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Platform Price Parity Clauses and Market Segmentation*

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Abstract

Price parity clauses (PPCs) are widely adopted by online platforms to force client sellers not to lower their prices elsewhere. We investigate under what conditions online travel agencies (OTAs) decide to apply PPCs, and how this affects hotels' listing decisions on OTAs. We find OTAs adopt PPCs when there is a sufficiently large competitive pressure in the market, either between OTAs, or between hotels (or both). PPCs allow OTAs to charge higher commission fees to hotels, which can respond by delisting from certain OTAs, thereby segmenting the market. We also find that consumers and hotels generally lose out with PPCs.

Keywords: Price parity clauses, online platforms, online travel agencies, market segmentation.

JEL Classification: D40, L42, L81.

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1 Introduction

Price parity clauses (PPCs) are contractual terms used by online platforms to prevent client sellers from offering their services at cheaper prices on alternative sales channels. These clauses are specific to an "agency" model, in which sellers decide the final price on the platform, which then charges a commission fee when the transaction is completed.[1] PPCs are widespread in the lodging sector, but have been also applied to other industries such as entertainment, insurance, digital goods, and payment systems. Amazon, for example, has long adopted PPCs in its contracts with third-party marketplace sellers, and was only recently compelled to remove them in the US and EU following the intense scrutiny of large tech companies.[2]

In tourist accommodation, Online Travel Agencies (OTAs), such as *Booking.com* and *Expedia*, often apply *wide* PPCs, which require that the prices posted by hotels in the contracted OTA cannot be higher than those offered to consumers who book directly or through rival OTAs. The aim is to prevent *showrooming*, which occurs when consumers use the platform to verify the availability of products and prices, and then directly buy from the seller. In spite of this, antitrust authorities in several countries are concerned that PPCs may reinforce the dominant position of large OTAs. In particular, wide PPCs are deemed responsible for raising hotel prices and discouraging the entry of new platforms that may offer better conditions to client hotels. A milder version of these clauses, *narrow* PPCs, allows hotels to price differentiate across OTAs, although still prohibiting them from charging lower prices when selling directly.

In the EU, the Bundeskartellamt (the German competition authority) prevented *Hotel Reservation Service* in 2013 and *Booking.com* in 2015 from using PPCs. In August 2015, the French government imposed a law prohibiting any type of PPCs. A similar ban was adopted in Austria in 2016, Italy in 2017, Belgium and Sweden in 2018. In 2017, the EU commissioned a report to evaluate the effect of the removal of PPCs, but the results were not conclusive as the percentage of hotels responding to the survey was rather small.[3] No other countries have regulated the use of these clauses, with the notable exception of Australia and New Zealand, where *Booking.com* and *Expedia* have reached an agreement with regulators to substitute wide for narrow PPCs. In most major markets, such as the US, OTAs continue to apply wide PPCs, notwithstanding the fact that leading scholars such as Baker and Scott Morton (2018) have stressed that antitrust enforcement against this practice should become a priority.

A growing body of the literature, both theoretical and empirical, has investigated the economic effects of adopting PPCs (see, among others, Edelman and Wright, 2015; Boik and Corts,

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[1] Johnson (2017) and Condorelli *et al.* (2018) rationalize the prevalence of the agency model in online markets, whereby the suppliers set retail prices and the platforms charge intermediation fees.

[2] More precisely, Amazon dropped PPCs in the EU in 2013 after regulators in UK and Germany voiced concerns about its anticompetitive effects. In the US, Amazon decided to voluntarily remove these clauses from its contracts with third-party sellers in 2019, following mounting political pressure.

[3] European Commission and the Belgian, Czech, French, German, Hungarian, Irish, Italian, Dutch, Swedish and UK NCAs, 'Report on the monitoring exercise carried out in the online hotel booking sector by the EU competition authorities in 2016', April 2017, available at: http://ec.europa.eu/competition/ecn/hotel_monitoring_report_en.pdf.

2016; Johnson, 2017; Hunold *et al.*, 2018; Mantovani *et al.*, 2018). However, an aspect that has received meager attention is how PPCs affect the suppliers' incentives (hotels in our example) to simultaneously participate in several platforms (OTAs). This is a relevant aspect since the imposition of price restrictions usually allow OTAs to charge high commission fees. Hotels may respond by delisting from OTAs, thereby forcing a reduction in these fees. The idea that PPCs may induce market segmentation, whereby hotels are only listed on some platforms, has been empirically examined by Hunold *et al.* (2018), who show that German hotels increased their participation to multiple OTAs when PPCs were prohibited. They also find that prices decreased, especially on hotels' own websites, which were increasingly used by consumers.

The aim of this paper is to develop a theoretical model to examine how platforms' contractual arrangements may affect not only sellers' pricing strategies but also their listing decisions. The paper considers hotels and OTAs but its main findings are generally applicable to situations in which sellers resort to platforms that can adopt price restrictions such as PPCs. For the sake of realism, we take into account a model with both *inter-brand* (*i.e.*, between sellers) and *intra-brand* competition (*i.e.*, between platforms).

More specifically, two horizontally differentiated hotels resort to OTAs in order to reach hotel seekers that would have not known about their existence otherwise. OTAs allow hotels to expand their customer base but charge them a per-sale commission fee. We assume there are two symmetric OTAs providing the same type of service to client hotels. However, they are perceived by customers as horizontally differentiated in terms of the booking experience. In the baseline model, we focus on the case in which consumers reserve hotels' rooms only through the OTAs. We then extend the analysis to account for the possibility that consumers can book directly from the hotel websites, after visiting the OTAs, giving rise to showrooming.

OTAs decide whether or not to impose PPCs and set their commission fees accordingly; hotels then choose whether to list on one OTA (segmentation) or on both OTAs (no segmentation). We show that their respective decisions crucially depends on the degree of both inter-brand and intra-brand competition, and explain how they are intertwined. The contribution of our analysis is manifold. First, we shed light on the conditions under which OTAs benefit from adopting PPCs, and show this occurs not only when OTAs compete aggressively, but also when hotels do. Second, we prove the imposition of PPCs can induce hotels to single-home, thereby limiting the sales channels in which they are listed. Third, we confirm the accepted view that PPCs allow OTAs to inflate commission fees, inducing an increase in the final price charged by hotels. Remarkably, OTAs can adopt PPCs even when hotels single-home in equilibrium, as this measure helps them to sustain higher fees. Lastly, our analysis further supports the notion that PPCs can be detrimental to society at large as they reduce consumer surplus and total welfare.

Our paper starts by considering the benchmark case in which hotels are free to set their prices in all the sales channels they use. Regarding their listing decision, hotels face a trade-off: they attract more consumers by multi-homing, but obtain a higher price margin per room (difference between the retail price and the commission fee) by single-homing. The degree of inter-brand competition plays a pivotal role to navigate this trade-off. In particular, we find that hotels prefer to multi-home when they are sufficiently differentiated, as they benefit from receiving consumers from both OTAs, and their sacrifice in terms of price margin is not very high. By contrast, when they are perceived as close substitutes, hotels prefer to be listed on a different OTA each. Segmentation reduces inter-brand competitive pressure and enhances price margins, even if this entails a lower demand. We also explain that, when the market is segmented, OTAs would benefit by setting a high commission fee, but they may fail to do so because they have a unilateral incentive to lower their fee to also attract the hotel listed on the other OTA. In particular, we identify a region in which there is a mixed-strategy equilibrium as OTAs randomize over a range of commission fees and hotels multi-home or single-home with a positive probability. Only when hotels are extremely similar in the eyes of consumers (very high degree of inter-brand competition), OTAs succeed in raising their fees, as it becomes unprofitable to reduce them in the attempt to induce hotels to multi-home.

We then examine the case in which OTAs impose PPCs. First, we confirm the general knowledge that price parities enable platforms to significantly increase their fees with respect to the case of unrestricted prices. Second, with PPCs hotels still face a trade-off between multi-homing and single-homing, but now segmentation becomes more likely. In fact, with PPCs multi-homing is relatively less profitable for hotels than with unconstrained prices as commission fees are higher. As a result, single-homing occurs for a wider parametric region because the demand loss is compensated by a reduction in the commission fee. The finding that PPCs induce segmentation more often is one of the most important results of our paper.

Next, we investigate OTAs' contractual arrangements and find that the decision to adopt PPCs is determined by another trade-off. OTAs apply PPCs when the degree of intra-brand competition is relatively high (*i.e.* when they are close substitutes), as this allows them to set higher fees. In contrast, when they are sufficiently differentiated, OTAs refrain from adopting PPCs as the increase in booking offers compensates for lower commission fees. This trade-off is particularly evident when the degree of inter-brand competition is moderate. Conversely, when hotels are highly substitutable, our analysis shows that OTAs may apply PPCs as a mechanism to prevent the fee-undercutting dynamics that emerges with unconstrained prices if hotels single-home. This last finding adds to the analysis of Boik and Corts (2016), who consider a model with two platforms but only one seller, and find that platforms adopt price parity when they are relatively similar. We extend their model to account for competition among sellers, showing that OTAs apply PPCs also when inter-brand competition is sufficiently strong. This represents another relevant result of our analysis, as it highlights that PPCs can be used to keep commission fees relatively high when segmentation prevails as a result of high inter-brand competition.

In the last part of the paper we analyze the economic effects of PPCs in terms of industry profits, consumer well-being, and total surplus. The adoption of PPCs usually hurts hotels as they have to pay higher commission fees. There exists however a situation in which hotels could benefit from PPCs, but OTAs prefer to leave prices unconstrained. This occurs for low levels of intra-brand competition and relatively high levels of inter-brand competition: OTAs forgo PPCs in order to increase their bookings, but hotels would have preferred this arrangement as it induces market segmentation, thus allowing them to enjoy a higher price margin. Regarding consumers, they are never better off when PPCs are applied since platform prices increase following the surge in commission fees. The same applies to total welfare, which decreases when PPCs are adopted, as potential gains for OTAs do not compensate for losses on the sides of both consumers and hotels. The only exception is represented by a small parametric area in which hotels are almost perfect substitutes, and commission fees and prices are unaffected by PPCs.

To sum up, our simplified model of the lodging sector highlights the role of PPCs for market segmentation and price dynamics on different sales channels. In line with the empirical evidence by Hunold *at al.* (2018), we show the removal of PPCs has the desired effect of increasing the number of hotels listed on different OTAs, promoting platform competition. Moreover, this measure reduces commission fees and this translates into lower retail prices for end customers, thus enhancing total welfare. Our analysis also reveals that OTAs find it profitable to adopt PPCs when both hotels and OTAs are relatively similar. Overall, the results of our paper provide useful economic as well as managerial insights for all players involved in the lodging market, and have relevant implications for policy makers interested in the economic effects of PPCs.

Literature review. In the last years, a growing number of studies have analyzed the economic effect of PPCs, and their removal thereof, in the context of online platforms. From a theoretical perspective, we build upon and contribute to these recent works. Boik and Corts (2016) and Johnson (2017) show that PPCs increase commissions fees set by the OTAs, thereby damaging final consumers. Intuitively, platforms' incentive to compete by offering better terms of trade to suppliers is undermined because the final price is constrained to be the same across platforms. Boik and Corts (2016) find results similar to ours concerning platforms' decision to forgo price parities when they are relatively differentiated. However, they consider a model with two platforms but only one seller. We extend their analysis to consider two horizontally differentiated sellers, as we previously introduced, and this allows us to analyze the impact of inter-brand competition on PPCs adoption and market segmentation.

Edelman and Wright (2015) develop a model in which consumers can purchase directly from the preferred sellers or from a platform. In this context, PPCs enable platforms to prevent showrooming by raising the price of the direct channel. They also find that PPCs lead to excessive investment in ancillary services by the platform in order to lock-in consumers. The result is a reduction in consumer surplus and sometimes welfare. Wang and Wright (2020) consider instead a sequential search model in which platforms provide both a search and intermediation service. In this context, competition implies that wide PPCs lead to higher prices in order to eliminate showrooming, whereas narrow PPCs may preserve competition and limit price surges while avoiding free-riding on the platforms' search services.[4] These papers provide very useful results but do not explicitly study the impact of PPCs on market segmentation.

[4] Wals and Schinkel (2018) find that narrow PPCs combined with a best price guarantee (BPG) may reproduce the detrimental effects for consumers of wide PPCs. In fact, the dominant platform can deter entry with the BPG, while at the same time using narrow PPCs to eliminate competition from direct sales channels.

Ronayne and Taylor (2021) analyze a market where two producers sell a homogeneous product to consumers through both a direct and a competitive channel, whose size significantly affects market outcomes. In this context, they examine the effect of Most Favored Nation (MFN) clauses, a form of PPCs. Similarly to our analysis, they find that some firms delist under MFNs, and that consumers are harmed by MFNs. However, our paper differs from theirs as we analyze competition between horizontally differentiated platforms in addition to competition between sellers. This allows us to highlight that OTAs' decision about the adoption of price restrictions crucially depends on their degree of substitutability combined with that of sellers.

Johansen and Vergé (2017) develop a model where there are two OTAs, several sellers, and consumers characterized by preferences *à la* Singh and Vives (1984), based on a representative agent and elastic demand. An important feature of their analysis is the interplay between hotels' substitutability and their possibility to delist from the OTAs and only offer the services through their direct channels; this imposes a limit to the fee OTAs can charge.[5] They also assume the fees are secretly offered to hotels. As a consequence, each supplier does not observe the commission fee paid by its rivals. They adopt the "contract equilibrium" approach developed by Cremer and Riordan (1987) and Horn and Wolinsky (1988), finding scenarios in which PPCs may benefit both hotels and consumers. Differently from them, we assume that hotels observe all commission fees and choose their listing strategy accordingly. This is an important aspect of our model, as we show that PPCs may induce segmentation, thereby reducing the number of hotels on each OTA.

Our paper contributes to the literature on competition in two-sided markets. Seminal contributions by Caillaud and Jullien (2003), Rochet and Tirole (2003, 2006), and Armstrong (2006) focus on cross-group externalities between agents on both sides. Recent papers by Gal-Or *et al.* (2019) and Gal-Or (2020) study differentiation across matching platforms that arises endogenously due to the self-selection of the participants in the market. In these models, price competition leads to platform segmentation when individuals want to reduce incompatibilities with their matching partners. By contrast, in our paper, segmentation occurs when sellers prefer to sacrifice part of their demand to reduce price competition. In fact, the presence of two platforms provides sellers an instrument to increase product differentiation.

Another distinctive feature of our analysis is that we explicitly consider competition between agents on the same side. Hence, we are close to Karle *et al.* (2020), who examine the optimality of agglomeration (all buyers and sellers in one platform) *vs.* segmentation for both consumers and sellers in the presence of homogeneous platforms.[6] They show there are in-

[5]Mariotto and Verdier (2020) consider a model in which sellers can sell directly to consumers or through a monopolistic platform that provides a higher quality to consumers and may generate efficiency gains for sellers. The platform adopts PPCs when the degree of heterogeneity between consumers is high with respect to the quality of service on the seller side. As in Johansen and Vergé (2017), this paper shows that PPCs do not necessarily lead to higher fees and higher retail prices.

[6]Armstrong and Wright (2007) endogenize the decision of agents to single-home or multi-home by considering how platform differentiation affects this choice. They also investigate the use of exclusive contracts that prevent agents from multi-homing. Bryan and Gans (2019) examine competition among ride-sharing platforms and

stances in which sellers prefer segmentation in order to reduce competition, as some consumers will not be informed about all offers. Homogeneous platforms can benefit from this situation by charging higher fees. Our model allows for the existence of differentiated platforms, and shows that sellers choose segmentation instead of multi-homing when competition between both sellers and platforms is strong. More generally, while their analysis focuses on how competition in the product market affects platform market structure, we examine the market characteristics that incentivize platforms' adoption of PPCs, and how these price restrictions affect sellers' segmentation decisions.

A few empirical papers have analyzed the impact of PPCs in European markets. The aforementioned paper by Hunold *et al.* (2018) is based on meta-search data of more than 30,000 hotels in *Kayak.com* from January 2016 until January 2017. Consistently with our results, they obtain that the abolition of PPCs in Germany at the end of 2015, although not changing the commission rates, encouraged hotels to publish their offers on more OTAs and to increase the use of their own websites to commercialize their services. They also document a sharper price decrease of hotel rooms on the direct channel in Germany, as compared to countries that did not abolish PPCs. Cazaubiel *et al.* (2020) obtain an exhaustive dataset of reservations from 2013 to 2016 in 13 hotels in Oslo belonging to the same chain. They estimate the degree of substitution between *Booking.com* and *Expedia*, and hotels' own websites, and show that the direct sales channel appears to be a credible alternative to the OTAs. Finally, Mantovani *et al.* (2021) have collected data of listed prices on *Booking.com* in the period 2014-17 for tourism regions that belong to France and Italy. They compare prices before and after the prohibition of PPCs in France and find significant price decreases on the platform in the short run, followed by a more limited effect in the medium run. Moreover, they show that hotels characterized by a more complex organizational structure decreased their prices more substantially, both in the short and medium run.

The remainder of the article proceeds as follows. The next section presents the basic model. Section 3 considers the benchmark case of unrestricted prices, whereas Section 4 presents the case in which both OTAs adopt PPCs. Section 5 examines the OTAs' decision regarding the adoption of PPCs (or not) and it highlights the economic effects of adopting PPCs. Section 6 provides additional discussion and possible extensions to the baseline model. Section 7 concludes.

2 The model

We develop a model in which platforms enable trade between consumers and sellers. We refer to hotels and OTAs as representative examples of sellers and platforms, respectively. In what follows, we describe the main actors of the model.

consider the case in which both drivers and consumers multi-home. They find that socially superior outcomes may involve monopoly or competition under various multi-homing regimes.

OTAs. There are two horizontally differentiated OTAs (A and B). Think of *Booking.com* and *Expedia*. These platforms, although perceived as similar by many users, differ in several aspects. *Expedia* caters to consumers who look for full-service deals, as it also offers flights, car rental, and packages. *Booking.com* mainly focuses on lodging services, whose description is more accurate than its rival. In recent years, both OTAs increased their offerings in alternative accommodations to include private homes and apartments, and in this respect they somehow converged. However, they also undertook significant structural changes in order to differentiate themselves. *Booking.com* innovated its website by adding complementary features to enhance the customers' interaction with hotels.[7] Conversely, Expedia's major effort was carried out to improve travellers' experience and reduce possible frictions.[8]

OTAs enable transactions between the hotels and their prospective consumers, and can decide whether or not to adopt PPCs. To be listed on OTA i, with $i \in \{A, B\}$, a hotel has to pay a per-transaction fee f_i, while consumers can access OTAs for free. OTAs' profits depend on the number of hotels that are listed on their platforms. For simplicity, we assume that OTAs announce their fees simultaneously and cannot price discriminate among hotels.[9] This captures the evidence that commission fees are usually publicly available online within the OTAs' contractual conditions.[10]

Hotels. There are two horizontally differentiated hotels (1 and 2) that decide whether to single-home or multi-home (*i.e.*, to be listed on one or two OTAs) before setting prices on the product market. This timing is justified as listing choices are typically longer-term decisions than price setting. We denote by p_{ih} and q_{ih} the price and demand obtained by hotel h on OTA i, respectively, with $h \in \{1, 2\}$ and $i \neq j \in \{A, B\}$. If hotels join both OTAs, there is No Segmentation (NS) and their profits are:

$$\pi_h^{NS}(f_i, f_j) = [p_{ih}^{NS}(f_i, f_j) - f_i]q_{ih}^{NS}(f_i, f_j) + [p_{jh}^{NS}(f_i, f_j) - f_j]q_{jh}^{NS}(f_i, f_j).$$

On the contrary, if they are listed on one OTA each, there is Segmentation (S) and hotels' profits are:

$$\pi_h^{S}(f_i, f_j) = [p_{ih}^{S}(f_i, f_j) - f_i]q_{ih}^{S}(f_i, f_j).$$

[7] *Booking.com* recently launched the PassionSearch service to help travellers to easily search and uncover destinations matching their interests. It also released the Booking Messages Interface, a chat tool to better connect hotels and travelers.

[8] For instance, *Expedia* launched a trip assistance function on the app in order to alert the booked hotel if the traveler experiences a flight delay.

[9] We abstract from the presence of preferred partner programs (PPPs) created by some OTAs to increase a hotel's visibility on the platform in exchange for a higher commission fee. The main results of our paper do not change if we relax this assumption, which considerably simplifies our computations.

[10] The interested reader could visit *Booking.com*'s Partner Hub, which provides a calculator for computing the commission rate, depending on property type or location: https://partner.booking.com/en-gb/help/commission-invoices-tax/how-much-commission-do-i-pay. In terms of our modeling assumption, this means that an OTA would charge the same commission fee to two horizontally differentiated hotels offering a similar quality and in the same location.

Lastly, in case of Partial Segmentation (PS), one hotel multi-homes and the other single-homes. For example, if hotel h joins both OTAs while its rival is listed only on one, then hotel h's profits are:

$$\pi_h^{PS}(f_i, f_j) = [p_{ih}^{PS}(f_i, f_j) - f_i]q_{ih}^{PS}(f_i, f_j) + [p_{jh}^{PS}(f_i, f_j) - f_j]q_{jh}^{PS}(f_i, f_j).$$

When the opposite occurs (hotel h single-homes - say on OTA i - when its rival multi-homes), hotel h's profits are:

$$\widehat{\pi}_h^{PS}(f_i, f_j) = [\hat{p}_{ih}^{PS}(f_i, f_j) - f_i]\hat{q}_{ih}^{PS}(f_i, f_j).$$

Notice that we assume OTAs are the only way for hotels to inform consumers about their presence in the market. Therefore, hotels have no incentive to delist from both OTAs.[11] In Section 6, we discuss how our results change when, after observing the hotels' availability on the OTAs, consumers can directly reserve the rooms through the hotels websites, giving rise to showrooming.

Microfoundation of the Buyer-Hotel Interaction. To determine hotels' demands, we provide a simple microfoundation of the buyer-hotel interaction. This is based on a representative consumer model with linear demand à la Singh and Vives (1984), which is also the demand specification recently adopted by Johansen and Vergé (2017), and used in one of the examples by Karle *et al.* (2020) in order to microfound their buyer-seller relationship. The indirect utility function is:

$$\sum_{i=A,B}\sum_{h=1,2} q_{ih} - \frac{1}{2}\sum_{i=A,B}\sum_{h=1,2} q_{ih}^2 - \alpha \sum_{i=A,B} q_{ih}q_{ik} - \beta \left(\sum_{h=1,2} q_{ih}q_{jh} + \alpha \sum_{i=A,B} q_{ih}q_{ik}\right) - \sum_{i=A,B}\sum_{h=1,2} p_{ih}q_{ih}. \tag{1}$$

Parameters $\alpha \in (0, 1)$ and $\beta \in (0, 1)$ measure the degree of inter-brand (*i.e.*, between hotels) and intra-brand competition (*i.e.*, between platforms), respectively. A relatively high value of α (resp. β) means that hotels (resp. OTAs) are perceived by consumers as close substitutes, and *vice versa*. This is a representative consumer setting where each buyer obtains utility from positive quantities of each product. Maximizing this utility function with respect to q_{ih}, we obtain the inverse demand system:

$$p_{ih} = 1 - [q_{ih} + \alpha q_{ik} + \beta(q_{jh} + \alpha q_{jk})], \;\; h \neq k \in \{1, 2\}, i \neq j \in \{A, B\}. \tag{2}$$

Timing of the model and Equilibrium Concept. In Stage 1, OTAs decide whether to adopt PPCs or not. In Stage 2, OTAs simultaneously set the linear commission fees for the hotels. In Stage 3, hotels decide whether to be active on both OTAs or only on one OTA. In Stage 4, hotels set their retail prices in all channels in which they are active. In Stage 5, consumers observe all offers on the OTAs and make their purchasing decisions.

[11] Gomes and Mantovani (2020) consider a model in which consumers have some information about the hotels available in the market. A monopolistic OTA expands consumer information, augmenting each hotel's potential demand. They find all hotels join the OTA because of the contractual externality that listed hotels impose on the non-listed ones. Indeed, if a hotel forgoes the OTA, it risks facing a very high degree of competition on its demand, as its clients now consider all rival hotels listed on the platform.

Our solution concept is Subgame Perfect Nash Equilibrium and the game is solved by backward induction. In case of multiple equilibria, we adopt Pareto dominance for both OTAs and hotels as a selection criterion. If a Pareto superior equilibrium is available, this will lead to a unique equilibrium of the game. In our model, as hotels decide which platform to join before consumers do, we do not need other refinements to guarantee equilibrium uniqueness. This sequentiality in decisions is a realistic assumption in markets in which sellers and consumers trade via platforms. In our setting, OTAs can operate only if they secure deals with hotels in the first place, whereas consumers' decisions are only made afterwards.

The objective of the next two sections is to determine the hotels' listing decision as well as OTAs' commission fees under two alternative scenarios: *(i)* the benchmark case of unrestricted prices, in which hotels are free to set their prices in all platforms in which they offer their rooms; and *(ii)* full adoption of PPCs, which are applied by both OTAs towards client hotels. The partial adoption of PPCs, which occurs when only one OTA adopts PPCs, is not relevant in our setting since it turns out to be equivalent to the case in which both OTAs adopt PPCs.[12] Also notice that in the absence of direct selling, the distinction between wide and narrow PPCs becomes immaterial, and for this reason we simply use the terminology PPCs along the text.

3 The benchmark case: unrestricted pricing

This section considers the case in which OTAs do not impose contractual price restrictions on hotels, that are therefore free to set their prices in the fourth stage of the game. All mathematical computations as well as proofs of lemmas and propositions are shown in the Appendix.

Consumers' choices in Stage 5 and hotels' pricing decisions in Stage 4 are straightforward. In Stage 5, consumers make their purchasing decisions according to their demand functions, which are computed from Equation (2). In Stage 4, each hotel sets its retail prices taking into account the rival's listing decision. In the Appendix, we derive the demand functions and hotels' prices as functions of the commission fees.

The next lemma reports hotels' profits as functions of the fees in the three possible scenarios: No Segmentation (NS), in which both hotels multi-home; Segmentation (S), in which each hotel is listed on a different OTA; Partial Segmentation (PS), where only one hotel is listed on both OTAs, whereas the other is listed only on one. In case of segmentation, we assume that hotel h joins OTA i whereas hotel k joins OTA j. The lemma is written in terms of hotel h's profits but the expressions hold, *mutatis mutandis*, for hotel k as well.

Lemma 1. *In Stage 4, hotel h's profits are as follows:*

- *when hotels are listed on both OTAs:*

$$\pi_h^{NS}(f_i, f_j) = \frac{(1-\alpha)[(1-f_i)^2 - 2\beta(1-f_i)(1-f_j) + (1-f_j)^2]}{(2-\alpha)^2(1+\alpha)(1-\beta^2)};$$

[12] Additional details are provided in the Appendix.

- *when hotel h joins OTA i, while hotel k joins OTA j:*

$$\pi_h^S(f_i,f_j) = \frac{[(2-\alpha^2\beta^2)(1-f_i)-\alpha\beta(1-f_j)]^2}{(4-\alpha^2\beta^2)^2(1-\alpha^2\beta^2)};$$

- *when hotel h multi-homes, while hotel k single-homes on OTA j:*

$$\pi_h^{PS}(f_i,f_j) = \frac{1}{8}\left[\frac{2\alpha(3\alpha-\alpha^2-4)(1-f_j)^2}{(1+\alpha)(2-\alpha)} + \frac{(f_i-f_j)^2}{1-\beta} + \frac{(2-f_i-f_j)^2}{1+\beta}\right];$$

- *when hotel h single-homes on OTA i, while hotel k rival multi-homes:*

$$\widehat{\pi}_h^{PS}(f_i,f_j) = \frac{(1-\alpha)(1-f_i)^2}{(1+\alpha)(2-\alpha)^2}.$$

3.1 Hotels' listing decisions

We now turn to Stage 3, in which hotels compare the profits they obtain in each of the previous three scenarios and decide their profit-maximizing listing strategies. We first evaluate the incentives of a hotel to single-home when its rival is active on both platforms. To do so, we compare hotel h's profits when it multi-homes with its profits when it single-homes, provided the rival multi-homes. We find that $\pi_h^{NS}(f_i,f_j) > \widehat{\pi}_h^{PS}(f_i,f_j)$ is always satisfied, given that:

$$\pi_h^{NS}(f_i,f_j) - \widehat{\pi}_h^{PS}(f_i,f_j) = \frac{(1-\alpha)[1-f_j-\beta(1-f_i)]^2}{(1+\alpha)(2-\alpha)^2(1-\beta^2)} > 0.$$

It follows that No Segmentation can always be an equilibrium in pure strategy for any fee charged by the OTAs and for any values of the parameters.

Next, we consider hotel h's incentives to multi-home when the rival hotel k single-homes. To this end, we compare hotel h's profits when both hotels single-home with those obtained when only its competitor does. We obtain that $\pi_h^{PS}(f_i,f_j) \geq \pi_h^S(f_i,f_j)$ if $\alpha \leq \alpha_S(f_i,f_j)$, which implies that Segmentation can also be an equilibrium when α is sufficiently large. Notice that, if both OTAs set the same fees in Stage 2 (*i.e.*, $f_i = f_j$), then the threshold value $\alpha_S(f_i,f_j) = \alpha_S$ is determined by the following condition, which does not depend on the specific values taken by the fees:

$$\frac{2(2-\alpha)^2(1+\alpha)-\alpha(1+\beta)[4-(3-\alpha)\alpha]}{4(2-\alpha)^2(1+\alpha)(1+\beta)} \geq \frac{(1-\alpha\beta)}{(2-\alpha\beta)^2(1+\alpha\beta)}. \tag{3}$$

We also obtain that, when condition (3) is satisfied, $\pi_h^{PS}(f_i,f_j) \geq \pi_h^S(f_i,f_j)$ for any fee with $f_i \geq f_j$. This is because hotel h's profits are more negatively affected by an increase in OTA i's fee when it single-homes than when it multi-homes, that is: $\frac{\partial\pi_h^S(f_i,f_j)}{\partial f_i} \leq \frac{\partial\pi_h^{PS}(f_i,f_j)}{\partial f_i} \leq 0$.[13] As a result, the threshold value $\alpha_S(f_i,f_j)$ increases in the difference between fees, rendering the No Segmentation equilibrium more likely.[14]

Lemma 2 uses the previous results to summarize the hotels' decision in the absence of PPCs.

[13]This occurs because an increase in OTA i's fee has a stronger negative effect on hotel j's total demand under single-homing than multi-homing. This effect on the demand translates to hotels' profits.

[14]This implies that the region in which Segmentation is a possible equilibrium, $\alpha \in (\alpha_S(f_i,f_j),1)$, can shrink, or even disappears, if in Stage 2 OTAs set different fees. However, in the next subsection we will demonstrate that there is always a parametric region in which hotels decide to segment the market.

Lemma 2. *In Stage 3, hotels' listing strategy is the following:*

- *if* $\alpha \in (0, \alpha_S(f_i, f_j)]$*, there exists a No Segmentation equilibrium;*
- *if* $\alpha \in (\alpha_S(f_i, f_j), 1)$*, both Segmentation and No Segmentation equilibria can occur.*

This lemma highlights that hotels' decision crucially depends on inter-brand competitive pressure. When hotels' competition is mild, *i.e.* $\alpha \in (0, \alpha_S(f_i, f_j)]$, No Segmentation is the only equilibrium. By contrast, when hotels' competition is severe, *i.e.* $\alpha \in (\alpha_S(f_i, f_j), 1)$, both No Segmentation and Segmentation equilibria can arise. The latter interval exists as long as OTAs' fees are sufficiently close to each other, otherwise the interval shrinks and there is always No Segmentation. We also obtain that $\pi_h^{NS}(f_i, f_j) \geq \pi_h^S(f_i, f_j)$ for $\alpha \leq \alpha_{PD}(f_i, f_j)$. For symmetric fees the threshold value $\alpha_{PD}(f_i, f_j) = \alpha_{PD}$ is computed from:

$$\frac{2(1-\alpha)}{(2-\alpha)^2(1+\alpha)(1+\beta)} \geq \frac{(1-\alpha\beta)}{(2-\alpha\beta)^2(1+\alpha\beta)}. \tag{4}$$

By comparing (3) and (4), one can see that the right-hand sides are the same, whereas the left-hand side of (3) is bigger than that of (4), which implies that $\alpha_{PD} < \alpha_S$. Hence, with symmetric fees, Segmentation is the Pareto dominant equilibrium when $\alpha > \alpha_S$, and we assume that hotels coordinate on the decision to single-home. Indeed, segmentation would stifle the competitive pressure, thus allowing hotels to increase their price margins. Importantly, note that in $\alpha \in (\alpha_{PD}, \alpha_S]$ hotels are trapped in a prisoners' dilemma (PD) as they would obtain higher profits by single-homing, but multi-homing is a dominant strategy.

We can conclude that, when competition between hotels is severe and fees are sufficiently close to each other, each hotel aims at differentiating itself from its competitor by segmenting the market, even if this implies a sacrifice in terms of the amount of sales. On the contrary, when the degree of inter-brand competition is relatively mild, hotels offer their rooms on both OTAs, thereby increasing demands.

Interestingly, our analysis reveals that, when hotels are highly substitutable, segmentation can also occur in the absence of OTAs, as long as differentiated distribution channels are available. *A priori*, one may expect that joining a second channel is always beneficial for hotels, if the rival is listed only on one. Indeed, this strategy would enable the multi-homing hotel to sell more rooms, while enjoying a higher price margin on each room than the single-homing hotel. However, when hotels are perceived as highly substitutable (α is relatively high), hotels prefer segmentation to gain even more on each unit of output rather than expanding sales through multi-homing. This is more likely to occur when distribution channels are highly substitutable as well (β is relatively high), as competitive pressure between channels exacerbates inter-brand competition. On the other hand, the higher the degree of differentiation between the two distribution channels (the lower the β), the higher the degree of inter-brand substituability that leads hotels to single-home, and segmentation never occurs when the channels are independent ($\beta = 0$).[15] This incentive to segment the market is maintained in the presence of differentiated OTAs, unless they charge substantially different fees.

[15] For a graphical interpretation of this result, we refer the reader to Figure 1, which appears later in the text.

3.2 OTAs' fees decisions

We now analyze how OTAs simultaneously set their commissions fees in Stage 2, anticipating the hotels' listing and pricing decisions in the subsequent stages of the game. OTA i's profits under No Segmentation and Segmentation are respectively given by:

$$\pi_i^{NS} = f_i \, [q_{ih}^{NS}(f_i, f_j) + q_{ik}^{NS}(f_i, f_j)];$$
$$\pi_i^{S} = f_i \, q_{ih}^{S}(f_i, f_j).$$

The next proposition shows how OTAs set the commission fees and reports the resulting retail prices and profits of both OTAs and hotels.

Proposition 1. *In Stage 2, when prices are unrestricted:*

- *if $\alpha \in (0, \alpha_S]$, there is No Segmentation, and equilibrium prices and profits are:*

$$f_i^{NS} = \frac{1-\beta}{2-\beta}; \; p_{ih}^{NS} = \frac{3-\alpha(2-\beta)-2\beta}{(2-\alpha)(2-\beta)};$$

$$\pi_h^{NS} = \frac{2(1-\alpha)}{(1+\alpha)(2-\alpha)^2(1+\beta)(2-\beta)^2}; \; \pi_i^{NS} = \frac{2(1-\beta)}{(1+\alpha)(2-\alpha)(1+\beta)(2-\beta)^2}.$$

- *If $\alpha \in (\alpha_S, \alpha_{SS}]$, No segmentation and Segmentation occur with positive probability, and there is a mixed-strategy equilibrium in which OTAs set their fees in the domain $f_i^{SS} \in (\underline{f}_i, \overline{f}_i)$, with $\underline{f}_i \geq f_i^{NS}$ and $\overline{f}_i \leq f_i^{S}$. The expected retail prices and profits satisfy: $p_{ih}^{NS} < p_{ih}^{SS} < p_{ih}^{S}$, $\pi_h^{S} < \pi_h^{SS} < \pi_h^{NS}$, and $\pi_i^{NS} < \pi_i^{SS} < \pi_i^{S}$.*

- *If $\alpha \in (\alpha_{SS}, 1)$, there is Segmentation, and equilibrium prices and profits are:*

$$f_i^{S} = \frac{(1-\alpha\beta)(2+\alpha\beta)}{4-\alpha\beta(1+2\alpha\beta)}; \; p_{ih}^{S} = \frac{2(1-\alpha\beta)(3-\alpha^2\beta^2)}{(2-\alpha\beta)\left[4-\alpha\beta(1+2\alpha\beta)\right]};$$

$$\pi_h^{S} = \frac{(1-\alpha\beta)(2-\alpha^2\beta^2)^2}{(2-\alpha\beta)^2(1+\alpha\beta)\left[4-\alpha\beta(1+2\alpha\beta)\right]^2}; \; \pi_i^{S} = \frac{(1-\alpha\beta)(2+\alpha\beta)(2-\alpha^2\beta^2)}{(2-\alpha\beta)(1+\alpha\beta)\left[4-\alpha\beta(1+2\alpha\beta)\right]^2}.$$

Proposition 1 reveals that OTAs' pricing policy depends on the intensity of inter-brand competition. When hotels are sufficiently differentiated, $\alpha \in (0, \alpha_S]$, OTAs set the symmetric commission fee f_i^{NS} and hotels multi-home. This fee maximizes OTAs' profits, as no deviation is profitable. Notice that f_i^{NS} approaches zero when OTAs are perfect substitutes ($\beta \to 1$).

When $\alpha \in (\alpha_S, \alpha_{SS}]$, there is a mixed-strategy equilibrium that can generate No Segmentation or Segmentation. Hotels would choose Segmentation if OTAs set the symmetric fee f_i^{S}, but each OTA has a unilateral incentive to lower this fee in order to attract the hotel that is listed on its rival. This gives rise to an undercutting process that continues until the fee is sufficiently low, but does not converge to an equilibrium. Indeed, when the rival's fee is sufficiently, OTAs can have an incentive to raise their fee to increase profits, while still inducing segmentation. As a result, OTAs randomize over the commission fees.[16] Specifically, there is a fee charged by

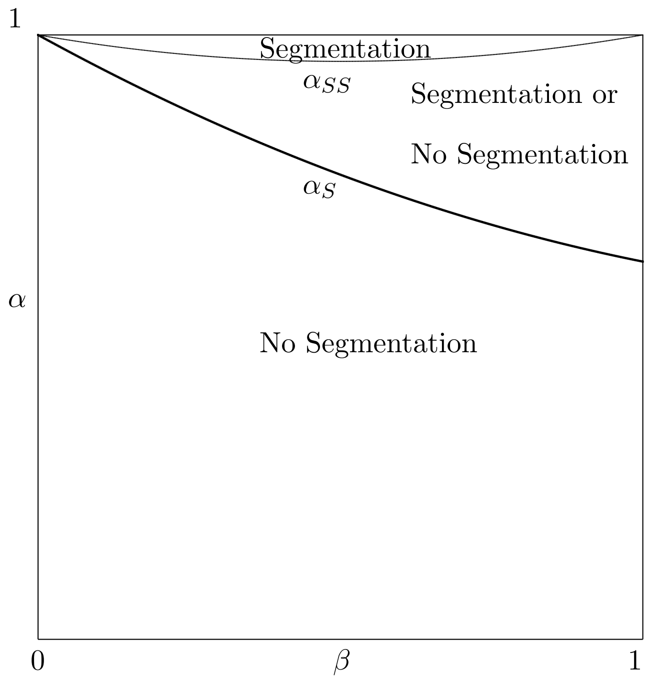
[16] The intuition behind this result is similar to that provided by Karle et al. (2020) in their Propositions 3 and 8, in which they obtain a region where there is a cycle of best responses and platforms' fees do not converge.

OTA j for which OTA i randomizes in the range $f_i^{SS} \in (\underline{f_i}, \overline{f_i})$. This range can be divided in two intervals: there is a lower interval in which OTA i sets a low fee to induce multi-homing by both hotels, and an upper one in which it sets a high fee to induce segmentation. This implies that in this range OTAs' commission fees can lead to No Segmentation or Segmentation with a positive probability. Moreover, OTAs' expected profits (denoted by π_i^{SS}) are the same in all the domain in which they randomize, and satisfy $\pi_i^{NS} < \pi_i^{SS} < \pi_i^{S}$. Regarding hotels, depending on the fees, either both of them multi-home or single-home, whereas Partial Segmentation is never an equilibrium, as shown in Lemma 2. Given that OTAs randomize in $f_i^{SS} \in (\underline{f_i}, \overline{f_i})$, hotels' profits (denoted by π_h^{SS}) are such that $\pi_h^{S} < \pi_h^{SS} < \pi_h^{NS}$.

When $\alpha \in (\alpha_{SS}, 1)$, competition in the retail market is so strong that OTAs cannot profitably deviate to attract the other hotel, as this would imply an excessive sacrifice in terms of fee reduction. As a result, they both set f_i^S and there is Segmentation. We observe that $f_i^S > 0$ also when $\beta \to 1$, meaning that even identical OTAs can charge a positive fee when they host one hotel each, provided $\alpha \neq 1$. Hence, with market segmentation, OTAs exploit the degree of competition between hotels to increase their profits.

To summarize, Proposition 1 shows that, in the absence of PPCs, No Segmentation always occurs when hotels are sufficiently differentiated; both No Segmentation and Segmentation occur with a positive probability for higher values of α; and there is Segmentation when hotels are closer substitutes. Figure 1 illustrates these regions and the threshold values α_S and α_{SS}.[17]

Figure 1: Hotels' decisions without PPCs



[17] While α_S is derived from Inequality (3), α_{SS} is obtained from comparing OTA i's profits when it unilaterally deviates (by setting a lower fee f_i^{dev} that induces the hotel on the rival OTA to multi-home) with its profits when it does not deviate, *i.e.*, $\pi_i^{NS}(f_i^{dev}, f_j^S)$ vs. $\pi_i^S(f_i^S, f_j^S)$. For additional details, see the proof of Proposition 1 in the Appendix.

4 Price parity clauses

When both OTAs adopt PPCs, hotels cannot offer their rooms at cheaper prices on the rival platform, and for this reason we have that $p_{ih} = p_{jh} = p_h$ (and $p_{ik} = p_{jk} = p_k$). Similarly to the previous section, it is straightforward to obtain how consumers derive their demand functions in Stage 5, and how hotels set their retail prices in Stage 4 (see the Appendix). The next lemma illustrates hotels' profits as functions of the commission fees in each of the three possible scenarios: No Segmentation (NS); Segmentation (S); and Partial Segmentation (PS).[18] The superscript P indicates that we are in the presence of PPCs.

Lemma 3. *In Stage 4, hotel h's profits are as follows:*

- *when hotels join both OTAs:*
$$\pi_h^{NSP}(f_i, f_j) = \frac{(1-\alpha)(2-f_i-f_j)^2}{2(2-\alpha)^2(1+\alpha)(1+\beta)};$$
- *hotel h joins OTA i, while hotel k joins OTA j:*
$$\pi_h^{SP}(f_i, f_j) = \frac{[(2-\alpha^2\beta^2)(1-f_i)-\alpha\beta(1-f_j)]^2}{(4-\alpha^2\beta^2)^2(1-\alpha^2\beta^2)};$$
- *when hotel h multi-homes, while hotel k single-homes on OTA j:*
$$\pi_h^{PSP}(f_i, f_j) = \pi_h^{PS}(f_i, f_j) - \Omega(f_i, f_j),$$
where $\Omega(f_i, f_j) > 0$ is reported in the Appendix;
- *when hotel h single-homes on OTA i, while hotel k multi-homes:*
$$\widehat{\pi}_h^{PSP}(f_i, f_j) = \frac{(1-\alpha)\left\{[4+\alpha(f_j+2)-\alpha^2(1-f_j-\beta)-f_i[4+\alpha(3+\alpha\beta)]\right\}^2}{(1+\alpha)[8-\alpha^2(5-3\beta)]^2}.$$

In our framework, hotels' profits when they both single-home are the same with and without PPCs, *i.e.* $\pi_h^{SP}(f_i, f_j) \equiv \pi_h^{S}(f_i, f_j)$.

4.1 Hotels' listing decisions

In Stage 3, hotels decide their profit-maximizing listing strategy. Akin to the case of unrestricted prices, we first evaluate the incentives of a hotel to single-home when its rival is active on both platforms. To do so, we compare hotel h's profits when it multi-homes and when it single-homes, provided the rival multi-homes. We find that $\pi_h^{NSP}(f_i, f_j) \geq \widehat{\pi}_h^{PSP}(f_i, f_j)$ is satisfied if $\alpha \leq \alpha_{NSP}(f_i, f_j)$, meaning that No Segmentation is an equilibrium when inter-brand competition is sufficiently low. Interestingly, while with unconstrained prices No Segmentation is always a possible equilibrium, with PPCs this equilibrium does not exist when α is high. Moreover, if

[18] Also in this case the lemma is written in terms of hotel h's profits but similar expressions can be obtained for hotel k.

in Stage 2 OTAs set the same fees (*i.e.*, $f_i = f_j$), the threshold value $\alpha_{NSP}(f_i, f_j) = \alpha_{NSP}$ is derived from the following condition, which does not depend on the specific values taken by the fees:

$$\frac{2}{(2-\alpha)^2(1+\beta)} \geq \frac{[4+2\alpha-\alpha^2(1-\beta)]^2}{[8-\alpha^2(5-3\beta)]^2}. \tag{5}$$

Next, we consider hotel h's incentives to multi-home when hotel k single-homes and only joins OTA j. To this end, we compare its profits when both hotels single-home with those obtained when it multi-homes. We obtain that $\pi_h^{PSP}(f_i, f_j) \geq \pi_h^{SP}(f_i, f_j)$ if $\alpha \leq \alpha_{SP}(f_i, f_j)$, which implies that Segmentation is an equilibrium when α is sufficiently large. When OTAs set the same fees (*i.e.*, $f_i = f_j$), this threshold does not depend on the fees and is derived from the following condition:

$$\frac{(1-\alpha)[4+\alpha(3-\beta)]^2[2-\alpha^2(1-\beta)]}{(1+\alpha)(1+\beta)[8-\alpha^2(5-3\beta)]^2} \geq \frac{(1-\alpha\beta)}{(2-\alpha\beta)^2(1+\alpha\beta)}. \tag{6}$$

By comparing (5) and (6) when fees are symmetric, we find that $\alpha_{SP} < \alpha_{NSP}$. Notice that this inequality could be reversed if commission fees were largely asymmetric, leading to Partial Segmentation.[19] For simplicity of exposition, the following lemma summarizes hotels' listing decisions when OTAs adopt PPCs, focusing on the case in which fees are not very different.

Lemma 4. *In Stage 3, hotels' listing strategies are as follows:*

- *if* $\alpha \in (0, \alpha_{SP}(f_i, f_j)]$, *there only exists an equilibrium of No Segmentation;*
- *if* $\alpha \in (\alpha_{SP}(f_i, f_j), \alpha_{NSP}(f_i, f_j)]$, *both Segmentation and No Segmentation equilibria can occur;*
- *if* $\alpha \in (\alpha_{NSP}(f_i, f_j), 1)$, *there only exists an equilibrium of Segmentation.*

In order to apply our refinement criterion for the case of multiple equilibria, we investigate Pareto optimality and find that $\pi_h^{NSP}(f_i, f_j) \geq \pi_h^{SP}(f_i, f_j)$ when $\alpha \leq \alpha_{PD}(f_i, f_j)$. When OTAs set symmetric fees, this is the same threshold resulting from (4).[20] Moreover, by comparing (4) with (6), we notice that the right-hand sides of the inequalities are the same, whereas the left-hand side of (4) is lower than that of (6), rendering the latter condition easier to hold. This implies that $\alpha_{PD} < \alpha_{SP}$. Therefore, if $\alpha \in (\alpha_{PD}, \alpha_{SP}]$, hotels still face a prisoners' dilemma, as multi-homing is a dominant strategy, but single-homing would yield a higher payoff. Conversely, if $\alpha \in (\alpha_{SP}, 1)$, hotels opt for market segmentation, as it is Pareto dominant for them.

[19] We refer the reader to the Proof of Proposition 2 in the Appendix for a formal analysis of the case in which OTAs can set different fees.

[20] As already explained, equilibrium profits are the same in the case of market segmentation, with or without PPCs: $\pi_h^S(f_i, f_j) = \pi_h^{SP}(f_i, f_j)$. Moreover, one can see that $\pi_h^{NSP}(f_i, f_j) = \pi_h^{NS}(f_i, f_j)$ when $f_i = f_j$. Conversely, equilibrium profits with No Segmentation do not coincide with or without PPCs, given that OTAs set different commission fees in these two cases.

This result shows that hotels find it profitable to offer their services on both platforms when inter-brand competition is mild. Conversely, when the competitive pressure is severe, they choose to single-home in order to differentiate themselves from their rival. This result is similar to the one that we obtained in the absence of PPCs, even though prices and profits differ.

Finally, it is interesting to show that for some fixed and symmetric fees market segmentation is more likely when OTAs adopt PPCs. By comparing (3) and (6), we observe that the right-hand sides of both expressions are the same, but the left-hand side of the former is bigger than the latter. This implies that $\alpha_{SP} < \alpha_S$, meaning that hotels' decision to single-home is more likely to occur when OTAs adopt PPCs than with unrestricted prices. Indeed, hotels' profits with partial segmentation (in our example, hotel k single-homes, while hotel h multi-homes) are lower with PPCs than with unconstrained prices, $\pi_h^{PSP}(f_i, f_j) < \pi_h^{PS}(f_i, f_j)$, whereas hotels' profits with segmentation are the same in the two scenarios, $\pi_h^{SP}(f_i, f_j) = \pi_h^{S}(f_i, f_j)$. As a consequence, deviating from segmentation becomes less profitable when PPCs are in place.

The economic intuition for this result is that hotels' incentives to deviate from segmentation are lower in the presence of PPCs, which induce hotels to diminish their price in the OTA in which they are initially alone. To see this, imagine that hotel k only joins OTA j. The decision for hotel h about whether to single-home or multi-home depends on the trade-off between increasing the profit margin on each unit by only using OTA i or expanding sales through multi-homing. In comparison to the case of unconstrained prices, PPCs reduce hotel h's incentive to multi-home. In fact, this hotel would like to charge a lower price on the OTA where it competes with hotel k, and a higher price on the OTA in which it has exclusivity, but PPCs force it to set a uniform price on the two OTAs. As a result, it prefers segmentation for a wider parametric region with PPCs than with unconstrained prices. This key result is emphasized in the next corollary.

Corollary 1. *Hotels' segmentation is more likely to occur when PPCs are in place.*

4.2 OTAs' fees decisions

In Stage 2 OTAs set the commission fees that maximize their profits. The next proposition reports the equilibrium fees and the resulting retail prices and profits with PPCs.

Proposition 2. *In Stage 2, when OTAs adopt PPCs:*

- *if $\alpha \in (0, \alpha_{SP}]$ there is No Segmentation and the equilibrium prices and profits are:*

$$f_i^{NSP} = \frac{2}{3}; \quad p_{ih}^{NSP} = \frac{5-3\alpha}{3(2-\alpha)};$$

$$\pi_h^{NSP} = \frac{2(1-\alpha)}{9(2-\alpha)^2(1+\alpha)(1+\beta)}; \quad \pi_i^{NSP} = \frac{4}{9(2-\alpha)(1+\alpha)(1+\beta)};$$

- *if $\alpha \in (\alpha_{SP}, 1)$, there is Segmentation and the equilibrium prices and profits are:*

$$f_i^{SP} = \frac{(1-\alpha\beta)(2+\alpha\beta)}{4-\alpha\beta(1+2\alpha\beta)}; \quad p_{ih}^{SP} = \frac{2(1-\alpha\beta)(3-\alpha^2\beta^2)}{(2-\alpha\beta)\left[4-\alpha\beta(1+2\alpha\beta)\right]};$$

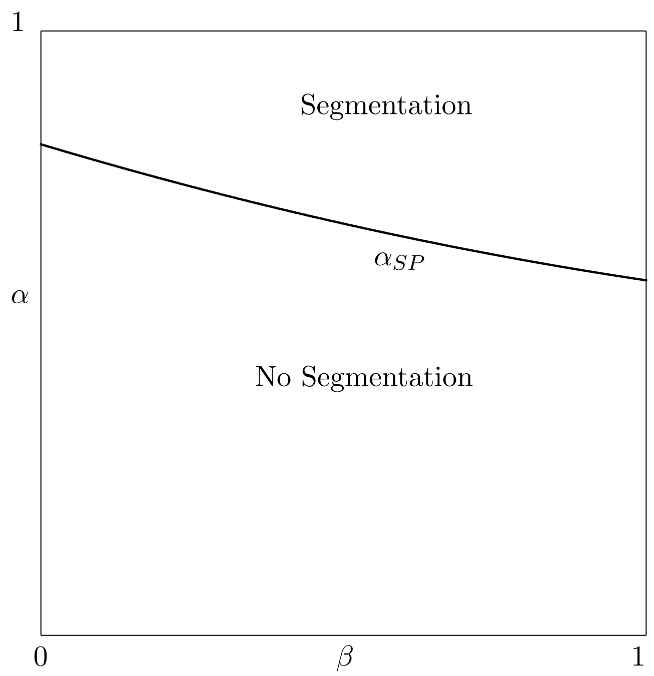
$$\pi_h^{SP} = \frac{(1-\alpha\beta)(2-\alpha^2\beta^2)^2}{(2-\alpha\beta)^2(1+\alpha\beta)\left[4-\alpha\beta(1+2\alpha\beta)\right]^2}; \quad \pi_i^{SP} = \frac{(1-\alpha\beta)(2-\alpha^2\beta^2)(2+\alpha\beta)}{(2-\alpha\beta)(1+\alpha\beta)[4-\alpha\beta(1+2\alpha\beta)]^2}.$$

Proposition 2 shows that OTAs set different fees depending on how many hotels they anticipate will be listed on their platform. When $\alpha \leq \alpha_{SP}$ OTAs anticipate that hotels will multi-home at Stage 3 if they simultaneously set $f_i^{NSP} = \frac{2}{3}$. Interestingly, this fee is independent from both inter- and intra-brand competition parameters, and it is the highest fee that OTAs set in the different scenarios that we have examined. Notice that this region can be divided into two subregions if we allow for large deviations from the equilibrium commission fees. For low values of β, OTAs set f_i^{NSP} and have no incentive to deviate. On the contrary, when β is relatively large, OTAs may find it profitable to lower their fee in order to induce one hotel to delist from the rival. We do not explicitly include this case in the proposition for simplicity, but in the Proof of Proposition 2 we show that this situation leads to a mixed-strategy equilibrium in which both No Segmentation and Partial Segmentation occur with positive probability.

When $\alpha > \alpha_{SP}$, OTAs anticipate that hotels will single-home if they both set f_i^{SP}, which is significantly lower than f_i^{NSP}, especially when α is high. Differently from the case of unrestricted prices, in the presence of price restrictions OTAs do not have an incentive to deviate from f_i^{SP} when hotels single-home, as this will imply an excessive reduction in the fee to attract the hotel that is listed on their rival. Indeed, with unconstrained prices OTAs have an incentive to slightly undercut their fee to induce partial segmentation, but with PPCs OTAs need to offer a larger fee reduction to the hotel that is listed on their rival, as this hotel has to set a uniform price in the two OTAs. However, the hotel cannot be competitive on the fee-reducing OTA without also reducing its price on its initial OTA.

Our analysis reveals that PPCs represent a useful commitment device for OTAs to eliminate the incentive to undercut the rival's fee when the market is segmented. Figure 2 shows a graphical representation of the hotels' listing decision with PPCs and of the threshold value α_{SP}.

Figure 2: Hotels' decisions with PPCs



Finally, by comparing Propositions 1 and 2, we find that, for $\alpha \in (0, \alpha_{SS}]$, fees are always higher with PPCs than with unrestricted prices. In the small parametric region $\alpha \in (\alpha_{SS}, 1)$, we obtain that $f_i^{SP} \equiv f_i^S$, which implies that PPCs have a neutral effect when hotels are almost perfect substitutes, as they segment the market anyway. As we will explain in Section 6, this result may change when we allow hotels to sell directly their rooms through their own websites.

5 PPCs adoption and economic effects

Armed with the equilibrium configurations obtained in the previous two sections, we now examine the OTAs' decision about adopting PPCs or not in the first stage of the game. We then proceed to evaluate the economic effects of imposing these price restrictions for the firms involved and for society at large.

5.1 OTAs' contractual decision

OTAs' decision to adopt PPCs depends on the interplay between inter-brand and intra-brand competition. Imagine first that hotels are perceived by consumers as sufficiently differentiated, *i.e.*, $\alpha \leq \alpha_S$. In this case, the adoption of PPCs crucially depends on the degree of competition between OTAs. We can identify two cases. When $\alpha \in (0, \alpha_{SP}]$, hotels multi-home regardless of whether or not OTAs adopt PPCs. In this situation, OTAs can choose between maintaining the retail prices unconstrained or adopting PPCs, which allows them to set higher commission fees, $f_i^{NSP} > f_i^{NS}$, at the cost of a demand reduction. We find that OTAs apply PPCs when intra-brand competition is high enough, *i.e.*, $\pi_i^{NSP} > \pi_i^{NS}$ when $\beta > \dfrac{1}{2}$.[21] Notice that $\Delta f_i = f_i^{NSP} - f_i^{NS}$ is increasing in β.[22] For this reason, when β takes high values OTAs prefer to adopt PPCs, as the possibility to charge a higher fee dominates the demand reduction.

We obtain similar results when $\alpha \in (\alpha_{SP}, \alpha_S]$, though in this case hotels multi-home when retail prices are unconstrained and single-home with PPCs. When OTAs leave retail prices unconstrained, the commission fee is small and the demand is therefore relatively large. By contrast, if OTAs apply PPCs hotels single-home, but OTAs are able to increase their fee, since $f_i^{SP} > f_i^{NS}$. As in the previous case, this trade-off is solved in favor of PPCs when competition between OTAs is intense, *i.e.*, $\pi_i^{SP} > \pi_i^{NS}$ when $\beta > \tilde{\beta}$, where $\tilde{\beta} > \dfrac{1}{2}$. Notice that the adoption of PPCs is less likely than in $\alpha \in (0, \alpha_{SP}]$, as it entails the additional cost of inducing segmentation.

Imagine now that hotels are perceived by consumers as close substitutes, *i.e.*, $\alpha > \alpha_S$. We can identify two situations in which hotels segment the market. First, when $\alpha \in (\alpha_S, \alpha_{SS}]$, we obtain that OTAs prefer to adopt PPCs, as the OTAs' expected profits from randomizing in

[21] As explained in the proof of Proposition 2, when $\alpha \in (0, \alpha_{SP}]$ there is a region in which OTAs deviate from setting the symmetric fee $f_i^{NSP} = 2/3$ and this leads to a mixed-strategy equilibrium, where Partial Segmentation is also possible. In such a case, the incentive to apply PPCs is even higher as with this deviation OTAs set a lower fee that increases their profits. For simplicity, we do not report this case in the proposition.

[22] Remember that, while f_i^{NS} decreases in β, $f_i^{NSP} = 2/3$. This implies that PPCs eliminate the impact of β on the equilibrium commission fees when hotels multi-home.

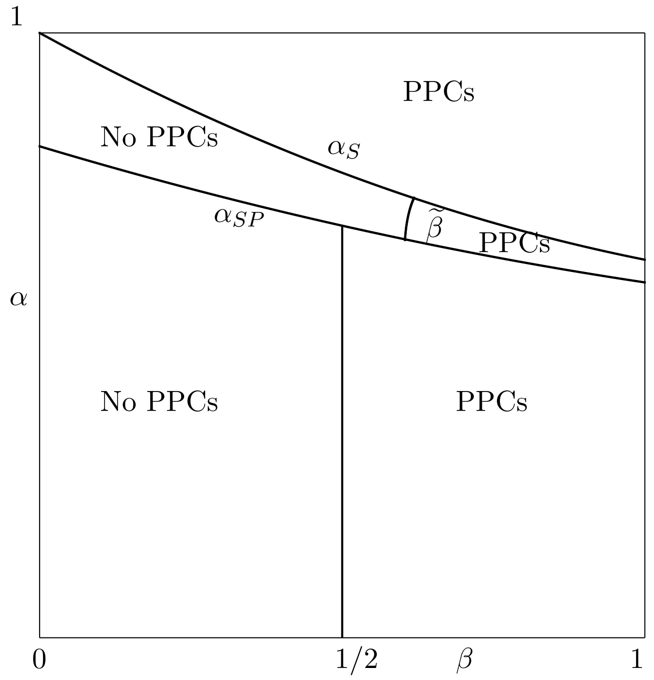
the domain $f_i^{SS} \in (\underline{f}_i, \overline{f}_i)$ are smaller than those obtained when they adopt PPCs and hotels segment the market, *i.e.*, $\pi_i^{SP} > \pi_i^{SS}$. Second, when $\alpha \in (\alpha_{SS}, 1)$, OTAs always set $f_i^{SP} \equiv f_i^S$ regardless of whether or not they adopt PPCs. This implies that their profits are unaffected by the adoption of PPCs, as $\pi_i^{SP} \equiv \pi_i^S$. We break the tie and consider that OTAs adopt PPCs, as these contractual restrictions allow them to reduce showrooming, as we will see in Section 6.

The following proposition summarizes the OTAs' decisions about PPCs, and Figure 3 graphically represents the relevant threshold values and parametric regions of interest.

Proposition 3. *In Stage 1, OTAs' contractual decision is the following:*

- *If $\alpha \in (0, \alpha_S]$, OTAs adopt PPCs when they are not perceived as sufficiently differentiated. This occurs for: (i) $\beta > \dfrac{1}{2}$, if $\alpha \in (0, \alpha_{SP}]$; (ii) $\beta > \tilde{\beta}$, if $\alpha \in (\alpha_{SP}, \alpha_S]$. Otherwise, they leave the prices unconstrained.*
- *If $\alpha \in (\alpha_S, 1)$, OTAs always adopt PPCs.*

Figure 3: OTAs' contractual decisions



To summarize, the proposition shows that when inter-brand competition is weak ($\alpha \leq \alpha_S$), OTAs' contractual decisions are driven by navigating the trade-off between increasing the commission fee or expanding the demand. In this region, we confirm the result by Boik and Corts (2016), who find that platforms adopt price parities when intra-brand competition is intense (relatively high values of β in our context). Conversely, when inter-brand competition is strong ($\alpha > \alpha_S$), OTAs always apply PPCs in order to be able to set higher fees in a context in which hotels segment the market. PPCs are neutral in $\alpha \in (\alpha_{SS}, 1)$, but OTAs can adopt them to eliminate showrooming when this is relevant.

These results unveil new scenarios in which PPCs are beneficial to OTAs, especially when competition on the seller market is intense, a situation not considered by Boik and Corts (2016). When competition between hotels is strong, OTAs can adopt PPCs as a commitment device in order to keep commission fees relatively high when sellers decide to single-home.

Our analysis shows that OTAs can apply PPCs even when hotels do not have a direct channel and there is no showrooming, which is the usual justification for this measure. We find that, besides the reduction of showrooming, OTAs might implement PPCs to reduce competition and to set higher fees. Indeed, in the absence of showrooming, we can better identify how the interplay between intra- and inter-brand competition drives OTAs' contractual decisions.

We also show that the adoption of PPCs expands the parametric region in which hotels single-home, in line with Corollary 1. Indeed, in $\alpha \in (\alpha_{SP}, \alpha_S]$ OTAs apply PPCs when $\beta > \tilde{\beta}$, thereby inducing market segmentation. Moreover, in the interval $\alpha \in (\alpha_S, \alpha_{SS}]$, segmentation is more likely with PPCs. This result is confirmed by the empirical work of Hunold *et al.* (2018), who show the adoption of PPCs can be associated with a reduction of the sales channels used by hotels.

5.2 Economic effects of PPCs

The results of this section are important to assess the economic effects of PPCs, and the highly debated consequences of their removal. We first examine the effects of PPCs on hotels and consumers, and then consider social welfare overall.

Effects on hotels. As we stressed above, commission fees are higher under PPCs, and therefore hotels usually lose out when they are bound to accept them.[23] We can identify a case in which hotels would benefit from PPCs. When $\alpha \in (\alpha_{SP}, \alpha_S]$ and β is small, there exists a tiny region in which hotels have larger profits in the presence of PPCs and segmentation than with unconstrained prices and multi-homing. However, OTAs are sufficiently differentiated, and therefore refrain from adopting PPCs.

Effects on consumers. Consumers are never better off with PPCs, given that retail prices increase following the rise in the commission fees. The loss for consumers is particularly evident when inter-brand competition is weak, $\alpha \in (0, \alpha_{SP}]$, as retail prices substantially increase when OTAs adopt PPCs: $p^{NSP} > p^{NS}$. When inter-brand competition is intermediate, $\alpha \in (\alpha_{SP}, \alpha_S]$, the adoption of PPCs leads to market segmentation with an increase in the retail price $p^{SP} > p^{NS}$. Finally, when hotels are close substitutes, $\alpha \in (\alpha_S, 1)$, the use of PPCs allows OTAs to set higher fees in $\alpha \in (\alpha_S, \alpha_{SS}]$, and therefore consumers end up paying a higher price: $p^{SP} > p^{SS}$. Our analysis in the Appendix confirms that in all these cases consumers surplus is reduced with PPCs. Only in $\alpha \in (\alpha_{SS}, 1)$, prices are the same with and without price parities and, consequently, consumer surplus is unaffected.

[23] Only in the interval $\alpha \in (\alpha_{SS}, 1)$ commission fees are equal, but hotels may end losing again if showrooming is taken into consideration.

Social welfare. Turning to social welfare, apart from the small parametric region $\alpha \in (\alpha_{SS}, 1)$ in which PPCs are innocuous, we find that total welfare decreases with PPCs, as the gains for OTAs never compensate for the losses suffered by hotels and consumers. The following proposition summarizes the results in terms of welfare.

Proposition 4. *The adoption of PPCs always results in a loss for consumers and for society at large, except when the degree of competition between hotels is very strong, in which case PPCs have no effect.*

All in all, under the conditions specified by our model, the removal of PPCs should contribute to increase the amount of sales channels used by hotels and to reduce commission fees and retail prices, benefiting not only consumers but also hotels.

6 Showrooming

This section studies the case in which a fraction of consumers can directly book their rooms from the hotels' websites after observing the offers available on the two OTAs. This extension allows us to analyze how OTAs adapt the use of PPCs in the presence of showrooming. To examine this case, we assume that there is a fraction $(1-\gamma)$ of consumers who always book through the OTAs, without checking for potential discounts on the hotels' website. The remaining fraction γ of consumers book directly from the hotels' websites whenever the price is lower or equal than the price on the OTA's. Therefore, parameter γ captures the intensity of showrooming.[24]

Demands for consumers booking their rooms from OTAs are as in Equation (2), whereas those for consumers booking directly from the hotels are $p_{Dh} = 1 - (q_{Dh} + \alpha q_{Dk})$, where p_{Dh} and q_{Dh} are the price and the demand of hotel h in the direct channel, with $h \neq k \in \{1, 2\}$. Therefore, we assume showroomers only consider the degree of differentiation in the services directly offered by the two hotels. This approach significantly simplifies our computations but still captures the fact that there is a group of active consumers who look for better deals on the hotel websites. We also assume that, if both hotels close their direct channels, these consumers resort to OTAs and then take into account the degree of intra-brand competition.

As in the previous sections, we start by analyzing the case in which OTAs leave prices unconstrained. In this case, the retail prices set by hotels on the OTAs are the same as those obtained without showrooming. In addition, we find that hotel h's prices and profits in the direct channel are always given by:

$$p_{Dh} = \frac{1-\alpha}{2-\alpha} \quad \text{and} \quad \pi_{Dh} = \gamma \left(p_{Dh} \cdot q_{Dh}\right) = \gamma \left[\frac{(1-\alpha)}{(1+\alpha)(2-\alpha)^2}\right].$$

[24] Our model implicitly assumes that a fraction of consumers are willing to bear some additional search cost and/or to give up additional services provided by the OTAs when hotels offer cheaper prices in their websites. A similar approach is used by Varian (1980). Along the same line, Ronayne and Taylor (2021) distinguish between two types of consumers: captive consumers (who shop directly on the seller's website or at its physical store) and shoppers (who buy at the lowest price anywhere in the market).

As hotel h obtains the same profits in the direct channel in the three possible scenarios (No Segmentation, Segmentation, and Partial Segmentation), its listing decision in Stage 3 is the same as in Lemma 1. In other words, the presence of showrooming does not affect the hotels' segmentation strategy. Consequently, the optimal fees and retail prices on the platforms do not change either. The following lemma shows hotel h's and OTA i's profits with unrestricted prices, where the subscript S indicates the presence of showrooming.

Lemma 5. *In Stage 2, when prices are unrestricted and there is showrooming:*

- *if* $\alpha \in (0, \alpha_S]$*, there is No Segmentation, and hotel* h*'s and OTA* i*'s profits are:*

$$\pi_{hS}^{NS} = \pi_{Dh} + (1-\gamma)\pi_h^{NS}; \quad \pi_{iS}^{NS} = (1-\gamma)\pi_i^{NS};$$

- *if* $\alpha \in (\alpha_S, \alpha_{SS}]$*, both Segmentation and No Segmentation occur with positive probabilities, and hotel* h*'s and OTA* i*'s profits are:*

$$\pi_{hS}^{SS} = \pi_{Dh} + (1-\gamma)\pi_h^{SS}; \quad \pi_{iS}^{SS} = (1-\gamma)\pi_i^{SS};$$

- *if* $\alpha \in (\alpha_{SS}, 1)$*, there is Segmentation, and hotel* h*'s and OTA* i*'s profits are:*

$$\pi_{hS}^{S} = \pi_{Dh} + (1-\gamma)\pi_h^{S}; \quad \pi_{iS}^{S} = (1-\gamma)\pi_i^{S}.$$

Notice that π^{NS}, π^{SS} and π^{S} are hotels' and OTAs' equilibrium profits obtained in Proposition 1, for the different intervals of α. It is then immediate to see that the intensity of showrooming has a negative effect on OTAs' profits.

We now study the case in which OTAs adopt PPCs. The price charged by hotel h on OTA i cannot be higher than that on the rival OTA or on its own website, as PPCs mandate that $p_{ih} \leq p_{jh}$ and $p_{ih} \leq p_{Dh}$, with $h \in \{1, 2\}$ and $i \neq j \in \{A, B\}$. As a result, hotels set the same uniform price in all channels. Then, in Stages 4 and 5, when we derive hotels' retail prices and demands in the direct market, they are not only affected by α, but they also depend on the OTAs' commission fees and on β.

Moreover, prices vary in the different scenarios and, consequently, influence hotels' listing decisions in Stage 3. Akin to the baseline model, we determine hotels' listing decisions by comparing profits as functions of the fees. By comparing hotel h's profits under PPCs with single-homing and multi-homing, while its rival single-homes, we obtain the threshold value $\alpha_{SH}(f_i, f_j)$ above which Segmentation is an equilibrium. As an increase in the fraction of showroomers γ reduces both profits in a similar way, we find that this threshold value slightly differs from that found under PPCs but in the absence of showrooming (*i.e.*, α_{SH} is very similar to α_{SP}). This confirms our previous findings without showrooming: *(i)* Segmentation occurs when competition between hotels is severe; *(ii)* Segmentation is more likely to arise in the presence of PPCs, as $\alpha_{SH} < \alpha_S$.

In Stage 2, each OTA optimally chooses its commission fee and we obtain hotel h's and OTA i's profits shown in Lemma 6. For ease of exposition and to reduce the number of cases, we consider values of γ that are not too high.[25] Moreover, without loss of generality, we forego the small parametric region (with low inter-brand competition and high intra-brand competition) obtained in the baseline model in which OTAs randomize over the commission fee with PPCs.

Lemma 6. *In Stage 2, with PPCs and showrooming:*

- *If $\alpha \in (0, \alpha_{SH}]$, there is No Segmentation, and hotel h's and OTA i's profits are:*

$$\pi_{hS}^{NSP} = \frac{(1-\alpha)[2-(1-\beta)\gamma]}{9(2-\alpha)^2(1+\alpha)(1+\beta)}; \quad \pi_{iS}^{NSP} = \frac{4-2(1-\beta)\gamma}{9(2-\alpha)(1+\alpha)(1+\beta)}.$$

- *If $\alpha \in (\alpha_{SH}, 1)$, there is Segmentation, and hotel h's and OTA i's profits are:*

$$\pi_{hS}^{SP} = \pi_h^{SP} - \phi(\alpha,\beta,\gamma); \quad \pi_{iS}^{SP} = \pi_i^{SP} + \xi(\alpha,\beta,\gamma),$$

where both functions $\phi(\alpha,\beta,\gamma)$ and $\xi(\alpha,\beta,\gamma)$ are increasing in γ.

Similarly to the baseline model, Segmentation occurs when competition between hotels is severe. The lemma also shows that hotels' profits are negatively affected by γ. This is because the OTAs' commission fees under both No Segmentation and Segmentation increase in the intensity of showrooming, as OTAs penalize hotels for selling directly.[26] Notice that hotels would gain by coordinating in shutting down their direct channels. However, this does not occur when γ is sufficiently small, as each of them has an incentive to keep its direct channel active, if the rival decides to close it. Conversely, if the number of showroomers is very high, both hotels can decide to shut down their direct channel to avoid negative profits. This situation can occur when competition between hotels is severe. We formally illustrate this result in the Appendix.

Finally, we analyze OTAs' contractual decisions in Stage 1. Firstly, consider that $\alpha \le \alpha_{SH}$, which implies there is No Segmentation with and without PPCs. It can be seen that in this parametric region there is a threshold value $\beta_{SH}(\gamma)$ above which OTAs apply PPCs. Notice that an increase in γ has a stronger negative impact on π_{iS}^{NS} than on π_{iS}^{NSP}. This implies that the threshold value that determines the use of PPCs is smaller with showrooming than without it, meaning that PPCs are more likely to be adopted with showrooming. Secondly, when $\alpha > \alpha_{SH}$, OTAs always obtain a higher profit with PPCs. This is because they can set a higher commission fee while at same time obtaining a larger demand as hotels are forced to lower their uniform retail price. These two findings lead to the next proposition.

[25] When γ is very high, showrooming generates a large distortion in the retail prices and hotels may be interested in closing this distribution channel. To avoid this case, OTAs need to modify their commission fees and, as a consequence, firms' profits differ from those reported in Lemma 6. However, we find that the OTAs' decision of whether or not to adopt PPCs will not qualitatively change.

[26] This is also a consequence of the assumptions of our model, in which the search process is not explicitly modelled. One possible alternative is to endogenize the share of consumers that buy directly as a function of the discount provided by the direct channel, but this extension goes beyond the scope of this paper.

Proposition 5. *In Stage 1, in the presence of showrooming, OTAs' contractual decision is the following:*

- *If $\alpha \in (0, \alpha_S]$, OTAs adopt PPCs when they are not perceived as sufficiently differentiated. This occurs for: (i) $\beta > \beta_{SH}(\gamma)$, with $\beta_{SH}(\gamma) < \frac{1}{2}$, if $\alpha \in (0, \alpha_{SH}]$; (ii) $\beta > \tilde{\beta}_{SH}(\gamma)$, with $\tilde{\beta}_{SH}(\gamma) < \tilde{\beta}$, if $\alpha \in (\alpha_{SH}, \alpha_S]$. Otherwise, they leave the prices unconstrained.*
- *If $\alpha \in (\alpha_S, 1)$, OTAs always adopt PPCs, and obtain π_{iS}^{SP}.*

The proposition confirms the results of our baseline model but also shows that showrooming makes PPCs more appealing for OTAs. Firstly, when intra-brand competition is strong ($\alpha > \alpha_S$), OTAs continue to adopt PPCs. Secondly, when intra-brand competition is weak ($\alpha \leq \alpha_S$), OTAs adopt PPCs more often in the presence of showrooming. Both threshold values β_{SH} and $\tilde{\beta}_{SH}$ decrease in γ. Therefore, the area in which OTAs leave prices unconstrained can disappear when the number of showroomers is high. In other words, the higher the intensity of showrooming, the more likely is that OTAs adopt PPCs in order to limit the possibility for hotels to use their direct channel. This is a rather intuitive result as OTAs usually justify the adoption of PPCs to avoid the free-riding behaviour of consumers who first visit the OTA to verify hotels' prices and characteristics, and then book directly from hotels.[27] Notice that our baseline model shows that PPCs can be adopted even in the absence of showrooming, and explains the conditions under which this occurs.

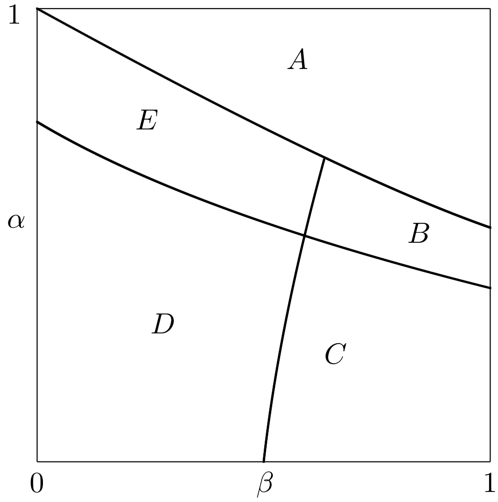
7 Concluding remarks

In this paper we have considered a scenario in which OTAs showcase the listed hotels to uninformed consumers. We have accounted for the presence of both inter-brand (between hotels) and intra-brand (between OTAs) competition. The novelty of our analysis has consisted in the fact that hotels decide on how many OTAs to offer their rooms to. Hotels set the prices of the rooms listed on the OTAs and pay a per-transaction fee to the platforms. Fees are publicly available and are determined by OTAs before hotels' pricing and listing decisions are made.

Our main findings can be summarized with the help of Figure 4, which abstracts from the precise threshold values obtained through our formal analysis in order to provide an intuitive and reader-friendly graphical representation.

[27] Similar conclusions can be obtained by using an alternative model in which consumers book only through OTAs when prices are the same in the OTAs than in the hotels' direct channel. In this case, with PPCs OTAs obtain the same profits as in Proposition 2. Hence, the presence of showrooming does not affect OTAs' profits with PPCs, whereas it reduces them in their absence. It is thus immediate to show that an increase in γ lowers the threshold value of β above which OTAs adopt PPCs.

Figure 4: Summary of main results



The first contribution of the paper has been to determine under what conditions OTAs apply price parity clauses (PPCs). We have shown that OTAs adopt these restrictive clauses when they want to smooth out the competitive pressure in platform market (Areas B and C), and when they are not capable of raising commission fees when hotels single-home (Area A). PPCs allow OTAs to set higher commission fees, but total demand may significantly decrease, also because hotels can respond by delisting. For these reasons, OTAs decide to leave prices unconstrained when they are perceived as sufficiently differentiated (Areas D and E), provided inter-brand competition is not too high.

Our second contributions has consisted of articulating the interplay between OTAs' adoption of PPCs and hotels' listing decisions. We have proven that there exist circumstances in which PPCs induce hotels to reduce their sales channels (Areas A and B), thus providing a theoretical support to empirical papers demonstrating that sellers increase the number of sales channels when PPCs are prohibited (see, in particular, Hunold *et al.*, 2018).

Our third contribution is not only to confirm the accepted view that PPCs allow OTAs to charge higher commission fees, thereby increasing final prices for consumers, but also to unveil a new mechanism through which this occurs. In Area A, in fact, PPCs are applied notwithstanding the fact that hotels single-home in equilibrium, as these contractual restrictions provide a commitment device for OTAs not to lower their fees at equilibrium.

Our last contribution is related to the economic effect of PPCs for hotels and consumers. We have demonstrated that both client hotels and final consumers are worse off when price restrictions are in place (Areas A, B, and C), unless hotels are almost perfect substitutes. In general, our model confirms the general wisdom that price restrictions such as PPCs are detrimental to social welfare.

In the last part of the paper, we have considered an extension of the model with direct selling, and have shown that OTAs end up adopting PPCs more often when showrooming is taken into account (Areas B and C expand to the detriment of Areas E and D). Additional robustness characterizations can be found in the Online Appendix, in which we prove that our main results are robust to: (i) an alternative scenario in which OTAs offer a menu of fees, depending on how many hotels decide to sell through OTAs' platforms; (ii) the introduction of a setting where consumers have unitary demand.

We have not considered the possibility that OTAs invest to reduce intra-brand competition. The idea that firms invest in R&D activities to increase product differentiation has been studied in static (Harrington, 1995) and in dynamic models (Cellini and Lambertini, 2002; Lambertini and Mantovani, 2009) in a context similar to ours. Given the symmetric nature of product differentiation when using the demand structure of Singh and Vives (1984), there exists a complete spillover effect in the R&D activity carried out by each OTA. For this reason, in a non-cooperative setting, the degree of intra-brand differentiation may not be very high, as each OTA relies on the other to carry out this form of R&D.[28] Our model reveals that PPCs may be used as an alternative to this costly investment activity when competition between OTAs is intense.

Another important assumption of our model is related to the fact that OTAs cannot price discriminate among hotels. Commission fees are usually displayed on OTAs' webpage and do not vary among hotels, unless we take into account specific partnership programs, which are outside the scope of our analysis. In an extension of the model, we have considered the case in which commission fees charged by the same OTA to different hotels can be *ex ante* asymmetric, and verified that our results are unchanged. However, we have not reported these computations for brevity. For future research, it could be interesting to analyze the use of different fees when hotels differ in size or in terms of service offered to consumers. Indeed, OTAs may be interested in attracting those hotels that generate more reservations or that are well known by consumers.

Notwithstanding its limitations, this paper has shown under which conditions platforms adopting an agency model gain by imposing PPCs, and how these price restrictions affect suppliers' listing choice. These issues have been partially neglected by the literature, which has mostly focused on the anticompetitive effects of PPCs, which reduces platform competition and produces an increase in commission fees usually passed through to final customers.

We have shown that the interplay between OTAs' contractual arrangements and hotels' listing strategy has relevant implications, both for managers and for policy makers. We have explained that the interests of OTAs and hotels regarding the impositions of price restrictions are usually not aligned, even in the absence of showrooming, and have identified the potential consequences of PPCs for consumers and society in general.

[28]OTAs coordinating their R&D efforts would obviously invest more, as they would internalize the externality exerted by product differentiation via the demand functions.

Appendix

Unrestricted pricing

Proof of Lemma 1. In Stage 5, consumers make their purchasing decisions according to their demand functions, whose direct form can be computed from (2). In Stage 4, hotels consider the demand functions in each scenario and set the retail prices to maximize profits. In what follows, we compute the equilibrium prices and demands in each case.

When both hotels multi-home:

$$p_{ih}^{NS}(f_i) = \frac{1-\alpha+f_i}{2-\alpha}; \quad q_{ih}^{NS}(f_i, f_j) = \frac{1-f_i-\beta(1-f_j)}{(2-\alpha)(1+\alpha)(1-\beta^2)}.$$

When each hotel joins a different OTA:

$$\begin{aligned} p_{ih}^{S}(f_i, f_j) =& \frac{1-\alpha\beta}{2-\alpha\beta} + \frac{2f_i+\alpha\beta f_j}{(2-\alpha\beta)(2+\alpha\beta)}; \\ q_{ih}^{S}(f_i, f_j) =& \frac{1}{(1+\alpha\beta)(2-\alpha\beta)} + \frac{\alpha\beta f_j - (2-\alpha^2\beta^2)f_i}{(1-\alpha^2\beta^2)(4-\alpha^2\beta^2)}. \end{aligned}$$

When hotel h multi-homes, while its rival single-homes on OTA j:

$$\begin{aligned} p_{ih}^{PS}(f_i, f_j) &= \frac{1}{2}\left[1+f_i-\frac{\alpha\beta(1-f_j)}{2-\alpha}\right]; \quad p_{jh}^{PS}(f_j) = \frac{1-\alpha+f_j}{2-\alpha}; \\ q_{ih}^{PS}(f_i, f_j) &= \frac{1-\beta-f_i+\beta f_j}{2(1-\beta^2)}; \\ q_{jh}^{PS}(f_i, f_j) &= \frac{1}{2}\left[\frac{1}{1+\beta} - \frac{(1-\alpha)\alpha}{(1+\alpha)(2-\alpha)} + \frac{\beta f_i}{1-\beta^2} - \frac{[2+(1-\alpha)\alpha\beta^2]f_j}{(1+\alpha)(2-\alpha)(1-\beta^2)}\right]. \end{aligned}$$

When hotel h single-homes on OTA i, while its rival multi-homes:

$$\widehat{p}_{ih}^{PS}(f_i) = \frac{1-\alpha+f_i}{2-\alpha}; \quad \widehat{q}_{ih}^{PS}(f_i) = \frac{1-f_i}{(1+\alpha)(2-\alpha)}.$$

Substituting the respective prices and demands into hotel h's profits, we obtain the expressions in Lemma 1. Notice that an increase in f_i drives up the retail price set by hotel h on OTA i in all the three scenarios. As it can be ascertained, this effect is lower under Segmentation than under No Segmentation. Also notice that retail prices are increasing in both commission fees when the market is segmented. On the other hand, OTAs cannot increase their commission fees without losing demand as an increase in f_i has a negative impact on q_{ih}, whereas an increase in f_j has a positive impact on it. □

Proof of Lemma 2. It is shown in the main text. □

Proof of Proposition 1. Suppose first that α is low, which implies that hotels multi-home in Stage 3. By maximizing OTA i's profits when both hotels multi-home with respect to f_i, we obtain the reaction function: $f_i = \frac{1-\beta+\beta f_j}{2}$. This expression shows that OTAs' fees are strategic complements: a reduction in the fee forces the rival to cut its commission fee as well. Solving the system of two reaction functions, we obtain $f_i^{NS} = \frac{1-\beta}{2-\beta}$. Notice that OTAs are not interested in deviating from f_i^{NS} given that hotels multi-home for any value of the fees and that charging a higher fee will entail a profit loss. It follows that, in the region $\alpha \in (0, \alpha_S]$, both OTAs set f_i^{NS} and there is No Segmentation. By substituting these fees in the equilibrium retail prices and profits we obtain the results reported in the proposition.

Suppose now that α is high enough so that hotels single-home in Stage 3 if fees are sufficiently close to each other. The maximization of OTA i's profits when both hotels single-home with respect to f_i yields the following reaction function: $f_i = \frac{1}{2}\left(1 - \frac{\alpha\beta}{2-\alpha^2\beta^2}\right) + \left(\frac{\alpha\beta}{2(2-\alpha^2\beta^2)}\right) f_j$. Solving the system of the reaction functions for the two OTAs, we obtain $f_i^S = \frac{(1-\alpha\beta)(2+\alpha\beta)}{4-\alpha\beta(1+2\alpha\beta)} > f_i^{NS}$. In what follows, we need to verify whether f_i^S is an equilibrium fee or if each OTA has a unilateral incentive to deviate and set a lower fee that attracts the hotel that is listed on the other platform. In order to examine the profitability of a deviation, we consider two steps. Firstly, notice that if OTA i, which is hosting hotel h in Segmentation, reduces f_i^S to also attract hotel k, the new fee has to guarantee that hotel k obtains at least the same profits by multi-homing than by single-homing. We denote by f_i^{dev} the fee that satisfies the condition $\pi_k^{PS}(f_i^{dev}, f_j^S) \geq \pi_k^S(f_i^{dev}, f_j^S)$. Secondly, OTA i will be interested in such a deviation only if the deviation fee f_i^{dev} generates more profits than f_i^S. In order to analyze this case, we have to take into account that if hotel k multi-homes, hotel h will do the same (in the proof of Lemma 2, we have demonstrated that the condition $\pi_h^{NS}(f_i, f_j) \geq \pi_h^{PS}(f_i, f_j)$ is satisfied for any values of the fees). Therefore, OTA i will check whether with f_i^{dev} its profits are higher under No Segmentation than under Segmentation, $\pi_i^{NS}(f_i^{dev}, f_j^S) \geq \pi_i^S(f_i^S, f_j^S)$. Comparing these profits, we find that OTA i has a unilateral incentive to deviate by setting f_i^{dev} while OTA j sets f_j^S, when $\alpha \leq \alpha_{SS}$ (we do not present this threshold due to its complexity, but its graphical representation is provided in Figure 1). Taking this into account, we can establish that for $\alpha \in (\alpha_{SS}, 1)$ OTAs do not have an incentive to deviate, set f_i^S, and the retail prices and the firms profits are those illustrated in the proposition.

Consider now the interval $\alpha \in (\alpha_S, \alpha_{SS}]$ in which OTAs have an incentive to deviate from the segmentation fee f_i^S to attract the hotel that is listed on the rival OTA. Suppose both OTAs set a fee that is lower than f_i^S. Then, OTA i has two options: it can either reduce its fee to induce multi-homing or increase its fee to raise profits under segmentation. Define $\widehat{f}_j$ as the fee set by OTA j for which OTA i is indifferent between these two options (setting either a lower or a higher fee than its rival). When OTA j sets $f_j > \widehat{f}_j$, OTA i prefers to decrease its fee to induce multi-homing. Let $\underline{f}_i$ be the minimum fee that will be set in this is case, that is the largest fee compatible with multi-homing when OTA j sets $\widehat{f}_j$. When $f_j < \widehat{f}_j$, OTA i can set a higher fee that maintains segmentation. Let $\overline{f}_i$ be the maximum fee that will be set in this case, which is the largest fee compatible with segmentation when OTA j sets $\widehat{f}_j$. These values define OTA i's randomization domain $f_i^{SS} \in (\underline{f}_i, \overline{f}_i)$. Importantly, OTAs' expected profits have to be the same in all this domain, that is:

$$\pi_i^{NS}(\underline{f_i}, \widehat{f}_j) = \pi_i^S(\overline{f_i}, \widehat{f}_j) = \pi_i^{SS}(\widehat{f}_j). \tag{A1}$$

Indeed, all fees in the mixing domain must give the same expected profits, as otherwise OTAs would not be indifferent between these fees. Moreover, OTAs' expected profits are smaller than those they would obtain under Segmentation, $\pi_i^{SS}(\widehat{f}_j) < \pi_i^S(f_i^S, f_j^S)$, but higher than those obtained under No Segmentation, $\pi_i^{SS}(\widehat{f}_j) > \pi_i^{NS}(f_i^{NS}, f_j^{NS})$. As both $\pi_i^{NS}(f_i, \widehat{f}_j)$ and $\pi_i^S(f_i, \widehat{f}_j)$ are increasing in $\widehat{f}_j$ and $f_j^{NS} < \widehat{f}_j < f_j^S$, we find that $\pi_i^{NS}(f_i, \widehat{f}_j) > \pi_i^{NS}(f_i, f_j^{NS})$ and $\pi_i^S(f_i, \widehat{f}_j) < \pi_i^S(f_i, f_j^S)$. As a result, $\pi_i^{NS}(f_i^{NS}, f_j^{NS}) < \pi_i^{SS}(\widehat{f}_j) < \pi_i^S(f_i^S, f_j^S)$. The inequalities go in the opposite direction when we consider hotels' profits as they are decreasing in the fees: $\pi_h^{NS}(f_i^{NS}, f_j^{NS}) > \pi_h^{SS}(\widehat{f}_j) > \pi_h^S(f_i^S, f_j^S)$.

On the other hand, hotel k (the one listed on OTA j with Segmentation) must be indifferent between No Segmentation and Segmentation when OTA i sets $\underline{f}_i$, while OTA j sets $\widehat{f}_j$:

$$\pi_k^{NS}(\underline{f}_i, \widehat{f}_j) = \pi_k^S(\underline{f}_i, \widehat{f}_j). \tag{A2}$$

In contrast, hotel h (the one listed on OTA i with Segmentation) must be indifferent between No Segmentation and Segmentation when OTA i sets $\overline{f}_i$, while OTA j sets $\widehat{f}_j$:

$$\pi_h^{NS}(\overline{f}_i, \widehat{f}_j) = \pi_h^S(\overline{f}_i, \widehat{f}_j). \tag{A3}$$

Solving together Equations (A1), (A2), and (A3), we determine the fees $\underline{f_i}$, $\overline{f_i}$, and $\widehat{f}_j$ that characterize the mixing range. Finally, OTA i's best response function $f_i(f_j)$ is implicitly defined by:

$$\begin{aligned} \pi_h^S(f_i, f_j) =& \pi_h^{NS}(f_i, f_j) \quad \text{for} \quad f_j = [\underline{f}_j, \widehat{f}_j]; \\ \pi_k^{NS}(f_i, f_j) =& \pi_k^S(f_i, f_j) \quad \text{for} \quad f_j = (\widehat{f}_j, \overline{f}_j]. \end{aligned}$$

Using these best responses and determining expected profits, we can determine the mixing probabilities that characterize the mixed-strategy equilibrium, similarly to Karle et al., (2020). □

Price parity clauses

Proof of Lemma 3. In Stage 5, consumers choose from which platform to reserve the room. Under PPCs, hotels have to set the same price on all sales channels, *i.e.*, $p_{ih} = p_{jh} = p_h$ with $h = 1, 2$. As with the case of unconstrained prices, we compute the direct demand functions for the different scenarios and substitute them into hotels' profits. In Stage 4, hotels set the retail prices to maximize profits. Taking this into account, we obtain the following results for the price and the demands in each possible scenario.

When both hotels multi-home:

$$p_h^{NSP}(f_i, f_j) = \frac{1-\alpha}{(2-\alpha)} + \frac{f_i + f_j}{2(2-\alpha)}; \quad q_{ih}^{NSP}(f_i, f_j) = \frac{2 - f_i - f_j}{2(2-\alpha)(1+\alpha)(1+\beta)}.$$

When each hotel single-homes on a different OTA:

$$p_{ih}^{SP}(f_i, f_j) = \frac{1-\alpha\beta}{2-\alpha\beta} + \frac{2f_i + \alpha\beta f_j}{(2-\alpha\beta)(2+\alpha\beta)}; \quad q_{ih}^{SP}(f_i, f_j) = \frac{1}{(1+\alpha\beta)(2-\alpha\beta)} + \frac{\alpha\beta f_j - (2-\alpha^2\beta^2) f_i}{(1-\alpha^2\beta^2)(4-\alpha^2\beta^2)}.$$

These retail prices are exactly the same than with unrestricted prices, *i.e.*, $p_{ih}^{SP}(f_i, f_j) \equiv p_{ih}^{S}(f_i, f_j)$. This explains why with segmentation profits, expressed as a function of the commission fees, are the same with unrestricted prices and with PPCs.

When hotel h multi-homes, while its rival single-homes on OTA j:

$$p_h^{PSP}(f_i, f_j) = \frac{2f_i(1-\alpha^2) + (1-\alpha)[4+\alpha(3-\beta)] + f_j[2+\alpha+\alpha\beta(1+2\alpha)]}{8-\alpha^2(5-3\beta)};$$

$$q_{ih}^{PSP}(f_i, f_j) = \frac{4+\alpha[1-2\alpha(1-\beta)+\beta]}{(1+\beta)[8-\alpha^2(5-3\beta)]} - \frac{2(1-\alpha^2)f_i}{(1+\beta)[8-\alpha^2(5-3\beta)]} - \frac{[2+\alpha+\alpha\beta(1+2\alpha)]f_j}{(1+\beta)[8-\alpha^2(5-3\beta)]};$$

$$q_{jh}^{PSP}(f_i, f_j) = \frac{1}{12}\left[\frac{6}{1+\beta} - \frac{4\alpha}{1+\alpha} - \frac{2\alpha(2+\alpha)}{[8-\alpha^2(5-3\beta)]} - \left[\frac{3}{1+\beta} + \frac{3\alpha^2}{[8-\alpha^2(5-3\beta)]}\right] f_i\right] +$$
$$+\frac{1}{12}\left[\frac{4\alpha}{1+\alpha} - \frac{3}{1+\beta} + \frac{\alpha(4+5\alpha)}{[8-\alpha^2(5-3\beta)]}\right] f_j.$$

When hotel h single-homes on OTA i, while its rival multi-homes:

$$\widehat{p}_h^{PSP}(f_i, f_j) = \frac{(1-\alpha)[4+\alpha(f_j+2)-\alpha^2(1-f_j-\beta)] + f_i[4+\alpha-2\alpha^2+\alpha^2\beta(2+\alpha)]}{8-\alpha^2(5-3\beta)};$$

$$\widehat{q}_{ih}^{PSP}(f_i, f_j) = \frac{4+\alpha[2-\alpha(1-\beta)]}{(1+\alpha)[8-\alpha^2(5-3\beta)]} + \frac{\alpha f_j}{[8-\alpha^2(5-3\beta)]} - \frac{[4+\alpha(3+\alpha\beta)]f_i}{(1+\alpha)[8-\alpha^2(5-3\beta)]}.$$

Finally, hotels' profits as functions of the fees are illustrated in the lemma. Here, we report the precise value of $\Omega(f_i, f_j)$:

$$\frac{1}{72}\left[\frac{9(f_h-f_i)^2}{1-\beta} + \frac{[20(1-f_h)-(2+7f_h-9f_i)][4+\alpha(2+3f_i)-f_h(4+5\alpha)]}{8-\alpha^2(5-3\beta)}\right] +$$
$$-\frac{1}{72}\left[\frac{2(1-f_h)^2[16-\alpha(12-5\alpha)]}{(2-\alpha)^2} + \frac{8(1-\alpha^2)[4+\alpha(2+3f_i)-f_h(4+5\alpha)]^2}{[8-\alpha^2(5-3\beta)]^2}\right].$$

We find that the first row is strictly positive, while the second is negative and its size is always lower than the first one for any values of the parameters, so that $\Omega(f_i, f_j) > 0$. □

Proof of Lemma 4. It is shown in the main text. □

Proof of Proposition 2. Consider first the case in which $\alpha \in (0, \alpha_{SP}]$. According to Lemma 4, both hotels multi-home in Stage 3 if OTAs set similar fees. By maximizing OTA i's profits with respect to f_i, we obtain that OTA i's reaction function is $f_i = 1 - \frac{f_h}{2}$. Interestingly, with PPCs, OTAs' fees are now strategic substitutes: an increase in the commission fee of an OTA generates a reduction in the commission fee of the rival (reaction functions are downward sloping). Solving the system of two reaction functions we obtain $f_i^{NSP} = \frac{2}{3}$. Notice that this fee is higher that the one that maximizes the joint profits of the two OTAs, which is $f_i = \frac{1}{2}$.

In what follows, we need to verify whether f_i^{NSP} is an equilibrium fee or if each OTA has a unilateral incentive to set a lower fee in order to induce one of the hotels to delist from the other OTA. In order to examine the profitability of such a deviation, we consider two steps. First, if OTA i sets a fee lower than f_i^{NSP} to induce the delisting of one hotel (hereinafter hotel h) from OTA j, this deviation fee f_i^{dev} has to guarantee that the hotel obtains at least the same profits with multi-homing than with single-homing, *i.e.* $\widehat{\pi}_h^{PSP}(f_i^{dev}, f_j^{NSP}) \geq \pi_h^{NSP}(f_i^{dev}, f_j^{NSP})$. Moreover, hotel h's profit has to be the same when it delists from OTA j while hotel k multi-homes, and when it multi-homes while hotel k delists from OTA j, *i.e* $\pi_h^{PSP}(f_i^{dev}, f_j^{NSP}) = \widehat{\pi}_h^{PSP}(f_i^{dev}, f_j^{NSP})$ (see proof of Proposition 5 in Karle et al. 2020). It can be shown that the latter condition is more stringent than the former one, and we denote as f_i^{devP} the fee that satisfies it. Second, OTA i will be interested in such a deviation only if f_i^{devP} generates more profits than f_i^{NSP}. In order to analyze this case, we assume that hotel k continues to multi-home when hotel h delists from OTA j. Therefore, OTA i compares its profits when it sets f_i^{NSP} and the two hotels multi-home with its profits when it sets f_i^{devP} and hotel h single-homes in i while hotel k multi-homes, $\pi_i^{PSP}(f_i^{devP}, f_j^{NSP}) \geq \pi_i^{NSP}(f_i^{NSP}, f_j^{NSP})$. We find that OTA i has a unilateral incentive to deviate and to set f_i^{devP} when $\alpha \geq \alpha_{SSP}(f_i^{devP}, f_j^{NSP}) = \alpha_{SSP}$. We do not present this threshold due to its complexity, but its graphical representation shows that OTAs might be interested in deviating from f_i^{NSP} when α takes low values and β is sufficiently large.

In order to complete the analysis for the interval $\alpha \in (\alpha_{SSP}, \alpha_{SP}]$, we find that when both OTAs decide to deviate they undercut each other's fee until they reach a point where they have two options. Given the rival's fee, OTA i can either lower its fee to induce partial segmentation by hotel h, or it can increase its fee to augment its profits while inducing hotel k to multi-home. We define $\widehat{f}_j$ as OTA j's fee for which OTA i is indifferent between these two options. When $f_j > \widehat{f}_j$, OTA i can reduce its fee to induce partial segmentation by hotel h. The minimum fee it sets in this is case is $\underline{f}_i$, which is the maximum fee that induces partial segmentation when OTA j sets $\widehat{f}_j$. When $f_j < \widehat{f}_j$, OTA i can set a higher fee while inducing multi-homing. The maximum fee it can set is $\overline{f}_i$, which is the minimum fee guaranteeing that hotels multi-home. It can be seen that, for any value of $\widehat{f}_j$, the maximum fee is always binding at $\overline{f}_i = 2/3$.[29] The previous values define OTA i's randomization domain $f_i^{MP} \in (\underline{f}_i, \overline{f}_i)$ that characterizes a mixed-strategy equilibrium for OTAs. Notice that OTA i must be indifferent between setting $\underline{f}_i$ and $\overline{f}_i$:

$$\pi_i^{PSP}(\underline{f}, \widehat{f}_j) = \pi_i^{NSP}(\overline{f}, \widehat{f}_j). \tag{A4}$$

This occurs because its expected profit should be the same in all the randomization domain, i.e. $\pi_i^{MP}(\widehat{f}_j) \equiv \pi_i^{PSP}(\underline{f}, \widehat{f}_j) = \pi_i^{NSP}(\overline{f}, \widehat{f}_j)$, otherwise it would not be indifferent between these fees. We also find that OTAs' profits are bigger in this mixed equilibrium than with multi-homing. Indeed, $\pi_i^{NSP}(f_i, f_j)$ is decreasing in f_j, so that $\pi_i^{MP}(\widehat{f}_j) \equiv \pi_i^{NSP}(\overline{f}, \widehat{f}_j) > \pi_i^{NSP}(\overline{f}, f_j^{NSP})$. On the other hand, hotel k (the hotel that is listed on OTA j with partial segmentation) is indifferent between multi-homing and partial segmentation when OTA i sets $\overline{f}_i$ and OTA j sets $\widehat{f}_j$ such that:

$$\pi_k^{PSP}(\overline{f}_i, \widehat{f}_j) = \pi_k^{NSP}(\overline{f}_i, \widehat{f}_j). \tag{A5}$$

[29] Remember that, when both hotels multi-home, OTA i reaction function is $f_i = 1 - \frac{f_h}{2}$, which implies that OTA i would charge $f_i > 2/3$ if $f_j < 2/3$.

Moreover, hotel h (the hotel that is listed on OTA i with partial segmentation) is indifferent between multi-homing and partial segmentation when OTAs respectively set $\underline{f}_i$ and $\widehat{f}_j$:

$$\pi_h^{PSP}(\underline{f}_i, \widehat{f}_j) = \pi_h^{PSP}(\underline{f}_i, \widehat{f}_j). \tag{A6}$$

Equations (A4), (A5), and (A6) determine the fees $\underline{f}$, $\overline{f}$ and $\widehat{f}$ that characterize the mixing range. Finally, OTA i best response function $f_i(f_j)$ is implicitly defined as:

$$\pi_h^{PSP}(f_i, f_j) = \pi_h^{NSP}(f_i, f_j) \text{ for } f_j = [\underline{f}, \widehat{f}_j];$$

$$\pi_k^{NSP}(f_i, f_j) = \pi_k^{PSP}(f_i, f_j) \text{ when } f_j = (\widehat{f}_j, \overline{f}].$$

Using these best responses and the expected profit, we can determine the mixing probabilities that fully characterize OTAs' mixed-strategy equilibrium.

To sum up, when $\alpha \in (0, \alpha_{SSP}]$, OTAs do not have an unilateral incentive to deviate and they set f_i^{NSP}. In this interval, retail prices and equilibrium profits are those reported in the first part of the proposition. On the other hand, when $\alpha \in (\alpha_{SSP}, \alpha_{SP}]$, each OTA has an incentive to deviate from f_i^{NSP} in the attempt to force a hotel to delist from the rival OTA. We do not present the results for this small parametric region in the main text in order to reduce the number of cases and focus on the main economic intuitions.

Finally, we analyze the parametric region $\alpha \in (\alpha_{SP}, 1)$. Consider the case in which each hotel is listed on a different OTA. By maximizing OTA i's profits when both hotels single-home with respect to f_i, we obtain that OTA i's reaction function is $f_i = \frac{1}{2}\left(1 - \frac{\alpha\beta}{2-\alpha^2\beta^2}\right) + \left(\frac{\alpha\beta}{2(2-\alpha^2\beta^2)}\right) f_j$. By solving the system of two reaction functions, we get $f_i^{SP} = \frac{(1-\alpha\beta)(2+\alpha\beta)}{4-\alpha\beta(1+2\alpha\beta)} < f_j^{NSP}$. We next verify that f_i^{SP} is an equilibrium fee by demonstrating that OTAs have no incentives to undercut the rival in order to induce multi-homing. First, notice that if OTA i, which is hosting hotel h uner Segmentation, reduces f_i^{SP} to also attract hotel k, then hotel k obtains at least the same profits by multi-homing than by single-homing, when its rival single-homes. We label as f_i^{dev} the fee that satisfies this condition, i.e. $\pi_k^{NSP}(f_i^{dev}, f_j^S) \geq \pi_k^{SP}(f_i^{dev}, f_j^S)$. Second, OTA i will be interested in such a deviation only if f_i^{dev} generates more profits than f_i^S, i.e. $\pi_i^{NSP}(f_i^{dev}, f_j^S) \geq \pi_i^{SP}(f_i^S, f_j^S)$. Comparing these profits, we find that OTA i never has a unilateral incentive to deviate by setting f_i^{dev}. As a result, when $\alpha > \alpha_{SP}$, OTAs set the equilibrium fee f_i^S. Considering this result, we can finally derive hotel h's and OTA i's profits by substituting the equilibrium fees into their expressions. □

Partial adoption of price parity clauses

Consider the case in which only one OTA decides to apply PPCs, while the other leaves prices unconstrained. Let us start from Stage 4 of the game and consider the three possible scenarios. When both hotels multi-home, and when both single-home, we obtain exactly the same results as with PPCs. In the former case price parities are binding and retail prices are the same in the two OTAs, whereas in the latter case PPCs are irrelevant.

In case of partial segmentation, we have two possible cases. On the one hand, if the OTA that applies PPCs hosts only one hotel, then PPCs are binding. This is because the multi-homing hotel is interesting in charging a lower price on the other OTA, but the PPCs force it to set the same retail prices on the two OTAs. Therefore, our results are as in the case of full PPCs. On the other hand, if the OTA that applies PPCs hosts both hotels, then PPCs are not binding, because the price of the multi-homing hotel is higher on the rival OTA. This is *ex post* compatible with the contractual arrangements and profits will be as those reported in Lemma 1 for partial segmentation. However, we can discard this case, as the OTA that only host one hotel can always increase its profits by adopting PPCs, and therefore we will be back to the case in which both OTAs adopt PPCs.

OTAs' contractual arrangements

Proof of Proposition 3. When $\alpha \in (0, \alpha_{SP}]$, hotels multi-home irrespective of whether OTAs adopt PPCs. If OTAs leave prices unconstrained, they obtain π_i^{NS}, whereas under PPCs their profit is π_i^{NSP}. It is immediate to verify that $\pi_i^{NS} - \pi_i^{NSP} = \frac{2(1-2\beta)}{9(2-\alpha)(1+\alpha)(2-\beta)^2} > 0$ when $\beta < \frac{1}{2}$.

Consider next the interval $\alpha \in (\alpha_{SP}, \alpha_S]$. In this region, hotels multi-home in the absence of PPCs and OTAs obtain π_i^{NS}, whereas hotels single-home when OTAs adopt PPCs and OTAs get π_i^{SP}. The profit comparison shows that $\pi_i^{NS} > \pi_i^{SP}$ when $\beta < \tilde{\beta}$. The threshold value $\tilde{\beta}$ is a function of α and we find that it is always higher than 1/2.

In the interval $\alpha \in (\alpha_S, \alpha_{SS}]$, hotels single-home when OTAs adopt PPCs and OTAs obtain π_i^{SP}. By contrast, with unconstrained prices OTAs randomize in the domain $f_i^{SS} \in (\underline{f}_i, \overline{f}_i)$, obtaining $\pi_i^{SS} < \pi_i^{SP}$ (see proof of Proposition 1).

Finally, when $\alpha \in (\alpha_{SS}, 1)$, OTAs obtain the same profits irrespective of the adoption of PPCs, given that hotels always single-home and OTAs set $f_i^{SP} = f_i^S$. As a result, $\pi_i^{SP} \equiv \pi_i^S$. $\square$

Social welfare

Proof of Proposition 4. In order to calculate the results of this proposition, we first present the expressions of the consumer surplus (CS) and the social welfare (SW) with unrestricted prices and with PPCs. We calculate the consumer surplus from the indirect utility function (1) for the cases of No Segmentation and Segmentation, respectively (Partial Segmentation is never an equilibrium). For the case of Segmentation, for example, only two possible choices are available for consumers (suppose q_{A1} and q_{B2}), whose utility is therefore given by:

$$q_{A1} + q_{B2} - \frac{1}{2}(q_{A1}^2 + q_{B2}^2) - \alpha\beta(q_{A1}q_{B2}) - p_{A1} - p_{B2}.$$

By using equilibrium prices to compute demands and by substituting the corresponding expressions into the above utility, we obtain the consumer surplus. Finally, we consider that social welfare is the sum of the consumer surplus and firms' profits (2 hotels and 2 OTAs).

When prices are unrestricted, consumer surplus and social welfare are as follows:

- When $\alpha \in (0, \alpha_S]$, there is No Segmentation, and

$$CS^{NS} = \frac{2}{(1+\alpha)(2-\alpha)^2(1+\beta)(2-\beta)^2};\ SW^{NS} = \frac{14 - 4\alpha(2-\beta) - 8\beta}{(1+\alpha)(2-\alpha)^2(1+\beta)(2-\beta)^2}.$$

- When $\alpha \in (\alpha_S, \alpha_{SS}]$, No segmentation and Segmentation occur with positive probability, and consumer surplus and social welfare are such that $CS^{NS} > CS^{SS} > CS^S$; $\quad SW^{NS} > SW^{SS} > SW^S$.

- When $\alpha \in (\alpha_{SS}, 1)$, there is Segmentation, and

$$CS^S = \frac{(2-\alpha^2\beta^2)^2}{(2-\alpha\beta)^2(1+\alpha\beta)\left[4-\alpha\beta(1+2\alpha\beta)\right]^2};\ SW^S = \frac{(2-\alpha^2\beta^2)^2\left\{14-\alpha\beta[12+\alpha\beta(5-4\alpha\beta)]\right\}}{(2-\alpha\beta)^2(1+\alpha\beta)\left[4-\alpha\beta(1+2\alpha\beta)\right]^2}.$$

Conversely, when OTAs apply PPCs, the consumer surplus and social welfare are as follows:

- When $\alpha \in (0, \alpha_{SP}]$, there is No Segmentation, and

$$CS^{NSP} = \frac{2}{9(2-\alpha)^2(1+\alpha)(1+\beta)};\ SW^{NSP} = \frac{2(11-6\alpha)}{9(2-\alpha)^2(1+\alpha)(1+\beta)}.$$

- When $\alpha \in (\alpha_{SP}, 1)$, there is Segmentation, and

$$CS^{SP} = \frac{(2-\alpha^2\beta^2)^2}{(2-\alpha\beta)^2(1+\alpha\beta)\left[4-\alpha\beta(1+2\alpha\beta)\right]^2};\ SW^{SP} = \frac{(2-\alpha^2\beta^2)^2\left\{14-\alpha\beta[12+\alpha\beta(5-4\alpha\beta)]\right\}}{(2-\alpha\beta)^2(1+\alpha\beta)\left[4-\alpha\beta(1+2\alpha\beta)\right]^2}.$$

Finally, we derive the results of the proposition by comparing the expressions for consumer surplus and social welfare with or without PPCs in the parametric regions highlighted in Proposition 3. When $\alpha \in (0, \alpha_{SP}]$, there is always No Segmentation and we obtain that $CS^{NSP} < CS^{NS}$ and $SW^{NSP} < SW^{NS}$. When $\alpha \in (\alpha_{SP}, \alpha_S]$, there is No Segmentation with unconstrained prices and Segmentation with PPCs, and we find that $CS^{SP} < CS^{NS}$ and $SW^{SP} < SW^{NS}$. Finally, in the interval $\alpha \in (\alpha_S, \alpha_{SS}]$, there is segmentation with PPCs, while both No Segmentation and Segmentation can occur with a positive probability without PPCs. As retail prices and commission fees are lower in the latter than in the former case, we obtain that $CS^{SP} < CS^{SS}$ and $SW^{SP} < SW^{SS}$. Finally, when $\alpha \in (\alpha_{SS}, 1)$, there is always Segmentation, and we get that $CS^{SP} = CS^{SP}$ and $SW^{SP} = SW^{SP}$. □

Showrooming

Proof of Lemma 5. Without PPCs, hotels' listing and OTAs' fees decision do not change. However, the presence of showrooming affects OTAs' and hotels' profits. We find that:

- If $\alpha \in (0, \alpha_S]$, hotel h's and OTA i's profits are:

$$\pi_{hS}^{NS} = \frac{(1-\alpha)[2+\gamma(2-(3-\beta)\beta^2)]}{(1+\alpha)(2-\alpha)^2(1+\beta)(2-\beta)^2}; \quad \pi_{iS}^{NS} = \frac{2(1-\gamma)(1-\beta)}{(1+\alpha)(2-\alpha)(1+\beta)(2-\beta)^2}.$$

- If $\alpha \in (\alpha_S, \alpha_{SS}]$, hotel h's and OTA i's profits are:

$$\pi_{hS}^{SS} = \gamma\left[\frac{(1-\alpha)}{(1+\alpha)(2-\alpha)^2}\right] + (1-\gamma)\pi_j^{SS}; \quad \pi_{iS}^{SS} = (1-\gamma)\pi_i^{SS}.$$

- If $\alpha \in (\alpha_{SS}, 1)$, hotels h's and OTA i's profits are:

$$\begin{aligned}\pi_{hS}^{S} =& \gamma\left[\frac{(1-\alpha)}{(1+\alpha)(2-\alpha)^2}\right] + \frac{(1-\gamma)(1-\alpha\beta)(2-\alpha^2\beta^2)^2}{(2-\alpha\beta)^2(1+\alpha\beta)\left[4-\alpha\beta(1+2\alpha\beta)\right]^2};\\ \pi_{iS}^{S} =& \frac{(1-\gamma)(1-\alpha\beta)(2+\alpha\beta)(2-\alpha^2\beta^2)}{(2-\alpha\beta)(1+\alpha\beta)\left[4-\alpha\beta(1+2\alpha\beta)\right]^2}.\end{aligned}$$

□

Proof of Lemma 6. In Stage 2, OTAs choose the fees. Suppose first that α is sufficiently low so that both hotels join both OTAs. In that case, maximizing OTA i's profit with respect to the commission fee we obtain

$$f_{iS}^{NSP} = \min\left\{\frac{2-(1-\beta)\gamma}{3(1-\gamma)}, \frac{(1-\alpha)[2-(1-\beta)\gamma]}{2(1+\beta\gamma)-\alpha[2-(1-\beta)\gamma]}\right\}.$$

The latter fee guarantees that hotels obtain non-negative profits from selling through the platforms, i.e., $p_{hS}^{NSP} - f_{iS}^{NSP} \geq 0$. However, the former fee is lower or equal than the latter when $\gamma \leq \gamma_{NSP} \equiv \frac{1-\alpha}{3+2\beta-\alpha(2+\beta)}$. Therefore, we distinguish between two cases. When $\gamma \leq \gamma_{NSP}$, $f_{iS}^{NSP} = \frac{2-(1-\beta)\gamma}{3(1-\gamma)}$, and hotel h's and OTA i's profits are those provided in Lemma 6. Instead, when $\gamma > \gamma_{NSP}$, $f_{iS}^{NSP} = \frac{(1-\alpha)[2-(1-\beta)\gamma]}{2(1+\beta\gamma)-\alpha[2-(1-\beta)\gamma]}$, and hotel h's and OTA i's profits are:

$$\pi_{hS}^{NSP} = \frac{(1-\alpha)(1+\beta)\gamma^2[2-(1-\beta)\gamma]}{(1+\alpha)[2(1+\beta\gamma)-\alpha(2+\beta\gamma-\gamma)]^2}; \quad \pi_{iS}^{NSP} = \frac{2(1-\alpha)\gamma[2-(1-\beta)\gamma]}{(1+\alpha)[2(1+\beta\gamma)-\alpha(2+\beta\gamma-\gamma)]^2}.$$

Suppose now that α is high enough so that each hotel joins a different OTA. Similarly to the previous case, the maximization of OTA i's profit with respect to the fee yields:

$$f_{iS}^{SP} = \min\left\{\frac{(1-\alpha\beta)(2+\alpha\beta)}{4-\alpha\beta(1+2\alpha\beta)} + \xi(\alpha,\beta,\gamma), \frac{(1-\alpha)[1+\alpha-(1-\beta)\alpha\gamma]}{1+\gamma-\alpha[\alpha+\gamma-(1-\beta)\alpha\gamma-2\beta\gamma]}\right\},$$

where $\xi(\alpha,\beta,\gamma)$ is an increasing function of γ. The latter fee guarantees that hotels obtain non-negative profits from selling through the platforms, *i.e.*, $p_{hS}^{SP} - f_{iS}^{SP} \geq 0$. We find that the former fee is lower or equal than the latter when $\gamma \leq \gamma_{SP}$. Again, we distinguish between two cases. When $\gamma \leq \gamma_{SP}$, $f_{iS}^{SP} = \frac{(1-\alpha\beta)(2+\alpha\beta)}{4-\alpha\beta(1+2\alpha\beta)} + \xi(\alpha,\beta,\gamma)$, and hotel j's and OTA i's profits are those provided in Lemma 6. Instead, when $\gamma > \gamma_{SP}$, $f_{iS}^{SP} = \frac{(1-\alpha)[1+\alpha-(1-\beta)\alpha\gamma]}{1+\gamma-\alpha[\alpha+\gamma-(1-\beta)\alpha\gamma-2\beta\gamma]}$, and hotel h's and OTA i's profits are:

$$\begin{aligned}\pi_{hS}^{SP} =& \frac{(1-\alpha)(1+\alpha\beta)\gamma^2[1+\alpha-\alpha\gamma(1-\beta)]}{(1+\alpha)[1+\gamma-\alpha[\alpha+\gamma-\alpha\gamma(1-\beta)-2\beta\gamma]]^2};\\ \pi_{iS}^{SP} =& \frac{(1-\alpha)(1-\gamma)\gamma[1+\alpha-\alpha\gamma(1-\beta)]}{[1+\gamma-\alpha[\alpha+\gamma-\alpha\gamma(1-\beta)-2\beta\gamma]]^2}.\end{aligned}$$

In the case in which $\gamma > \gamma_{SP}$, we also find that if α is very high, hotels do not open their direct channel. While OTA i's profits do not change, hotels h gets:

$$\pi_{hS}^{SP} = \frac{(1-\alpha^2\beta^2)(1-\gamma)\gamma^2}{(2-\alpha\beta)^2[1+\gamma-\alpha[\alpha+\gamma-\alpha\gamma(1-\beta)-2\beta\gamma]]^2}.$$

□

Proof of Proposition 5. We now consider the OTAs' decision about whether to adopt PPCs in the presence of showrooming when γ is sufficiently small, *i.e.*, γ is smaller that the minimum of γ_{NSP} and γ_{SP}.[30] If $\alpha \leq \alpha_{SH}$, both hotels multi-home regardless of OTAs' decision about PPCs. In this case, we compare OTA i's profits under No Segmentation without PPCs with those obtained with PPCs. We find that $\pi_{iS}^{NS} < \pi_{iS}^{NSP}$ if

$$\beta > \beta_{SH} = \frac{3\gamma - 1 + \sqrt{(1-\gamma)(1-4\gamma)}}{\gamma}.$$

The threshold β_{SH} is decreasing in γ. This implies that an increase in γ makes the adoption of PPCs more likely.[31]

If $\alpha \in (\alpha_{SH}, \alpha_S]$, hotels multi-home in the absence of PPCs, and single-home otherwise. In the former case OTAs obtain π_{iS}^{NS}, whereas in the latter they get π_{iS}^{SP}. The profit comparison shows that $\pi_{iS}^{SP} > \pi_{iS}^{NS}$ if $\beta > \tilde{\beta}_{SH}$. As this threshold value is a decreasing function of γ, we obtain that $\tilde{\beta}_{SH} < \tilde{\beta}$.

Finally, if $\alpha \in (\alpha_S, 1)$, OTAs adopt PPCs with and without showrooming, given that $\pi_i^{SS} < \pi_i^{SP}$. The reason is that without PPCs OTAs have an incentive to set lower fees to induce hotels to multi-home, and this reduces their profits. Furthermore, an increase in γ has a positive impact on π_{iS}^{SP}, whereas it affects negatively OTA i's profits in the absence of PPCs. □

[30] The results can be easily replicated for the case in which γ is high and are qualitatively the same.

[31] Notice also that $\frac{\partial(\pi_{iS}^{NS}-\pi_{iS}^{NSP})}{\partial\gamma} = -\frac{2(5-\beta)(1-\beta)}{9(2-\alpha)(1+\alpha)(2-\beta)^2} < 0$.

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