CESifo WORKING PAPERS

6660
2017
September 2017

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CESifo

Impressum:

CESifo Working Papers
ISSN 2364-1428 (electronic version)
Publisher and distributor: Munich Society for the Promotion of Economic Research - CESifo GmbH
The international platform of Ludwigs-Maximilians University's Center for Economic Studies and the ifo Institute
Poschingerstr. 5, 81679 Munich, Germany
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Editors: Clemens Fuest, Oliver Falck, Jasmin Gröschl
www.cesifo-group.org/wp

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CESifo *Working Paper No. 6660*
Category 11: Industrial Organisation

Apparent Competition in Two-Sided Platforms

Abstract

We study a platform's design of membership and transaction fees when sellers compete and buyers cannot observe the prices and features of goods without incurring search costs. The platform alleviates sellers' competition by charging them transaction fees that increase with sales revenue, and extracts surplus via membership fees. It prices consumers' membership below its cost to encourage their search. Examples include malls and online marketplaces. Most malls do not charge for parking while most lease contracts include percentage rents as well as fixed rents. Online marketplaces charge sellers for membership and per transaction while letting consumers access website for free.

JEL-Codes: D210, D400, D830, L130, R330.

Keywords: consumer search, membership fees, retail agglomeration, transaction fees, two-sided platforms.

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This version: September 2017
We would like to thank Jan Brueckner, Anna D'Annunzio, seminar participants at VU Amsterdam (2016), and session participants at International Transportation Economics Association Annual Conference (2016) and the Meeting of the Turkish Academy of Sciences (2016) for useful comments. Inci would like to acknowledge financial support from the Turkish Academy of Sciences (Outstanding Young Scientist Award, TUBA-GEBIP). Any remaining errors are our responsibility.

1 Introduction

A substantial share of economic activity takes place in platforms that bring buyers and sellers together. Shopping malls and online marketplaces are prime examples of such platforms.[1] These platforms usually host several sellers that offer competing goods. A longstanding literature studies why such competing sellers colocate, pointing out a trade-off between centripetal and centrifugal forces (see., e.g., Wolinsky, 1983; Dudey, 1990; Fischer and Harrington, 1996; Anderson and Renault, 1999; Konishi, 2005).[2] The presence of multiple stores in a marketplace signals consumers a higher chance of finding goods that match their taste. By increasing market size, this creates the centripetal force for agglomeration. Going against is the centrifugal force of price cutting that stems from fiercer competition between sellers in close proximity. Thus, when consumer search is costly, sellers may find it beneficial to colocate because they enjoy a larger market size although they may also need to cut down on prices.

The crucial aspect of competition in a two-sided platform is that the platform's profit depends on its ability to extract the surplus that buyers and sellers obtain as a result of transactions between them. Hence, the platform has an incentive to shape the competitive environment according to its own benefit. Given that it caters to both sides of the market, its optimal strategy is not obvious. Should it foster competition in order to increase the buyers' willingness to pay for participation, or should it soften competition to extract higher surplus from sellers? What is the fee structure that implements its desired outcome? Does agglomeration in a platform necessarily bring in lower prices? The objective of this paper is to shed some light on these questions.

We develop a model of a two-sided platform that hosts retailers selling substitute goods. Consumers learn the prices and exact features of goods only after visiting the platform, which entails a search cost.[3] The platform can charge consumers and retailers lump-sum *membership fees*. It can also charge *transaction fees* based on buyer-seller transactions. For the sake of concreteness, we refer to the platform as a shopping mall, but our model applies also to online marketplaces.

[1] International Council of Shopping Centers (2014) reports that more than half of the retail sales in the US took place in shopping malls in 2013. The US Department of Commerce (2017) reports based on quarterly data that on average 8 percent of retail activity took place in online marketplaces in 2016.

[2] As Murry and Zhou (2017) explain in detail, the empirical evidence about this trade-off is mixed.

[3] Consumers may have expectations about prices, but have virtually no chance to know ex ante the particular price of each good on sale. Even for goods bought on a regular basis, imperfect recall prevents a perfect knowledge of all prices. Moreover, in the case of goods such as laptops, cars, or clothes, consumers typically do not even know their exact willingness to pay for a particular good before physically examining them.

We first focus on the mall's role in shaping competition between retailers. We show that the mall has retailers charge prices above what they would actually charge if they were competing with each other independently. That is, the mall virtually acts as a tacit-collusion device, and thus, competition between stores is only apparent. The mall achieves this outcome by imposing a fee on the retailers' transactions, which in practice takes the form of a *percentage rent* clause in the rental lease contract.[4] The percentage rent is chosen to maximize retailers' joint profits. The mall can extract this surplus by imposing a high enough membership fee, which in practice takes the form of a *base (fixed) rent.* Because consumers cannot observe the prices of goods prior to visiting, the mall anticipates that raising retail prices has little effect on the number of consumers who visit the mall, while it increases the surplus extracted from those who do. Therefore, it has an incentive to alleviate retailers' price competition.

Next, we take a broader look at the structure of fees charged by the platform. In principle, in addition to "taxing" transactions between consumers and retailers with percentage rents, the mall can charge either side for membership. In reality, malls do charge retailers membership fees in the form of base rents.[5] However, they typically do not charge consumers for visiting the mall. Almost every mall provides free parking.[6] Similarly, online marketplaces charge transaction and membership fees to sellers, but do not charge membership fees to consumers. A priori, it is not obvious why choosing such fee structures is optimal. An alternative strategy would be encouraging competition among retailers for the benefit of consumers, and then recovering consumer surplus through high parking fees (or other membership charges). However, this strategy is actually dominated when consumers are imperfectly informed about the prices of goods prior to visiting. The mall anticipates that lowering retail prices cannot expand the market size (nor can it increase the parking fee revenue) when consumers do not observe retail prices prior to their search. Yet, consumers typically know the parking fee prior to visiting the mall. Hence, lowering the parking fee does expand the market size. In fact, given high retail prices, raising the parking fee has a high

[4]Unlike traditional rental contracts, rental lease contracts between shopping malls and retailers often require the latter to pay a percentage of their sales revenue in addition to a fixed rent. Gould et al. (2005) and Wheaton (2000) show that a large number of retailers in malls have a clause specifying a percentage rent. Online marketplaces levy similar fees. Although the rates may vary by category, Amazon and eBay charge sellers between 3 to 15 percent on each transaction in addition to membership fees. We provide additional details on these fees in Section 2.

[5]Some exceptions exist. For instance, 73 percent of anchor stores pay no rent (Gould et al., 2005). In Section 6.2, we analyze the case of anchor stores and explain why they may be asked to pay no rent.

[6]The International Council of Shopping Centers and Urban Land Institute (2003) report that parking is free in 94 percent of the US malls.

implicit cost for the mall because losing the marginal consumer means a substantial loss in expected retail revenue. This means that the mall generally prefers charging low or no fees for parking.

Our results highlight the role of consumer uncertainty in shaping the platform's fee structures. Because consumers are imperfectly informed about retail prices, the mall follows a logic similar to, yet at the same time opposite of, a standard two-part tariff. This tariff maximizes consumer surplus and extracts it via a membership fee (Oi, 1971). In our setting, the mall maximizes the *producer* surplus by making retailers charge high prices, and recovers their surplus by charging a base rent. However, the flip side is that the mall *minimizes* the surplus of consumers who visit, although it subsidizes their search by providing parking below cost.[7] If we assumed, rather unrealistically, that consumers observe all prices ex ante, the standard two-part tariff result would emerge: the mall would then actually boost retailer competition by charging negative percentage rents (i.e., subsidizing transactions) combined with a high parking fee. This pricing strategy is the opposite of what is commonly observed in reality, implying the relevance of our assumption of consumer uncertainty.

Finally, we analyze the relationship between the number of retailers in the platform and the equilibrium prices. We show that, quite surprisingly, agglomeration does not necessarily result in lower prices. The mall's incentive is to soften competition between retailers, which means that having more of them may not make the marketplace more competitive. In fact, when retailers sell substitute goods and consumers are uncertain about their tastes prior to visiting the mall, a higher number of retailers means a higher chance of finding a good that fits one's taste. Thus, a higher number of consumers visits the mall. As a result, the aggregate demand faced by the mall becomes less elastic, which implies that retail prices increase with the number of retailers at the mall. We argue that this result is context-dependent and more likely to hold for certain types of goods than for others. It applies more reasonably to goods that consumers typically buy in single units and when taste uncertainty is relevant (e.g., TVs, laptops, or shoes) than to goods typically bought in multiple units with well-known characteristics (e.g. groceries).

Previous literature recognizes that platforms manipulate the competitive environment that they host. Armstrong (2006) argues that a platform may limit the number of competing sellers if it

[7] Nonetheless, the fact that parking fees are below their marginal cost does not mean that consumers do not actually pay for parking. They do pay for parking in the form of higher retail prices.

cannot charge buyers for membership. Hagiu and Jullien (2011, 2014) show that a platform may divert consumer search to generate more revenue on the seller side of the market even when competing with other platforms.[8] Dukes and Liu (2015) show that platforms may increase consumers' search costs in order to mitigate competition.

Empirical evidence on the platform's impact on competition between retailers is mixed. Scott Morton et al. (2001) consider an online referral platform connecting customers to car dealers and find that, although online customers pay about 2 percent less for a car than offline ones, dealers realize higher margins per sale on the online platform.[9] Iyer and Pazgal (2003) study internet shopping agents that allow consumers to compare CD prices at online retailers. They find that, although consumers are generally able to find a better deal when using the shopping agent, the average price charged by retailers on the platform increases with the number of retailers in the platform. These mixed results are possibly due to the fact that joining platforms allows retailers to realize some cost savings (e.g., lower labor costs per transaction), which are partly passed through to consumers. Furthermore, these studies focus on platforms as information gatekeepers in that they only refer consumers to retailers but do not keep track of buyer-seller transactions. Thus, they cannot really charge transaction fees. Baye and Morgan (2001) provide a theoretical treatment of such platforms.

By providing a novel explanation for the role of transaction fees in alleviating competition in platforms, we contribute to different strands of literature. The real estate literature studies provisions of percentage rents in mall lease contracts. Using data from approximately 2500 stores in 35 US malls, Gould et al. (2005) find that rents positively vary with retailers' sales revenue underlining the relevance of percentage rents. As a matter of fact, 99 percent of the rental contracts of non-anchor stores in their sample has a clause specifying a percentage rent.[10] Gould et al. (2005) interpret these provisions as the mall's response to its own inability to commit to costly actions that benefit the retailers (e.g., renovations, cleanliness of communal areas, etc.). In a similar vein,

[8] They provide some anecdotal evidence of this behavior. For example, Netflix sometimes leads viewers towards movies that generate higher revenues (Shih et al., 2007). Shopping malls and stores are often designed to increase the distance consumers have to walk to reach the most popular stores or products (Petroski, 2003).

[9] It is worth pointing out that the platform take measures to limit competition between its members, assigning them exclusive territories.

[10] Although almost all non-anchor stores have a percentage rent clause, the threshold over which percentage rents apply is usually high. Only 18 percent end up paying these additional rents in practice. We show in Section 6.1 that our results continue to hold even if only one of the retailers is charged a percentage rent. We further show in Appendix B that having a two-part tariff structure rather than three-part is without loss of generality.

Wheaton (2000) argues that percentage rents serve as commitments for the mall not to alter the tenant mix in ways that may damage existing tenants. Brueckner (1993) argues that percentage rents internalize inter-store externalities, but obtains negative percentage rents as optimal. Our results stem from explicitly modeling the pricing decisions of the retailers in the mall, which this literature ignored.

The fee structures have also been studied in the literature on two-sided platforms (Rochet and Tirole, 2006). Nevertheless, very few papers actually model the transactions between buyers and sellers. Bedre-Defolie and Calvano (2013) study the design of membership and transaction fees by a payment network, showing that the network subsidizes consumers' transactions because, contrary to merchants, they can decide which means of payment to use. Wang and Wright (2017) consider a platform hosting competing sellers and show that ad valorem transaction fees are an effective form of third-degree price discrimination in the presence of heterogeneous product categories. Hagiu (2009) shows that transaction fees solve a commitment problem of the platform, which is unable to commit not to bring in potential competitors of existing sellers. Finally, Gans (2012) shows that a digital platform relies on revenue sharing agreements with application developers, rather than charging consumers directly, when the latter observe the prices set by developers only after joining. Although revenue sharing is equivalent to transaction fees, these agreements have no effect on the prices of applications in Gans' (2012) model. Furthermore, there is no competition among developers.[11]

Another related strand of the literature concentrates on the pricing of parking space at shopping malls, but simplifies the problem by taking the mall and stores as a single entity (Hasker and Inci, 2014; Ersoy et al., 2016). Our setting differs by modeling these entities as separate players. Molenda and Sieg (2017) allows for two competing shopping malls located at the end points of a Hotelling line while treating the relationship between the mall and retailers in a reduced form.

Last but not least, we contribute to the literature that explores retail pricing strategies (see, among others, Konishi and Sandfort, 2002; Rhodes, 2015) and agglomeration forces that lead to the concentration of competing sellers in the presence of imperfectly informed consumers (see, e.g.,

[11] A related literature (e.g., Foros et al., 2014; Gaudin and White, 2014; Johnson, 2017) studies revenue-sharing agreements between a retailer platform and suppliers in the so-called agency model. The focus of this literature is not on the platform's incentives to alleviate competition among suppliers. Shy and Wang (2011) compare ad valorem and unit transaction fees, showing that a monopolist platform prefers the former when sellers have market power.

Konishi and Sandfort, 2003; Konishi, 2005). This literature neglects the strategic behavior of platforms. Our model extends Konishi and Sandfort (2002, 2003) by incorporating such interactions, which is the driving force behind our results. We argue that platforms have strong incentives to distort retail prices in order to weaken competition. This restrains price cutting, which is considered to be one of the most important benefits of agglomeration of competing retailers for consumers.

The paper is organized as follows. Section 2 presents our base model. Section 3 reports our findings on the role of the platform in distorting competition between retailers. Section 4 shows the importance of our assumption of unobservability of prices on the fee structures imposed by the platform. Section 5 analyzes the relationship between agglomeration and prices. Section 6 makes a robustness check by introducing heterogeneous retailers in the model. Section 7 briefly discusses the case of competing platforms. Section 8 concludes. Appendices contain generalizations of our base model, and proofs of some of the results and claims.

2 The model

We present a model of a platform that brings sellers and buyers together. Although the model applies also to other kinds of platforms, such as online marketplaces, for the sake of concreteness, we refer to the platform as a shopping mall, to sellers as retailers and to buyers as consumers.

We build on the framework of Konishi and Sandfort (2002, 2003). There is a monopolist mall, M, and two retailers, indexed by $i = 1, 2$.[12] Each retailer sells a single good, also indexed by $i = 1, 2$, at a constant marginal cost $m < 1$. The marginal cost is assumed to be less than one because a consumer's maximum willingness to pay will be normalized to one. Retailers compete by choosing prices. Because we are not interested in the decision to locate at the mall but rather in the mall's pricing, we assume that a retailer makes an exogenous profit if it locates outside the mall and normalize this profit to zero.[13]

There is a unit mass of risk-neutral consumers. Each buys at most one good from at most one retailer. Consumers learn the price of each good, p_i, and their willingness to pay for it, v_i,

[12] Section 7 allows for competing malls and Appendix A allows for $n \geq 2$ retailers.

[13] Section 6.1 shows that allowing for heterogeneous outside options would alter the distribution of surplus between the retailers and the mall, but it would not change the main insights of the paper. Section 6.2 shows that allowing one of the retailers to charge an exogenous price (perhaps due to being a subsidiary of a chain whose prices are determined at the regional or national level) does not change the main insights, either.

only after visiting the mall (i.e., searching).[14] However, consumers have rational expectations. We assume that v_i is independently and identically distributed across consumers and goods. Let $G(v_i)$ be the cumulative distribution function for v_i. To ease exposition, we assume that this distribution is uniform with support on the $[0,1]$ interval.[15]

Given our assumptions, consumers are ex-ante (i.e. prior to visiting M) identical, except for a (sunk) search cost s, which is also uniformly distributed on the unit interval $[0,1]$. Following our interpretation of M as a shopping mall, it is natural to think of s as a transportation cost, but it can also be interpreted broadly to include the opportunity cost of the time spent searching for the good. We normalize the surplus of consumers who decide not to visit the mall to zero. The preferences distributions, search costs, and the number of retailers at the mall are common knowledge.

The mall charges a rent R_i to the retailers occupying its floor space. This rent is composed of a fixed payment (or *base rent*), a_i, and an additional payment r_i per each dollar of sales (the *percentage rent*). Thus, denoting the retailer's sales revenue by S_i, the rental contract has the form of a two-part tariff:[16]

$$R_i = a_i + r_i S_i \qquad \forall i = 1, 2. \tag{1}$$

We assume the consumers do not observe the rental contracts between the mall and the retailers.

There is a fee $f \geq 0$ that consumers pay to enter the mall. To fix ideas, we interpret this fee as a parking charge (the implicit assumption is that all consumers travel to the mall by car). We assume that consumers observe this fee before visiting the mall.[17] It costs c for the mall to provide each parking space.

Although we maintain the shopping mall interpretation throughout the analysis, our model applies to other platforms hosting competing sellers. In online marketplaces, consumers incur search costs because browsing through different listings and checking the features of the goods

[14] Anderson and Renault (1999), Konishi and Sandfort (2002, 2003), and Konishi (2005) make similar informational assumptions.

[15] Appendix A generalizes the model to a broader range of preference distributions.

[16] As Wheaton (2000) describes in depth, retail lease contracts in malls actually have a three-part-tariff structure. The percentage rent (or the *overage rent* as Gould et al., 2005 and Baek and Brueckner, 2015, call it) applies only if the sales revenue exceeds a threshold. Appendix B shows that there is no loss of generality in restricting attention to two-part tariffs. Despite being less flexible, in our model, a two-part tariff is sufficient to implement the profit-maximizing equilibrium that the mall can implement with a three-part tariff.

[17] Although this fee is not crucial for our main result, having an ex-ante observable price helps to highlight the importance of the unobservability of retail prices.

are time consuming. These platforms generally do not charge consumers for access while the fee structure that they charge to retailers is similar to the one shown in equation (1).[18] Therefore, while going through the analysis, one should keep in mind the analogy between equation (1) and the fees typically encountered in other types of platforms. The base rent a_i is a membership fee levied on sellers and the percentage rent r_i is an (ad valorem) fee on transactions between sellers and buyers, and the parking fee f is a membership (or access) fee on buyers.[19]

The assumption that retailers are single-product firms is due to our main objective of studying the role of the platform. Given this focus, there is little loss in ignoring that retailers sell multiple products. In fact, as it will later become clear, the mall itself can be thought of as a multiproduct firm, because it has the extensive ability to influence the retailers' pricing decisions. With our assumption, we abstract from some of the complexities of multiproduct pricing (see, e.g., Rhodes, 2015). Our model is is more suitable for goods that consumers typically buy in single units per shopping trip (e.g. TVs, computers, or furniture) than for goods typically bought in multiple units (e.g. groceries).

3 Equilibrium

The sequence of the events in the model is as follows. First, the mall offers each retailer a take-it-or-leave-it rental contract, R_i, and sets f. Retailers simultaneously decide whether to accept. They then simultaneously choose the prices of their goods p_i. If there is only one retailer that accepted the contract, it chooses the price on its own. Consumers decide whether to visit the mall by incurring the search cost s. They learn p_i and v_i once they arrive at the mall. Finally, each consumer who visits the mall decides whether to buy (at most) one good from (at most) one retailer. Our equilibrium concept is Subgame Perfect Nash Equilibrium. Therefore, we solve the model by backward induction. We concentrate on the interior pure strategy equilibria of this game.

[18] For instance, Amazon charges professional sellers a monthly fixed fee plus a referral fee per each item sold, equal to a percentage of the selling price (https://sellercentral.amazon.com). Likewise, eBay offers several plans to professional sellers, which involve a monthly base fee and a "final value" fee computed as a percentage of the price of each good sold (http://pages.ebay.com/seller-center/stores/subscriptions.html). TMall.com charges sellers an annual technology and service fee in addition to commission fees on each transaction.

[19] The fact that the percentage rent is formally charged to retailers is immaterial. Due to the standard tax incidence arguments, the effect of r_i on transactions does not depend on to which group it is levied (Weyl and Fabinger, 2013).

3.1 Consumers

A consumer who visits M learns the price of both goods and his personal valuations v_i. He then buys the good that maximizes his net surplus, provided that it is positive. He makes no purchase if no good gives him a positive surplus. Formally, the consumer buys good i if and only if $v_i - p_i \geq \max[v_j - p_j, 0]$, where $i, j = 1, 2$. Let $\mathbf{p}^e = (p_1^e, p_2^e)$ be the vector of *expected* prices at the mall, which will coincide with the vector of equilibrium prices in the end due to rational expectations. The expected utility of a consumer who visits the mall is

$$
\begin{aligned}
EU(\mathbf{p}^e, f) =& E(\max[0, v_1 - p_1^e, v_2 - p_2^e]) \\
&= \int_{p_1^e}^{1} (v_1 - p_1^e)\, G(\min[v_1 - p_1^e + p_2^e, 1])\, dv_1 + \int_{p_2^e}^{1} (v_2 - p_2^e)\, G(\min[v_2 - p_2^e + p_1^e, 1])\, dv_2 \\
&\quad + 0 \times G(p_1^e) \times G(p_2^e) - f, \qquad (2)
\end{aligned}
$$

where $G(\cdot)$ is the cumulative distribution function of the valuations v_i. This expression excludes the search cost s, which is sunk once the consumer visits the mall. It will however be relevant in the consumer's decision to visit, which we analyze below.

Each line of equation (2) can easily be understood from Figure 1, which shows on the x–axis (y–axis) the level of the price of the good sold by retailer 1 (retailer 2) in the distribution of the consumer's valuation of the good. This figure concentrates on the case where $p_1 < p_2$, but the opposite case can easily be analyzed by interchanging the two axes. The two goods are imperfect substitutes, and thus, the consumer does not necessarily buy the cheapest one. He may buy the more expensive one if his valuation for it is high enough.

To understand the second line in equation (2), recall the condition for purchasing good i described above, and that the distribution of valuations for each good does not exceed one. Thus, assuming a positive surplus from the purchase, the consumer buys from retailer i with probability $G(\min[v_i - p_i^e + p_j^e, 1])$, in which case he gets $v_i - p_i^e$. The first term on the third line of equation (2) expresses the case in which the consumer does not buy any good. With probability $G(p_1^e)$, his valuation is below the price of good 1 (similarly for good 2). Given our assumptions, these events happen jointly with probability $G(p_1^e) \times G(p_2^e)$. Finally, the second term on the third line says that, conditional

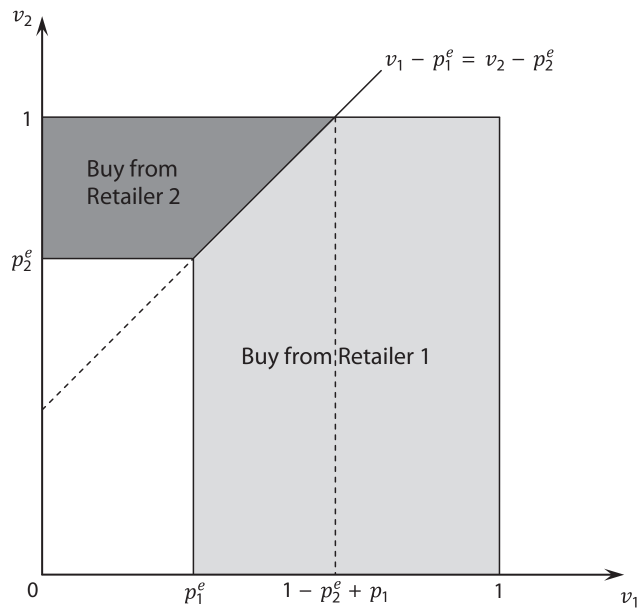

Figure 1: Consumer's decision when $p_1 < p_2$

on visiting the mall, the consumer pays the parking fee f whether he buys a good or not.

Because all consumers are ex-ante identical with respect to their preferences (as a consequence of v_i being i.i.d.), they obtain the same expected utility from visiting the mall. However, they still differ with respect to their search costs. A consumer visits M if and only if his expected utility in equation (2) is weakly higher than his search cost, i.e. $EU(\mathbf{p}^e, f) \geq s$. Thus, the marginal consumer, who is indifferent between visiting M and not, is such that $EU(\mathbf{p}^e, f) = s$. Hence, given our assumptions, the mass of consumers who visits, in other words the mall's *market size*, $\mu(\mathbf{p}^e, f)$, satisfies

$$\mu\left(\mathbf{p}^e, f\right) = EU\left(\mathbf{p}^e, f\right). \tag{3}$$

It is important to note that the market size is a function of the expected prices, not the actual ones. The reason is that consumers make their decision to visit before observing the prices.

3.2 Retailers

Consider now the retailers' pricing decision. Equation (2) states that a mass $\mu(\mathbf{p}^e, f)$ of consumers patronizes the mall. Each shaded area in Figure 1 is the probability that a consumer buys from retailer i. Given our assumptions on the distribution of preferences, these probabilities actually represent the share of consumers who buy from retailer i, $\theta_i(\mathbf{p})$, where $\mathbf{p} = (p_1, p_2)$ is the vector of *actual* prices at the mall. Using Figure 1, it is straightforward to calculate $\theta_i(\mathbf{p})$ for each $i = 1, 2$:

$$\theta_i(\mathbf{p}) = \begin{cases} \int_{p_i}^{1-p_j+p_i} (v_i - p_i + p_j)\, dv_i + \int_{1-p_j+p_i}^{1} dv_i & if\ p_i \leq p_j \\ \int_{p_i}^{1-p_j+p_i} (v_i - p_i + p_j)\, dv_i & if\ p_i > p_j. \end{cases} \tag{4}$$

We can now derive a retailer's profit. A mass $\theta_i(\mathbf{p})\mu(\mathbf{p}^e, f)$ of consumers buys from retailer i and pays p_i. Thus, retailer i's total revenue is $S_i = p_i\theta_i(\mathbf{p})\mu(\mathbf{p}^e, f)$, while its total cost (excluding the rental payment) is $m\theta_i(\mathbf{p})\mu(\mathbf{p}^e, f)$. Given equation (1), the retailer also pays a rent $a_i + r_iS_i$ to the mall. Hence, its net profit, π_i, is given by

$$\pi_i = (p_i(1 - r_i) - m)\,\theta_i(\mathbf{p})\,\mu(\mathbf{p}^e, f) - a_i \qquad \forall i = 1, 2. \tag{5}$$

The key point to realize here is that the retailer knows that consumers do not observe the prices before they visit. Hence, it treats the market size $\mu(\mathbf{p}^e, f)$ as given. This assumption captures the fact that consumers cannot have perfect information about the prices and the quality of the goods available in the mall before actually visiting it.[20]

Simultaneously maximizing the profits of the retailers, we find the price p_i as follows:

$$p_i = \sqrt{2\left(1 + \frac{m}{1 - r_i}\right)} - 1 \qquad \forall i = 1, 2. \tag{6}$$

This price is unique and symmetric.[21] The comparative static properties of this price equation are of interest. As expected, the higher the marginal cost m, the higher the equilibrium price. The parking fee f, which is ex-ante observable and ex-post sunk, does not affect p_i. It only affects the market size $\mu(\mathbf{p}^e, f)$, which retailers take as given. Because the base rent is a fixed cost for the retailer, it does not have an impact on pricing, either. However, the percentage rent does matter: the higher it is, the higher the price. The upshot is that the mall is able to influence the retail prices by appropriately designing the rental contract. Hence, it can soften the competition between the retailers.

[20]This is a standard assumption in the literature on consumer search. Ellison (2005) describes a similar mechanism where, for example, hotels announce low base prices for rooms while charging higher prices for add-ons, such as minibar items, meals, etc.

[21]We provide a formal proof of the uniqueness of the equilibrium in Appendix A in a more general setting.

Suppose the mall was not charging any percentage rent (i.e., $r_i = 0$). Then, the equilibrium price would have been

$$p_0 = \sqrt{2\,(1+m)} - 1, \tag{7}$$

which is lower than any p_i in equation (6) for any $r_i \in (0,1]$. We call p_0 the *competitive price.* In sum, our first result is that percentage rents make the market less competitive. The following proposition records this result.

Proposition 1 (Percentage rents alleviate competition)**.** *The equilibrium prices charged by the retailers are increasing in the percentage rent charged by the mall: $\partial p_i / \partial r_i > 0$.*

The percentage rent is essentially a fee that the mall levies on each transaction. As such, it is akin to an ad valorem sales tax (Wang and Wright, 2017). As we are now going to show, it is in the mall's interest to "tax" the transactions between buyers and sellers.

3.3 The mall

Consider now the mall's problem. Its profit, π_M, is composed of rents paid by the two retailers and the parking revenue left by the consumers:

$$\pi_M = \sum_{i=1}^{2} R_i + (f - c) \cdot \mu\left(\mathbf{p}^e, f\right). \tag{8}$$

The mall maximizes this profit by choosing a base rent of a_i, a percentage rent of r_i, and a parking fee of f. Because the retailers' outside option is exogenous, the mall can extract their entire net profits. It can do so by setting a base rent of $a_i = (p_i(1 - r_i) - m)\theta_i(\mathbf{p})\mu(\mathbf{p}^e, f)$. Therefore, the mall-optimal rental contract must satisfy

$$R_i = (p_i - m)\,\theta_i\left(\mathbf{p}\right)\mu\left(\mathbf{p}^e, f\right) \qquad \forall i = 1, 2. \tag{9}$$

Hence, the mall's profit function reduces to

$$\pi_M = \left(\sum_{i=1}^{2} (p_i - m)\,\theta_i\left(\mathbf{p}\right) + f - c\right)\mu\left(\mathbf{p}^e, f\right) \tag{10}$$

after replacing for the base rent.

Consider now the mall's choice of the percentage rent r_i. Maximizing π_M with respect to r_i yields the equilibrium value of the percentage rent, r_i^*:

$$r_i^* = 1 - \frac{m\left(3 - (m+3)\left(m - \sqrt{m^2+3}\right)\right)}{m^2 + 4m + 2} \qquad \forall i = 1, 2. \tag{11}$$

Because m is less than one, the second term in this equation is always strictly less than one, thus we have $0 < r_i^* < 1$. As a result, the mall charges a positive percentage rent, which we record in the following proposition.

Proposition 2 (Percentage rent)**.** *The mall charges a positive percentage rent:* $0 < r_i^* < 1$.

Recall from Proposition 1 that retail prices increase with the percentage rent. Hence, positive percentage rents mean that the mall induces the retailers to charge a price that exceeds the competitive price p_0 shown in equation (7). The mall wants to alleviate competition between the retailers because it can recover their entire profit by appropriately charging a fixed rent a_i. Hence, it wants the joint profit of retailers to be as high as possible. Like retailers, it knows that consumers do not observe the actual retail prices before visiting. As a result, it treats the market size $\mu(\mathbf{p}^e, f)$ as invariant to the actual price vector, $\mathbf{p}$. From its perspective, competition decreases the profits that can be extracted from the retailers without expanding the market.

Using r_i^* in (6), we obtain the equilibrium price, p_i^*:

$$p_i^* = \frac{m + \sqrt{m^2+3}}{3} \qquad \forall i = 1, 2. \tag{12}$$

This equilibrium price is in fact what a monopolist firm, owning both retailers, would choose. This property is striking because the retailers seemingly compete, and one would expect a more vigorous competition due to agglomeration within the mall. However, this reasoning ignores the incentives of the platform that hosts the sellers. By taxing buyer-seller transactions using a percentage rent, the mall "disciplines" retailers' competitive behavior and maximizes their joint surplus. In other words, the rental contract acts as a coordination device to alleviate competition. This finding leads to the following proposition.

Proposition 3 (Apparent competition)**.** *The equilibrium price that retailers charge, p_i^*, is the* *price that a monopolist firm, owning both retailers, would charge. Although the retailers appear to be competing, the outcome is a monopoly outcome.*

This result shows that two-sided platforms that bring sellers and buyers together adopt transaction fees in order to induce seller coordination on a desired vector of prices.

We now turn to the determination of the parking fee by maximizing π_M with respect to f. The parking fee cannot be negative because a parking subsidy is hard to implement in reality. Hence, if the maximization problem yields a negative f, we shall set it to zero. The first-order condition with respect to f is given by

$$\frac{\partial \pi_M}{\partial f} = \left(\sum_{i=1}^{2} (p_i - m)\, \theta_i(\mathbf{p}) + f - c \right) \frac{\partial \mu}{\partial f} + \mu(\mathbf{p}^e, f) = 0. \tag{13}$$

After replacing for the equilibrium price p_i^* from equation (12) and solving for f, we obtain

$$f^* = \max \left[\frac{c}{2} - A, 0 \right], \tag{14}$$

where

$$A = \frac{1}{6} \left(2\left(\sqrt{m^2+3} - 1\right) + m + \frac{\left(m + \sqrt{m^2+3}\right)^2 \left(5m - 4\sqrt{m^2+3}\right)}{27} \right). \tag{15}$$

It can be shown that A is strictly positive for all $m \in [0, 1]$. Hence, the equilibrium parking fee f^* is strictly lower than the variable cost of providing parking. In fact, because this marginal cost is close to zero in reality, the mall does not charge any parking fee in most circumstances, which is in line with empirical observations. In any case, parking is a loss leader, being priced below its marginal cost. The mall can then embed some of the costs of parking in the retail prices. The parking fee can be interpreted as an additional component of the search cost. Hence, the mall effectively subsidizes consumer search by pricing parking below cost. We summarize our findings in the following proposition.

Proposition 4 (Loss-leader pricing of parking)**.** *The parking fee is below the marginal cost of providing a parking space, c. If c is small enough, parking is provided for free.*

According to the International Council of Shopping Centers and Urban Land Institute's survey (2003), 94 percent of shopping malls in the US do not charge any parking fee. The practice is similar in other countries. Past work provides various explanations for this observation. In Hasker and Inci (2014), consumers are risk averse and find their desired good at the mall only with some probability. The mall thus provides free parking as a form of insurance to consumers. In Ersoy et al. (2016), the mall is accessible by both car and bus, and the latter can get crowded. The mall charges high prices for goods to internalize crowding externalities, but subsidizes parking in order not to penalize car users.

We provide an explanation for free parking different from the prior literature. Our explanation is based on the ex-ante observability of parking fees and ex-ante unobservability of prices of goods. The mall anticipates that decreasing the prices of goods does not expand the market size (and the parking fee revenue, $\mu(\mathbf{p}^e, f)f$). In contrast, decreasing the parking fee does expand the market size because consumers know it prior to their visit. As a matter of fact, given high retail prices, raising the parking fee has a high implicit cost for the mall because losing the marginal consumer implies a substantial loss in expected retail revenue. As a result, the mall is better off charging a parking fee below its cost.

An additional implication of the analysis is that the provision of free parking in shopping malls is second-best efficient from a social welfare perspective. It is straightforward to see it. First, note that it is usually not possible to regulate neither the price of goods within the mall nor the rental contracts between the mall and retailers. Given that the mall has retailers set prices above the competitive level, it is socially optimal to expand the market size by subsidizing parking.

4 Information and the structure of fees

Taken together with the results of Section 3.3, Proposition 4 highlights the role of information in shaping the fees charged by a platform. Because consumers are imperfectly informed about retail prices, the mall adopts a fee structure with a logic similar to, yet at the same time opposite of, a standard two-part tariff. A firm charging a conventional two-part tariff maximizes consumer surplus by making consumers pay for usage at marginal cost, and extracts this surplus via a membership fee (Oi, 1971). In a similar vein, we find that the mall maximizes the *producer* surplus by inducing higher retail prices to be charged, and extracts this surplus by imposing base rents.

To highlight the relevance of consumer uncertainty, assume for the moment that consumers perfectly observe the prices of goods before visiting the mall. This is rather an unrealistic assumption. As Appendix C shows in a more general setting, when prices are ex-ante observable, the mall's best strategy drastically changes. Because it recognizes that changes in the price of goods affect the market size, the mall now has retailers to price goods at marginal cost by adopting *negative* percentage rents. That is, it subsidizes the transactions between buyers and sellers in order to maximize the visiting consumers' expected surplus. The parking fee is then used to recover this surplus. Hence, we get:

$$p_i^* = m, \qquad r_i^* < 0, \qquad f^* = c + EU(\mathbf{p}_m, f), \tag{16}$$

where $\mathbf{p}_m = (m, m)$ is the vector of retail prices, and $EU(\mathbf{p}_m, f)$ is the expected utility from visiting the mall as defined in equation (2).

This exercise highlights that the structure of fees chosen by the mall hinges critically on consumers' information. When they are imperfectly informed about the prices of goods prior to visiting the mall, the mall prefers to tax buyer-seller transactions while subsidizing consumer search by loss-leader pricing of parking. In contrast, in the rather unrealistic case where consumers perfectly observe prices without searching, the mall wants to subsidize transactions while charging a high parking fee to recover surplus.

Proposition 5 (Information and the structure of fees)**.** *If consumers cannot observe the prices of goods prior to visiting the mall, the percentage rents are positive (i.e., the mall taxes buyer-seller transactions) and the parking fee is below cost (i.e., the mall subsidizes consumer search). However, if consumers can observe all prices ex ante, the percentage rents are negative (i.e., the mall subsidizes buyer-seller transactions) but the parking fee is high.*

Negative transaction fees and high membership fees charged to consumers are the opposite of what is commonly observed in reality. This means that consumer uncertainty is in fact quite relevant in determining the fee structure chosen by a platform. Nevertheless, the platform and retailers can decrease the uncertainty by advertising. If consumers can be made perfectly informed prior to visiting, then the platform has an incentive to induce lower retail prices. We do not expect advertising to fundamentally change our results. In practice, advertising does not completely eliminate uncertainty, at least not for all consumers. Even if retailers advertise, it is reasonable to expect that some consumers remain imperfectly informed. Then, as long as there are some consumers with uncertainty, the platform has an incentive to induce high retail prices. Thus, apparent competition prevails although we do not necessarily get the strict monopoly outcome. In addition, as Konishi and Sandfort (2002) and Rhodes (2015) argue in detail, sellers do not always find advertising advantageous, and if they do, they usually end up advertising only a small subset of goods in their product range.

5 Agglomeration and retail prices

We now investigate the relationship between the number of retailers in the mall and the equilibrium prices. In light of our previous results, we can say that it is not obvious that increasing the number of retailers at the mall leads to lower prices. To illustrate this result, we now compare the case in which there is only one retailer at the mall with the case in which there are two retailers, which we have already analyzed above. This comparison suffices to show the first-order intuition. Appendix A generalizes the result by allowing for $n \geq 2$ retailers.

Suppose there is a single retailer at the mall and let p denote the price of its good. A consumer visiting the mall buys the good if and only if $v \geq p$. Given our assumptions on preferences, this happens with probability

$$\theta_s(p) = \int_p^1 g(v)dv = 1 - p. \tag{17}$$

We use subscript s to denote the single-retailer case. We retain the assumption that consumers cannot observe p before visiting the mall, so the market size $\mu(p^e, f)$ depends on the expected price p^e. Thus, the retailer's profit is

$$\pi_s = (p(1-r) - m)\,\theta_s(p)\,\mu(p^e, f) - a, \tag{18}$$

where r is the percentage rent and a is the base rent. The market size $\mu(p^e, f)$ is given by

$$\mu(p^e, f) = EU(p^e, f) = E(\max[0, v - p_s^e]) = \int_{p_s^e}^1 (v - p_s^e)\, dG(v). \tag{19}$$

Maximizing π_s leads to the following equilibrium price:

$$p_s = \frac{1}{2}\left(1 + \frac{m}{1-r}\right). \tag{20}$$

As in the two-retailer scenario, the percentage rent increases the price charged by the retailer. Consider now the mall's problem. As we argue above, the mall is better off setting a such that $\pi_s = 0$. Hence, we can write its profit as

$$\pi_{M,s} = \left((p-m)\,\theta_s\,(p) + f - c\right)\mu\,(p^e, f)\,. \tag{21}$$

The comparison of this expression with equation (18) suggests that, when $r = 0$, the retail price p that maximizes the retailer's profit also maximizes the mall's profit. Therefore, the mall sets no percentage rent, $r^* = 0$. The intuition is simple: because there is no competition, the mall has no reason to distort prices. Hence, we have

$$p_s^* = \frac{1+m}{2}. \tag{22}$$

Let us now compare this price with equation (12). Because $m < 1$, we conclude that

$$p_s^* = \frac{1+m}{2} < p_i^* = \frac{m + \sqrt{m^2+3}}{3}. \tag{23}$$

Therefore, the equilibrium retail price when there are two retailers at the mall is higher than the price when there is one retailer.

Proposition 6 (Number of retailers and prices)**.** *The equilibrium price of goods is increasing in the number of retailers.*

Why do we get this result? A first reason is that the mall has an incentive to soften competition, which results in higher retail prices. The second reason is related to the market-expansion effect associated with a higher probability of finding a good that fits one's preferences when we increase the number of retailers at the mall. To see this effect formally, compare the market size in the case in which there are two retailers at the mall (see equation (2)) with the case in which there is only one retailer (see equation (19)), at a given level of retail prices. It is straightforward to see that the market size with two retailers is larger. As a result, the demand faced by the mall on the consumer side of the market becomes less elastic when the number of retailers increases. Then, the mall finds it optimal to have the retailers set even higher prices when their number increases. In other words, as a two-sided platform, the mall exploits the positive externality that the availability of retailers exerts on consumers (Rochet and Tirole, 2006). It extracts this additional surplus by having the retailers themselves charge higher prices, which it then extracts via base rent, rather than charging consumers directly via parking fees.

These results suggest that agglomeration does not necessarily result in lower prices. The past literature shows that agglomeration expands the market size of stores at the mall, but it also reduces the price they charge in equilibrium because of intense competition (see. e.g., Konishi, 2005). This last finding in the past literature stems from the fact that the mall has no means to influence the retailers' pricing decisions because it is allowed to charge only base rents. To see this transparently, we now compare the retail price in the single-retailer case with the retail price in the two-retailer case again, but this time by setting the percentage rents to zero in equation (7). In that case, we have

$$p_s^* = \frac{1+m}{2} > p_0 = \sqrt{2\,(1+m)} - 1. \tag{24}$$

Therefore, if the mall does not adopt transaction fees, competition does indeed decrease prices. However, once we incorporate the mall's incentives, the relationship between the number of stores and the equilibrium prices is reversed.

A caveat concerning Proposition 6 is that it partly depends on our assumption that consumers buy at most one good from at most one retailer per visit. In a model in which consumers can buy multiple goods per visit, Rhodes (2015) shows that a retailer charges lower prices when product range in the mall increases. The reason is that the demand by consumers who buy multiple goods is more elastic with respect to prices. Our model does not feature this effect. However, Rhodes (2015) assumes that consumers are not uncertain about their taste for goods, which is probably a better assumption for grocery shopping. We instead assume that this variable is realized only after the consumer visits the mall. Thus, a broader product range actually reduces the elasticity of demand perceived by the mall, leading to our price-increasing result. That is why we argue that Proposition 6 is more likely to apply for goods that consumers buy in single units per visit and that are difficult to evaluate without incurring substantial search costs. This description is more likely to be a good fit for such goods as TVs, computers, furniture, or cars, but less for groceries.

6 Retailer heterogeneity

We have so far assumed that the retailers in the mall are symmetric. However, malls contain various retailers that differ in certain important dimensions. To bolster confidence in our results, we now introduce heterogeneity to our model in two ways. First, in Section 6.1, we assume that the retailers have different bargaining powers so that the mall is able to charge a percentage rent only to one of them. We show that the other one is still charged a positive percentage rent. Thus, the mall continues to distort competition between the retailers even in that case. Second, in Section 6.2, we assume that one of the retailers is an anchor store. In line with empirical observations reported in Gould et al. (2005), we find that the mall charges no percentage rent (and possibly no fixed rent) to the anchor store, but still charges a positive percentage rent to the other retailer.

6.1 Heterogeneity in rental lease contract

This section entertains the possibility that some retailers have higher bargaining power or better outside options than others, so that they must be given better contractual terms by the mall. This extension is motivated by empirical evidence (e.g., Gould et al., 2005), which shows that, although percentage rent provisions are extremely common in rental contracts, some retailers are able to negotiate overage thresholds large enough that they only pay the base rent in equilibrium. Accordingly, suppose now that one of the retailers, say retailer 1, is not charged a percentage rent (i.e., $r_1 = 0$).[22] We are going to establish that the mall still charges a positive percentage rent to the other one, thereby distorting competition.

Although introducing heterogeneity is simple, equilibrium expressions get quite complicated. In equilibrium, we may have either $p_1 \leq p_2$ or $p_2 > p_1$. We first assume that the equilibrium prices satisfy $p_1 \leq p_2$ and show that this condition, in fact, holds in the end. We then assume $p_2 > p_1$, but show that there are no such equilibria. We do not report the details of this second case for

[22]This retailer may also be able to negotiate a lower base rent, but this would not change the analysis that follows. Indeed, we could impose a lump-sum discount on the base rent a_1 (see equation (25) below). Clearly, this additional term affects neither the retailer's pricing decisions nor the mall's fees.

brevity. When $p_1 \leq p_2$, retailers profits are given by

$$\pi_1 = (p_1 - m)\,\theta_1(\mathbf{p})\,\mu(\mathbf{p}^e, f) - a_1 \tag{25}$$

$$\pi_2 = (p_2(1 - r_2) - m)\,\theta_2(\mathbf{p})\,\mu(\mathbf{p}^e, f) - a_2, \tag{26}$$

where

$$\theta_1(\mathbf{p}) = \int_{p_1}^{1-p_2+p_1} (v_1 - p_1 + p_2)\,dv_1 + \int_{1-p_2+p_1}^{1} dv_1 \tag{27}$$

$$\theta_2(\mathbf{p}) = \int_{p_2}^{1-p_1+p_2} (v_2 - p_2 + p_1)\,dv_2. \tag{28}$$

The first-order condition of retailer 1's profit maximization yields

$$p_1 = \frac{1 + 2m + (2 - p_2)p_2}{4}, \tag{29}$$

which does not include any percentage rent. However, the first-order condition of retailer 2's profit maximization does depend on the percentage rent, r_2, as well as the price charged by the other retailer, p_1:

$$2m(1 + p_1 - p_2) + (1 - r_2)(1 - (4 - 3p_2)\,p_2 - p_1(-2 + 4p_2)) = 0. \tag{30}$$

In our base model, the mall indirectly chooses the price that each retailer charges via a proper choice of a percentage rent. Now that $r_1 = 0$, it does not have the ability to influence the pricing of retailer 1, but it can still indirectly choose p_2. So, in our solution procedure, we first compute the mall-optimal p_2 and then, by using equation (30), we back-up the r_2 value that implements the mall-optimal p_2. Of course, the mall takes into account that retailer 1 will find its best response to any p_2 by using equation (29).

The mall's profit is still given by equation (10). By following the procedure we outlined above, it can be written as a function of p_2 only, whose first-order condition gives

$$4 + 3m + 2m^2 - 5p_2 - 3(2 + m)p_2^2 + 5p_2^3 = 0. \tag{31}$$

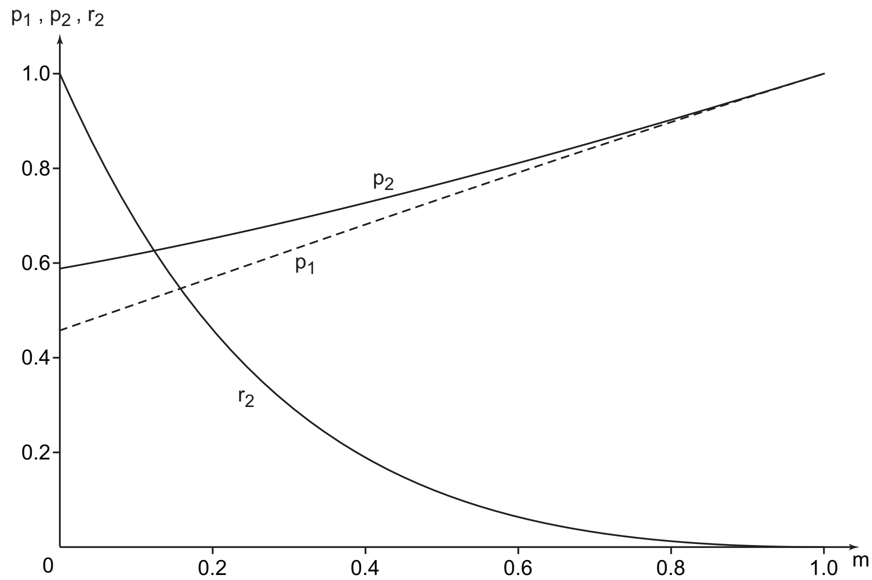

Figure 2: Equilibrium values when $r_1 = 0$

This expression gives a quite complicated solution for p_2. We find r_2 by comparing this equation with equation (30). The solution is prohibitively long to report here. We, thus, followed a numerical procedure to illustrate the following two facts: for all m values, $p_1 \leq p_2$ as we have assumed in the beginning, and $r_2 \in [0, 1]$, so retailer 2 is charged a positive percentage rent. For example, when $m = 0.2$, we have $p_1^* = 0.57$, $p_2^* = 0.65$, and $r_2^* = 0.46$. Figure 2 illustrates the relationship between p_1, p_2, and r_2 for all $m \in [0, 1]$.

We have also gone over the same solution procedure by assuming $p_2 > p_1$ and found no interior equilibrium satisfying this inequality. Hence, we have the following proposition.

Proposition 7 (Asymmetric tenant mix)**.** *Even if one of the retailers cannot be charged a percentage rent, the other one still is. The retailer who is not charged a percentage rent sets the lower equilibrium price.*

6.2 Heterogeneity in tenant mix

We now modify the model by introducing the distinction between the anchor and non-anchor stores. Anchor stores usually provide positive externalities by drawing customers to the malls. This should be reflected in anchor stores' rental contracts. Assume that retailer 1 is the anchor. Following Konishi and Sandfort (2003), we assume that it sells a standardized good for which all consumers have the same willingness to pay $\hat{v}_1$. Furthermore, consumers know their valuation of the good, $\hat{v}_1$, and its price, $\hat{p}_1$, prior to their visit. We further assume that $\hat{p}_1$ is exogenous. This assumption is justified by the fact that anchor stores are generally part of national or regional chains, whose pricing policy is to a large extent independent from the conditions at any given mall. We assume that the non-anchor retailer 2 has the same characteristics as in the baseline model.

Following similar steps as we have in the base model, we show that, given $\hat{v}_1$ and $\hat{p}_1$, retailer 2 chooses the following price for any given r_2:

$$p_2 = 1 - (\hat{v}_1 - \hat{p}_1) + \frac{m}{1 - r_2}. \tag{32}$$

This price is decreasing in the net surplus consumers get from buying the good sold by the anchor store. It is, however, increasing in the percentage rent r_2. We further show that retailer 1 is charged no percentage rent while retailer 2 is charged a positive percentage rent.[23] Formally, we have

$$r_1^* = 0, \qquad r_2^* = \frac{\hat{p}_1}{\hat{p}_1 + m}. \tag{33}$$

This, then, implies that retailer 2 charges the following price:

$$p_2^* = \hat{p}_1 + \frac{1 - \hat{v}_1 + m}{2}. \tag{34}$$

Remember that $\hat{p}_1$ is exogenous. The mall has no reason to charge a positive percentage rent to the anchor store because it cannot influence its pricing. By contrast, it wants to charge retailer 2 a positive percentage rent in order to increase the surplus that retailer 2 gains, which the mall extracts wholly in the end. This is, in fact, the same logic we have in the base model.

Finally, the parking fee f is given by $f^* = \max\left[\frac{c}{2} - B, 0\right]$, where

$$B = \frac{1 + \hat{v}_1^2 + 6\hat{p}_1 - 10\,(\hat{v}_1 - \hat{p}_1) + m\,(m + 2(1 - \hat{v}_1))}{16}. \tag{35}$$

As in the base model, parking is priced below its marginal cost, unless the surplus from buying the anchor store's good, $\hat{v}_1 - \hat{p}_1$, is very large. This surplus is likely to be low if the anchor store's good

[23] As Section 6.1, we could impose a lump-sum discount on the base rent paid by the anchor without affecting the analysis.

is pretty much standard. We record the results of this section in the following proposition.

Proposition 8 (Anchor store). *An anchor store is charged no percentage rent while the retailer is charged a positive percentage rent. Parking is a loss leader as long as the surplus from buying the anchor store's good is low.*

7 Competing malls

This section briefly illustrates that our results are robust to competition between platforms.[24] Although one can think of many situations where malls are de facto local monopolies, and online marketplaces may enjoy dominant positions due to network effects, platform competition is still relevant. Nevertheless, we show here that introducing competition does not change our analysis in any fundamental way.[25]

Suppose there are two horizontally-differentiated malls located at the end points of a Hotelling line, as in Armstrong (2006) and Molenda and Sieg (2017). Assume also that there are two retailers interested in opening a store in each mall, but consumers are one-stop shoppers who visit only one of the malls. Hence, the malls are "competitive bottlenecks" as defined in Armstrong (2006). In such a setting, because consumers single-home while retailers multi-home, malls can still extract the whole surplus from the retailers, just like in our base model. As Armstrong (2006) explains in detail, malls have monopoly power over the multi-homing side of the market since otherwise that side of the market does not have any other means to trade with the single-homing side of the market. As a result, each mall sets the base rent to capture the entire surplus that a retailer gets from joining it, as in our base model.

Consider now the implications of competition on the structure of the transaction fees. Because consumers observe the prices of retail goods only after visiting a mall, retailers take the respective market size as given when setting the prices of goods. The same condition applies to malls as well when they are choosing the transaction fees. Because consumers do not observe retail prices before visiting, each mall anticipates that decreasing these prices has no effect on luring consumers away from the competitor. As a result, as in the base model, each mall sets positive percentage rents in

[24] We omit the formal analysis to avoid repetition, but it is available upon request.

[25] Here, we present one natural way of introducing competition between malls. In principle, the results should depend on how one models competition.

equilibrium and induces stores to raise their prices above the competitive level.

Finally, consider the choice of parking fees. Because consumers observe the parking fees before visiting the mall, raising them reduces a mall's market size. Hence, malls compete over parking fees. As in our main model, because of the relatively high price of retail goods, each mall perceives a high implicit cost of charging consumers for parking. Furthermore, as competition increases the elasticity of consumer demand faced by each mall, competing malls are even less willing to charge for parking in equilibrium than the monopolist mall we have in the base model. Hence, in equilibrium, each will charge low or no parking fees.

8 Conclusion

In the presence of search costs, agglomeration is beneficial for competing sellers because consumers can economize on search cost by visiting many stores at once. This increases sellers' customer base because consumers with even higher search costs will find it optimal to visit the place. But apart from this centripetal force, there can potentially be a centrifugal force. If sellers operate independently at locations distant from each other, they can monopolize the local market to charge higher prices while they may have to charge lower prices when they are in close proximity because a consumer can easily switch from one seller to another. As a result, firms colocate if the centripetal force of market expansion is larger than the centrifugal force of profit loss due to price cutting if they colocate. In this paper, we show that this trade-off exists only if sellers come together in an uncoordinated fashion. When they colocate under a platform, such as a mall or an online marketplace, the platform has so much ability to alleviate competition that the centrifugal force does not exist.

Although consumers have rational expectations about price levels at platforms, they cannot learn the exact prices unless they engage in costly search. The platform can make use of this imperfect information by charging sellers transaction fees that vary with the performance of sellers. Such a transaction fee can serve as a tacit collusion device to increase prices and ultimately maximize aggregate surplus of sellers colocating under the platform. Then, the platform extracts this surplus by charging membership fees. In such an environment, there is no trade-off between increased market size and price-cutting effects simply because competition is only illusionary under the coordination of a platform.

The lively examples to the mechanism we describe include shopping malls and online marketplaces, which cover a substantial share of economic activity. For example, in addition to the traditional fixed rent, most rental leases at malls include overage rent clauses, which require retailers to pay a share of their sales revenue to the mall. A percentage rent can easily be used to alleviate competition among retailers operating in the mall. Then, the mall can easily extract surplus by also imposing a fixed rent. We also included parking in our model, not just to close the two-sided market but also to illustrate how the mall sets a price when it is ex-ante observable. We find that the mall uses parking as a loss leader (because lower parking fees attract more customers) while trying to induce retailers to charge higher markups over retail goods. Without the assumption of unobservability of prices, we get exactly the opposite (and unrealistic) result that the mall encourages the retailers for marginal cost pricing (by charging negative percentage rent along with a high enough fixed rent in order to leave no surplus to the retailers) while itself using parking as a profit generator.

Observing the fact that sellers are locating together, one cannot presume fiercer competition. Competition under platforms is occasionally only apparent, and if so, agglomeration is a no-tradeoff decision for sellers selling competing goods.

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Appendix

A Generalizing the model

We now generalize our base model. There are now n retailers, and the distribution of valuations satisfy the following assumptions.

Assumption 1 (Konishi, 2005). *The probability density $g(v)$ is log-concave.*

Assumption 2 (Konishi, 2005). *The probability density $g(v)$ is continuously differentiable, and satisfies $g(v) > 0$ and $(vg'(v))/g(v) \geq -1$ for every $v \in [0, 1]$.*

We borrow these assumptions from Konishi (2005). The first assumption ensures the existence of an equilibrium. The second one is sufficient to ensure the uniqueness of a symmetric equilibrium. Because retailers are ex-ante identical, we further assume that rental contracts are symmetric:

Assumption 3. *Rental contracts are symmetric, $R_i = a + rS_i$.*

We first concentrate on the retailers' problem followed by an analysis of the mall's problem.

A.1 Retailers

Consider retailer i, and let its price be p_i. Because we focus on symmetric equilibria, let all other retailers charge the proposed symmetric equilibrium price p. For the proof of existence of an equilibrium, we refer the reader to Theorem A.1 in Konishi (2005), which straightforwardly applies to our case. Here, we show that there is a unique price p_i for each r and that p_i is increasing in r. Our uniqueness proof closely follows the steps in Konishi (2005), with the difference that we introduce percentage rents in the problem. We present the uniqueness proof here because it makes further steps of our calculations (involving rents) more transparent and easier to comprehend.

There are two cases to consider. In the first, retailer i starts with a weakly higher price than others (i.e., $p_i \geq p$) and approaches the proposed equilibrium from above. In this case, its profit, $\pi_i^{n+}(p_i, p)$, is given by

$$\pi_i^{n+}(p_i, p) = (1-r)\left(p_i - \frac{m}{1-r}\right)\left(\int_{p_i}^{1} g(v_i)\, G^{n-1}(v_i - p_i + p)\, dv\right)\mu(\mathbf{p}^e, f) - a, \tag{A.1}$$

where $G(u) = \int_0^u g(v_i) dv_i$, and $G^{n-1}(v_i - p_i + p)$ is the probability that a consumer prefers retailer i's good to all other goods available at the mall.

In the second case, retailer i starts with a weakly higher price than others (i.e., $p_i \leq p$), and approaches the proposed equilibrium from below. In this case, its profit, $\pi_i^{n-}(p_i, p)$, is given by

$$\pi_i^{n-}(p_i, p) = (1-r)\left(p_i - \frac{m}{1-r}\right)\left(\int\limits_{p_i}^{1-p+p_i} g(v_i)\, G^{n-1}(v_i - p_i + p)\, dv + \int\limits_{1-p+p_i}^{1} g(v_i)\, dv\right)\mu(\mathbf{p}^e, f) - a, \quad \text{(A.2)}$$

where the second integral term in the third parenthesis says that the consumer buys from retailer i with probability one if $v_i \in [1-p+p_i, 1]$. The parameters must satisfy $p_i - m/(1-r) > 0$ in any equilibrium, otherwise no retailer can make nonnegative profits, in which case it prefers not to operate.

Note that $\pi_i^{n+}(p_i, p) = \pi_i^{n+}(p_i, p)$ if $p_i = p$. Moreover, because $p_i = p$, we can write $v_i = v$. Retailers treat a, r, and $\mu(\mathbf{p}^e, f)$ as fixed terms because the first two are chosen by the mall while the last one is based on consumers' prior expectation. Then, the first-order condition with respect to p_i is

$$\begin{aligned}\varphi_n(p; r) = \left.\frac{\partial \pi_i^{n+}(p_i, p)}{\partial p_i}\right|_{p_i = p} &= \left.\frac{\partial \pi_i^{n-}(p_i, p)}{\partial p_i}\right|_{p_i = p} \\ &= (1-r)\left(\int\limits_{p}^{1} g(v)\, G^{n-1}(v)\, dv - \left(p - \frac{m}{1-r}\right) g(p)\, G^{n-1}(p)\right. \\ &\left.\quad - (n-1)\left(p - \frac{m}{1-r}\right)\left(\int\limits_{p}^{1} g^2(v)\, G^{n-2}(v)\, dv\right)\right)\mu(\mathbf{p}^e, f) \quad \text{(A.3)}\end{aligned}$$

for a given r. This is a continuous function in the interval $[0, 1]$. Moreover $\varphi_n(0; r) > 0$ always holds and $\varphi_n(1; r) < 0$ holds because we must have $p_i - m/(1-r) > 0$ in any equilibrium. Hence, there must be a unique symmetric p_i satisfying the first-order condition if in addition $\varphi_n(p; r)$ is non-decreasing, which we show next.

After some manipulation, the derivative of the first-order condition with respect to p can be written as

$$\frac{\partial \varphi_n(p;r)}{\partial p} = -(1-r)\left(\left(2+\left(p-\frac{m}{1-r}\right)\frac{g'(p)}{g(p)}\right)g(p)\,G^{n-1}(p) + (n-1)\int_p^1 g^2(v)\,G^{n-2}(v)\,dv\right)\mu(\mathbf{p}^e, f). \quad \text{(A.4)}$$

This derivative is negative as long as $2+(p-m/(1-r))(g'(p)/g(p)) > 0$, which holds because $g'(p)/g(p) > -1/p$ by Assumption 2. Now, remember that $\varphi_n(0;r) > 0$ and $\varphi_n(1;r) < 0$, and $\varphi_n(p;r)$ is a continuous function in the interval $[0,1]$. As a result, there must be a unique symmetric equilibrium price p_i^* that satisfies the first-order condition (i.e., $\varphi_n(p_i^*;r) = 0$). The following proposition states the uniqueness of the equilibrium.

Proposition 9 (General model–uniqueness)**.** *Suppose that there are n firms and Assumptions 1-3 are satisfied. Then, there is a unique symmetric equilibrium price, p_i^*.*

We now derive the relationship between rents and prices. We already know that $\varphi_n(p;r)$ is decreasing in p and $\varphi_n(p_i^*;r) = 0$ is uniquely satisfied. Let us figure out what happens to $\varphi_n(p;r)$ if r is increased. The derivative of the first-order condition with respect to r is given by

$$\frac{\partial \varphi_n(p;r)}{\partial r} = \left(\left(2+\left(p-\frac{2m}{1-r}\right)\frac{g'(p)}{g(p)}\right)g(p)\,G^{n-1}(p) + (n-1)\int_p^1 g^2(v)\,G^{n-2}(v)\,dv\right)\mu(\mathbf{p}^e, f), \quad \text{(A.5)}$$

which is clearly positive as long as Assumption 2 holds. Therefore, $\varphi_n(p_2^*;r_2) > \varphi_n(p_1^*;r_1)$ if $r_2 > r_1$. We also know that $\varphi_n(p;r)$ is decreasing in p. Hence, the p_2^* value that satisfies $\varphi_n(p_2^*;r_2) = 0$ is higher than the p_1^* value that satisfies $\varphi_n(p_1^*;r_1) = 0$. This means that the retailer charges a higher price if the mall charges a higher percentage rent. We record this result in the following proposition.

Proposition 10 (General model–relationship between rents and prices)**.** *Retailers charge a higher price the higher the rent charged by the mall.*

This proposition shows only that higher rents lead retailers to charge higher prices, but it does not say anything about the percentage rent the mall wants to charge, which we concentrate on next.

A.2 The mall

We now turn to the mall's problem and show that the equilibrium price with no percentage rent (i.e., $r = 0$) is lower than the equilibrium price that the mall wants retailers to charge, which means that the mall charges positive percentage rents to increase prices.

With n retailers, the mall's profit is given by

$$\pi_M = \left(n \left(p - m \right) \int\limits_p^1 g(v) G^{n-1}(v) dv + (f - c) \right) \mu \left(\mathbf{p}^e, f \right). \tag{A.6}$$

The crucial point here is that although the mall does not have direct control over prices, it implicitly chooses them. Thus, the first-order condition of mall's profit maximization with respect to p characterizes the equilibrium price for all r values:

$$\varkappa \left(p \right) = n \left(\int\limits_p^1 g(v) G^{n-1}(v) dv - \left(p - m \right) g(p) G^{n-1}(p) \right) \mu \left(\mathbf{p}^e, f \right) = 0. \tag{A.7}$$

There is a unique p value satisfying this first-order condition, which is given by the following implicit formula:

$$p^* = m + \frac{1}{g(p) G^{n-1}(p)} \int_p^1 g(v) G^{n-1}(v) dv. \tag{A.8}$$

Integrating by parts further simplifies this expression to

$$p^* = m + \frac{1 - G^n(p)}{n g(p) G^{n-1}(p)}. \tag{A.9}$$

This formula simply says that the mall-optimal price of the good includes a monopoly markup over the marginal cost of the good.

The first-order condition given in (A.7) is decreasing in p because

$$\frac{\partial \varkappa \left(p \right)}{\partial p} = -n \left(\left(2 + \left(p - m \right) \frac{g'(p)}{g(p)} \right) G^{n-1}(p) g(p) + \left(n - 1 \right) \left(p - m \right) g(p) G^{n-2}(p) \right) \mu \left(\mathbf{p}^e, f \right) \tag{A.10}$$

is negative as long as Assumption 2 holds.

Equation (A.3) says that the equilibrium price with $r = 0$ is characterized by

$$\varphi_n(p;0) = n\left(\int_p^1 g(v)\,G^{n-1}(v)\,dv - (p-m)\,g(p)\,G^{n-1}(p)\right.$$
$$\left. -(n-1)(p-m)\left(\int_p^1 g^2(v)\,G^{n-2}(v)\,dv\right)\right)\mu(\mathbf{p}^e, f) = 0. \quad \text{(A.11)}$$

Here, the first two terms in the parenthesis are the same as those in $\varkappa(p)$, but there is also an additional positive term subtracted from them. Hence, when the first-order condition for retailer's profit maximization is satisfied (i.e., $\varphi_n(p;0) = 0$), the first-order condition characterizing the mall-optimal price is still positive (i.e., $\varkappa(p) > 0$), which means that the mall prefers to increase the price beyond the price that a retailer chooses. Remember also that we find in Proposition 10 that r and p covary. As a result, in order to achieve a higher p, the mall increases the percentage rent above $r = 0$, which gives the following proposition.

Proposition 11 (General model–positive percentage rent)**.** *The mall charges a positive percentage rent.*

This proposition validates the generality of our result that positive percentage rents alleviates competition in the mall.

We now characterize the parking fee that the mall charges. The first-order condition with respect to f is given by

$$\frac{\partial \pi_M}{\partial f} = \frac{\partial \mu(\mathbf{p}^e, f)}{\partial f}\left(n(p-m)\int_p^1 g(v)G^{n-1}(v)dv + (f-c)\right) + \mu(\mathbf{p}^e, f), \quad \text{(A.12)}$$

where $\mu(\mathbf{p}^e, f)$ is given by

$$\mu(\mathbf{p}^e, f) = n\int_{p^e}^1 (v-p^e)\,g(v)\,G^{n-1}(v)\,dv - f. \quad \text{(A.13)}$$

and hence $\frac{\partial \mu(\mathbf{p}^e, f)}{\partial f} = -1$. As a result, the first-order condition can be written as

$$\frac{\partial \pi_M}{\partial f} = -\left(n\,(p-m) \int_p^1 g(v) G^{n-1}(v) dv + (f-c) \right) + n \int_p^1 (v-p)\, g\,(v)\, G^{n-1}\,(v)\, dv - f. \quad \text{(A.14)}$$

Setting this first-order condition to zero yields an implicit expression for the equilibrium parking fee:

$$f = \frac{c}{2} - \frac{n}{2} \left((p-m) \int_p^1 g(v) G^{n-1}(v) dv - \int_p^1 (v-p)\, g\,(v)\, G^{n-1}\,(v)\, dv \right). \quad \text{(A.15)}$$

We have not been able to prove that the term in the large parentheses is generally positive, but we have numerically verified that it is positive for a large family of beta, triangular, and uniform distributions, for which the support is $[0, 1]$ and Assumption 1 is satisfied.[26]

We finally show that the mall charges a lower parking fee, the higher the equilibrium price. The first-order condition characterizes f as an implicit function of p. By using the Implicit Function Theorem, we can compute the impact of a higher price on f as follows:

$$\frac{\partial f}{\partial p} = -\frac{\frac{\partial^2 \pi_M}{\partial f \partial p}}{\frac{\partial^2 \pi_M}{\partial f^2}}. \quad \text{(A.16)}$$

Here, the relevant derivative terms are given by

$$\frac{\partial^2 \pi_M}{\partial f \partial p} = -n \int_p^1 g\,(v)\, G^{n-1}\,(v)\, dv < 0 \quad \text{(A.17)}$$

$$\frac{\partial^2 \pi_M}{\partial f^2} = -2 < 0. \quad \text{(A.18)}$$

As a result, we find that $\partial f / \partial p < 0$. That is, the parking fee negatively varies with the price. We report this result in the following proposition.

Proposition 12 (General model–relationship between parking fees and prices)**.** *The mall charges a lower parking fee, the higher the price (i.e., $\partial f / \partial p < 0$).*

Finally, we investigate the effect on prices of having more retailers at the mall. As we have

[26] The results of the numerical analysis are available upon request. We have even shown that the result holds also for a large family of distributions such that Assumption 2 is violated.

already shown in equation (A.10), the mall's first-order condition with respect to p is decreasing in p. Its derivative with respect to n is obviously positive because increasing n increases both the market size and the profit from the unit market size. Hence, for $n_2 > n_1$, the p_2 value that satisfies $\varkappa(p_2; n_2) = 0$ is larger than the p_1 value that satisfies $\varkappa(p_1; n_1) = 0$. This means that the higher the number of retailers in the mall, the higher the prices. This validates Proposition 6 in a more general setting.

B No loss of generality of two-part tariffs

We show here that the profit-maximizing equilibrium that the mall can implement with a three-part tariff of the form

$$\tilde{R}_i = a_i + r_i \cdot \max(0; S_i - L_i), \tag{B.1}$$

where L_i is the overage threshold, can be reproduced with a two-part tariff as in equation (1). Hence, there is no loss of generality in assuming that the mall adopts equation (1). To prove this claim, assume that the rental contract is structured as in equation (B.1) and recognize that the mall's equilibrium profit can still be written as follows:

$$\pi_M = \left(\sum_{i=1}^{n} (p_i - m)\, \theta_i(\mathbf{p}) + (f - c) \right) \mu(\mathbf{p}^e, f). \tag{B.2}$$

Because the retailers' outside option is common knowledge and given, the mall is able to extract their entire net surplus (it can always do so by an appropriate choice of the base rent a_i in equation (B.1)). Thus, the mall's profit, given in equation (B.2), is independent of r_i and L_i. More precisely, equation (B.2) does not depend on whether the rental contract is structured as in equation (1) or equation (B.1). Hence, to maximize the mall's profit, it is sufficient to ensure that r_i and L_i are such that $\mathbf{p} = \mathbf{p}^*$, where the latter is the vector of prices that maximizes equation (B.2), which we have characterized in the main text (note that this price vector is symmetric, as we have shown in Appendix A). To ensure that, two conditions have to be met. The first one is that, for each retailer i, the retail price p_i that satisfies the retailer's first-order condition shown in equation (A.3) should be equal to p_i^*. This condition can be satisfied by an appropriate choice of r_i, regardless of whether the tariff is in two or three parts.

The second condition is that, given the price vector $\mathbf{p}^*$, each retailer's volume of sales $S_i^* = p_i^* \theta_i(\mathbf{p}^*)\mu(\mathbf{p}^*, f)$ (which is obviously positive) should be strictly higher than the overage limit L_i. Otherwise, the percentage rent r_i does not apply and thus the mall cannot influence the retailer's pricing. Hence, the mall would never set such an L_i that is higher than the volume of sales. Therefore, the family of three-part tariffs (as shown in (B.1)) that maximizes the mall's profit includes a tariff with $L_i = 0$, which is actually a two-part tariff. Therefore, adopting a two-part tariff allows the mall to implement the same profit-maximizing equilibrium that it can implement with a three-part tariff.

C Optimal fees with observable prices

Assume that prices are ex-ante observable hence the actual price vector $\mathbf{p}$ replaces the expected price vector $\mathbf{p}^e$. Then, the mall's profit is

$$\pi_M = \left(n\left(p - m\right) \int_p^1 g(v)G^{n-1}(v)dv + (f - c) \right) \mu\left(\mathbf{p}, f\right). \tag{C.1}$$

As shown in the course of the analysis, there is no loss in proceeding as if the mall directly controlled $\mathbf{p}$. Furthermore, the vector of prices is symmetric and unique (we show these in Appendix A). Hence, in equilibrium, the first-order conditions of the mall's problem are

$$\begin{aligned} \frac{\partial \pi_M}{\partial p} =& \frac{\partial \mu\left(p, f\right)}{\partial p} \left(n\left(p - m\right) \int_p^1 g(v)G^{n-1}(v)dv + (f - c) \right) \\ &+ \mu\left(p, f\right) \left(n \int_p^1 g(v)G^{n-1}(v)dv - n\left(p - m\right) g(p)G^{n-1}(p) \right) = 0, \end{aligned} \tag{C.2}$$

$$\frac{\partial \pi_M}{\partial f} = \frac{\partial \mu\left(p, f\right)}{\partial f} \left(n\left(p - m\right) \int_p^1 g(v)G^{n-1}(v)dv + (f - c) \right) + \mu\left(p, f\right) = 0, \tag{C.3}$$

where

$$\frac{\partial \mu\left(p,f\right)}{\partial p} = -n \int_{p}^{1} g\left(v\right) G^{n-1}\left(v\right) dv, \tag{C.4}$$

$$\frac{\partial \mu\left(p,f\right)}{\partial f} = -1. \tag{C.5}$$

Using equation (C.3) in equation (C.2), we find the terms in equation (16). To see that $r_i^* < 0$, compare the symmetric price in equation (6) with $p^* = m$.