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Abstract

We study how a monopoly manufacturer optimally manages her contractual relations with retailers in markets with consumer search. By choosing wholesale prices, the manufacturer affects the degree of competition between retailers and the incentives of consumers to search. We show that depending on whether or not the manufacturer can commit to her price decisions and on the search cost, the manufacturer may be substantially better off choosing her wholesale prices not independent of each other, consciously allowing for asymmetric contracts. Thus, our analysis may shed light on when we may expect sales across different retailers to be positively or negatively correlated. Our model may be able to generate loss leaders at the wholesale level and show the rationale for creating "premium resellers".

JEL Classification: D40; D83; L13

Keywords: Vertical Relations, Retailer Channel Optimization, Consumer Search, Diamond Paradox

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1 Introduction

Consider a manufacturer selling to final consumers through different retailers. When setting prices, one of her main goals is to restrict retailers' ability to set high markups. These markups naturally depend on the degree of competition between retailers. Conventional wisdom from different setups then suggest that the manufacturer would have an incentive to set identical wholesale prices across the different retailers, so that they engage in fiercer competition that leads to higher demand. In this paper we show, however, that in consumer search markets there is an additional force that may result in a manufacturer setting different wholesale prices to different retailers, as a way to give consumers incentives to search. This consumer search effect is an additional stimulus for retailers to compete. It is the aim of our paper to investigate the optimal use of asymmetric wholesale prices to retailers operating in a search market.

In markets where consumers incur a search cost, it is inevitable that retail margins are positive. If all consumers incur a positive search cost and a manufacturer sets identical wholesale prices across retailers, the maximal profit she can hope to obtain is the double marginalization profit. The reason is that there is a Diamond paradox at the retail level (cf., Diamond (1971)): for any given equilibrium wholesale price, retailers will always choose the retail monopoly price.

Our first result is that if the manufacturer can commit to a wholesale pricing structure, she can do strictly better if consumer search cost is small by choosing a negative correlation across prices. The reason is as follows. When the search cost is small, the manufacturer is tempted to squeeze retailers by setting a wholesale price that is equal to the consumer reservation price. But since consumers expect both retailers to get the same wholesale price, they are willing to buy at an even higher price, and retailers can still make a considerable positive margin, making the deviation not profitable. If the manufacturer creates a negative correlation between wholesale prices, knowing that retailers will optimally react and set asymmetric retail prices, then consumers observing the higher price infer there is a reasonably high chance that the other retailer sets a lower price as the latter probably received the lower of the wholesale prices set by the manufacturer. This will make consumer more eager to search, putting downward pressure on retail margins. Interestingly, one of the two prices the manufacturer may choose with positive probability can be quite low and even below cost (and not profit maximizing on its own) somewhat similar to the literature on loss leaders (Hess and Gerstner (1987) and Lal and Matutes (1994)). In contrast, in the setting we study, a manufacturer only sells one product and he sells to one retailer at a price below cost in order to restrict the competing retailer to exploit his market power due to consumer search cost. Thus, in our model, selling at price below cost is a way to stimulate consumers to search. We show that, when search costs are very low, the manufacturer can obtain almost monopoly profits by carefully exploiting this asymmetry. Moreover, even if the manufacturer lacks full commitment to a price distribution, she can obtain substantially higher profits than the double marginalization outcome by using a deterministic asymmetric price schedule.

We next consider the Stahl (1989) solution to the Diamond paradox, where consumers are heterogeneous in their search cost and some consumers have a positive search cost, whereas others (the shoppers) have zero search cost. In that model, the manufacturer can benefit choosing a correlated wholesale pricing structure even if it cannot commit to it as the manufacturer optimally trade-offs the benefits from having retailers competing more fiercely for the shoppers if retailers buy at identical prices and the benefits from having retailers not being able to employ their market power over the non-shoppers.

Finally, we allow the manufacturer to set non-linear contracts to her retailers. We show that our main conclusion, namely that manufacturers may benefit from choosing asymmetric contracts across different retailers when retailers compete in consumer markets, continues to hold if manufacturers choose two-part tariffs. In this setting, when restricting the manufacturer to symmetric contracts, her rents are non-monotonic in the fraction of shoppers: she may extract monopoly rents both when all consumers are shoppers (Bertrand competition in the retail market) and when all consumers are non-shoppers, but not in between. Retail price dispersion creates noise in the manufacturer profit function, restricting the rents she can extract. By treating retailers asymmetrically, the manufacturer eliminates the retail price dispersion (and the noise from his perspective). We show that for intermediate values of the fraction of shoppers, the manufacturer may benefit behaving this way.

The literature on consumer search in vertical markets is small (Janssen and Shelegia (2015), Lubensky (2013) and Garcia et al. (Forthcoming)). In the monopoly manufacturer model of Janssen and Shelegia (2015) the incentive to squeeze retailers leads to a non-existence of reservation price equilibrium for certain parameter values. In Garcia et al. (Forthcoming) this same incentive leads to the existence of an equilibrium where oligopolistic manufacturers randomize over two prices leading to an equilibrium with a bimodal price distribution. The current paper solves the nonexistence result in

Janssen and Shelegia (2015) by allowing a manufacturer to set individualised prices to retailers. At the same time, we extend the randomization exploited in the oligopolistic model of Garcia et al. (Forthcoming) and show that this can be imitated by a monopoly manufacturer.

The paper is also related to the literature on price discrimination in input markets. So far, this literature has focused on the issue of whether a supplier wants to strengthen or weaken a-priori differences in terms of market access or cost structure across different retailers. The earlier work (Katz (1987) and DeGraba (1990)) studies third-degree price discrimination among retailers with heterogeneous costs who compete á la Cournot. In this setup, the monopolist has an incentive to foster competition by discriminating in favor of the least efficient firms, thus decreasing welfare. More recent contributions, however, provide more nuanced results (see, e.g. Yoshida (2000) and Inderst and Valletti (2009)). Our paper takes a different approach and gives a rationale for asymmetric treatment of ex-ante homogeneous retailers as a way to extract rents in vertically related industries. We find that in a variety of settings, the manufacturer has an incentive to treat ex ante symmetric retailers asymmetrically.

The paper also relates to the literature on sales. An important strand of papers, starting with Varian (1980), interprets sales as a sample path generated by an underlying static mixed strategy equilibrium. They predict no correlation across time or across different sellers. A different approach, introduced by Sobel (1984), rationalizes sales as a price discrimination device, which induces serial correlation over time. To the best of our knowledge, this is the first study that predicts contemporaneous correlation of sales across stores. Importantly, our model predicts either positive or negative correlation, depending on market characteristics. As such, it introduces a new set of testable predictions to be confronted with real world data. The empirical literature on sales is relatively scarce. There is evidence that a large part of the within-product variation in prices occurs at the store level (Kaplan et al. (2016)). Whether this is only due to demand-side heterogeneity or can also be attributed to vertical relations is still an open question. Another stylized fact in the empirical sales literature is that sales are almost independent across stores (Pesendorfer (2002)). Since the returns of a discount for the seller depend on the discounts offered by competitors, this empirical result seems paradoxical. Our model predicts that positive or negative correlation is expected in different environments and in different equilibria. Possibly, this "independence results" stems from not distinguishing that data may be collected from different enviornments.

The rest of the paper is organized as follows. Section 2 discusses the model and equilibrium concept. In section 3 we discuss the case of homogeneous consumers, while in section 4 we treat the heterogeneous consumer case. Both sections deal with the situation where the manufacturer may and may not be able to commit to his pricing decisions. Section 5 deals with nonlinear prices, while Section 6 concludes. All proofs are contained in the Appendix.

2 Retail Search Markets with a Monopoly Manufacturer

The model we study is very similar in nature to the one in Janssen and Shelegia (2015) and introduces a wholesale level in the search model developed by Stahl (1989), where a monopolistic manufacturer sells a homogenous product to two retailers. The difference with Janssen and Shelegia (2015) is that we explicitly allow the manufacturer to choose different prices to different retailers and that we explicitly distinguish between different scenarios.

A single manufacturer has the technology to produce a certain good. The manufacturer chooses (linear) prices (w_1, w_2) for each unit it sells to retailer 1 and 2.[1] We allow the manufacturer to choose random prices, and the randomization may involve positive or negative correlation. The distribution of wholesale prices chosen by the manufacturer is denoted by $G(w_1, w_2)$. For simplicity, we abstract away from the issue of how the cost of the manufacturer is determined and set this cost equal to 0.[2] Retailers take the wholesale price (their marginal cost) w_i as given and compete in prices. The distribution of retail prices charged by the retailers is denoted by $F(p; w_i)$ (with density $f(p; w_i)$). Each firm's objective is to maximize profits given their beliefs about prices charged by other firms and given consumers' behavior.

On the demand side of the market, we have a continuum of risk-neutral consumers with identical preferences. A fraction $\lambda \in [0, 1)$ of consumers, the *shoppers*, have zero search cost. Note that we explicitly allow for $\lambda = 0$, and the next Section is completely devoted to this case. Shoppers sample all prices and buy at the lowest price. The remaining fraction $1-\lambda$ of *non-shoppers*, have positive search cost $s > 0$ for every second

[1] Nonlinear prices are considered in Section 5.

[2] To focus on the new insights derived from studying the vertical relation between retailers and manufacturers in a search environment, we assume all market participants know that the manufacturer's cost equals 0. Alternatively, the manufacturer's cost could be set by a third party or could be uncertain. However, this would create additional complexity that may obscure the results.

search they make.[3] If a consumer buys at price p she demands $D(p)$. In our general analysis we assume that the demand function is thrice continuously differentiable, and in addition satisfies the following regularity properties: (i) $-\infty < D'(p) < 0$, (ii) for some finite P, $D(p) = 0$ for all $p \geq P$ and $D(p) > 0$ otherwise, (iii) for every $w < p$, $\pi_r(p; w) \equiv (p - w)D(p)$ is strictly concave and maximized at $p^m(w)$, the retail monopoly price for a given wholesale price, and (iv) for all given w, $(p-w)\pi_r'(p)/\pi_r(p)^2$ is decreasing in p for all $p \in (w, p^m(w)]$.[4] We define the wholesale monopoly price w^m by

$$w^m = \arg\max_{w \geq 0} wD(p^*(w)).$$

In the special case of linear demand $D(p) = 1 - p$ we have $p^m(w) = \frac{1+w}{2}$ and $w^m = 1/2$.

The timing is as follows. First, the manufacturer chooses (w_1, w_2), where each retailer observes her own wholesale price, but may, or may not know the price set for the other. Consumers do not observe the individual wholesale prices. Given the manufacturer observed choice each retailer i sets price p_i. Finally, consumers engage in optimal sequential search given the equilibrium distribution of retail prices, not knowing the actual prices set by individual retailers.

As consumers do not observe the wholesale price, the retail market cannot be analyzed as a separate sub-game for a given w. To accommodate this asymmetric information feature we use Perfect Bayesian Equilibrium (PBE) as the solution concept, focusing on equilibria where buyers use reservation price strategies where non-shoppers buy at a retail price $p \leq \rho$. The reservation price ρ is based on beliefs about (w_1, w_2), and in equilibrium, these beliefs are correct. PBE imposes the requirement that retailers respond optimally to any w, not only the equilibrium wholesale price. When there are shoppers, there may be price dispersion at the retail level and we denote by $\underline{p}(w_i)$ and $\bar{p}(w_i)$ the lower- and upper- bound of the equilibrium price support after observing wholesale price w_i.

[3] Our analysis for low search cost is unaffected when consumers also have to incur a cost for the first search. For higher search cost, the analysis would become more complicated (see, Janssen et al. (2005) for an analysis of the participation decision of non-shoppers in the Stahl model where the first search is not free). Janssen and Parakhonyak (2014) show that the Stahl equilibrium is unaffected by costly recall.

[4] These are standard assumptions in this literature. For example, the last condition (accounting for the fact that retailers' marginal cost is w) is used by Stahl (1989) to prove that the reservation price is uniquely defined. Stahl (1989) shows that the condition is satisfied for all concave demand functions and also for the demand function of the form $D(p) = (1 - p)^\beta$, with $\beta \in (0, 1)$.

3 Retail Management in the absence of shoppers

In this Section we consider markets where all consumers incur a positive search cost, i.e., there are no shoppers. Thus, the model in this Section is the monopolistic version of the model in Garcia et al. (Forthcoming). To understand the role of commitment in this market, we first consider the easiest case where the manufacturer cannot commit to any price level.

3.1 No Price commitment

We start the analysis by showing that despite the fact that the wholesale price is unrestricted, the equilibrium distribution of wholesale prices can put positive probability mass on at most two prices, w^m and a properly defined consumer reservation price ρ. This feature of the model is identical to that in Garcia et al. (Forthcoming). To provide some intuition for this result, let $\underline{w}$ be the lower bound of the wholesale price distribution and let $p(\underline{w})$ be the corresponding downstream price. As in any equilibrium the retail price reaction $p(w)$ must be weakly increasing, it is clear that all consumers buy at $p(\underline{w})$. Thus, by a standard Diamond paradox argument, it must be that $p(\underline{w}) = p^m(\underline{w})$. Given this, clearly $\underline{w} = w^m$. Now consider any other price $w \leq \rho$. Either $p(w) = \rho$ or $p(w) < \rho$. Since ρ is determined by consumers' beliefs, the manufacturer maximizes $wD(\rho)$ by choosing $w = \rho$. If $p(w) < \rho$, then $p(w) = p^m(w)$ and the optimal wholesale price is w^m.[5]

To further characterize the possible equilibrium configurations, we use the notation $\pi^m = w^m D(p^m(w^m))$ and $\pi(\rho) = \rho D(\rho)$ and write expected manufacturer profits as

$$\Pi = G(w^m, w^m)2\pi^m + 2G(w^m, \rho)[\pi^m + \pi(\rho)] + G(\rho, \rho)2\pi(\rho),$$

where (if $G(\rho, \rho) + G(w^m, \rho) > 0$)

$$\frac{G(w^m, \rho)}{G(\rho, \rho) + G(w^m, \rho)} \int_{p^m}^{\rho} D(p)dp = s.^6 \tag{1}$$

If we implicitly define $\overline{w}$ by $w^m D(p^m) = \overline{w} D(\overline{w})$, then we can define $\overline{s}$ as $\int_{p^m}^{\overline{w}} D(p)dp = \overline{s}$. It is easy to see then that if $s > \overline{s}$, we should have $G(w^m, w^m) = 1$ as there is no temptation for the manufacturer to deviate to ρ (as for ρ implicitly defined by $\int_{p^m}^{\rho} D(p)dp = s$

[5]Any $w > \rho$ is dominated by ρ because the $wD(w)$ is decreasing if $w > p^m(w^m)$.

[6]If $G(w^m, w^m) = 1$, then ρ is defined by $\int_{p^m}^{\rho} D(p)dp = s$.

we have that $w^m D(p^m) > \rho D(\rho))$. When s decreases and becomes equal to $\bar{s}$ we have that $\int_{p^m}^{\rho} D(p)dp = \bar{s}$ and $w^m D(p^m) = \rho D(\rho)$. Finally, if $s < \bar{s}$ from the manufacturer's profit equation it follows that it has to be the case that $\pi^m = \pi(\rho)$ as otherwise, without commitment he can deviate and set both its prices equal to ρ. This condition uniquely determines $\rho > p^m(w^m)$. Given that he is indifferent, the manufacturer may still randomize over w^m and ρ and it may even choose to a form of affiliation between the two prices. In fact, there is a continuum of choices he can make, where the ratio of $G(\rho, \rho)$ to $G(w^m, \rho)$ is determined by (1) and $G(w^m, w^m) + G(\rho, \rho) + 2G(w^m, \rho) = 1$. In particular, as will be important in the next Section, there are equilibria in which the manufacturer sets $G(w^m, w^m) = 0$, but in principle, all $G(w^m, w^m), G(\rho, \rho)$ and $2G(w^m, \rho)$ could be strictly positive.

Proposition 1. *There exists a critical search cost level $\bar{s}$ such that if $s > \bar{s}$, the unique equilibrium has $G(w^m, w^m) = 1$, whereas when $0 < s < \bar{s}$, there is a continuum of equilibria where the manufacturer gives positive probability to w^m and ρ, with $\pi^m = \pi(\rho)$, and $\frac{G(w^m,\rho)}{G(\rho,\rho)}$ being determined by (1).*

In all these equilibria, the manufacturer obtains the double marginalization profit level and he has no incentive to choose different prices or to change the probability distribution over the two prices. What is interesting is when s equals $\bar{s}$, then we have that $G(\rho, \rho)) = 0$, while $G(w^m, \rho) > 0$. That is for relatively large s, it is in the interest of the manufacturer to create sales that are negatively correlated. On the other hand, when s approaches 0 the probability $G(w^m, \rho)$ should approach 0 as well. Thus, for a given $G(w^m, w^m) > 0$, this implies that sales should be positively correlated when s becomes arbitrarily small. Given the multiplicity of equilibria for intermediate values of s, sales could be both positively and negatively correlated.

3.2 Full Commitment

We start the analysis of the full commitment case by showing that, similarly to the no commitment case, the optimal distribution of wholesale prices may put probability mass in at most two prices, w_0 and a properly defined consumer reservation price ρ. An important difference with the no commitment case analyzed above is that the manufacturer optimally distorts w_0 in order to foster search, so that $w_0 \leq w^m$.

Lemma 2. *The optimal price distribution has positive probability mass in at most two price levels: $w_0 \leq w^m$ and ρ.*

Denote by $\pi(w) = wD(\bar{p}(w))$ where $\bar{p}(w) = \min\{p^m(w), \rho\}$. Using this notation, we have that the manufacturer's profit can be written as

$$\Pi = G(w_0, w_0)2\pi(w_0) + 2G(w_0, \rho)[\pi(w_0) + \pi(\rho)] + G(\rho, \rho)2\pi(\rho), \tag{2}$$

where (if $G(\rho, \rho)+G(w_0, \rho) > 0$) and because in equilibrium it has to be that $G(\rho, \rho) < 1$

$$\frac{G(w_0, \rho)}{G(\rho, \rho) + G(w_0, \rho)} \int_{p^m(w_0)}^{\rho} D(p)dp = s. \tag{3}$$

The first trivial observation is that under commitment either $G(w_0, w_0) = 0$ or $G(w_0, w_0) = 1$ and $w_0 = w^m$. To see this note that $G(w_0, w_0)$ does not affect ρ and that the manufacturer can always guarantee himself a profit of $w^m D(p^m(w^m))$. At $s = \overline{s}$, the manufacturer is indifferent between choosing $G(w^m, w^m) = 1$ and $G(w^m, \rho) = 1/2$. However, under full commitment, $G(w^m, \rho) = 1/2$ is dominated by $G(w^m - \varepsilon, \rho) = 1/2$ because this deviation has a second-order cost on those consumers that visit the low cost retailer, and a first-order impact on the reservation price ρ, which leads to an increase in the profits over those consumers visiting the high cost retailer. Thus, under commitment and at $s = \overline{s}$, the manufacturer strictly prefers to have a negative affiliation between the retail prices. Notice that for very high search cost s the manufacturer's profits cannot exceed the double marginalization profit, so that there exists a $\widehat{s} > \overline{s}$ such that $G(w_0, w_0) = 1$ and $w_0 = w^m$ for all $s > \widehat{s}$.

If $s < \widehat{s}$ we have that $G(w_0, w_0) = 0$. In that case, the reservation price is defined by

$$\frac{G(w_0, \rho)}{1 - G(w_0, \rho)} \int_{p^m(w_0)}^{\rho} D(p)dp = s. \tag{4}$$

This implies that it is optimal for the manufacturer to commit to a pricing structure with *negative affiliation*, where the manufacturer sets the wholesale price to at least one retailer equal to the consumer reservation price. The low price and the probability with which it is chosen mostly serve to lower the consumer reservation price to increase profits. In particular, the lowest of the two wholesale prices has to be smaller than the monopoly wholesale price, unlike the no commitment case. This follows from the above argument where setting a price slightly lower than w^m to one retailer increases profits.

Proposition 3. *There exists an $\widehat{s} > 0$ such that if $s > \widehat{s}$, then $G(w^m, w^m) = 1$ and both retailers have the same wholesale price. If $s < \widehat{s}$, then G exhibits 'negative affiliation' with $G(w_0, w_0) = 0$ and $G(\rho, w_0) > 0$. Moreover, $w_0 < w^m$ and $\rho < p^m(w_0)$.*

The next Proposition goes one step further and argues that when the consumer search cost becomes arbitrarily small, the manufacturer can obtain profits that are arbitrarily close to the monopoly profits. Given the Diamond paradox, this is surprising. In our context, the Diamond paradox would imply that for a given (identical) wholesale price, retailers could guarantee themselves retail monopoly profits for any positive search cost. The next Proposition shows that the manufacturer can prevent the Diamond paradox from arising at the retail level by committing to a pricing structure with negative affiliation where for small search cost a (very) low price is charged with arbitrarily small probability.

Proposition 4. *As $s \to 0$, the manufacturer's profit converges to monopoly profits. Furthermore, $w_0 < 0$ with $G(w_0, \rho) \to 0$ so that the firm engages in loss-leader practices.*

This Proposition is also of interest for its new perspective on loss leaders. The usual loss leader story is that a retailer such as a supermarket may sell some products below cost in order to attract consumers that also buy other products when being in the shop. In our framework, it is the manufacturer that sells with a certain probability the product below cost (which is normalized to 0) to one of its retailer. The reason for doing so is to bring the consumer reservation price close to the monopoly price so that the manufacturer can extract maximal surplus most of the time. When s is arbitrarily close to 0, the manufacturer has to offer this low price to one of her retailers with only a very small probability for consumers already to continue to search IO the price is above the monopoly price of a vertically integrated monopolist. Thus, the manufacturer is able to extract almost monopoly profits.

In case demand is linear ($D(p) = 1 - p$), one can numerically find the optimal contract for different values of s. It turns out that the optimal contract parameters are remarkably stable for small s values. The manufacturer engages in large losses when selling at the lower price ($w_0 \approx -1.7$) while setting this price with very small probability. The manufacturer recoups these losses with almost monopoly profits at the higher of the two prices, which equals ρ. When s ranges from 0 to 0.04, the probability $G(\rho, w_0)$ ranges between 0 and 0.04, while ρ increases from 0.5 (the monopoly price) to 0.56. Figure 1 shows the manufacturer profit under commitment, among other things, as a function of s. It is the increase in the probability of selling at a loss that is responsibility for the relatively sharp decrease in profits at increasing s, while the manufacturer does not loose much by increasing her highest price to levels above the monopoly price.

3.3 Partial Commitment

In some circumstances, it is obviously not realistic to assume that a manufacturer can fully commit herself to a particular random pricing strategy. Without commitment, the manufacturer would, however, deviate and charge the same (reservation) price to both retailers to increase profits. Obviously, this cannot be an equilibrium. Instead, in practice, what the manufacturer could commit to is to have some retailers that are *premium re-sellers* and they are guaranteed to have a lower price than other retailers. If the manufacturer decides to have premium re-sellers, we will say that he is partially committed. In this Section we assume that retailers know whether they are chosen to be a premium re-seller or not, while consumers only know whether or not there are premium re-sellers, but do not know who they are. In the next Section, where we also include shoppers into the analysis, we may interpret the shoppers as knowing who the premium re-sellers are.

With two retailers, partial commitment implies that the manufacturer has one *premium* re-seller and and one other re-seller (retailer). thus, $G(\rho, w_0) = \frac{1}{2}$. in this case, the lower of the two wholesale prices has to be equal to $w_0 = w^m$ as in the no commitment case. Thus, the manufacturer optimal policy under partial commitment is to offer two contracts, one to each retailer (at prices w^m and ρ^*) with

$$\int_{p^m}^{\rho^*} D(p)dp = s. \tag{5}$$

Profits of the manufacturer are then given by $w^m D(p^m) + \rho^* D(\rho^*)$.

Given the above analysis, if $s < \bar{s}$, this profit is actually larger than the profit he gets by offering both retailers to buy at w^m. As under full commitment we have $0 < G(\rho, w_0) < \frac{1}{2}$, the outcome under partial commitment is more efficient, and for two reasons. First, there is an increase in the number of consumers buying at the lower price from $G(\rho, w_0)$ to $\frac{1}{2}$. Second, the highest wholesale price that is charged is now lower. this follows by comparing (4) and (5) and realizing that $\frac{G(\rho,w_0)}{1-G(\rho,w_0)} \leq 1$.

Thus, there are two different sources of gains that the manufacturer cannot exploit with partial commitment. First, she cannot engage in loss-leading practices. Second, she can only offer one of her retailers the more profitable contract. As a result, the profit gains are much more modest than under full commitment. This can be seen in Figure 1 which depicts the gains under full commitment (green line) and under partial commitment (red line) for linear demand ($D(p) = 1 - p$) for different values of s. The

s	$G(w_0, w^m)$	ρ	Π	CS	RP
0,001	0,5	0,754	0,1555	0.031	0.031
0,005	0,5	0,7708	0,151	0.029	0.031
0,01	0,5	0,7938	0,1443	0.026	0.031
0,015	0,5	0,8196	0,139	0.024	0.031
0,025	0	0,8819	0,125	0.031	0.063

Table 1: Equilibrium Outcomes with Partial Commitment

no-commitment benchmark corresponds to 1/8.

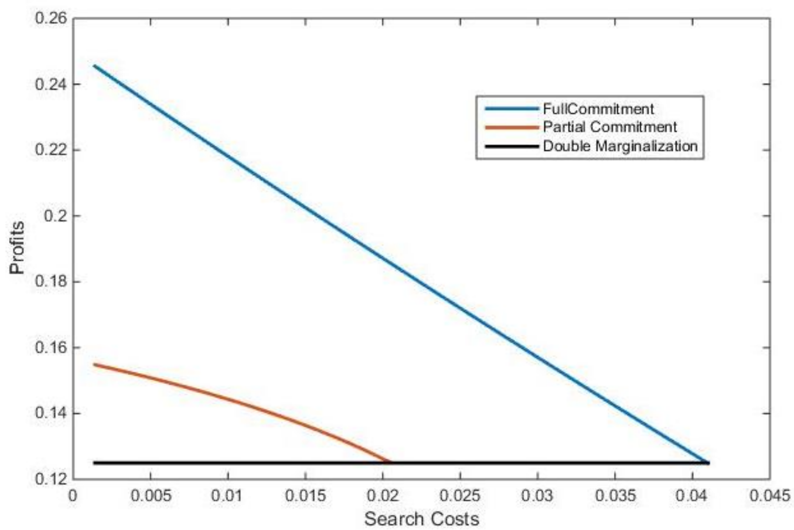

Figure 1: Gains from different levels of commitment

Nevertheless, when the search cost parameter is sufficiently small, a system with one premium re-seller and one ordinary retailer may still significantly increase manufacturer profit compared to the situation where she sells to both retailers at the same price. When search cost approaches 0, the gains reach up to 24.1% as can be seen in the next Table (where RP stands for retail profit).

4 Retail Management with retail competition

In this Section, we consider markets where a fraction λ of consumers, the shoppers, have zero search cost. This introduces a competition incentive between retailers. Competition between retailers generally will benefit the manufacturer as it leads to lower retail prices for given wholesale prices. Under the interpretation that asymmetries between retailers are persistent (e.g. because some sellers are *premium retailers*), shoppers could be interpreted as consumers who know which retailer is the premium reseller, whereas others may only know (or expect) that some retailers have lower prices without knowing who.

The introduction of shoppers makes the model we consider in this Section identical to the one analyzed in Janssen and Shelegia (2015). In what follows, we will distinguish again between the commitment and the no commitment case, but the difference with Janssen and Shelegia (2015) is that we allow the manufacturer to randomize her pricing decisions and to consciously create asymmetries between retailers. With commitment, both consumers and retailers know the correlation structure of the wholesale prices. Moreover, retailers know their own wholesale price and update their beliefs about the wholesale price of their competitor. Both consumers and retailers respond optimally according to their knowledge. Janssen and Shelegia (2015) considered a special case where the manufacturer chooses to set the same wholesale price to both retailers. In that case, both retailers and consumers act as if they observe the wholesale contracts. Without commitment, wholesale contracts are private information between manufacturers and individual retailers, and along the equilibrium path both retailers and consumers update their beliefs about the wholesale price of the other retailer. We will deal with off-the-equilibrium path beliefs when it becomes important to be specific.

Note that the presence of shoppers requires a different general analysis than the one considered in the previous Section. The best way to see that is by considering a situation where the manufacturer puts positive probability on two prices w_0 and ρ and where $G(w_0, \rho)$ and $G(w_0, w_0)$ are strictly positive. Consider then a retailer who observe a wholesale price w_0. In the presence of shoppers, this retailer will not choose $p^m(w_0)$ as there is a probability that the other retailer has observed the same wholesale price in which case they compete for the shoppers. Following standard arguments, retailers will randomize their pricing behaviour in this case and $F(p; w_0)$ is determined as follows. A retailer's expected profit setting price $p < \rho$ after observing wholesale price w_0 is

$$\pi_r(p; w_0) = Q(p, w_0)(p - w_0). \tag{6}$$

with

$$Q(p, w_0) = \frac{1+\lambda}{2} \frac{G(w_0, \rho)}{G(w_0, \rho) + G(w_0, w_0)} + \frac{G(w_0, w_0)}{G(w_0, \rho) + G(w_0, w_0)} \left(\frac{1-\lambda}{2} + \lambda(1 - F(p; w_0)) \right)$$

This expression can be understood as follows. After observing w_0 with probability $\frac{G(w_0,\rho)}{G(w_0,\rho)+G(w_0,w_0)}$ the rival retailer has obtained a wholesale price of ρ and in that case the retailer attracts all shoppers and half of the non-shoppers if he sets a price $p < \rho$ and the other retailer optimally prices at ρ. with the remaining probability the rival retailer also observed a wholesale price of w_0 and each retailer gets his share of the non-shoppers and all of the shoppers if they have the lowest retail price. Equating (6) with the profit the retailer makes when setting (a price just below) ρ after observing wholesale price w_0, given by

$$\pi_r(\rho; w_0) = \left(\frac{1-\lambda}{2} + \lambda \frac{G(w_0, \rho)}{G(w_0, \rho) + G(w_0, w_0)} \right) (\rho - w_0),$$

yields the retailer's mixed pricing decision $F(p; w_0)$. As this expression depends on $G(w_0, \rho)/G(w_0, w_0)$, the expected manufacturer profit of selling to a retailer at w_0 does not only depend on w_0 (as in the previous Section), but also on the ratio of these probabilities. For a given w_0, the more relative weight given to $G(w_0, w_0)$, the larger the expected manufacturer profit of selling to a retailer at w_0 as there will be more competition between retailers.

In the next subsection we show that under commitment the manufacturer may want to avoid these complications by setting the lowest wholesale price w_0 with positive probability such that $G(w_0, w_0) = 0$.

4.1 Price commitment

It is clear that if s is large enough, it remains true that the manufacturer optimally sets the same wholesale price to both retailers, as in the previous Section. For large s, the consumer reservation price ρ is irrelevant for the manufacturer's or the retailers' pricing decisions and if the manufacturer cannot manipulate the search incentives of the non-shoppers anyway, then there is no benefit to setting different wholesale prices.

The situation for smaller s is more interesting and we show that the analysis of the previous Section for the price commitment case remains valid for small values of λ and s and that the manufacturer wants to choose negatively affiliated wholesale prices. To do so, we denote by $\pi(w, w; \lambda)$ the manufacturer profit in a market with a fraction λ of shoppers in case she contracts both retailers at the same wholesale price w for sure, i.e., $G(w, w) = 1$. It is clear that $\pi(w^m, w^m; 0) = \pi^m$ and $\pi(w, w; \lambda)$ is continuous and increasing in λ.

Thus, like in the previous Section consider a manufacturer randomizing over two prices, w_0 and ρ, where $w_0 \leq w^m$ and $G(w_0, w_0) = 0$. It is easy to see that a retailer getting a wholesale price w_0 will respond by setting $p^m(w_0)$ and that all shoppers will buy at $p^m(w_0)$. Using the notation of the previous Section, we can write manufacturer profits as

$$\Pi = 2G(w_0, \rho) \left(\frac{1+\lambda}{2} \pi(w_0) + \frac{1-\lambda}{2} \pi(\rho) \right) + G(\rho, \rho)\pi(\rho), \tag{7}$$

where the reservation price ρ continues to be determined by

$$\frac{G(w_0, \rho)}{G(\rho, \rho) + G(w_0, \rho)} \int_{p^m(w_0)}^{\rho} D(p)dp = s. \tag{8}$$

Using the same pricing strategy as in case without shoppers, for small enough s the manufacturer profit is smaller than in the case without shoppers as all shoppers buy at the lower price yielding lower profits, while $\pi(w_0)$ and $\pi(\rho)$ are the same as before.

Without shoppers, we know that for all $s < \widehat{s}$, $\pi(w^m, w^m; 0) = \pi^m < \pi(\rho)$. As $\pi(w, w; \lambda)$ is continuous in λ it follows that for λ small enough, the manufacturer finds it optimal to keep the asymmetric structure of retail contracts.

Thus, we have the following proposition.

Proposition 5. *For any $s < \widehat{s}$, there exists a $\lambda_s > 0$ such that for all $\lambda < \lambda_s$ there exists a unique optimal contract with support on $w_0 < w^m$ and $\rho \geq w^m$ and $G(w_0, w_0) = 0$.*

4.2 No Price commitment

Next, we consider the case where the manufacturer cannot commit to a certain pricing strategy. This is the case analyzed in Janssen and Shelegia (2015). They restricted the manufacturer to offer both retailers the same linear contract. Importantly for our paper, they found that a pure strategy equilibrium does not always exist. We first show that if the manufacturer can discriminate among retailers, an equilibrium always exists (but may not be unique). Indeed, even restricting retailers to symmetric beliefs following an off-the-equilibrium path wholesale price (which is the closest assumption to the original model), there is a continuum of equilibrium outcomes with the manufacturer making different profit levels if the search cost is small enough.

Following Janssen and Shelegia (2015), consider a candidate wholesale price schedule whereby the manufacturer sets the same wholesale price w to both retailers in order to maximize

$$\pi(w,\bar{p}(w);\lambda) = w(1-\lambda)\int_{\underline{p}(w)}^{\bar{p}(w)} D(p)f(p;w)\,dp + 2w\lambda\int_{\underline{p}(w)}^{\bar{p}(w)} D(p)f(p;w)(1-F(p;w)\,dp \quad (9)$$

subject to

$$F(p) = \frac{1+\lambda}{2\lambda} - \frac{(1-\lambda)(\bar{p}(w)-w)D(\bar{p}(w))}{2\lambda(p-w)D(p)} \quad (10)$$

where $\bar{p}(w) = \min\{p^m(w),\rho\}$. Denote by w^* the optimal manufacturer price in such an equilibrium, if it exists. The associated profit level is increasing in λ and decreasing in s. Janssen and Shelegia (2015) show that if λ and s are such that the manufacturer's equilibrium profit exceeds $\rho D(\rho)$ an equilibrium exists, while it fails to exist otherwise. Equilibrium existence is, therefore, an issue if s and λ are relatively small.

The easiest way to establish existence of equilibrium once we allow the manufacturer to correlate her pricing decisions is to construct an equilibrium with $G(\rho,\rho) > 0$ and $G(w^m,\rho) > 0$. In the proof of Proposition 6 below we show that we can proceed as follows. Slightly modify the definition of $\pi(w,\bar{p}(w);\lambda)$ in (9) by having $\bar{p}(w) = \min\{p^m(w),z\}$, where z is the smallest price (as a function of w) such that $zD(z) = \pi(w,\bar{p}(w),\lambda)$. By choosing $G(w^m,\rho)/G(\rho,\rho)$ small enough, one can arbitrarily increase the consumer reservation price ρ even for small values of s, such that $\rho = z$. In this way, one can make it unattractive for the manufacturer to deviate to ρ. As long as $G(\rho,\rho) + G(w^*,\rho) > 0$, it is also convenient to define $\pi(\lambda) = \max_w \pi(w,\bar{p}(w);\lambda)$ and we show that one can always implement a manufacturer profit that is arbitarily close to $\pi(\lambda)$ as an equilibrium outcome.[7]

For many parameter values there are, however, many roots to the equation $zD(z) = \pi(w,z,\lambda)$, since the optimal policy of the manufacturer depends on the beliefs of consumers. These solutions may also constitute an equilibrium and we denote by $\Pi(s,\lambda)$ the lowest manufacturer profit such that $zD(z) = \pi(w,z,\lambda)$.

The equilibrium payoff set is even larger if we allow for more general belief systems. In particular, we can have the manufacturer randomizing over two prices w^m and ρ, and setting $G(w^m,w^m) = 0$ so that $G(\rho,\rho)+2G(w^m,\rho) = 1$. Writing expected manufacturer

[7]One cannot implement $\pi(\lambda)$ as to have z as the consumer reservation price, we should have $G(w^m,\rho), G(\rho,\rho) > 0$, implying $G(w^m,w^m) < 1$.

profits as

$$\Pi = 2G(w^m, \rho)\left(\frac{1+\lambda}{2}\pi^m + \frac{1-\lambda}{2}\pi(\rho)\right) + G(\rho,\rho)\pi(\rho),$$

we can repeat the argument of Section 3.1 to argue that for small enough s one should choose ρ such that $\pi^m = \pi(\rho)$ and the ratio of $G(\rho,\rho)$ to $G(w^m,\rho)$ such that (1) is satisfied. The main difference with the argument in section 3.1 is that in the presence of shoppers we should have that $G(w^m, w^m) = 0$ as otherwise the expected manufacturer profit of selling to a retailer at w^m is not equal to π^m. The remaining arguments in Section 3.1. remain valid and, in particular, there is no incentive for any player to deviate from these strategies. Note that in this equilibrium, manufacturer profits are low and equal to the profits without shoppers, since the manufacturer does not benefit from the potential competition between retailers. This may not be an equilibrium under symmetric beliefs, however, as when the manufacturer deviates to say $w^m + \varepsilon$, for some small $\varepsilon > 0$, retailers believe that they both have received the same wholesale price and they compete for the shoppers accordingly. For other retailer and consumer beliefs the manufacturer cannot benefit from deviating, however, as even if he would choose, for example, a wholesale price of $w^m + \varepsilon$ to both retailers, their beliefs can be such that they would continue to choose $p^m(w^m + \varepsilon)$.[8]

Thus, we have the following Proposition.

Proposition 6. *Assuming retailers hold symmetric out-of-equilibrium beliefs, for any $\lambda \in (0,1)$ there exists some $\bar{s}(\lambda)$ such that for all $s < \bar{s}(\lambda)$ a continuum of equilibria exists, with associated manufacturer profit $\pi \in [\pi(s,\lambda), \pi(\lambda))$,where $\pi^m \leq \pi(s,\lambda)$. Further, for some retailer out-of-equilibrium beliefs every $\pi \in [\pi^m, \pi(\lambda))$ can be implemented as an equilibrium outcome for every $s > 0$.*

Note that Proposition 6 does not claim that $\pi(\lambda)$ is an upper bound on the profit of the manufacturer. A surprising fact is that the properties of the distribution of wholesale prices differs in the range $[\pi^m, \pi(\lambda))$. The lowest possible equilibrium π^m can only be obtained by having perfect negative correlation of wholesale prices and in this case, the retail prices are also perfectly negative correlated. In the best equilibrium for the manufacturer in this class the wholesale prices are positively correlated as both $G(w^*, z)$ and $G(z, z)$ are arbitrarily small. In this equilibrium the degree of correlation also depends on the search cost as $G(w^*, z)/G(z, z)$ should be smaller, the lower the search cost.

[8]Deviating to out-of-equilibrium prices also does not benefit the manufacturer if retailers beieve that the other retailer has received a wholesale price of for example ρ.

5 Two-Part Tariffs

Finally, we turn our attention to non-linear contracts between manufacturer and retailers and consider the case where the manufacturer cannot commit and there is a positive fraction of shoppers. It is well-known that in the absence of retail competition, two-part tariffs are optimal for the manufacturer. In the presence of retail competition, however, there is an important caveat, namely that equilibrium contracts depend on out-of-equilibrium beliefs of retailers. Rey and Vergé (2004) show that optimal contracts may not exist when retailers have passive beliefs. The reason is that if a manufacturer provides an *unexpected* contract with a low per-unit price and a high fixed fee, and the retailer believes that her receives the equilibrium contract, then her rival may be willing to accept the contract expecting to gain a large market share due to its cost advantage in the retail market. In such a case, it is indeed optimal for the manufacturer to deviate to such an unexpected contract to both retailers, making the contract unprofitable for each of them (see also Inderst (2010)). Following Rey and Vergé (2004) and McAfee and Schwartz (1994) we use wary beliefs instead: when it receives an unexpected offer, a retailer anticipates the manufacturer acts optimally with its rival retailers, given the offer just received and that the manufacturer believes that he will accept the unexpected offer.

Our analysis on two-part tariffs proceeds in two steps. First, we show that with symmetric contracts the set of equilibrium payoffs for the monopolist is bounded above by a certain profit $\Pi^*(s, \lambda)$. Second, we discuss the existence of asymmetric equilibria where the manufacturer offers different contracts to different retailers. One retailer receives a two-part tariff with a low per-unit price, while the other retailer receives a high price and no fixed fee. In these equilibria with asymmetric contracts, the manufacturer obtains the same profit level with both contracts and has, therefore, no incentives to deviate *and offer both firms the same contract*. We show that these asymmetric contracts are not dominated by any other asymmetric configuration and for some parameter configurations they dominate any equilibrium with symmetric two-part tariffs.

5.1 Symmetric Contracts

We start with the symmetric contract case. Let $\{w, T\}$ be the equilibrium contract and $\pi_R(w) = (1-\lambda)D(\bar{p}(w))(\bar{p}(w) - w)$ the expected variable profit of a retailer observing w. Given any w, retailers expect their rival to receive the same contract so that T must satisfy $T \leq \pi_R(w)$. Let $F(p \mid w)$ be the retail distribution and let $F^{\min}(p \mid w)$ denote the distribution of the minimum price among both retailers. The per-retailer profit of the manufacturer equals

$$\Pi = w\{(1-\lambda)\int D(p)dF(p \mid w) + \lambda \int D(p)dF^{\min}(p \mid w)\} + \pi_R(w). \tag{11}$$

Proposition 7. *The maximal manufacturer profit that can be implemented by choosing symmetric two part tariffs, denoted by* $\Pi^*(s,\lambda)$, *is decreasing in* s *and non-monotone in* λ *with* $\Pi^*(s,0) = \Pi^*(s,1) > \Pi^*(s,\lambda)$ *for all* $0 < \lambda < 1$.

Note that both when $\lambda = 0$ and when $\lambda = 1$, the manufacturer can obtain the monopoly profits of a vertically integrated firm. With $\lambda = 0$, the manufacturer optimally sets $w = 0$ and capture all profits through the fixed component T. With $\lambda = 1$,the manufacturer may set w at the integrated monopoly level with the fixed component $T = 0$. Figure 2 depicts the optimal contract for linear demand $D(p) = 1 - p$ and $s = 0.02$ for different values of $\lambda \in (0, 0.5)$. The blue line depicts the linear component of the optimal two-part tariff, the other two lines correspond to the lower and the upper bound of the price distribution.Generally, as λ increases, the distribution of retail prices becomes more concentrated at the bottom, inducing a higher w, as can be seen in the Figure. Also, the difference between the upper and lower bound (in the legend of the Figure denoted by p_l) of the retail price distribution becomes larger.

It is also important to note that for intermediate values of λ the manufacturer cannot obtain the profit of the fully integrated monopolist even if it chooses the optimal two-part tariff. The reason is that from the point of view of the manufacturer, the retail price dispersion that always arises with $\lambda \in (0, 1)$ creates noise for her profit function. Appropriating the retailers' expected profit through T is not affecting the fact that some noise remains. As for any choice of $\{w, T\}$ the maximal profit is that of an integrated monopolist, noise implies that the realized profit is smaller (see also Figure 3 below).

5.2 Asymmetric Contracts

We now move to a more general class of equilibria involving asymmetric contracts across different retailers. As we have seen before, asymmetric contracts reduce competition between retailers and this may be suboptimal for the manufacturer. With two-part tariffs, the positive side of asymmetric contracts for the manufacturer is that they induce a pure strategy equilibrium in retail prices that eliminates the price dispersion

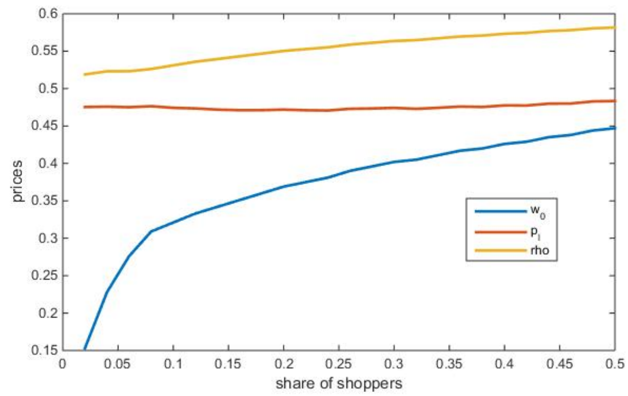

Figure 2: Wholesale price (blue line) and bounds of the support of the retail price distribution (red and yellow lines) in the optimal symmetric contract for different values of λ.

that is responsible for the manufacturer not being able to obtain the profit of a fully integrated monopolist. In general, it is very difficult to compare analytically the gains and losses due to these sources of profit loss for the manufacturer. In this Section, we first show that an equilibrium with asymmetric contracts exists, and then show numerically that these equilibria may be better for the manufacturer for intermediate values of λ. Thus, manufacturers may also induce asymmetries between retailers even in the presence of two-part tariffs.

In any asymmetric equilibrium without commitment it must be that the manufacturer is indifferent among all contracts. Since without price dispersion, manufacturer profits must be equal at both contracts, this basically imposes that there should be two retail prices $\{p_1, p_2\}$ such that $p_1 < p^m(0) < p_2$ and $p_1 D(p_1) = p_2 D(p_2)$.[9] It is obvious that the retailer observing the lowest wholesale linear component will be able to set the monopoly price, so that $p_1 = p^m(w_1)$. It should be the case that the retailer observing the higher wholesale linear component prefers to charge p_2 and get demand $(1-\lambda)D(p_2)$ to a deviation to $p_1 - \varepsilon$ so as to get demand $(1+\lambda)D(p_1-\varepsilon)$. Hence, in an asymmetric equilibrium with two-part tariffs, the following restriction should hold:

$$(p_2 - w_2)(1-\lambda)D(p_2) \geq (p_1 - w_2)(1+\lambda)D(p_1), \tag{12}$$

[9]That is, profits from the perspective of the manufacturer. If this condition is not met, the manufacturer could deviate and offer the same contract to both retailers and increase its profit.

and given the equal profit condition, this implies

$$(1-\lambda)\frac{p_2-w_2}{p_2} \geq (1+\lambda)\frac{p_1-w_2}{p_1}.$$

Optimality of the contract requires that $p_2 = \bar{p}(w_2) = \rho = \min\{p^m(w_2), \rho\}$, since if $p^m(w_2) < \rho$ the manufacturer can strictly improve her profit by deviating to $w_2^* - \epsilon$ leading the retailer to charge $p^m(w_2^* - \epsilon)$ which would strictly improve profits as $p^m(w_2) > p^m(0)$. This condition imposes an upper bound on s for which asymmetric contracts can be charged in equilibrium. As a result, we have the following Proposition.

Proposition 8. *For any $\lambda > 0$, there exists a $s(\lambda)$ such that for all $s \in (0, s(\lambda))$ an asymmetric equilibrium exists with contracts $\{w_1, T_1\}$ and $\{\rho, 0\}$ with*

$$p^m(w_1)D(p^m(w_1)) = \rho D(\rho) \tag{13}$$

and $T_1 = (p^m - w_1)D(p^m(w_1))$. Further, $w_1 < 0$.

Numerically, we now show that for intermediate values of λ and small values of s the manufacturer profit in this asymmetric equilibrium can be higher than the maximal profit in a symmetric equilibrium. This is depicted in Figure 3 for linear demand and search cost $s = 0.02$. The blue line is the profit level in the optimal symmetric contract, while the red line is the profit in the asymmetric contract. It is clear that for $\lambda = 0$ and $\lambda = 1$ the best symmetric contract cannot be beaten. Also, the profit level in the asymmetric contract is independent of λ. The Figure shows, however, that for intermediate values of λ, the asymmetric contract is better and its relative improvement increases with λ. The Figure does not show the analysis for λ close to 1 as the numerical analysis becomes relatively imprecise with most of the probability mass concentrated at the lowest retail prices, but the support of the retail price distribution not shrinking to 0.

6 Conclusion

In this paper we have looked at the incentive of manufacturers to treat retailers that sell their product to consumers asymmetrically. In general, as manufacturers have an incentive to lower retailer margins, they face a trade-off. On one hand, manufacturers may sell to different retailers at different prices to stimulate consumer search. Consumers that observe a relatively high price may infer that the chance they observe a

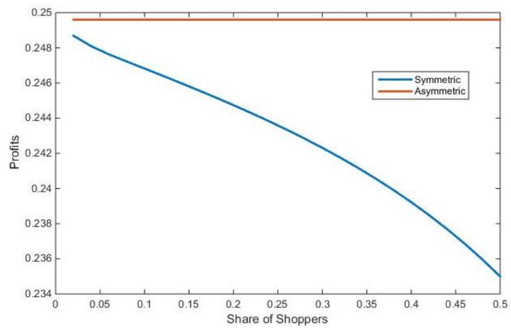

Figure 3: Gains from asymmetric contracts.

low price on their next search is considerably high and this will limit the market power of retailers. On the other hand, by creating an asymmetry retailers are competing less fierce for consumers who anyway consider all price offers before buying. This paper analyzes how manufacturers optimally deal with this trade-off in a variety of settings.

We first considered a situation where the competition aspect is absent as all consumers have to pay a search cost and typically will only visit one retailer. In that case we have analyzed three levels of commitment by the manufacturer: full commitment to a random price schedule, no commitment and partial commitment. Without commitment, the manufacturer's maximal profit equals the double marginalization profit, which he can reach with a variety of pricing schemes. With full commitment and small search costs, the manufacturer chooses a negative correlation structure between a low price and the consumer reservation price. The purpose of the low price the consumer reservation price, which is the price that attracts most of the sales. When the search cost becomes arbitrarily small the manufacturer may find it optimal to choose the low price below cost, but with low probability. By doing so, the manufacturer prevents the Diamond paradox from arising and makes profits that are close to monopoly profits. Under partial commitment, the manufacturer may announce that one of the retailers get the status of premium re-seller and that this retailer gets a lower wholesale price. Having a system of premium re-sellers may thus increase the manufacturer's profits and consumer welfare.

With competition for shoppers the analysis becomes more complicated. In this case, the manufacturer may stimulate competition between retailers by choosing identical wholesale prices with some positive probability. Generally speaking, competition for shoppers gives manufacturers in their most preferred equilibrium an incentive to choose prices with a positive affiliation. We also show that by having some correlation between the wholesale prices resolves the non-existence problem that is present in Janssen and Shelegia (2015)

Finally, we show that also under two-part tariffs the manufacturer may have an incentive to choose asymmetric contracts. In this case, the reason is that search creates price dispersion at the retail level and this price dispersion creates noise into the manufacturer profit function, which limits the manufacturer's ability to extract maximal rents. By choosing asymmetric contracts, the manufacturer is able to eliminate this noise but only at the expense of having less retail competition. When the retail price dispersion is maximal, the manufacturer may be better off under asymmetric contracts.

Generally, this paper is the first showing that in distribution channels where the retail market to final consumers is characterised by consumer search, manufacturers have an incentive to treat retailers asymmetrically. New theoretical and empirical research may focus on the question how manufacturers may want to organize their distribution channel, or reversely how retailers may organize their supply, in consumer search markets.

References

DeGraba, Patrick, "Input market price discrimination and the choice of technology," *The American Economic Review*, 1990, *80* (5), 1246–1253.

Diamond, Peter, "A Model of Price Adjustment," *Journal of Economic Theory*, 1971, *3* (2), 156–168.

Garcia, Daniel, Jun Honda, and Maarten Janssen, "The Double Diamond Paradox," *American Economic Journal: Microeconomics*, Forthcoming.

Hess, James D and Eitan Gerstner, "Loss leader pricing and rain check policy," *Marketing Science*, 1987, *6* (4), 358–374.

Inderst, Roman, "Models of vertical market relations," *International Journal of Industrial Organization*, 2010, *28* (4), 341–344.

_ **and Tommaso Valletti**, "Price discrimination in input markets," *The RAND Journal of Economics*, 2009, *40* (1), 1–19.

Janssen, Maarten and Sandro Shelegia, "Consumer Search and Double Marginalization," *American Economic Review*, 2015, *105* (6), 1–29.

Janssen, Maarten CW and Alexei Parakhonyak, "Consumer search markets with costly revisits," *Economic Theory*, 2014, *55* (2), 481–514.

Janssen, Maarten C.W., Jóse Luis Moraga-González, and Matthijs R. Wildenbeest, "Truly Costly Sequential Search and Olipolistic Pricing," *International Journal of Industrial Organization*, 2005, *23* (5), 451–466.

Kaplan, Greg, Guido Menzio, Leena Rudanko, and Nicholas Trachter, "Relative Price Dispersion: Evidence and Theory," Technical Report, National Bureau of Economic Research 2016.

Katz, Michael L, "The welfare effects of third-degree price discrimination in intermediate good markets," *The American Economic Review*, 1987, pp. 154–167.

Lal, Rajiv and Carmen Matutes, "Retail pricing and advertising strategies," *Journal of Business*, 1994, pp. 345–370.

Lubensky, Dmitry, "A model of recommended retail prices," *Available at SSRN 2049561*, 2013.

McAfee, R. Preston and Marius Schwartz, "Opportunism in Multilateral Vertical Contracting: Nondiscrimination, Exclusivity, and Uniformity," *American Economic Review*, 1994, *84* (1), 210–230.

Pesendorfer, Martin, "Retail Sales: A Study of Pricing Behavior in Supermarkets," *Journal of Business*, 2002, *75* (1), 33–66.

Rey, Patrick and Thibaud Vergé, "Bilateral control with vertical contracts," *RAND Journal of Economics*, 2004, pp. 728–746.

Sobel, Joel, "The Timing of Sales," *Review of Economic Studies*, 1984, *42* (3), 353–368.

Stahl, Dale O., "Oligopolistic Pricing with Sequential Consumer Search," *American Economic Review*, 1989, *79* (4), 700–712.

Varian, Hal R., "A Model of Sales," *American Economic Review*, 1980, *70* (4), 651–659.

Yoshida, Yoshihiro, "Third-degree price discrimination in input markets: output and welfare," *The American Economic Review*, 2000, *90* (1), 240–246.

A Omitted Proofs

Proof of Lemma 2. Let $\underline{w}$ be the lower bound of the wholesale price distribution. By the preceding argument, $p(\underline{w}) = p^m(\underline{w})$. Now suppose that $\underline{w} > w^m$ and consider a deviation to w^m. This shift induces a first order shift on the retail price distribution and since $wD(p(w)$ is decreasing for $w > w^m$, it induces an increase in profits. Hence, no price above w^m and such that $p(w^m) < \rho$ can be optimal. In order to complete the proof we show that there exists a unique price $w \leq w^m$ charged in equilibrium. In order to see this, we shall fix for now a certain reservation price ρ and consider the most efficient way to implement it. Let q_j be the mass on price $w_j < \rho$ and let $S(p, p')$ be the difference in consumer surplus between p and p'. The problem can be written as

$$\begin{aligned} \max_q \quad & \sum q_j \left(w_j D(p(w_j) - \rho D(\rho))\right) \\ & \sum q_j S(p(w_j), \rho) \geq s \\ & q_j \geq 0 \end{aligned}$$

with the additional constraint that $\sum q_j \leq 1$. If this additional constraint is not binding, we have that since $S(p, p')$ is decreasing and convex and $wD(p(w))$ is increasing and concave, this is a linear program in q_j whose solution is (generically) $q(w_j) > 0$ iff $w_j = w_0$.[10] If the additional constraint were binding, then the monopolist would not put any mass at ρ. In that case, the profit level cannot exceed w^m and so the optimal distribution has only one atom. □

Proof of Proposition 3. We can rewrite the profit level as

$$\Pi = 2\{\pi(\rho) - G(w_0, \rho)(\pi(\rho) - \pi(w_0))\} \tag{14}$$

where

$$\frac{G(w_0, \rho)}{1 - G(w_0, \rho)} \int_{p^m}^{\rho} D(p)dp = s \tag{15}$$

[10] In non-generic cases, the solution may be multiple but there still exists an optimal binary distribution.

In order to increase the gains from search at lower prices, the manufacturer has two instruments. First, it may increase the probability that a single store offers the best deal ($G(w_0, \rho)$). Second, it may reduce the lowest price (w_0) so that $p^m(w_0)$ yields a better deal for the consumer. Let $q_0 = G(w_0, \rho)$ and notice that

$$\frac{\partial \Pi}{\partial q_0} = 2(1 - q_0)\pi'(\rho)\frac{\partial \rho}{\partial q_0} - 2(\pi(\rho) - \pi(w_0)) \tag{16}$$

while

$$\frac{\partial \Pi}{\partial w_0} = 2(1 - q_0)\pi'(\rho)\frac{\partial \rho}{\partial w_0} + 2q_0\pi'(w_0). \tag{17}$$

In an interior solution we must have that

$$\frac{\pi(\rho) - \pi(w_0)}{2q_0\pi'(w_0)} = -\frac{\frac{\partial \rho}{\partial w_0}}{\frac{\partial \rho}{\partial q_0}}. \tag{18}$$

It is obvious then that $w_0 < w^m$ as long as $\pi(\rho) > \pi(w_0)$. This is the case if the manufacturer can secure a profit level above the double marginalization equilibrium. Notice also that

$$\frac{\partial \rho}{\partial w_0} = \frac{D(p^m(w_0))}{D(\rho)} \tag{19}$$

and

$$\frac{\partial \rho}{\partial q_0} = \frac{-s}{q_0^2 D(\rho)} \tag{20}$$

Combining all of these pieces we have

$$\frac{\pi(\rho) - \pi(w_0)}{\pi'(w_0)} D(p^m(w_0) = \frac{s}{q_0} \tag{21}$$

This condition depends on the demand function. For linear demand the LHS has a minimum in $w_0 \in (0, 1/2)$ while the RHS is decreasing in w_0. For future reference, notice that $w_0 = 0$, LHS equals $\pi(\rho)$. . In addition, we have that

$$-(1 - q_0)\frac{\pi'(\rho)}{D(\rho)} = q_0 \frac{\pi'(w_0)}{D(p^m(w_0))} \tag{22}$$

This condition can be understood as a marginal return of an increase in each of the two prices must be proportional to their impact on ρ. □

Proof of Proposition 4. For the first part, choose $w_0^* < 0$ so that $\int_{p^m(w_0^*)}^{p^m} D(p)dp = s_1$

for some $s_1 > 0$ and consider the sequence of search costs $\{s_n\} = \frac{s_1}{n}$. For each s_n in the sequence, $w_0(n) = w_0^*$ and $\rho(n) = p^m$. Thus, $q_0(n) \to 0$ so that profits converge to monopoly. Now, to see that $w^m > w_0 \geq 0$ is suboptimal for s small enough, consider first the case in which $w_0 > w^*$ for any s. Clearly, the profit is a linear combination of $w_0 D(p^m(w_0)$ and $\rho D(\rho)$ and both would be bounded away from monopoly level. Hence, it must be that w_0 converges to zero as s vanishes. So assume that this is the case and notice that, along any such sequence of optimal contracts, it must be that $s_n/q_0(n) = \delta(n)\pi(\rho(n))$ for some sequence $\delta(n) < 1$ converging to 1. In such a case, the consumers' reservation price is

$$\begin{aligned} \int_{p^m}^{\bar{\rho}} D(p)dp &= \frac{(1 - q_0(n)s_n}{q_0(n)} && (23) \\ &\geq (1 - q_0(n^*))\lambda(n^*)\pi(\rho(n^*)) > w^m D(p^m(w^m)) && (24) \end{aligned}$$

for some n^* large enough. But then $\bar{\rho}$ is bounded away from $p^m(0)$ and so the manufacturer cannot obtain monopoly profits. Thus, $w_0 = 0$ is not a solution for the system. $\square$

Proof of Proposition 6. We begin by a description of the equilibrium strategies.

1. The manufacturer randomizes with support in w^* and ρ, with joint distribution $G(w_1, w_2)$.
2. Retailer i observes w_i and chooses p_i according to
   - If $w_i < w^*$, $p_i = p^m(w_i)$.
   - If $w_i = w^*$, p_i follows $F(p; w^*)$
   - If $\rho > w_i > w^*$, $p_i = \min\{p^m(w_i), \rho\}$
   - If $w_i \geq \rho$, $p_i = w_i$
3. Consumers follow a reservation price strategy so that they buy a quantity $D(p_i)$ right away iff $p_i \leq \rho$ and they search otherwise.

We now show that these strategies constitute an equilibrium.

First, it is clear that w^* and ρ have to give the same profits for the manufacturer to randomize. We can compute its profit using

$$\pi(w^*) = \left((1 - \lambda) \int_{\underline{p}(w^*)}^{\bar{p}(w^*)} D(p) f(p; w^*)\, dp + 2\lambda \int_{\underline{p}(w^*)}^{\bar{p}(w^*)} D(p) f(p; w^*)(1 - F(p; w^*)\, dp \right) w^*.$$

It must hold then that

$$\pi(w^*) = \rho D(\rho). \tag{25}$$

For a given $G(w_1, w_2)$, we have a unique $F(p; w^*)$ so that given w^* and $G(w_1, w_2)$, there is a unique ρ that satisfies this relation. Importantly, $F(p; w^*)$ only depends on $G(w^*, w^*)$, while ρ has to satisfy

$$\frac{G(w^*, \rho)}{G(w^*, \rho) + G(\rho, \rho)} \int \int_p^\rho D(t)dtf(p; w^*)dp = s \tag{26}$$

So we can pick ρ by appropriately choosing the conditional probability that the other retailer observed w^* given that the retailer the consumer visited observed ρ.

Moreover, given the strategy profile of retailers, the manufacturer has no incentive to deviate to any other price.[11] Similarly, consumers' indifference condition is satisfied at ρ. For simplicity, we assume that if the consumer observes any price outside the support of the equilibrium retail price distribution, he assumes that the retailer observed a price of ρ. Therefore, in order to ensure that he follows a reservation price strategy we need to verify that the gains from search following any price in the support of the price distribution renders search unprofitable. Notice that this is not guaranteed by the fact that the upper bound of the support is no higher than ρ since the beliefs are different. In particular, it must hold that

$$\frac{G(w^*, w^*)}{G(w^*, w^*) + G(w^*, \rho)} \int \int_p^{\bar{p}(w)} D(t)dtf(p; w^*)dp \leq s. \tag{27}$$

This implies that if $\bar{p}(w) = \rho$, a necessary condition is that $G(w^*, w^*) * G(\rho, \rho) \leq G^2(\rho, w^*)$ (i.e., that the wholesale price distribution exhibits negative affiliation). If $\bar{p}(w) < \rho$, this condition is only sufficient but not necessary.

We turn now to the problem of the retailers. Since they hold symmetric beliefs, for every $w < \rho$, they should charge a price according to $F(p; w)$, with upper-bound $\bar{p}^m(w, z)$.

Notice that for each $z > p^m(0)$, $F(p; w)$ is maximized at some $w_0(z)$. Hence, an equilibrium requires the manufacturer to choose $w_0(\rho)$. The profits obtained by charging ρ are $\rho D(\rho)$ are single-peaked. If $\rho > p^m(0)$, then, $\rho D(\rho)$ is decreasing and equals 0 for ρ sufficiently large. On the other hand, the profits associated with $w_0(z)$ are decreasing

[11] Notice, in particular, that the upper bound of the distribution of retail prices following w^* is no higher than $p^m(w^*$ and that $pD(p)$ is decreasing in the relevant range

in z but whenever $z > p^m(w)$, profits become constant. Hence, these two functions intersect at least once for some $z > p^m(0)$.

Define $\bar{s}(\lambda)$ such that if $G(w^*, \rho) = 0.5$, $\rho D(\rho) = \pi(\lambda)$. For any $s < \bar{s}(\lambda)$, there are then many possible combinations of $z, w_0(z)$ that yield an equilibrium and, generically, they will give different payoffs. Because both are continuous functions, the equilibrium set is compact. By definition, $\Pi(s, \lambda)$ is the lower bound of such support. Notice that $\Pi(s, \lambda) \geq \pi^m$ since, regardless of the upper-bound of the price distribution, the monopolist can obtain π^m by setting $w = p^m$. On the other hand, if $s = \bar{s}(\lambda)$, $\pi(\lambda)$ is independent of z, so that there exists a single possible payoff level and $\Pi(s, \lambda) = \Pi(\lambda)$. Finally, if $s > \bar{s}(\lambda)$, the consumers' reservation price is no longer binding and so the equilibrium no longer involves randomization. This was the equilibrium characterized in Janssen and Shelegia (2015)

We now show that for every payoff vector in $[\pi^m, \pi(\lambda)]$ there is an equilibrium that implements it. To show this, we shall use wary beliefs so that for every w off-the-equilibrium path triggers a belief so that the retailer optimally charges $p^m(w)$. It is clear that no equilibrium can exist whereby the monopolist obtains less than the double marginalization profit since in such a case the monopolist can deviate to $G(w^m, w^m) = 1$, and each retailer will choose $p(w^m) \leq p^m(w^m)$. Notice also that to implement $\pi(\lambda)$ we need that $G(w^*, w^*) = 1$ so that $F(p; w^*)$ is defined by (10). This equilibrium payoff can be implemented exactly on only if $\rho > p^m(w^*)$. Otherwise, we can obtain an equilibrium that is arbitrarily close to it.[12] Consider the following class of equilibria that span the whole set. First, fix $w^* = w(\lambda)$, the wholesale price that induces the highest possible profit level, and consider the equilibria indexed by $G(w(\lambda), w(\lambda)) \in [q(\lambda), 1]$, where $q(\lambda)$ is the lowest value such that (i) the expected profit at $w(\lambda)$ is at least as high as the double-marginalization profit and (ii) $G(w(\lambda), w(\lambda)) * G(\rho, \rho) \geq G^2(\rho, w(\lambda))$. It is clear that if $G(w(\lambda), w(\lambda) = 0$, then the profit level associated with this distribution is no higher than that of the double-marginalization. By continuity, there exists a unique such value and because the profit function is continuous in $F(p)$ and $F(p)$ is continuous in $G(w(\lambda), w(\lambda))$ an equilibrium exists for each value above the one corresponding to $q(\lambda)$. If the profit level associated with it is the double-marginalization profit, the result follows. If the profit level is higher, it must be that $G(w^*, w^*) * G(\rho, \rho) = G^2(\rho, w^*)$. Now, fix the distribution $G(w_1, w_2)$ to satisfy this condition and consider the equilibria indexed by $\tilde{w} \leq w(\lambda)$. Because F is First-Order Stochastically ranked on w, the

[12]The problem is that if $G(w^*, w^*) = 1$, observing ρ does not lead the consumer to believe that $w_i = \rho$ but rather $w_i = w^*$.

indifference constraints hold. Because the profit function is continuous, there is an equilibrium that yields each profit level in the desired range. □

Proof of Proposition 7. Fix an equilibrium contract $\{w, T\}$ and consider a deviation to some other contract $\{w', T'\}$ and consider the belief that their rival received another contract $\{w'', T''\}$ such that $p^m(w'') \geq w'$. In such a case, it is optimal for the retailer receiving the deviating contract to choose $\bar{p}(w'^m(w')\}$ and get profits $(1-\lambda)\bar{p}(w')D(\bar{p}(w'))$. Thus, they will accept a fee $T' = (1-\lambda)(\bar{p}(w')-w')D(\bar{p}(w'))$. These deviations (if given to both firms simultaneously) give profits $(1-\lambda)(\bar{p}(w')-w')D(\bar{p}(w')) + w'D(\bar{p}(w'))$. Let Π_0 be the maximum of such profits. On the other hand, given some (s, λ) and some common linear component of the contract w, the equilibrium price distribution is $F(p)$ as derived before. This yields the required conditions. For the comparative statics, simply notice that if $\lambda \in (0,1)$, F is non-degenerate and this puts an upper bound on $\int pD(p)dF(p \mid w)$, and, thus, on overall profits. To see the effect of s just notice that if $s < s^*(\lambda)$, $\bar{p} = \rho$ and ρ decreases in s. As a result the variance of F increases in s and so profits decrease in s. □