Regulating Recommended Retail Prices*

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Abstract

This paper analyses the effects of regulated recommended retail prices (RRPs). Such recommendations by manufacturers are non-binding in nature and thus retailers do not have to adhere to them. We look at regulations, similar to that by the Federal Trade Commission (FTC), requiring at least some sales to take place at RRPs. Such regulations were introduced with the aim of protecting consumers. In the absence of regulation an equilibrium exists where the manufacturer charges the same wholesale prices across retailers. We show that regulating RRPs enables manufacturers to commit to their unobserved contracts, creating an equilibrium with wholesale price discrimination. We find that such an equilibrium increases manufacturer's profits, but harms retailers and consumers.

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1 Introduction

Recommended retail prices (RRPs) are non-binding suggestions of manufacturers at which prices retailers should sell their product. As retailers are free to deviate from the recommendation, an important question is whether these price proposals affect market behaviour and if so how. Competition authorities have been concerned that RRPs affect competition negatively through their impact on consumers. By seeing prices at or below the RRP, a consumer may be tempted to buy and not continue to search, enabling retailers to increase their margins. In practice, it has also been documented that retailers often come up with false recommendations of this nature in order to influence the purchasing decision of consumers.[1] Retailers have been found to post high "regular" prices at which their products were never available for purchase. These practices, labelled as "fictitious pricing", have attracted quite some attention in policy discussions and are regulated in many jurisdictions. In the U.S., the Federal Trade Commission (FTC) has established the *Guides Against Deceptive Pricing* to offer guidance to sellers on how to comply with pricing standards.[2] Nowadays, more than forty states in the U.S. have similar regulations in place and often apply even stricter rules.[3] For instance, California's False Advertising Law (FAL) imposes a higher standard for establishing the prior reference or regular price compared to the FTC Guides, by requiring it to be the prevailing market price and not only a former price that was offered in good faith.[4]

Even though in practice retailers' compliance with the rules against deceptive pricing has received most attention, manufacturers can also be liable for such practices according to the existing regulations. The FTC specifically addresses fictitious pricing practices that have been established or suggested by manufacturers and states that "to the extent that list or suggested retail prices do not in fact correspond to prices at which a substantial number of sales of the article in question are made, the advertisement of a reduction may mislead the consumer"[5]. The Code rightfully observes that a recommended retail price may also be addressed to consumers (and not only to retailers) and may affect their purchasing behaviour. We interpret this as an implicit recognition of the importance of consumer search. If consumers do not engage in search, the markets become less competitive and retailers are able to increase their margins. The regulation specifically states that a manufacturer will not be found liable of having engaged in deceptive practices only if "he advertises or disseminates a list or pre-ticketed price in good faith (i.e., as an honest estimate of the actual retail price) which does not appreciably exceed the highest

[1]See, e.g., https://www.nytimes.com/2016/03/06/technology/its-discounted-but-is-it-a-deal-how-list-prices-lost-their-meaning.html

[2]https://www.ecfr.gov/current/title-16/chapter-I/subchapter-B/part-233

[3]In the UK, the Advertising Standards Authority also requires availability of product sales at recommended prices.

[4]For more details on deceptive pricing regulations in different jurisdictions see Friedman [2016].

[5]https://www.ecfr.gov/current/title-16/chapter-I/subchapter-B/part-233/section-233.3

price at which substantial sales are made in his trade area".[6] [7]

In this paper, we analyse the effect of this type of regulation on vertical markets with search. We argue that despite its intention to protect consumers, such regulations may actually adversely affect them. We point out that while the regulation might make deceptive pricing more difficult, it has an additional unintended effect of serving as a commitment device for manufacturers. Once manufacturers are able to commit to their wholesale prices, we show that they will engage in wholesale price discrimination. We will explain how this mechanism works and why it makes consumers (and retailers) worse off. In order to do so, we develop a simple model where a manufacturer sells a homogeneous product via retailers to consumers. We focus on homogeneous products given the intention of RRPs to help standardize prices of identical products. Consumers have heterogeneous search costs drawn from a continuous distribution and engage in optimal sequential search for low prices.

Our main results are as follows. First, we characterize equilibrium behavior in the absence of the regulation on RRPs and show that it features a uniform wholesale price where the manufacturer charges all retailers the same wholesale price. This equilibrium in itself is already interesting as it generalizes Janssen and Shelegia [2015] showing that markets can be quite inefficient if consumers search sequentially while not observing the wholesale arrangement between the manufacturer and retailers as manufacturers have a temptation to secretly set wholesale prices that are much higher than the integrated monopoly price to squeeze retailers. Janssen and Shelegia [2015] use a Stahl type model with a fraction of shoppers and non-shoppers and a duopoly retail market to establish this result, while we use a continuous search cost distribution and allow for for any number of retailers. Importantly, the equilibrium in Janssen and Shelegia [2015] does not exist if the fraction of shoppers is small, while in our set-up this type of equilibrium always exists, establishing that the non-existence is due to the bimodal distribution of the search cost distribution in the Stahl model.

To transit to our second set of results, it is important to understand why, in the absence of a regulation, like the one imposed by the FTC's Code of Federal Regulations, there is no equilibrium where the manufacturer engages in wholesale price discrimination. If the manufacturer discriminates, it charges low prices to some retailers and high prices to others. The retailers then respond to these costs optimally and thus some of them sell at higher retail prices than others. The price dispersion that emerges in the retail market stimulates consumers to search. This increased search implies that both low and high cost retailers face more price sensitive demands compared to uniform pricing. It is important to note that, while high search cost consumers stop their search early on, consumers with low search costs will stop searching only once they find a low cost retailer. In this

[6] Id.

[7] A similar view is followed by the Competition Bureau of Canada. For details see: https://www.competitionbureau.gc.ca/eic/site/cb-bc.nsf/eng/00522.html#sec01

way, the retailers that are charged the lower wholesale price face a more elastic demand compared to high cost retailers and thus react less to increases in the wholesale price. Despite the fact that the manufacturer charges a lower wholesale price, the increased demand per consumer resulting from lower retail margins implies that the manufacturer makes more profits per consumer over the low cost retailers compared to the high cost retailers. Consider then that the manufacturer deviates and charges all retailers the low wholesale price. As retailers only observe their own wholesale price, and are thus not able to observe such a deviation, they continue to choose their equilibrium price strategy and given the manufacturer's deviation all charge the low equilibrium retail price. It is clear that such a deviation is profitable. Therefore, without the regulation on RRPs, only uniform wholesale pricing can be sustained in equilibrium.

This is also important for our next results showing that the regulations like the one imposed by the Code of Federal Regulations effectively provide the manufacturer with a commitment device that enables them to engage in wholesale price discrimination. The manufacturer may announce the price at which the high cost retailer sells her product as the recommended retail price. Given the announcement, she should make sure that at least some products are sold at this price and thus she is not free to deviate and sell to all retailers at the lower wholesale price that generates more profits. Some retailers follow the recommended retail price, as this is simply their optimal price given their individual wholesale price. Other retailers sell at a price below the recommended retail price as they receive lower wholesale prices. We show that once the possibility to secretly deviate and charge all retailers the lower wholesale price is eliminated, wholesale price discrimination can be sustained as an equilibrium outcome.

Finally, we show that under wholesale price discrimination the average wholesale and retail prices increase, increasing manufacturer profits, but decreasing retailers' profits and consumer welfare compared to uniform pricing. As consumers search more, retailers face more elastic demands under discrimination. In this way, retail prices react less to wholesale price changes creating a more inelastic demand for the manufacturer. This, together with the fact that wholesale contracts are unobserved, provides the manufacturer with an incentive to set even higher wholesale prices than under uniform pricing, resulting in higher retail prices. In this way, irrespective of the lower retail margins, consumers face higher prices under discrimination. On top of that, a fraction of consumers with low search costs has to search to find the low retail price, while they do not need to do so under uniform pricing. We thus show that although the regulation on RRPs is introduced with the aim of protecting consumers, it indirectly provides a mechanism that enables wholesale price discrimination and makes consumers worse off. For our analysis it is important that consumers differ in their search costs and that they do not know retail prices before searching. For this to hold it must be that either retailers cannot effectively advertise their prices to a majority of consumers (for example because consumers do not read these advertisements), or that a minimum advertised price (MAP) is in place forbidding retailers to advertise low retail prices (see Asker and Bar-Isaac [2020]).

We now provide a brief discussion of some antitrust cases to put our results in context. During the 1960s, around 30% of the FTC's advertising trials were in relation to fictitious pricing techniques (Pitofsky, Randal, and Mudge [2003]). The FTC discontinued the enforcement of fictitious pricing approximately a decade later as the Commission determined that discount retailers needed to be nurtured in order to foster competition. During its strict enforcement era, the FTC pursued cases against manufacturers as well. An early example, discussed in Friedman [2016], is the case of the watch manufacturer Orloff Co.,[8] that attached high price tags to its watches before shipping them to retailers. According to the FTC, the manufacturer was aware that it was granting its retailers with an instrument with which purchasing consumers could be deceived.[9] Another example where a manufacturer was found liable for engaging in deceptive practices is the case of *Regina Corp.*[10] The Commission found that Regina's recommended retail prices were higher than the generally prevailing retail prices at which its products were being sold and that the manufacturer was aware of this fact when it set its RRPs.[11]

In more recent years, individual states have been enforcing their regulation quite strictly. Recommended retail prices are still highly used as selling tactics in both the physical and online world, and companies are regularly sued for abusing them. In 2015, for instance, J.C. Penney was accused of violating California consumer protection laws for deceiving customers into thinking they were getting big discounts from posted RRPs and it had to set aside $50 million for settlement.[12] In 2019, a lawsuit was filed in the U.S. District Court of Washington against Carter's clothing manufacturer. According to the complaint, "Carter's intentionally sets the MSRP at an inflated dollar amount which Carter's knows with certainty is grossly above the true market price for the product".[13]

There are several branches of the literature to which this paper contributes. First, the paper adds to the literature on non-binding recommended retail prices in vertical markets.[14] Two empirical papers (Faber and Janssen [2019] and De los Santos, Kim,

[8]52 F.T.C. 709 (1956).

[9]Id. at 715 ("It is absurd to suppose that [Orloff] would... engage in the empty and financially wasteful practice of supplying retail price tags to their customers if such tags were not being used by [retailers] to advantage in the sale of [the] watches... [Orloff] cannot therefore deny their authorship of , or escape responsibility for, a device which to their knowledge is being widely used for deceptive purposes.").

[10]See Regina Corp. v. FTC, 322 F.2d 765 (3rd Cir. 1963).

[11]For more examples of cases against manufacturers during the early years of enforcement, see Carleton A. Harkrader, Fictitious Pricing and the FTC: A New Look at an Old Dodge, 37 St. John's L. Rev. 1, 3– 4 (1962).

[12]https://www.nytimes.com/2015/11/12/business/jc-penney-settles-shoppers-suit-over-false-advertising.html

[13]Aguilar v. Carter's, Inc., see https://www.manatt.com/Manatt/media/Documents/Articles/Aguilar-v-Carter-s,-Inc.pdf

[14]There also exists a literature focusing on list prices in markets with only retailers and consumers, where the vertical setup is ignored, and where retailers use list prices to collude by signalling their costs, i.e., Boshoff, Frübing, and Hüschelrath [2018] and Harrington and Ye [2019].

and Dmitry [2018]) show that recommended retail prices do affect market behaviour. Buehler and Gärtner [2013] see recommended retail prices as communication devices between a manufacturer and its retailers and where recommended retail prices are part of a relational contract enabling the manufacturer and retailer to maximize joint surplus in a indefinitely repeated setting. Lubensky [2017] is closer in spirit to our model. He shows that a manufacturer can use recommended retail prices to signal production cost to searching consumers. As both, consumers and the manufacturer, prefer more search when the manufacturer production cost is low and less search when it is high, the manufacturer's recommendation informs consumers via cheap talk of its cost. In contrast to these papers, we are the first to analyse the effect of regulation on RRPs in vertical markets with search. The easiest way to study the effect of such regulation is to start with markets where RRPs would otherwise be ineffective. We show that such regulation helps manufacturers enforce their recommendations and increase their profits, even in markets where the manufacturers' cost is stable over time and where uncertainty does not play a role. In this sense, our analysis is complementary to, and could in principle be combined with, an explanation for RRP as in Lubensky [2017]. Lubensky [2017] assumes that for every cost realization manufacturers choose one and the same wholesale price to all their retailers. Combining his model with ours, manufacturers could for every different cost realization choose different wholesale prices. Our model of wholesale price discrimination then would apply to each and every cost state. In such a combined model, the mechanism described in Lubensky [2017] would explain why manufacturers choose RRPs even in the absence of regulation and how they affect consumer search, while our model would add that regulating RRPs may backfire.

Second, the paper relates to the literature on unobservable contracts. The seminal papers in this literature have shown that a manufacturer may be subject to opportunism when contracting secretly with downstream retailers and that equilibrium behaviour depends on the type of beliefs retailers hold (see, Hart and Tirole [1990], O'Brien and Shaffer [1992] and McAfee and Schwartz [1994]). We differ from these papers by analysing wholesale price discrimination in search markets where regulations on RRPs are imposed. We find that when contracts are unobserved, an equilibrium with wholesale price discrimination does not exist. We show that, unlike the argument on opportunism, the reason for this non-existence result in our context is not because of specific assumptions on out-of-equilibrium beliefs. The profitable deviation is the unilateral deviation where the manufacturer gives the retailer that is supposed to get a higher wholesale price the same (lower) wholesale equilibrium price as all the other retailers.

Third, the paper adds to the growing literature on vertically related industries with consumer search (Janssen and Shelegia [2015], Garcia, Honda, and Janssen [2017], Garcia and Janssen [2018], Janssen and Reshidi [Forthcoming], Asker and Bar-Isaac [2020], Janssen and Shelegia [2020] and Janssen [2019]). As indicated above, Janssen and Shelegia [2015] show that markets can be quite inefficient if consumers search sequentially while not observing the wholesale arrangement between the manufacturer and retailers. Garcia, Honda, and Janssen [2017] extend that argument to wholesale markets where retailers search sequentially among different manufacturers. Both these papers assume that manufacturers treat retailers symmetrically and do not engage in wholesale price discrimination (although the latter paper allows for manufacturers to randomize their decision to choose wholesale prices). Garcia and Janssen [2018] allows for wholesale price discrimination, but mainly focuses on how a manufacturer can correlate his wholesale prices to increase profits. By contrast, we focus on the competitive impact of wholesale price discrimination by changing the search cost composition of different retailers. Asker and Bar-Isaac [2020] study the impact of minimum advertised prices (MAPs). Janssen and Shelegia [2020] study consumer beliefs in vertical markets with differentiated goods while Janssen [2019] focuses on cases where the manufacturer can offer unobserved two-part tariff contracts. The paper closes to ours is Janssen and Reshidi [Forthcoming]. In that paper, wholesale price discrimination in vertical markets is analysed under the assumption that wholesale contracts are observed. In contrast, we study a setting where the contract between manufactures and retailers are not observed by retailers or by consumers.[15] Similar to Janssen and Shelegia [2015], we find that wholesale and retail prices will be higher when contracts are unobserved compared to settings when they are observed. We show that the regulations like the one imposed by the Code of Federal Regulations effectively provide the manufacturer with a weak commitment device that is enough to make wholesale price discrimination a feasible strategy.

Finally, the paper also adds to the literature on price discrimination with search. The idea that a monopolist may want to sell at different prices to discriminate between consumers with different search cost is not new. In fact, Salop [1977] argues that a monopolist may want to sell at higher prices to less price-sensitive consumers with higher search cost, while selling at lower prices to consumers with lower search cost. His argument, however, critically depends on the assumption that the monopolist is committed to charging prices according to a price distribution and that any deviation from this distribution is observed by consumers and consumers will react by changing their search strategy. From a formal game theoretic point of view, however, it is difficult to see how consumers may observe a price distribution, while maintaining the assumption underlying the search cost literature that the consumer does not know the prices the firm sets. Without this commitment, Salop's argument breaks down, however, as the monopolist will have an incentive to secretly increase the prices in the lower part of the price distribution. Our paper shows that with unobserved wholesale contracts, screening consumers with different search costs can be effective in a vertical relations model where the manufacturer imposes the screening con-

[15]The assumption that wholesale arrangements are observed by retailers and consumers may be reasonable in markets where long-term supply contracts are in place and where consumers are aware of this and they repeatedly buy. However, unless there are good reasons to believe that long-term wholesale contracts are being used, it is more natural to consider of wholesale arrangements between manufacturers and retailers as being unobserved by others. This is the approach we follow here.

tract to retailers, while consumers search for low retail prices. Finally, Fabra and Reguant [2018] have introduced heterogeneity in buyers' size in a simultaneous search model. In contrast to our paper, they find that differences in demand, and not in search costs, give rise to discrimination.

The remainder of this paper is organized as follows. In the next section, we present the model and the equilibrium concept we use. The analysis under uniform wholesale pricing is presented and discussed in Section 3. Section 4 analyses the implications of imposing the regulation on RRPs, as the Code of Federal Regulations does. Finally, Section 5 concludes with a discussion.

2 The Model

We analyse a setting where in the upstream market a single manufacturer sells a homogeneous product to $N \geq 3$ downstream retailers.[16] The manufacturer chooses linear wholesale contracts and can charge different wholesale prices w_i to retailers, and so the manufacturer's strategy is a tuple $(w_1, w_2, ..., w_N)$.[17] For simplicity, the production costs of the manufacturer are set to zero. Retailers compete in prices and the wholesale price is the only cost they are faced with. For given expected wholesale prices and given their own wholesale price, an individual retailer i sets his retail price p_i, $i = 1, ..., N$.

In the downstream market, there is a unit mass of final consumers. At price p, every consumer demands $D(p)$ units of the good. We make standard assumptions on the demand function so that it is well-behaved. In particular, there exists a $\overline{p}$ such that $D(p) = 0$ for all $p \geq \overline{p}$ and the demand function is twice continuously differentiable and downward sloping whenever demand is strictly positive, *i.e.*, $D^{'}(p) < 0$ for all $0 \leq p < \overline{p}$. For every $w \geq 0$, the retail monopoly price, denoted by $p^M(w)$ is uniquely defined by $D^{'}(p^M(w))(p^M(w) - w) + D(p^M(w)) = 0$ and $D''(p)(p-w) + 2D'(p) < 0$. Note that for $w = 0$, this condition gives that the profit function of an integrated monopolist is concave. We denote by $p^M(w^M)$ the double marginalization retail price, which arises in case there would be a monopoly at both levels of the supply chain.

In order to observe prices consumers have to engage in costly sequential search with perfect recall. Consumers differ in their search cost s. Search costs are distributed on

[16] The reason we focus on at least three retailers is that in the case of the manufacturer discriminating between retailers we need that there continues to be some competition between the retailers that get the lowest wholesale price and this requires that at least two retailers get the lowest wholesale price.

[17] In this paper we analyse markets with linear wholesale pricing given that two-part tariffs, despite their theoretical appeal, are not often used in actual business transactions. Blair and Lafontaine [2015] state that, even in situations when two-part tariffs are adopted, the fixed component seems to be a relatively small part of the overall payment between firms (see, also, Kaufmann and Lafontaine [1994]). Differences in demand expectations, in risk attitude, the possibility of ex-post opportunism by the supplier and wealth constraints by the retailers are mentioned among reasons why two-part tariffs are not often implemented in actual transactions. For an analysis with two-part tariffs, we refer the reader to see Janssen [2019].

the interval $[0, \overline{s}]$ according to a twice continuously differentiable distribution function $G(s)$, with $G(0) = 0$. We denote by $g(s)$ the density of the search cost distribution, with $g(s) > 0$ for all $s \in [0, \overline{s}]$ and a finite M such that $-M < g'(s) < M$.[18] In numerical examples, we consider $G(s)$ to be uniformly distributed. As consumers are not informed about retail prices before they search, an equal share of consumers visits each retailer at the first search.

For given expected wholesale prices, consumers sequentially search for retail prices. We will focus on two types of equilibria: (i) in a uniform pricing equilibrium the manufacturer chooses $w_i = w^*$, whereas (ii) in an equilibrium with price discrimination the manufacturer chooses two prices w_L^* and w_H^*, with $w_L^* < w_H^*$, and charges some retailers the low and others the high wholesale price. With unobserved contracts the manufacturer may secretly deviate from the prices retailers and consumers expect her to charge. A retailer only observes her own wholesale price and does not observe the wholesale arrangements of the other retailers. Consumers only observe the retail price they encounter when searching and do not know the wholesale arrangements. Thus, we should not only consider consumers', but also retailers' out-of-equilibrium beliefs. Moreover, we can have pure strategy equilibria that are consistent with consumers not knowing which retailer has the high wholesale price.

We define an equilibrium with wholesale price discrimination as follows.

Definition 1 *An equilibrium with wholesale price discrimination is defined by a tuple $((w_L^*, w_H^*), p^*(w))$, with $w_L^* < w_H^*$, and an optimal sequential search strategy for all consumers such that*

(i) the manufacturer maximizes profits given $p^*(w)$ and consumers' optimal search strategy,

(ii) retailers maximize their retail profits given the wholesale price they observe, their beliefs about the wholesale prices received by other retailers and consumers' optimal search strategy and

(iii) consumers' sequential search strategy is optimal given $((w_L^*, w_H^*), p^*(w))$ and their beliefs about retail prices not yet observed.

Beliefs are updated using Bayes' rule whenever possible.

The above definition does not specify off-the-equilibrium path beliefs. The most common assumption that has been used in papers analysing unobserved contracts with consumer search, is that retailers and consumers hold passive beliefs. Under wholesale price discrimination, however, passive beliefs do not provide enough precision to determine consumers' optimal search behaviour. As we will explain later, in that case consumers have to also form expectations about the cost of the retailer that has deviated.

[18] This last assumption is used in proposition 3 to show the limiting prices if the search cost distribution is concentrated at low values.

3 Uniform Pricing

First, let us consider the case of uniform pricing where all retailers are expected to be charged the same wholesale price w^*. We denote the equilibrium retail price by $p^*(w^*)$. To determine $p^*(w^*)$, we investigate how a retailer's demand depends on his own price, which in turn depends on how consumers' search behaviour reacts to a price deviation. If a retailer deviates to a price $\widetilde{p} > p^*(w^*)$ then a consumer who buys at this price would get a surplus of $\int_{\widetilde{p}}^{\overline{p}} D(p)dp$. Given passive beliefs, only a fraction $1 - G\left(\int_{p^*(w^*)}^{\widetilde{p}} D(p)dp\right)$ will buy from the deviating retailer while all other consumers will continue searching for the equilibrium retail price $p^*(w^*)$.[19] Therefore, a retailer that charges $\widetilde{p}$ will make a profit of:

$$\pi_r(\widetilde{p}, p^*) = \frac{1}{N}\left(1 - G\left(\int_{p^*(w^*)}^{\widetilde{p}} D(p)dp\right)\right) D(\widetilde{p})(\widetilde{p} - w^*).$$

Maximizing this profit and using the equilibrium condition $\widetilde{p}(w^*) = p^*(w^*)$, gives:

$$-g(0)D^2(p^*)(p^* - w^*) + D^{'}(p^*)(p^* - w^*) + D(p^*) \leq 0. \tag{1}$$

In order to understand this condition it is important to start from the standard monopoly retail price condition $D^{'}(p^*(w))(p^*(w) - w) + D(p^*(w)) = 0$. First note that the last two terms in (1) describe the standard monopoly condition for a retail price. The first (negative) term in (1) depicts the first difference compared to the monopoly retail price condition and represents the search effect: in a market with retail competition and consumer search, retailers have less market power compared to a monopolist retailer given that price increases result in the loss of low search cost consumers. Therefore, for a given w, the equilibrium retail price is smaller than the retail monopoly price. The impact of the search cost distribution also becomes clear: if $g(0)$ is large, monopoly considerations are relatively unimportant as the first term dominates whenever p^* is not close to w; if on the other hand $g(0)$ is small, the first term is relatively unimportant and retail prices are close to their monopoly levels.

An additional difference comes from the fact that (1) holds with a weak inequality: given that consumers cannot observe price deviations without searching, retailers cannot attract additional demand and will not have an incentive to deviate to lower prices as long as $p^* \leq p^M(w^*)$. Thus, in line with the search literature, this condition can be satisfied with a weak inequality, which for a given w^* implies the existence of a continuum of

[19] The case of symmetric beliefs is easy to analyse and results in the standard double marginalization outcome for any search cost distribution. If consumers have symmetric out-of-equilibrium beliefs then they believe that the manufacturer has deviated and offered all retailers the same wholesale price. In that case, all consumers with search costs $s > 0$ that first searched a retailer will not want to continue searching as they believe the other retailers charge the same price. In this way, each retailer will act like a monopolist to the consumers that visit him first.

pure-strategy equilibria in the downstream market. Lastly, condition (1) shows that the equilibrium retail price does not depend on the number of retailers.

To determine the wholesale equilibrium price under uniform pricing under unobserved contracts, we should consider that it is not optimal for the manufacturer to deviate to one retailer and offer him a wholesale price $w > w^*$, while keeping the other retailers at w^*. If the manufacturer would deviate in this way and the retailer would react to w by choosing $\widetilde{p}$ (to be determined later), her profits would be:

$$\pi(w^*, w) = w^* D(p^*(w^*)) + \frac{1}{N}\left(1 - G\left(\int_{p^*(w^*)}^{\widetilde{p}} D(p)dp\right)\right)(wD(\widetilde{p}(w)) - w^* D(p^*(w^*))).$$

This expression is easily understood. Of the consumers who come across a price of $\widetilde{p}(w)$ at their first search (which is a fraction $1/N$ of them) a fraction $G\left(\int_{p^*(w^*)}^{\widetilde{p}} D(p)dp\right)$ continues to search for the equilibrium retail price as their search cost is low enough, while the consumers with a search cost larger than $\int_{p^*(w^*)}^{\widetilde{p}} D(p)dp$ will buy at the deviation price $\widetilde{p}(w)$. All other consumers buy at the equilibrium price $p^*(w^*)$. A uniform pricing equilibrium requires that the first-order condition evaluated at $w = w^*$ is non-positive, i.e.,

$$g(0)D(\widetilde{p})\frac{\partial \widetilde{p}}{\partial w}(w^* D(p^*(w^*)) - wD(\widetilde{p}(w))) + \left(1 - G\left(\int_{p^*(w^*)}^{\widetilde{p}} D(p)dp\right)\right)\left(wD'(\widetilde{p})\frac{\partial \widetilde{p}}{\partial w} + D(\widetilde{p})\right)$$

which reduces to

$$w^* D'(p^*(w^*))\frac{\partial \widetilde{p}(w^*)}{\partial w} + D(p^*(w^*)) \leq 0. \tag{2}$$

We now argue that condition 2 also implies that deviating to more retailers is not optimal. First note that as consumers do not observe the wholesale prices (in combination with passive beliefs), they assume that other retailers still charge the equilibrium retail price if they see a non-equilibrium retail price and therefore their search behaviour is unaffected by whether only one or multiple retailers received a non-equilibrium wholesale price. Second, as the retailers do not observe the wholesale prices of their competitors their reactions can also be studied independently of how many retailers get a non-equilibrium price. Finally, even if all retailers get a non-equilibrium price, condition 2 applies and essentially says that the manufacturer does not make more profit per retailer (and thus does not make more profit overall).

Similar to the retailer's behaviour, the manufacturer does not have an incentive to lower his wholesale price as long as $p^* < \min(p^M(w^*), p^M(w^M))$ as retailers will not follow suit and keep their price at the equilibrium level if this condition is satisfied. Thus, the only requirement we have to impose is that the manufacturer does not want to increase her wholesale price and this is what (2) requires. On the other hand, nothing we have said so far precludes the possibility that the solutions to (1) and (2) result in such a high wholesale (and retail) price that $w^* D(p^*(w^*)) < w^M D(p^M(w^M))$. In this case, it would be optimal, however, for the manufacturer to deviate to all retailers by setting w^M and they will respond by setting $p^M(w^M)$. Thus, another condition that an equilibrium needs to fulfil is that the manufacturer's equilibrium profit satisfies $w^* D(p^*(w^*)) \geq w^M D(p^M(w^M))$.

Finally, it is important to note that, when taking the vertical structure into account, for an equilibrium to exist (1) should hold with equality. If (1) would hold with inequality, the manufacturer would have an incentive to set higher wholesale prices as retailers would not react to an increase in the wholesale price. While (1) needs to hold with equality, this does not hold true for (2), which can still hold with inequality.

To finalize the description of an equilibrium, we still have to evaluate how $\widetilde{p}$ depends on the deviation wholesale price w. For this we need to determine the best response function of retailers to non-equilibrium wholesale prices, taking into account that consumers do not observe the manufacturer deviation and blame the individual retailer for any deviation from the equilibrium price. Given the retailers' profit function $\pi_r(\widetilde{p}, p^*) = \frac{1}{N}\left(1 - G\left(\int_{p^*(w^*)}^{\widetilde{p}} D(p)dp\right)\right) D(\widetilde{p})(\widetilde{p} - w)$, an individual retailer will react to upward deviations from w^* by setting $\widetilde{p}$ such that

$$-g\left(\int_{p^*}^{\widetilde{p}} D(p)dp\right) D^2(\widetilde{p})(\widetilde{p} - w) + \left(1 - G\left(\int_{p^*}^{\widetilde{p}} D(p)dp\right)\right)\left(D'(\widetilde{p})(\widetilde{p} - w) + D(\widetilde{p})\right) = 0. \tag{3}$$

Thus, the retailer's best response to any w depends on w itself as well as on the equilibrium price p^* that is expected by consumers. The retailer should not only consider the wholesale price itself, but also how consumers who do not observe the wholesale price react (and this depends on the retail prices they expect). In the proof of the next Proposition we show that evaluated at the equilibrium values we obtain:

$$\frac{\partial \widetilde{p}(w^*)}{\partial w} = \frac{D'(p^*) - g(0)D^2(p^*)}{-g'(0)D^3(p^*)(p^* - w) - 3g(0)D(p^*)D'(p^*)(p^* - w) - 2g(0)D^2(p^*) + 2D'(p^*) + 2D''(p^*)(p^* - w)}. \tag{4}$$

We then have the following result.

Proposition 2 *Under unobserved wholesale contracts, a uniform pricing equilibrium has to satisfy (1) with equality, inequality (2), where* $\frac{\partial \widetilde{p}(w^*)}{\partial w}$ *is given by (4) and* $w^* D(p^*(w^*)) \geq w^M D(p^M(w^M))$.

Note that there can be multiple equilibria due to the fact that the first-order condition of the manufacturer only needs to hold with inequality. When multiple equilibria exist, we focus on the one where the manufacturer makes most profits. This is the equilibrium where (2) holds with equality. Equilibria can be indexed by the wholesale price that retailers and consumers expect the manufacturer to choose. As the manufacturer is a monopolist, we believe it is natural to think that retailers and consumers expect that the manufacturer chooses the equilibrium wholesale price that maximizes her profits, which is the lowest of all equilibrium wholesale prices and is thus also in the interest of consumers.

As (1) has to hold with equality we can see that if $g(0) \to \infty$ we have $p^*(w^*) \to w^*$. Intuitively, when $g(0)$ is large the retail market is very competitive with very small retail margins. Furthermore, when $g(0) \to \infty$ and $p^* \to w^*$ we can solve (2) for w^*. From (4) it is easy to see that if $g(0) \to \infty$ the expression for $\frac{\partial \widetilde{p}(w^*)}{\partial w}$ reduces to $\frac{1}{2}$. The next Proposition states the result.

Proposition 3 *A uniform pricing equilibrium exists if* $g(0) \to \infty$. *As* $g(0) \to \infty$, *the equilibrium retail price* p^* *is close to* w^*, *where* w^* *is such that* $\frac{1}{2}w^*D'(w^*) + D(w^*) \leq 0$ *and* $w^*D(p^*(w^*)) \geq w^M D(p^M(w^M))$. *Moreover, in the manufacturer optimal equilibrium* $\frac{dp^*}{d\frac{1}{g(0)}} = -\frac{x}{D(p^*)} < 0$ *and* $\frac{dw^*}{d\frac{1}{g(0)}} = -\frac{1+x}{D(p^*)} < 0$, *where* $x = \frac{2D'(p^*)}{w^*D''(p^*)+3D'(p^*)}$.

In the context of a Stahl (1989) type model, where a fraction λ of consumers (the shoppers) has zero search cost and the remaining consumers have a search cost $s > 0$, Janssen and Shelegia [2015] show that if the search cost s is small an equilibrium exists if, and only if, λ is large enough. For linear demand, the critical value λ^* is approximately 0.47. The first part of the above Proposition says that if the search cost distribution is concentrated at small values equilibrium existence is not an issue in our model where $g(s) > 0$ for all $s \geq 0$. Thus, our result shows that the equilibrium non-existence result in Janssen and Shelegia [2015] is due to the discreteness of the search cost distribution.

The second part of the Proposition says that when $g(0) \to \infty$, the equilibrium wholesale prices approaches the solution to $\frac{1}{2}w^*D'(w^*)+D(w^*) \leq 0$. In order to understand the implication of this result it is important to recall that the standard integrated monopoly price solves $w^*D'(w^*) + D(w^*) = 0$. Therefore, the proposition establishes that the manufacturer sets a much higher price than an integrated monopolist. This result is akin to Theorem 2 of Janssen and Shelegia [2015] where they show that as $g(0) \to \infty$, wholesale and retail prices converge to a price w^* that solves $\lambda w^*D'(w^*) + D(w^*) = 0$. The reason why equilibrium prices are much higher than the price an integrated monopolist would set (despite the retail margins being close to 0) is that the manufacturer may deviate from the equilibrium price without consumers noticing it. This makes the manufacturer's demand much less elastic to her own price changes than the demand of an integrated monopolist. Theorem 2 of Janssen and Shelegia [2015] is obtained for duopoly retail markets and the Stahl (1989) specification of search costs. The above result shows that the intuition is much more general and holds for any search cost distribution and for any number of retailers. Also, as in Janssen and Shelegia [2015], an equilibrium only exists if λ is large enough, their limit prices tend to be smaller than in our model.

In terms of comparative statics, Proposition 3 shows that $g(0)$ is large both the wholesale and retail price are increasing in $g(0)$. This implies that consumers are better off if search costs are not vanishing. Janssen and Shelegia [2015] have a similar result, but only for the case of linear demand. This result indicates that price comparison websites that effectively reduce search costs and are believed to help consumers in getting better deals may in the end lead to higher prices.

For linear demand $D(p) = 1 - p$, the Proposition implies that in the limit when $g(0) \to \infty$, in the manufacturer optimal equilibrium $w^* \to 2/3$ and expected consumer surplus converges to $\frac{1}{18}$.[20] Using Proposition 3, we have that $\frac{dp^*}{d\bar{s}} = -2$, $\frac{dw^*}{d\bar{s}} = -5$ and $\frac{dECS}{d\bar{s}} = -(1-p^*)\frac{dp^*}{d\bar{s}} = \frac{2}{3}$. Figure 1 shows when $G(s)$ follows a uniform distribution over

[20]Other equilibria are such that $w^* \geq 2/3$, while the condition that deviation to the double marginalization solution is not optimal results in the condition $w^*(1-w^*) \geq 1/8$, or $w^* \leq \frac{2+\sqrt{2}}{4}$.

the interval $[0, \overline{s}]$ how the equilibrium retail and wholesale prices change for different values of $\overline{s}$. For small values of $\overline{s}$ the figure also confirms that both p^* and w^* are decreasing in $\overline{s}$.

As a comparison, it is also useful to compare a benchmark model where the wholesale contracts are observed to consumers. In that case, for every set of values of wholesale prices one can analyze the retail market as a separate subgame: the manufacturer cannot secretly deviate. This has several implications, one of which is that condition (1) can hold with a strict inequality. Considering the manufacturer optimal equilibrium where (1) holds with equality, the figure also plots in red the equilibrium wholesale and retail prices when wholesale contracts are observed to consumers. One sees that if $\overline{s}$ is close to 0, the manufacturer sets the wholesale price at the level of the integrated monopolist as one would expect with a competitive retail market. One also sees that retail margins are increasing in $\overline{s}$ and that the manufacturer accommodates these higher margins by lowering the wholesale price. We see that wholesale and retail prices are much lower than if wholesale contracts are not observed and the main reason is that in the latter case manufacturers face a less elastic demand as explained above.

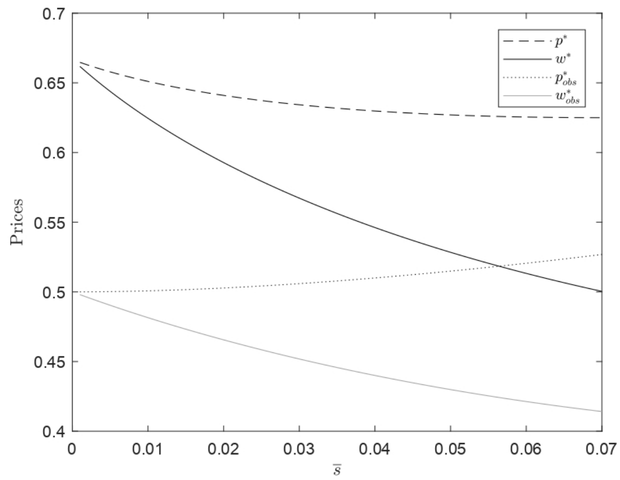

Figure 1: Uniform retail and wholesale prices for different values of $\overline{s}$

4 The effects of regulation on RRPs

In this section, we will analyse the effect of regulation policies on RRPs that are in place in many jurisdictions. Such regulation requires that manufacturers make honest estimations of recommended retail prices. Therefore, in order for manufacturers not to be liable for having engaged in deceptive pricing practices, they have to make sure that at least some sales take place at these list prices. We will show, that this regulation gives rise to another equilibrium in which the manufacturer can price discriminate its retailers. We will show that in this setting, wholesale and retail prices are higher compared to the uniform equilibrium presented in the previous section. Moreover, we will also show that the regulation is instrumental in providing a commitment device in the sense that if the regulation does not hold, an equilibrium with wholesale price discrimination will fail to exist.

4.1 Equilibrium under regulation

As we have explained in the Introduction, many jurisdictions have regulations in place that require at least some sales to take place at RRPs. Such regulations usually acknowledge that many consumers believe that RRPs are prices at which products are generally sold. The regulation also addresses manufacturers' actions by claiming that in order for a manufacturer, that makes use of RRPs, not to be sued for having participated in fictitious pricing it should suggest RRPs that are honest estimates of the actual retail price charged and make sure that at least some sales take place at the RRP. We will show that, by requiring that at least some sales take place at the RRP, such regulation allows the manufacturer to use RRP announcements to commit to wholesale price discrimination.

To illustrate the impact of wholesale price discrimination, consider one example of discrimination where a manufacturer is expected to set a wholesale price of w_L^* to $N-1$ retailers and w_H^* to 1 retailer, but consumers do not know which retailer faces the higher wholesale price. Focusing on two distinct wholesale prices enables a tractable analysis of vertical markets and is consistent with many real-world examples.[21] In subsection 4.3 we discuss how this example helps us to support our general claim that RRPs increase manufacturer's profits and may harm retailers and consumers.

Reacting to these two distinct wholesale prices, the low and high cost retailers, on their part, are expected to set p_L^* and p_H^*, respectively. Under discrimination, consumers with low search costs that come across a high retail price on their first search will simply continue to search for the low retail price. If we let $\widehat{s} = \int_{p_L^*}^{p_H^*} D(p)dp$, then all consumers with search cost $s < \widehat{s}$ will continue to search for p_L^*. To understand how retailers will react to wholesale price discrimination, we have to be more specific here about consumer beliefs and go beyond passive beliefs: after the observation of an out-of-equilibrium price, consumers should also have beliefs about whether a high or a low cost retailer has deviated.

In order for a retail equilibrium to exist, consumers should blame high-cost retailers for deviations to prices in the neighbourhood of p_H^*.

$$s < \widehat{s} + \int_{p_H^*}^{\overline{p}} D(p)dp - \int_{p_H}^{\overline{p}} D(p)dp = \int_{p_L^*}^{p_H} D(p)dp.$$

Thus, the profit of a high cost retailer that deviates to a price p_H in the neighbourhood

[21] In many real-world examples the distribution of wholesale prices has been found to be bimodal with a high (regular) price and a lower (sale) price. This pattern is documented and is a salient feature of the well-known Dominick's database. For a specific example of a beer product we refer the reader to Figure 1 in Garcia et al. [2017]

of p_H^* will be:

$$\pi_r^H(p_H, p_L^*; w_H^*) = \frac{1}{N}\left(1 - G\left(\int_{p_L^*}^{p_H} D(p)dp\right)\right) D(p_H)(p_H - w_H^*). \tag{5}$$

If the low cost retailers were to blame for such deviations, then more consumers would decide to buy and not search after seeing a price of p_H compared to seeing a retailer that sells at p_H^*. Such a deviation would then be profitable for a high cost retailer.[22]

Let us now analyse a low cost retailer's deviation to a price p_L in the neighbourhood of p_L^*. Given that prices are not observed until a consumer visits a specific retailer, deviations to lower prices do not attract more demand and thus are not optimal. We should therefore only focus on analysing deviations to higher prices. When it comes to deviations to prices p_L higher than p_L^*, we are less restricted in specifying consumer's beliefs. We will continue with assuming that if consumers see a price p_L in a neighbourhood of p_L^* that they will blame the low cost retailer.[23] For price deviations that are not in a neighborhood of the low or the high retail equilibrium price, we have more flexibility to specify out-of-equilibrium beliefs as they do not determine the price reactions of retailers and we only need to make sure that retailers and the manufacturer do not have an incentive to deviate. By choosing that consumers blame the low cost retailer, we make sure that no one has an incentive to deviate.

Thus, under these beliefs, deviating to a price p_L, with $p_L^* < p_L < p_H^*$, a low cost retailer's profit function will be:

$$\pi_r^L(p_L; p_L^*, p_H^*, w_L^*) = \tfrac{1}{N}\left[1 - G\left(\tfrac{N-1}{N}\int_{p_L^*}^{p_L} D(p)dp\right) + \tfrac{G\left(\int_{p_L^*}^{p_H^*} D(p)dp\right)}{(N-1)}\right] D(p_L)(p_L - w_L^*). \tag{6}$$

Taking the first-order condition of (5) with respect to p_H and substituting $p_H = p_H^*$ yields

$$-\frac{g(\widehat{s})D^2(p_H^*)(p_H^* - w_H^*)}{1 - G(\widehat{s})} + \left[D'(p_H^*)(p_H^* - w_H^*) + D(p_H^*)\right] = 0. \tag{7}$$

This FOC condition has to hold with equality as a high-cost retailer may also have an incentive to lower price to prevent more consumers from continuing to search. On the other hand, taking the first-order condition of (6) with respect to p_L and evaluating it at p_L^* yields:

[22] If consumers attribute a deviation in the neighbourhood of p_H^* to a low cost retailer, then after observing a price $p_H \neq p_H^*$ they become more pessimistic about finding lower prices on their next search than after observing p_H^*. The main reason is that initially expecting k (with k possibly equal to 1) out of N retailers to have a high price, after observing p_H^* they expect that $N-k$ out of the remaining $N-1$ retailers have a low price. If after observing a marginally different price consumers suddenly expect only $N-k-1$ out of the remaining $N-1$ retailers to have a low price, then fewer consumers continue to search if they observe such a deviation price than after observing p_H^*, making it profitable for a high cost retailer to deviate.

[23] Consumers observing the equilibrium price p_L^* believe that if they continue to search, there is a probability of $\frac{1}{N-1}$ they will observe a price p_H^* on their next search. Consumers observing the equilibrium price p_H^* believe that there is zero probability that they will observe a price p_H^* on their next search.

$$-\frac{\left(\frac{(N-1)^2}{N}g\left(0\right)+g(\widehat{s})\right)D^2(p_L^*)(p_L^*-w_L^*)}{(N-1)+G(\widehat{s})}+\left[D^{'}(p_L^*)(p_L^*-w_L^*)+D(p_L^*)\right]\leq 0. \quad (8)$$

Now, we can analyse the upstream market. The manufacturer's profit function if she deviates in terms of w_H and w_L (to one low cost retailer) and retailers react to these deviations by setting p_H and p_L (to be determined later) is:

$$\begin{aligned}\pi(w_L,w_H)&=\frac{1}{N}\left(1+\frac{1}{(N-1)}G\left(\int_{p_L}^{p_H}D(p)dp\right)-G\left(\frac{N-1}{N}\int_{p_L^*}^{p_L}D(p)dp\right)\right)w_LD(p_L(w_L))\\&+\frac{N-2}{N}\left(1+\frac{G\left(\int_{p_L^*}^{p_H}D(p)dp\right)}{(N-1)}+\frac{G\left(\int_{p_L^*}^{p_L}D(p)dp\right)}{(N-1)(N-2)}+\frac{G\left(\frac{N-1}{N}\int_{p_L^*}^{p_L}D(p)dp\right)}{N-2}\right)w_L^*D(p_L^*(w_L^*))\\&+\frac{1}{N}\left(1-G\left(\int_{p_L^*}^{p_H}D(p)dp\right)\right)w_HD(p_H(w_H)).\end{aligned}$$

This expression can be understood as follows. First, the term $\frac{1}{N}G\left(\int_{p_L^*}^{p_H}D(p)dp\right)$ in the last line is the share of consumers that first saw p_H and continue to search as they believe that all other firms choose p_L^*. The remaining share of these consumers buy at the price p_H. Each of the other retailers gets $1/(N-1)$ of the consumers that continue to search. Retailers charging p_L^* will sell to these consumers, while a retailer that charges p_L will only get a fraction of these consumers, namely those with relatively higher search cost. Since they still believe that the other retailers charge p_L^*, all consumers with a search cost smaller than $G\left(\int_{p_L^*}^{p_L}D(p)dp\right)$ continue searching for the remaining retailers and buy there. Finally, there is a share of consumers that on their first search observes p_L and they continue to search if their search cost is smaller than $\frac{N-1}{N}\int_{p_L^*}^{p_L}D(p)dp$.

The first-order condition for the manufacturer with respect to w_H should be satisfied with equality. The reason is that in an equilibrium with wholesale price discrimination, a fraction $G(\widehat{s})$ of consumers continues to search if observing p_H^* so that both upward and downward deviations in w_H (and subsequently in p_H) affect demand. At w_L^*, however, only upward deviations can be profitable: as consumers will only find out about the deviations once they have visited the retailer in question, downward deviations in retail price (and thus in wholesale prices) do not attract additional demand making such deviations always unprofitable.

Profit maximization by the manufacturer yields the following first-order conditions with respect to w_L and w_H evaluated at the equilibrium wholesale prices yield

$$w_L^*D^{'}(p_L^*(w_L))\frac{\partial p_L}{\partial w_L}+D(p_L^*)\leq 0, \quad (9)$$

and

$$(1-G(\widehat{s}))\left[w_H^*D^{'}(p_H^*)\tfrac{\partial p_H}{\partial w_H}+D(p_H^*)\right]+g(0)D(p_H^*)\tfrac{\partial p_H}{\partial w_H}\left[w_L^*D(p_L^*)-w_H^*D(p_H^*)\right]=0, \quad (10)$$

where the expressions for $\frac{\partial p_L}{\partial w_L}$ and $\frac{\partial p_H}{\partial w_H}$ are given in the Appendix. Note that (9) implies that the manufacturer does not have an incentive to deviate to multiple or even all low-cost retailers.

Proposition 4 *Assume $g(0)$ is large enough and regulation on RRPs (as the one described above) exists and the manufacturer announces p_H^* as the RRP, then an equilibrium with wholesale price discrimination exists and satisfies equations (7), (8), (10) and inequality (9).*

The next Proposition argues that the efficient equilibrium prices under wholesale price discrimination converge to the efficient equilibrium prices in the uniform pricing case if $g(0) \to \infty$. Moreover, the comparative statics with respect to $g(0)$ is such that if $g(0)$ is large enough the lowest wholesale and retail prices behave as in the uniform pricing equilibrium, whereas the highest wholesale and retail price charged are higher. Thus, consumers are worse off because of wholesale price discrimination. Furthermore, a fraction of consumers with low search costs has to search to find the low retail price p_L^*, while under uniform pricing consumers pay lower retail prices without further search.

Proposition 5 *As $g(0) \to \infty$, in a wholesale price discrimination equilibrium, the retail and wholesale prices converge to $p_L^* = w_L^* = p_H^* = w_H^*$, where $w_L^* = w_H^* = w^*$ solves $\frac{1}{2}w^* D'(w^*) + D(w^*) = 0$. Moreover, in a neighbourhood of $\overline{s} = 0$ the comparative statics with respect to $\overline{s}$ are such that*

$$\begin{aligned}
\frac{dp_L^*}{d\overline{s}} &= -\frac{x}{D(p_H^*)}, \frac{dp_H^*}{d\overline{s}} = -\frac{1}{D(p_H^*)}\frac{xN-1}{N}, \\
\frac{dw_L^*}{d\overline{s}} &= -\frac{1+x}{D(p_H^*)} \text{ and } \frac{dw_H^*}{d\overline{s}} = -\frac{1}{D(p_H^*)}\frac{(1+x)N-2}{N},
\end{aligned}$$

where $x = \frac{2D'(p^*)}{w^* D''(p^*) + 3D'(p^*)}$.

Analytical results for search cost distributions where $g(0)$ is not large are difficult to obtain. In the remaining of this section, we show with numerical results that the qualitative conclusions continue to hold by considering linear demand, three retailers and a uniform search cost distribution on $[0, \overline{s}]$. For the uniform search cost distribution taking $\overline{s} \to 0$ is equivalent to $\to \infty$. From the Proposition it thus follows that in a neighbourhood of $\overline{s} = 0$ and $N = 3$, $x = 2/3$, so that $\frac{dp_L^*}{d\overline{s}} \approx -2$, $\frac{dw_L^*}{d\overline{s}} \approx -5$, $\frac{dp_H^*}{d\overline{s}} \approx -1$,$\frac{dw_H^*}{d\overline{s}} \approx -3$. Figure 2(Left) shows how wholesale and retail prices change for different values of $\overline{s}$. It is clear that wholesale and retail prices are decreasing in $\overline{s}$.

Figure 2(Right) shows the difference in consumer surplus under wholesale price discrimination and uniform pricing. From the figure we can see that the impact of wholesale price discrimination on consumer surplus can be quite large. For instance, for an upper bound of the search cost distribution of 0.04, consumer surplus under wholesale price discrimination decreases by approximately 5%.

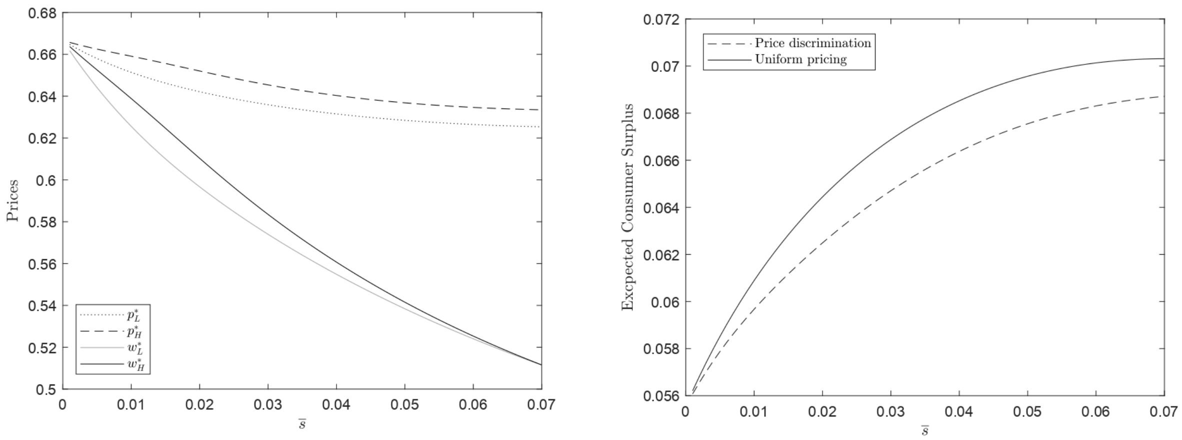

Figure 2: **Left:** Wholesale and Retail prices for different values of $\overline{s}$ and $N = 3$. **Right:** Expected Consumer Surplus for different values of $\overline{s}$ and $N = 3$.

The comparison of retail prices under wholesale price discrimination and uniform pricing is depicted in Figure 3(Left) for general values of $\overline{s}$. It is clear that under wholesale price discrimination, both the low and the high retail prices are larger than the retail price under uniform pricing. The comparison between wholesale prices is depicted in Figure 3(Right) reinforcing Figure 3(Left) in that wholesale prices under wholesale price discrimination are larger than under uniform pricing.

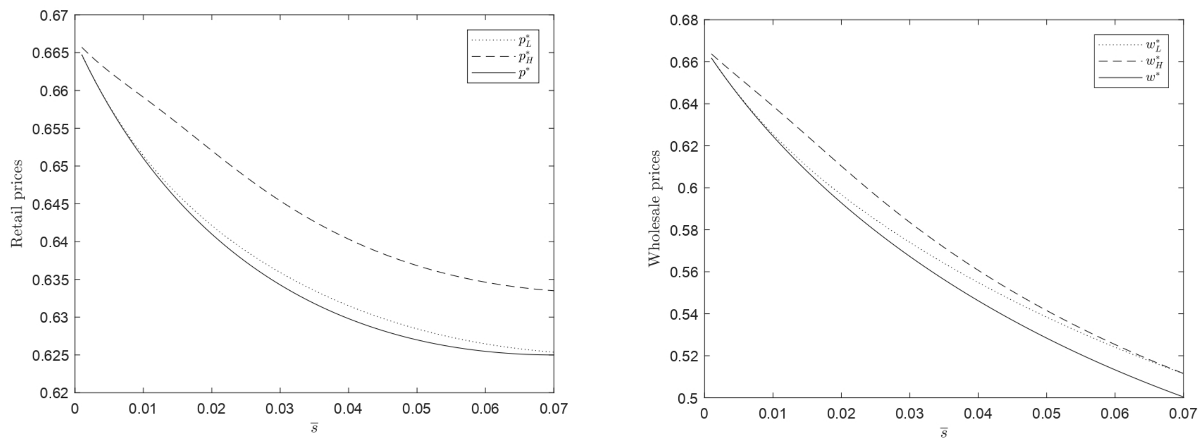

Figure 3: **Left:** Retail prices under uniform pricing and price discrimination and $N = 3$. **Right:** Wholesale prices under uniform pricing and price discrimination and $N = 3$.

Figure 4(Left) shows that both, low and high cost retailers, have lower margins under wholesale price discrimination. Wholesale price discrimination acts as a mechanism that indirectly screens searching consumers: consumers with different search costs react differently to retail prices inducing more competition between retailers. As argued before, low search cost consumers continue to search if they observe a high retail price at their first search, while high search cost consumers immediately buy whatever the retail price they

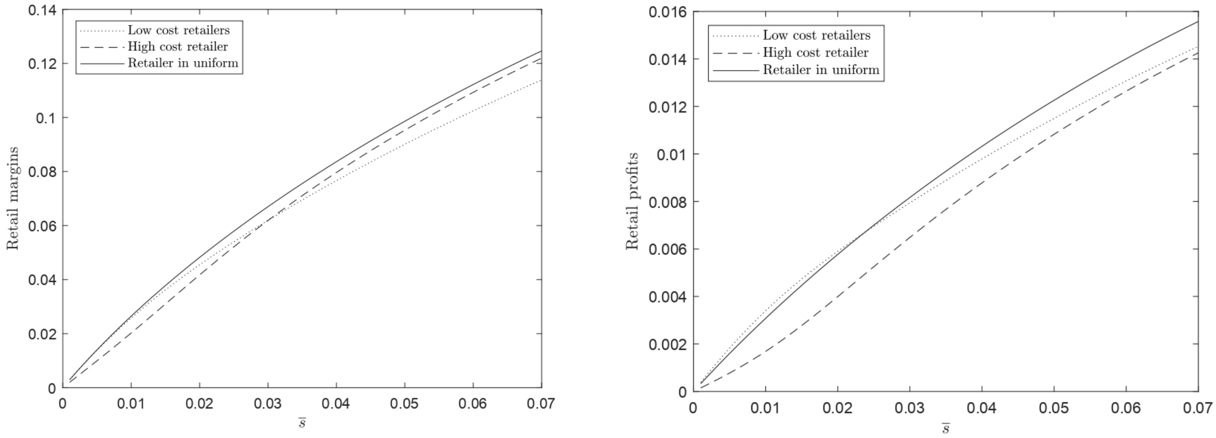

Figure 4: **Left:** Retail margins for different values of $\overline{s}$ and $N = 3$. **Right:** Retailers' Profit for different values of $\overline{s}$ and $N = 3$.

observe. Figure 4(Right) shows the difference in retail profits between uniform pricing and wholesale price discrimination. Despite the lower margins, low cost retailers earn higher profits compared to a retailer under uniform pricing for smaller values of $\overline{s}$. The reason is that the difference in margins is small, while low cost retailers gain more sales due to low cost searchers that first visited the high cost retailer and then continued to search for the low cost retailers. From Propositions 3 and 5 it follows that this is actually a general result for small values of $\overline{s}$: the first-order approximation for retail margins of the low cost retailers under wholesale price discrimination are equal to the ones under uniform pricing, but under price discrimination each of these retailers gets a share of $\frac{1}{N}\left(1 + \frac{1}{N(N-1)}\right)$ of the consumers, while under uniform pricing each retailer gets a share of $\frac{1}{N}$ of the consumers. For larger values of $\overline{s}$, the numerical analysis shows that it is the lower margins that dominate the impact on the low cost retailers' profits. The profit of retailers under uniform pricing are always higher than the profit the high cost retailer makes under wholesale price discrimination. Finally, we confirm in Figure 5 for $N = 3$ that the manufacturer earns higher profit under wholesale price discrimination and that the difference is increasing in $\overline{s}$.

4.2 Equilibrium under no regulation

In markets where wholesale arrangements are unobserved and there is no regulation on RRPs manufacturers are free to deviate from their prices as nobody can observe such changes. The regulation restricts the manufacturer in the sense that it is not free to set wholesale prices to retailers in such a way that all retailers find it optimal to set retail prices below the RRP. For a discriminating equilibrium to exist, apart from the first-order conditions of the manufacturer, that were presented in the previous subsection, we also need to guarantee that the manufacturer does not have an incentive to give all retailers the same wholesale price, whether it is w_L^* or w_H^*. In principle, the manufacturer could set

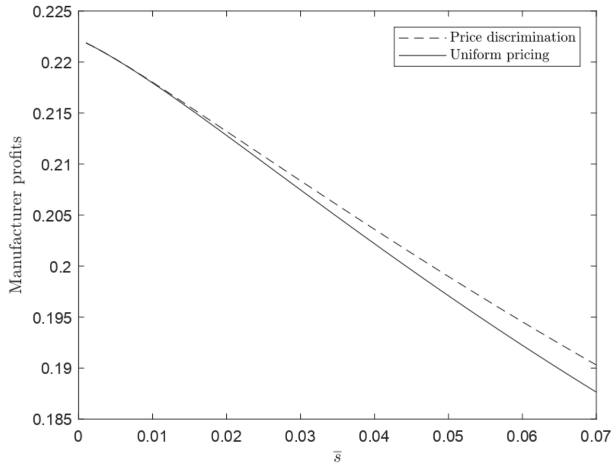

Figure 5: Manufacturer's Profit for different values of $\overline{s}$ and $N = 3$

w_L^* or w_H^* to all retailers without any retailer noticing it at their price setting stage. To make such deviations unprofitable, we have to have that the manufacturer makes equal profits over the low and high cost retailers, thus we need:

$$w_H^* D(p_H^*) = w_L^* D(p_L^*) \tag{11}$$

in any equilibrium with wholesale price discrimination. Given (11) the first-order condition with respect to w_H can be simplified to

$$w_H^* D^{'}(p_H^*) \frac{\partial p_H}{\partial w_H} + D(p_H^*) = 0. \tag{12}$$

The next Proposition shows that, when wholesale contracts are unobserved, the manufacturer cannot commit to its wholesale prices and there does not exist an equilibrium with wholesale price discrimination.

Proposition 6 *Assume there is no regulation on RRPs, then an equilibrium with wholesale price discrimination does not exist.*

The proof of the proposition basically shows that the only way to satisfy the equal profit condition (11) and not to have an incentive to set a different high wholesale price ((12) is satisfied) is for the manufacturer to set a low wholesale price w_L^* for which it has an incentive to deviate. Alternatively, the only way to guarantee that (9) is satisfied, i.e., that the manufacturer does not want to set a higher w_L, is if $w_H^* D(p_H^*) < w_L^* D(p_L^*)$. However, given that retailers do not observe the wholesale prices set to their competitors, the manufacturer would then be able to profitably and secretly deviate and set w_L^* to all retailers. Figure 6 shows that for linear demand if, together with (7), (8) and (12), (9) is satisfied with equality, then $w_H^* D(p_H^*) < w_L^* D(p_L^*)$ for any value of $\overline{s}$. Non-existence of an equilibrium with wholesale price discrimination is thus not only an issue for small enough values of $\overline{s}$.

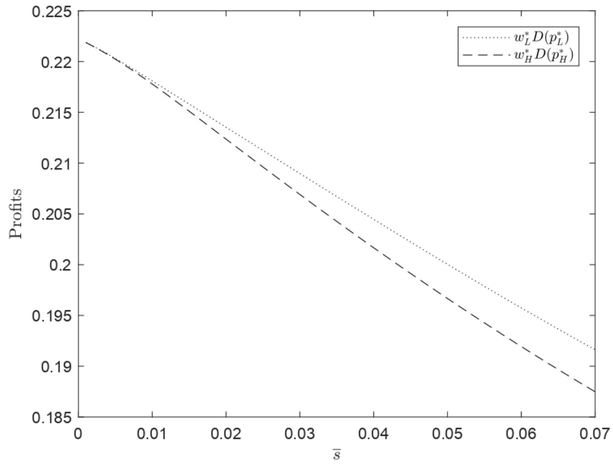

Figure 6: Manufacturer profit over the low and high cost retailers for different values of $\overline{s}$

The regulation on RRPs, imposed by the Code of Federal Regulations, effectively resolves the issue of the non-existence of an equilibrium with wholesale price discrimination and allows the manufacturer to use RRPs to commit to wholesale price discrimination. The manufacturer announces the high retail price p_H^* as an RRP. She is then effectively committed to at least one retailer selling at this price and therefore has to choose w_H^* such that the retailer optimally reacts by setting p_H^*. Other retailers get a lower wholesale price w_L^* and sell at a price below the RRP. The deviation that destroyed the equilibrium with wholesale price discrimination (namely the manufacturer secretly setting the wholesale price w_L^* to all retailers) is penalized by the regulation and therefore not optimal any more. As the remaining equilibrium conditions (7), (8), (9) and (12) imply that $w_H^* D(p_H^*) < w_L^* D(p_L^*)$, the manufacturer is not tempted to set w_H^* to more than one retailer. Note that the observation that recommendations often do not bind in practice as most products sell at a price below the RRP naturally follows from our framework.

4.3 Interpreting the Results

In the previous two subsections, we have focused on two types of equilibria: a uniform price equilibrium in the absence of regulation and a discriminating equilbrium under regulation where one retailer gets a higher wholesale price. We have shown that comparing these two equilibria, the regulation increases manufacturer's profits and harms retailers and consumers. We will now explain how the argumentation underlying the above analysis supports our general claim that RRPs increase manufacturer's profits and may harm retailers and consumers, despite the fact that we have not studied the full set of equilibria.

First, consider markets where $N = 3$, as analysed in our numerical examples. In this case, all alternative ways to discriminate between retailers have one retailer receiving the lowest wholesale price. This would give the retailer with the lowest market price monopoly power up to the second lowest retail price. Generally, this should not be optimal for the manufacturer as she could make more profit by squeezing this retailer more.

Next, consider markets where $N > 3$ and there is no regulation on RRPs in place. In subsection 4.2. we have shown that the equilibrium with price discrimination where the manufacturer only uses two distinct wholesale prices cannot exist without regulation, but we have not formally shown that other discriminatory equilibria with more than two wholesale prices fail to exist. However, the argument we have used in the previous subsection should continue to apply, namely that in any such candidate equilibrium the manufacturer would make more profits over some retailers than over others. The manufacturer would then have an incentive to secretly deviate and charge all retailers the same price. Thus, it is unlikely that without regulation equilibria other than the one with uniform pricing exist.

Finally, consider markets where $N > 3$ and there is regulation in place. The regulation on RRPs grants the manufacturer with the power to commit to only one wholesale price as she can only announce one price as the RRP. If the manufacturer would set more than two distinct wholesale prices, then the argument that the manufacturer should make the same profit over all retailers that it sets different wholesale prices to would apply to all wholesale prices apart from the one that is restricted due to the RRP regulation. In other words, as the manufacturer is free to deviate from all wholesale prices apart from the one that is restricted by the regulation on RRPs the same logic as the one in Section 4.2 should apply to rule out candidate equilibria with more than two distinct wholesale prices.

The above arguments should convey the idea that it is unlikely that other possible equilibria would disprove our general claim. But even if these conjectures are not true, what the above two subsections have shown beyond doubt is that the regulation enables one type of discriminatory equilibrium to exist that would not have done so otherwise. In that discriminatory equilibrium, the manufacturer makes more profit than under uniform pricing, while consumers and retailers are harmed.

Another interesting question concerns the possible effects of a regulation that stipulates that a higher fraction of sales should be made at the RRP. If with N retailers, a manufacturer would not give at least $n > 1$ retailers a high retail price to satisfy the regulation, then this would generally be working against the manufacturer's interest for the following reason. If more than one retailer would receive the high wholesale price, consumers are less inclined to continue to search after seeing a deviation as it becomes more likely that they will discover a high retail price on their next search. This will give retailers more market power, increasing their profit at the expense of the manufacturer. Consumers are likely also going to be worse off as more retailers have higher prices. This effect may be so strong that it may become not optimal for the manufacturer anymore to engage in discriminatory wholesale pricing.

5 Conclusion

This paper contributes to the policy discussion on whether recommended retail prices should be regulated or not. More specifically, we have analysed the role of legislation requiring that a substantial number of sales are made at RRPs. Such regulation was initially introduced by the Federal Trade Commission with the intention of protecting consumers from fictitious retail practices. Since then, many other jurisdictions have introduced similar regulations. We have found that without such legislation equilibria with wholesale price discrimination cannot exist. The reason is that in the absence of such restrictions, wholesale price discrimination can only be an equilibrium when the manufacturer makes identical profits over all retailers (those that received a low and a high wholesale price). If not, the manufacturer may secretly deviate and charge the same wholesale price to all retailers. However, this equal profit condition cannot be satisfied together with the first-order conditions that the low and high wholesale price have to satisfy. Thus, in the absence of the restrictions imposed on RRPs, a manufacturer will sell at a uniform price to all retailers, creating uniform pricing at the retail level.

We have demonstrated that such regulation grants manufacturers with the possibility to commit to their unobserved wholesale prices and allows them to engage in wholesale price discrimination. The discrimination prices are accompanied by an announcement that the retail price of the high cost retailer(s) is the RRP. Once such an announcement is made, the manufacturer is not free to deviate and charge all retailers the same low wholesale price without violating the legislation. When discrimination is enabled, the price dispersion that emerges in the retail market induces consumers to search more. In this way, retail competition intensifies and retailer react less to increases in the wholesale prices. The manufacturer thus faces a less elastic demand and charges higher wholesale prices which result in higher retail prices. Therefore, despite the fact that competition authorities impose such restrictions with the aim of protecting consumers, we have shown that such rulings may actually have the opposite effect on consumer welfare. Crucial to our analysis is that consumers in the retail market have heterogeneous search costs and that they do not know which retailer has which retail (or wholesale) price. In particular, it is important that consumers only observe the retail price they encounter when searching and that they do not know the wholesale arrangements. Retailers, on the other hand, only observe their own wholesale price and are not aware of the prices that other retailers face.

Finally, it is important to point out that in this paper we have focused our attention to the manufacturer's use of RRP announcements and their adherence to the regulation. Regulations regarding RRPs also address the retailers' incentives to stick to RRPs, however. As we discussed before, it is important for our mechanism that consumers do not know retail prices before searching and that is why we have abstracted away from retailers' advertising incentives. In our setup, even if retailers could advertise, however, there would be no distinction between them advertising a certain price or them advertising a certain discount of the RRP if this discount effectively results in the same retail price. The reason is that as consumers are fully rational they will understand the implications of giving a discount of the RRP. Thus, in order to account for retailers' incentives to advertise discounts off of RRPs, one would have to incorporate bounded rationality on the consumer side into the model. This may be an interesting area for future research.

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6 Appendix

Proof of Proposition 2: Apart from the expression for $\frac{\partial \widetilde{p}(w^*)}{\partial w}$ all the equilibrium conditions are explained in the main text. From (3) it follows that:

$$
\begin{aligned}
&- g^{'}\left(\int_{p^*(w^*)}^{\widetilde{p}} D(p)dp\right) D^3(\widetilde{p})(\widetilde{p}-w)\frac{d\widetilde{p}}{dw} - 2g\left(\int_{p^*(w^*)}^{\widetilde{p}} D(p)dp\right) D(\widetilde{p})D^{'}(\widetilde{p})(\widetilde{p}-w)\frac{d\widetilde{p}}{dw} \\
&- g\left(\int_{p^*(w^*)}^{\widetilde{p}} D(p)dp\right) D(\widetilde{p})\left(D^{'}(\widetilde{p})(\widetilde{p}-w)+D(\widetilde{p})\right)\frac{d\widetilde{p}}{dw} - g\left(\int_{p^*(w^*)}^{\widetilde{p}} D(p)dp\right) D^2(\widetilde{p})(\frac{d\widetilde{p}}{dw}-1) \\
&+ \left(1 - G\left(\int_{p^*(w^*)}^{\widetilde{p}} D(p)dp\right)\right)\left(\left(D^{''}(\widetilde{p})(\widetilde{p}-w)+D^{'}(\widetilde{p})\right)\frac{d\widetilde{p}}{dw} + D^{'}(\widetilde{p})(\frac{d\widetilde{p}}{dw}-1)\right) = 0,
\end{aligned}
$$

or,

$$- g^{'}\left(\int_{p^*(w^*)}^{\widetilde{p}} D(p)dp\right) D^3(\widetilde{p})(\widetilde{p}-w)\frac{d\widetilde{p}}{dw} - 3g\left(\int_{p^*(w^*)}^{\widetilde{p}} D(p)dp\right) D(\widetilde{p})D^{'}(\widetilde{p})(\widetilde{p}-w)\frac{\partial\widetilde{p}}{\partial w}$$

$$- g\left(\int_{p^*(w^*)}^{\widetilde{p}} D(p)dp\right) D^2(\widetilde{p})(2\frac{\partial\widetilde{p}}{\partial w}-1) + \left(1-G\left(\int_{p^*(w^*)}^{\widetilde{p}} D(p)dp\right)\right)\left(D^{''}(\widetilde{p})(\widetilde{p}-w)\frac{\partial\widetilde{p}}{\partial w} + D'(\widetilde{p})(2\frac{\partial\widetilde{p}}{\partial w}-1)\right) = 0.$$

Using the fact that we want to evaluate $\frac{d\widetilde{p}}{dw}$ at $w = w^*$ we can use (1) to get

$$-g^{'}(0)\, D^3(\widetilde{p})(\widetilde{p}-w)\frac{d\widetilde{p}}{dw} - 3g(0)D(\widetilde{p})D^{'}(\widetilde{p})(\widetilde{p}-w)\frac{d\widetilde{p}}{dw} - g(0)D^2(\widetilde{p})(2\frac{d\widetilde{p}}{dw}-1)$$

$$+D^{''}(\widetilde{p})(\widetilde{p}-w)\frac{d\widetilde{p}}{dw} + D'(\widetilde{p})(2\frac{d\widetilde{p}}{dw}-1) = 0,$$

which gives the expression in (4).

Proof of Proposition 3: The first part of the Proposition easily follows as the expression for $\frac{\partial\widetilde{p}(w^*)}{\partial w}$ reduces to $\frac{1}{2}$ if $g(0) \to \infty$. To show existence we first show that the manufacturer does not want to *increase* her wholesale price. In particular, we show that

$$D(\widetilde{p}) + wD'(\widetilde{p})\frac{\partial\widetilde{p}}{\partial w} \leq 0 \quad \text{for all } w > w^*.$$

First, note that if the manufacturer deviates and sets a w to one or multiple retailers such that all consumers who visit these retailers continue to search, she cannot make more profit than in equilibrium. In the best case, if the manufacturer sticks to the wholesale equilibrium price for one retailer, she will make the same profit as in equilibrium, while if she deviates to all retailers, she will make less profit as the retailers will react by setting $\widetilde{p} = w$ and $wD(w)$ is decreasing in w for all $w > w^*$ (because $2D'(w) + wD''(w) < 0$ and the equilibrium wholesale price is such that $\frac{1}{2}w^*D^{'}(w^*) + D(w^*) \leq 0$ and thus larger than the optimal price of an integrated monopolist).

Thus, consider deviations such that some consumers still buy from the retailer where the manufacturer has deviated. Given that we impose that $w^*D(p^*) \leq w^M D(p^M(w^M))$, it is clear that the manufacturer does not want to deviate downward as either retailers would not react to such a deviation, or if they do they will set the monopoly price $p^M(w)$ for the manufacturer setting w. In the first case the profit is certainlöy smaller than $w^*D(p^*)$, while in the second case profit is smaller than $w^M D(p^M(w^M))$ Upward deviations are not profitable if the derivative of the LHS of the above inequality with respect to w is such that

$$2D'(\widetilde{p})\frac{\partial\widetilde{p}}{\partial w} + wD''(\widetilde{p})\left(\frac{\partial\widetilde{p}}{\partial w}\right)^2 + wD'(\widetilde{p})\frac{\partial^2\widetilde{p}}{\partial w^2} < 0 \quad \text{for all } w > w^*. \tag{13}$$

If $g(0) \to \infty$, $\frac{\partial\widetilde{p}}{\partial w}$ can be approximated by

$$\frac{d\widetilde{p}}{dw} = \frac{1}{2 + \frac{3D^{'}(\widetilde{p})(\widetilde{p}-w)}{D(\widetilde{p})}} > \frac{1}{2}.$$

As $\lim_{\overline{0}\to\infty} \frac{\partial\widetilde{p}}{\partial w} = \frac{1}{2}$, it must be the case that $\frac{\partial^2\widetilde{p}}{\partial w^2} > 0$ for large enough values of $g(0)$. Thus, (13) holds true if $(2D'(\widetilde{p}) + wD''(\widetilde{p}))\,\frac{\partial\widetilde{p}}{\partial w} < 0$. This is certainly the case as $2D'(\widetilde{p}) + wD''(\widetilde{p}) \approx 2D'(w) + wD''(w) < 0$ for large enough values of $g(0)$ and $\frac{\partial\widetilde{p}}{\partial w} > 0$.

To establish that an equilibrium exists for for large enough values of $g(0)$, we also have to consider the retailer's decision problem. It is clear that downward deviations are not optimal for the retailer as they do not attract new customers by doing so. From the retailer's profit function, it follows that for all $\widetilde{p} \geq p^*$ the first-order derivative equals

$$-g\left(\int_{p^*}^{\widetilde{p}} D(p)dp\right) D^2(\widetilde{p})(\widetilde{p}-w) + D^{'}(\widetilde{p})(\widetilde{p}-w) + D(\widetilde{p}),$$

while the second-order derivative equals:

$$-g'\left(\int_{p^*}^{\widetilde{p}} D(p)dp\right) D^3(\widetilde{p})(\widetilde{p}-w) - g\left(\int_{p^*}^{\widetilde{p}} D(p)dp\right) D(\widetilde{p})\left(2D^{'}(\widetilde{p})(\widetilde{p}-w) + D(\widetilde{p})\right) + D^{''}(\widetilde{p})(\widetilde{p}-w) + 2D^{'}(\widetilde{p}).$$

As $(\widetilde{p}-w)$ is close to 0 if $g(0)$ is large and as $g'(s) > -M$ this expression is smaller than 0. Thus, for large enough values of $g(0)$ the profit function is concave and the retailers' FOC yields the global maximum.

To prove the comparative statics results, we first rewrite the equilibrium condition for the manufacturer in a manufacturer-optimal equilibrium for large enough values of $g(0)$ as

$$\begin{aligned} 0 &= wD'(p^*)\left(\frac{D'(p^*)}{g(0)} - D^2(p^*)\right) - 3D^2(p^*)D^{'}(p^*)(p^*-w) - 2D^3(p^*) \\ &\quad + \frac{2D'(p^*)D(p^*) + 2D^{''}(p^*)D(p^*)(p^*-w) - g^{'}(0)\, D^4(p^*)(p^*-w)}{g(0)}. \end{aligned}$$

Taking the total differential and taking into account that if $g(0) \to \infty$ this approximately yields

$$\begin{aligned} 0 &\approx D'(p^*)\left(w^*D'(p^*) + 2D(p^*)\right) d\frac{1}{g(0)} + 2D'(p^*)D^2(p^*)dw \\ &\quad + \left(-w^*D''(p^*)D^2(p^*) - 2w^*D'^2(p^*)D(p^*) - 9D^2(p^*)\; D^{'}(p^*)\right) dp^*. \end{aligned}$$

As $\frac{1}{2}w^*D'(p^*) + D(p^*) = 0$ the first term is approximately equal to 0 so that we have

$$dw^* = \frac{w^*D''(p^*) + 5D^{'}(p^*)}{2D'(p^*)} dp^*.$$

Taking the total differential of the first-order condition (1) of the retailer evaluated for large enough values of $g(0)$ yields approximately

$$d\frac{1}{g(0)} + D(p^*)dw^* - D(p^*)dp^* = 0.$$

Combining these two equations gives

$$\frac{dw^*}{d\frac{1}{g(0)}} = -\frac{w^*D''\;(p^*) + 5D^{'}(p^*)}{D(p^*)\left(w^*D''(p^*) + 3D^{'}(p^*)\right)}.$$

As the demand function satisfies $w^* D''(p^*) + 2D'(p^*) < 0$ it follows that both $\frac{dw^*}{d\frac{1}{g(0)}}$ and $\frac{dp^*}{d\frac{1}{g(0)}}t$ are negative.

Proof of Proposition 4. In an equilibrium the FOCs for profit maximization for both retailers should be satisfied. For the high-cost retailer the FOC can be written as

$$-g\left(\widehat{s}+\int_{p_H^*}^{p_H} D(p)dp\right) D^2(p_H)(p_H-w_H)+\left(1-G\left(\widehat{s}+\int_{p_H^*}^{p_H} D(p)dp\right)\right)\left[D'(p_H)(p_H-w_H)+D(p_H)\right]. \tag{14}$$

Taking the total differential gives

$$\begin{aligned}
&-3g\left(\widehat{s}+\int_{p_H^*}^{p_H} D(p)dp\right) D(p_H)D'(p_H)(p_H-w_H)\frac{dp_H}{dw_H}\\
&-g\left(\widehat{s}+\int_{p_H^*}^{p_H} D(p)dp\right) D^2(p_H)(2\frac{dp_H}{dw_H}-1)-g'\left(\widehat{s}+\int_{p_H^*}^{p_H} D(p)dp\right) D^3(p_H)(p_H-w_H)\frac{dp_H}{dw_H}+\\
&\left(1-G\left(\widehat{s}+\int_{p_H^*}^{p_H} D(p)dp\right)\right)\left[D''(p_H)(p_H-w_H)\frac{dp_H}{dw_H}+D'(p_H)(2\frac{dp_H}{dw_H}-1)\right]=0,
\end{aligned}$$

which evaluated at the equilibrium values yields

$$\begin{aligned}
&-g'\left(\widehat{s}\right) D^3(p_H^*)(p_H^*-w_H^*)\frac{dp_H}{dw_H}-3g\left(\widehat{s}\right) D(p_H^*)D'(p_H^*)(p_H^*-w_H^*)\frac{dp_H}{dw_H}\\
&+\left(1-G\left(\widehat{s}\right)\right)\left[D''(p_H^*)(p_H^*-w_H^*)\frac{dp_H}{dw_H}+D'(p_H^*)(2\frac{dp_H}{dw_H}-1)\right]\\
&-g\left(\widehat{s}\right) D^2(p_H^*)(2\frac{dp_H}{dw_H}-1)=0.
\end{aligned}$$

Thus, $\frac{dp_H}{dw_H}$ is:

$$\frac{(1-G(\widehat{s}))D'(p_H^*)-g(\widehat{s})D^2(p_H^*)}{-g'(\widehat{s})D^3(p_H^*)(p_H^*-w_H^*)-3g(\widehat{s})D(p_H^*)D'(p_H^*)(p_H^*-w_H^*)+(1-G(\widehat{s}))\left[D''(p_H^*)(p_H^*-w_H^*)+2D'(p_H^*)\right]-2g(\widehat{s})D^2(p_H^*)}.$$

Using the first-order condition (7), we can rewrite

$$\frac{dp_H}{dw_H}=\frac{-\frac{D(p_H^*)}{(p_H^*-w_H^*)}}{-\left(3D'(p_H^*)+\frac{g'(\widehat{s})}{g(\widehat{s})}\right)\left[\frac{D'(p_H^*)(p_H^*-w_H^*)}{D(p_H^*)}+1\right]+D''(p_H^*)(p_H^*-w_H^*)-\frac{2D(p_H^*)}{(p_H^*-w_H^*)}}. \tag{15}$$

For the low-cost retailer we can perform a similar analysis to evaluate $\frac{\partial p_L}{\partial w_L}$. Taking the first-order condition of (6) with respect to p_L yields

$$\begin{aligned}
0=&\left[1-G\left(\frac{N-1}{N}\int_{p_L^*}^{p_L} D(p)dp\right)+\frac{G\left(\int_{p_L}^{p_H^*} D(p)dp\right)}{(N-1)}\right]\left[D'(p_L)(p_L-w_L)+D(p_L)\right]\\
&-\left(\frac{N-1}{N}g\left(\frac{N-1}{N}\int_{p_L^*}^{p_L} D(p)dp\right)+\frac{g\left(\int_{p_L}^{p_H^*} D(p)dp\right)}{N-1}\right) D^2(p_L)(p_L-w_L).
\end{aligned}$$

Taking the total differential and inserting equilibrium values gives

$$
\begin{aligned}
0 &= -\left[\frac{N-1}{N}g\left(0\right)+\frac{g\left(\widehat{s}\right)}{N-1}\right]D(p_L)\left[D'(p_L)(p_L-w_L)+D(p_L)\right]\frac{dp_L}{dw_L}+ \\
&\left[1+\frac{G\left(\widehat{s}\right)}{(N-1)}\right]\left[D''(p_L)(p_L-w_L)\frac{dp_L}{dw_L}+D'(p_L)(2\frac{dp_L}{dw_L}-1)\right] \\
&-\left(\left(\frac{N-1}{N}\right)^2 g'\left(0\right)-\frac{g'\left(\widehat{s}\right)}{N-1}\right)D^3(p_L)(p_L-w_L)\frac{dp_L}{dw_L} \\
&-\left(\frac{N-1}{N}g\left(0\right)+\frac{g\left(\widehat{s}\right)}{N-1}\right)D(p_L)\left(2D'(p_L)(p_L-w_L)\frac{dp_L}{dw_L}+D(p_L)(\frac{dp_L}{dw_L}-1)\right),
\end{aligned}
$$

which can be rewritten as

$$
\begin{aligned}
0 &= -3\left[\frac{N-1}{N}g\left(0\right)+\frac{g\left(\widehat{s}\right)}{N-1}\right]D(p_L)D'(p_L)(p_L-w_L)\frac{dp_L}{dw_L}+ \\
&\left[1+\frac{G\left(\widehat{s}\right)}{(N-1)}\right]\left[D''(p_L)(p_L-w_L)\frac{dp_L}{dw_L}+D'(p_L)(2\frac{dp_L}{dw_L}-1)\right] \\
&-\left(\left(\frac{N-1}{N}\right)^2 g'\left(0\right)-\frac{g'\left(\widehat{s}\right)}{N-1}\right)D^3(p_L)(p_L-w_L)\frac{dp_L}{dw_L} \\
&-\left(\frac{N-1}{N}g\left(0\right)+\frac{g\left(\widehat{s}\right)}{N-1}\right)D^2(p_L)(2\frac{dp_L}{dw_L}-1),
\end{aligned}
$$

or

$$
\frac{dp_L}{dw_L}=\frac{\left[1+\frac{G(\widehat{s})}{(N-1)}\right]D'(p_L^*)-\left(\frac{N-1}{N}g(0)+\frac{g(\widehat{s})}{N-1}\right)D^2(p_L^*)}{-\left(\left(\frac{N-1}{N}\right)^2 g'(0)-\frac{g'(\widehat{s})}{N-1}\right)D^3(p_L^*)(p_L^*-w_L^*)-\left[\frac{N-1}{N}g(0)+\frac{g(\widehat{s})}{N-1}\right]\left(3D(p_L^*)D'(p_L^*)(p_L^*-w_L^*)+2D^2(p_L^*)\right)+\left[1+\frac{G(\widehat{s})}{(N-1)}\right]\left[D''(p_L^*)(p_L^*-w_L^*)+2D'(p_L^*)\right]} \tag{16}
$$

Using the first-order condition (8) evaluated at equilibrium values, we can rewrite

$$
\frac{dp_L}{dw_L}=\frac{-\frac{D(p_L^*)}{(p_L^*-w_L^*)}}{-\left[\frac{D'(p_L^*)}{D(p_L^*)}(p_L^*-w_L^*)+1\right]\left(3D'(p_L^*)+\frac{\left(\frac{N-1}{N}\right)^2 g'(0)-\frac{g'(\widehat{s})}{N-1}}{\left(\frac{N-1}{N}g(0)+\frac{g(\widehat{s})}{N-1}\right)}\right)+D''(p_L^*)(p_L^*-w_L^*)-\frac{2D(p_L^*)}{p_L^*-w_L^*}}. \tag{17}
$$

Next, we will show, separately for both both w_H^* and w_L^*, that the manufacturer does not want to increase these respective wholesale prices beyond their equilibrium values. It is clear that the manufacturer does not want to increase its prices such that all consumers visiting that retailer will continue to search. In addition, in the range of prices where some consumers continue to buy from a retailer it suffices that the second-order derivative of the manufacturer's profit function with respect to $w_i, i = L, H$, is negative, i.e.,

$$
2D'(\widetilde{p}_i)\frac{\partial\widetilde{p}_i}{\partial w_i}+w_iD''(\widetilde{p}_i)\left(\frac{\partial\widetilde{p}_i}{\partial w_i}\right)^2+w_iD'(\widetilde{p}_i)\frac{\partial^2\widetilde{p}_i}{\partial w_i^2}<0 \quad \text{for } i=L,H \text{ and all } w>w^*.
$$

From (15) it follows that when $g(s)\to\infty$ $\frac{\partial\widetilde{p}_H}{\partial w_H}$ can be approximated by

$$
\frac{\partial\widetilde{p}_H}{\partial w_H}\approx\frac{1}{2}+\frac{3D'(p_H^*)(p_H-w_H)}{-4D(p_H)}>\frac{1}{2}.
$$

Similarly, when $g(s) \to \infty$ (17) can be approximated by

$$\frac{\partial \widetilde{p}_L}{\partial w_L} \approx \frac{1}{2} + \frac{3D'(p_L^*)(p_L - w_L)}{-2D(p_L)} > \frac{1}{2}.$$

Thus, we can argue that $\frac{\partial^2 \widetilde{p}_i}{\partial w_i^2} > 0, i = L, H$ if $g(0)$ is large enough. Therefore, the second-order condition is satisfied and the manufacturer does not want to increase her wholesale prices beyond their equilibrium values.

To show that the manufacturer does not want to deviate with multiple wholesale prices, we proceed in a few steps. First, it is clear that the manufacturer does not want to decrease w_L, as these retailers will not follow suit in lowering retail prices in response. Second, consider an increase in w_H and an increase in one or more w_L's. From the above it is clear that, keeping all w_L's at their equilibrium values, an increase in w_H cannot increase profits, despite the fact that $w_H^* D(p_H^*) < w_L^* D(p_L^*)$. As it follows from (9) that $w_L D(p_L(w_L))$ is decreasing in w_L it cannot be the case that increasing w_H and one or more w_L's is profitable. Third, and similar to the second step, one can argue that a decrease in w_H combined with an increase in one or more w_L's is not profitable.

Finally, we need to show that in the equilibrium $w_L^* D(p_L^*) > w_H^* D(p_H^*)$ so that the manufacturer does not want to set w_H^* to more firms (while the regulation requiring some sales to occur at p_H^* after announcing p_H^* as the RRP prevents the manufacturer to charge all firms w_L^*. This part of the proof relies heavily on the proof of Proposition 6. First, from that proof we know that $w_L^* D(p_L^*)$ cannot be equal to $w_H^* D(p_H^*)$. Suppose then that $w_L^* D(p_L^*) < w_H^* D(p_H^*)$. From (10) it then follows that $w_H^* D'(p_H^*) \frac{\partial p_H}{\partial w_H} + D(p_H^*) > 0$. We need to show that this implies that $w_L^* D'(p_L^*) \frac{\partial p_L}{\partial w_L} + D(p_L^*) > 0$. We can follow the same steps as in the proof of Proposition 6. In particular, we can use (23) and use that from the hypothesis that $w_L^* D(p_L^*) < w_H^* D(p_H^*)$ in a neighbourhood of $\overline{s} = 0$ (while $w_L^* D(p_L^*) = w_H^* D(p_H^*)$ at $\overline{s} = 0$) it follows that $D(p^*) dw_L + w^* D'(p^*) dp_L < D(p^*) dw_H + w^* D'(p^*) dp_H$ so that $dw_H - dw_L > 2\,(dp_H - dp_L)$ and continue using the proof of Proposition 6.

Proof of Proposition 5. We will show that if an equilibrium exists, it must be that $\frac{1}{2} w^* D'(w^*) + D(w^*) = 0$ in the limit where $g(0) \to \infty$. From (7) it is clear that in any equilibrium with wholesale price discrimination $p_H^* \to w_H^*$. As $0 < \widehat{s} < \overline{s}$, where $\widehat{s} = \int_{p_L^*}^{p_H^*} D(p)dp$, it must be the case that $p_H^* \to p_L^*$ if $g(0) \to \infty$. Next, consider (8) if $g(0) \to \infty$. Since $\overline{s} \to 0$ as $g(0) \to \infty$ also $\hat{s} \to 0$, and $D'(p_L^*) < 0$ while $D(p_L^*) > 0$ it must be that in any equilibrium with wholesale price discrimination $p_L^* \to w_L^*$. Thus, if $g(0) \to \infty$ it follows that $p_H^* \approx p_L^* \approx w_H^* \approx w_L^*$. It remains to be seen to which values the wholesale and retail prices converge. Consider (10) and that (16) implies that $\frac{\partial p_L}{\partial w_L} \approx \frac{1}{2}$ as $g(0)$ is large where $p_L^* - w_L^* \approx 0$ the first-order condition determining w_L^* can be simplified to $\frac{1}{2} w_L^* D'(w_L^*) + D(w_L^*) \approx 0$.

We now prove the comparative statics results assuming an equilibrium exists and come back to the existence issue at the end of the proof. Substituting (17), (9) can be written as

$$
\begin{aligned}
0 &= -w_L^* D^{'}(p_L^*)D(p_L^*) + D''(p_L^*)2D(p_L^*)(p_L^* - w_L^*)^2 - 2D^2(p_L^*) \\
&\quad - \left[D'(p_L^*)(p_L^* - w_L^*)^2 + D(p_L^*)(p_L^* - w_L^*)\right] \left(3D'(p_L^*) + \frac{\left(\frac{N-1}{N}\right)^2 g'(0) - \frac{g'(\widehat{s})}{N-1}}{\left(\frac{N-1}{N} g(0) + \frac{g(\widehat{s})}{N-1}\right)}\right).
\end{aligned}
$$

Taking the total differential when $p_L^* \approx w_L^*$ and $g(0)$ and $g(\widehat{s})$ are large, gives

$$
-D(p_L^*)D'(p_L^*)dw_L^* - w_L^* \left(D(p_L^*)D''(p_L^*) + D'^2(p_L^*)\right) dp_L^* - 4D(p_L^*)D'(p_L^*)dp_L^* - 3D^{'}(p_L^*)D(p_L^*)\left(dp_L^* - dw_L^*\right) \approx 0,
$$

which can be rewritten as

$$
2D'(p_L^*)dw_L^* - \left(w_L^* D''(p_L^*) + w_L^* \frac{D'^2(p_L^*)}{D(p_L^*)} + 7D'(p_L^*)\right) dp_L^* \approx 0.
$$

Thus, we have

$$
dw_L^* \approx \left(\frac{w_L^* D''(p_L^*) + 5D'(p_L^*)}{2D'(p_L^*)}\right) dp_L^*. \tag{18}
$$

As $g'(s)$ is bounded we can approximate $G(\widehat{s})$ in a neighbourhood of $\overline{s} = 0$ by $g(0)\int_{p_L^*}^{p_H^*} D(p)dp$ and approximate the first-order condition of the low-cost retailer as

$$
\begin{aligned}
0 \approx & -\left(\frac{(N-1)^2}{N} + 1\right) D^2(p_L^*)(p_L^* - w_L^*) + \int_{p_L^*}^{p_H^*} D(p)dp \left[D^{'}(p_L^*)(p_L^* - w_L^*) + D(p_L^*)\right] + \\
& \frac{(N-1)\left[D^{'}(p_L^*)(p_L^* - w_L^*) + D(p_L^*)\right]}{g(0)}.
\end{aligned}
$$

Taking the total differential in a neighbourhood of $\overline{s} = 0$ gives

$$
0 \approx -\left(\frac{(N-1)^2}{N} + 1\right) D(p_L^*)(dp_L^* - dw_L^*) + (N-1)d\frac{1}{g(0)} + D(p_L^*)dp_H^* - D(p_L^*)dp_L^*. \tag{19}
$$

Similarly, we can rewrite the first-order condition of the high-cost retailer as

$$
-D^2(p_H^*)(p_H^* - w_H) - \left[D^{'}(p_H^*)(p_H^* - w_H) + D(p_H^*)\right] \int_{p_L^*}^{p_H^*} D(p)dp + \frac{\left[D^{'}(p_H^*)(p_H^* - w_H) + D(p_H^*)\right]}{g(0)} \approx 0.
$$

Taking the total differential in a neighbourhood of $\overline{s} = 0$ gives

$$
-D^2(p_H^*)(dp_H^* - dw_H) + D(p_H^*)d\frac{1}{g(0)} - D^2(p_H^*)dp_H^* + D(p_H^*)D(p_L^*)dp_L^* \approx 0,
$$

or

$$
-D(p_H^*)(2dp_H^* - dw_H) + d\frac{1}{g(0)} + D(p_H^*)dp_L^* \approx 0, \tag{20}
$$

Finally, we consider the first-order condition of the manufacturer for the high-cost wholesale price

$$(1-G(\widehat{s}))\left[w_H^* D'(p_H^*)\tfrac{\partial p_H}{\partial w_H}+D(p_H^*)\right]+g(0)D(p_H^*)\tfrac{\partial p_H}{\partial w_H}\left[w_L^* D(p_L^*)-w_H^* D(p_H^*)\right]=0.$$

This can be approximated as

$$\left(\tfrac{1}{g(0)}-\int_{p_L^*}^{p_H^*} D(p)dp\right)\left[w_H^* D'(p_H^*)\tfrac{\partial p_H}{\partial w_H}+D(p_H^*)\right]+D(p_H^*)\tfrac{\partial p_H}{\partial w_H}\left[w_L^* D(p_L^*)-w_H^* D(p_H^*)\right]\approx 0,$$

so that the total differential in a neighbourhood of $\overline{s}=0$ yields

$$w_L^* D'(p_L^*)dp_L^* + D(p_L^*)dw_L^* \approx w_H^* D'(p_H^*)dp_H^* + D(p_H^*)dw_H^*,$$

or, using $w_L^* D'(p_L^*)\frac{1}{2}+D(p_L^*)=0$,

$$-2dp_L^* + dw_L^* \approx -2dp_H^* + dw_H^*, \tag{21}$$

Thus, we should solve the four equations (18), (19), (20) and (21) to solve for the respective derivatives. Combining (20) and (21) gives

$$D(p_H^*)(dp_L^* - dw_L^*) \approx d\frac{1}{g\left(0\right)}. \tag{22}$$

Combined with (18) gives

$$dp_L^* \approx -\frac{1}{D(p_H^*)}\frac{2D'(p_L^*)}{w_L^* D''(p_L^*)+3D'(p_L^*)}d\frac{1}{g\left(0\right)},$$

and

$$dw_L^* \approx -\frac{1}{D(p_H^*)}\frac{w_L^* D''(p_L^*)+5D'(p_L^*)}{w_L^* D''(p_L^*)+3D'(p_L^*)}d\frac{1}{g\left(0\right)}$$

Substitute (22) into (19) gives

$$-\frac{1}{N}(dp_L^* - dw_L^*) + dp_H^* - dp_L^* \approx 0.$$

Combined with the expressions for dp_L^* and dw_L^* gives

$$dp_H^* \approx -\frac{1}{D(p_H^*)}\left(-\frac{1}{N}+\frac{2D'(p_L^*)}{w_L^* D''(p_L^*)+3D'(p_L^*)}\right)d\frac{1}{g\left(0\right)}.$$

Substituting all expressions into (21) yields

$$\begin{aligned} dw_H^* &\approx 2\left(dp_H^* - dp_L^*\right) + dw_L^* \approx \frac{2}{N}\left(dp_L^* - dw_L^*\right) + dw_L^* \\ &\approx -\frac{1}{D(p_H^*)}\left(-\frac{2}{N}+\frac{w_L^* D''(p_L^*)+5D'(p_L^*)}{w_L^* D''(p_L^*)+3D'(p_L^*)}\right)d\frac{1}{g\left(0\right)}. \end{aligned}$$

This proves the comparative statics results.

Proof of Proposition 6.

We prove that when $g(0)$ is large we have that if (12), then: $w_L^* D'(p_L^*) \frac{\partial p_L}{\partial w_L} + D(p_L^*)$

$$\approx w_L^* D'(p_L^*) \left(\frac{\partial p_H}{\partial w_H} - \frac{\left(3D'(p_L^*) + \frac{\left(\frac{N-1}{N}\right)^2 g'(0) - \frac{g'(\widehat{s})}{N-1}}{\left(\frac{N-1}{N} g(0) + \frac{g(\widehat{s})}{N-1}\right)}\right)(p_H^* - w_H^*)}{4D(p_L^*)} + \frac{\left(3D'(p_H^*) + \frac{g'(\widehat{s})}{g(\widehat{s})}\right)(p_L^* - w_L^*)}{4D(p_H^*)} \right) + D(p_L^*) > 0.$$

Our claim is true if

$$\begin{aligned} 0 > \quad & (w_H^* D'(p_H^*) - w_L^* D'(p_L^*)) \frac{\partial p_H}{\partial w_H} + D(p_H^*) - D(p_L^*) + \\ & w_L^* D'(p_L^*) \left(\frac{\left(3D'(p_L^*) + \frac{\left(\frac{N-1}{N}\right)^2 g'(0) - \frac{g'(\widehat{s})}{N-1}}{\left(\frac{N-1}{N} g(0) + \frac{g(\widehat{s})}{N-1}\right)}\right)(p_H^* - w_H^*)}{4D(p_L^*)} - \frac{\left(3D'(p_H^*) + \frac{g'(\widehat{s})}{g(\widehat{s})}\right)(p_L^* - w_L^*)}{4D(p_H^*)} \right). \end{aligned}$$

When $g(0)$ is large, we can write $w_i^* = w^* + dw_i, D(p_i^*) = D(p^*) + D'(p_i^*)dp_i^*$ and $D'(p_i^*) = D'(p^*) + D''(p_i^*)dp_i^*$, $i = L, H$. Thus, the first-order approximation of the right-hand side is

$$\begin{aligned} & 0 > (D'(p^*)(dw_H - dw_L) + w^* D''(p^*)(dp_H - dp_L)) \frac{\partial p_H}{\partial w_H} + D'(p^*)(dp_H - dp_L) \\ & - w^* \frac{D'(p^*)}{4D(p^*)} \left(3D'(p^*) \left(dw_H - dw_L - (dp_H - dp_L)\right) - \frac{\left(\frac{N-1}{N}\right)^2 g'(0) - \frac{g'(\widehat{s})}{N-1}}{\left(\frac{N-1}{N} g(0) + \frac{g(\widehat{s})}{N-1}\right)} (dp_H - dw_H) + \frac{g'(\widehat{s})}{g(\widehat{s})} (dp_L - dw_L) \right). \end{aligned} \tag{23}$$

From the equal profit condition $w_L^* D(p_L^*) = w_H^* D(p_H^*)$ it follows that $D(p^*)dw_L + w^* D'(p^*)dp_L = D(p^*)dw_H + w^* D'(p^*)dp_H$ so that using $\frac{1}{2} w^* D'(p^*) + D(p^*) = 0$ we have $dw_H - dw_L \approx 2 (dp_H - dp_L)$. As $g(0) \to \infty$ and $g'(s)$ is bounded so that $\frac{g'(\widehat{s})}{g(\widehat{s})}$ also approaches 0, we can rewrite (23) as

$$\left(w^* D''(p^*) \frac{\partial p_H}{\partial w_H} + 2D'(p^*) - \frac{3}{4} \frac{w^* D'^2(p^*)}{D(p^*)} \right) (dp_H - dp_L) < 0.$$

This clearly needs to be the case as in an equilibrium with wholesale price discrimination $dp_H - dp_L > 0$, whereas $w^* D''(p^*) \frac{\partial p_H}{\partial w_H} + 2D'(p^*) < 0$ because of the second-order condition for profit maximization.