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:

$$CS^{PPC} = \frac{5 - 2\sqrt{M_d} + 12v - 12s - 2s\sqrt{M_d}}{12} + \frac{s^2}{2w} + \frac{2s}{3\sqrt{M_d}}, \tag{21}$$

$$CS^{3PPC} = \frac{5 - 2\sqrt{M_d} + 12v - 12s - 2s\sqrt{M_d}}{12} + \frac{3s^2}{4w} + \frac{2s}{3\sqrt{M_d}}. \tag{22}$$

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:

$$CS^{UP} = \frac{348vw - 160w - 408sw + 24sM_d w + 144s^2 - 15w^2(1 - 2M_d + M_d^2)}{348w}, \tag{23}$$

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

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

$$\frac{72s^2 + 5w^2(M_d - 1)^2}{348w}, \tag{25}$$

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

The total welfare under PPC is

$$W^{PPC} = \frac{3s^2}{w} - \frac{1}{12} + v - s, \tag{26}$$

while the total welfare in the triopoly case is:

$$W^{3PPC} = \frac{9s^2}{2w} - \frac{1}{12} + v - s. \tag{27}$$

The difference between equation 26 and equation 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

$$W^{UP} = \frac{336s^2 - 32w + 384vw - 312sw - 72M_d sw - 3w^2 + 6M_d w^2 - 3M_d^2 w^2}{384w} \tag{28}$$

and in the triopoly case it is equal to

$$W^{3UP} = \frac{504s^2 - 32w + 384vw - 312sw - 72M_d sw - 2w^2 + 4M_d w^2 - 2M_d^2 w^2}{384w}. \tag{29}$$

The difference between equation 28 and equation 29 is:

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

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