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Multi-Product Pricing and Minimum Resale Price Maintenance*

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Abstract

We provide a novel explanation for why manufacturers want to enforce a minimum resale price (min RPM) on retailers. A manufacturer sells her good via a multi-product retailer to final consumers by charging a linear wholesale price. The manufacturer then maximizes her profit through min RPM whenever the Edgeworth taxation paradox (ETP) occurs, that is, whenever the retailer could increase profits by decreasing all prices. Unlike many other justifications for RPM, our ETP-driven explanation for min RPM critically relies on inter-brand competition, and it is—at least in the case of linear demand functions—always to the detriment of consumers.

JEL-Classification: L12, L41, D42, K21.

Keywords: Resale Price Maintenance, Vertical Restraints, Retailing.

1 Introduction

Manufacturers often restrain retailers' flexibility of setting retail prices by using resale price maintenance (RPM). The Supreme Court in *Leegin Creative Leather Products, Inc. v. PSKS, Inc.*, 551 U.S. 877 (2007) removed the per-se ban on RPM—which was in place before—and replaced it by a rule-of-reason approach in the US. According to most recent estimates, more than \$300 billion sales alone in the U.S. are affected annually by RPM agreements (Gundlach and Krotz, 2020). While RPM is considered a hardcore restraint of competition in the European Union and therefore illegal, there is nevertheless empirical support for the usage of RPM also in the European Union (Bonnet and Dubois, 2010). Most commonly, RPM comes in the form of *minimum*

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retail prices (in short: min RPM, see Ippolito, 1991, 2010). As a min RPM typically protects the retailer's margin and keeps demand relatively low, how can this apparently ubiquitous phenomenon be explained?¹

In the aftermath of the *Leegin* case an instructive expert panel discussion reported in the OECD Policy Roundtables Report on Resale Price Maintenance (2008, p. 259) offers two positive perspectives on why min RPM is used.² Firstly, min RPM can counter retailer service free-riding and thereby protect the provision of retailer services (Telser, 1960; Mathewson and Winter, 1984).³ In practice, however, min RPM is also applied for a broad range of products for which the service-based justification for RPM is simply not plausible (see Pitofski 1982; Ippolito 1991; MacKay and Smith, 2017). Why is min RPM so frequent also in cases where the service-argument has no bite? Here, the second perspective discussed on the Roundtables report comes into play. Hereby, *"the manufacturer may want to induce the retailer to have a stronger interest in the manufacturer's product. If the retailer is allocating scarce display space, and if it earns 1 dollar/unit from product A and 1.25 dollars/unit from product B, the retailer will devote more or better space to product B. Under this approach RPM is a device for enhancing the margin of the retailer. This can improve interbrand competition."* Accordingly, it is presumed that min RPM helps to enhance the margin of the retailer and thereby improve interbrand competition.

In this paper, we present a novel reason for min RPM (not relying on the service-provision argument), which on the one hand backs the insight that a min RPM is used to enhance the retailer's margin, but on the other hand leads to a *reduction* of interbrand competition, consumer surplus and social welfare by raising *all* prices. This new explanation for the use of min RPM that is based on the *Edgeworth taxation paradox* (in short: ETP; Edgeworth, 1925; Hotelling, 1932) whereby the implementation of a positive tax per unit of quantity on *one* good ("first-class" railway ticket) can induce a multi-product monopolist to decrease *all* of his prices ("first- and second-class" tickets).⁴ Intuitively, the tax increase makes it relatively more attractive to sell the other good (i.e., "second-class" tickets). In order to steer consumers toward the other good, it could be necessary to lower its price. If it is then optimal to lower also the taxed good's

¹The usage of the less frequently used maximum retail prices, is easily explained by the fact that these allow the manufacturer to prevent double marginalization, which reduces sales volume and is detrimental to social as well as consumer welfare.

²Even though some articles have argued that other channel coordination devices are more profitable than RPM (e.g., price-dependent profit sharing rules, see Foros et al., 2018), RPM is particularly widespread used.

³Relatedly, Marvel and McCafferty (1984) have shown that a manufacturer can benefit from RPM, as this way retailers with a high reputation (that signals quality to consumers) can be incentivized to sell her product.

⁴Edgeworth (1925) referred to the example of first- and second-class tickets, where the first-class ticket is the taxed good (see below Section 2).

price, the ETP is obtained. The ETP takes care of the fact that most firms offer many products, which are often imperfectly substitutable from the buyers' point of view. This holds particularly for retailers which offer many substitutable products per product category (e.g., manufacturer brands and retail brands). The ETP may then become relevant in vertical relations where an upstream manufacturer sells to a multi-product retailer.

Typically, in a single good successive monopoly model with one upstream (brand) manufacturer ("she") and one downstream retailer ("he"), a double mark-up problem emerges (Spengler, 1950). Using a max RPM the manufacturer can reduce the retailer margin which in turn increases the demand for the brand. We extend this setting by considering a *multiproduct* retailer offering a second good which is an imperfect substitute to the manufacturer's brand. It then follows that the manufacturer has a strict incentive to impose a min RPM if and only if the demand system fulfills the ETP property; that is, whenever a wholesale price increase induces the retailer to charge lower prices for *all* products to sell the brand product to less, relatively low-value consumers and shift most of the demand from the brand product to the substitute good. With a min RPM a brand manufacturer is able to prevent this manifestation of the ETP.

The profitability of a min RPM follows directly from observing that the multi-product retailer's *derived* demand for the manufacturer's good is *increasing* in its retail price whenever the demand system fulfills the ETP property. Notably, the ETP applies to a standard "downward sloping" demand system. Put another way, with a min RPM the manufacturer can induce an increase of *all* retail prices which drives relatively high value consumers back to the manufacturer's brand and thereby increases its sales volume.

Our ETP-based explanation of min RPM is related to the "exclusivity/prestige" argument (or "image theory") in favor of min RPM, which assumes that consumer demand for a brand increases in its own price (see, Orbach, 2010).⁵ Interestingly, our ETP-based argument for min RPM also relies on an "upward sloping demand" mechanism; but it is now the retailer's *derived* demand which may increase in the manufacturer's retail price, while consumer demands are downward sloping as usual. Moreover, while min RPM can be socially desirable when "prestige" matters, it is likely to harm consumers in our model, which is always the case when demands are linear.

The literature on the ETP so far has concerned itself mostly with the demand conditions

⁵The argument goes back to Taussig (1916) who was puzzled why manufacturers want to keep prices high by use of min RPM. To resolve the paradox, Taussig argued that because of "psychological" reasons some demand curves are positively sloped as it is the case for "prestige goods" (see also Breit, 1991, for a survey). See also Inderst (2019) for a model where the retail price signals the product's quality and thereby increases its demand.

leading to the ETP (Hotelling, 1932; Garver, 1933; Hotelling, 1933; Bailey, 1954; Vickrey, 1960; Selten 1970), and, taken together, it has shown that the ETP is relevant for standard demand specifications (e.g., linear demand).⁶ Indirect evidence for the empirical relevance of the ETP follows from studies which show that vertical integration involving multi-product downstream firms has caused all prices to increase (see, for instance, Luco and Marshall, 2020, for the US beverage industry and the literature cited therein).⁷

Our explanation for the usage of min RPM is complementary to other explanations for the use of RPM clauses in vertical relations. By large, the relevant literature can be divided into two strands, one highlighting their procompetitive effects and the other one providing theories of harm that support their anticompetitive nature. With regard to the former strand, minimum RPM can be desirable as it could counter retailer service free-riding and thereby protect the provision of retailer services (see discussion above), as it could protect the reputation of the brand (Inderst, 2019), and as it could help to avoid destructive retailer competition (Deneckere et al., 1997).

The literature which deals with the anticompetitive effects of min RPM has singled out the following anticompetitive mechanisms, which are largely surveyed in Marvel (1994), Rey and Vergé (2008), Elzinga and Mills (2008), and Bennett et al. (2010). Min RPM can weaken intrabrand competition as a facilitating practice for downstream collusion, and it could weaken interbrand competition as a facilitating practice for upstream collusion (Jullien and Rey, 2007; Hunold and Muthers, 2020) as well as for the exclusion of lower-cost rival firms (Asker and Bar-Isaac, 2014). Industrywide min RPM can also serve as a commitment device to protect upstream monopoly rents, which is an issue under secret contracting (see Hart and Tirole 1990; O'Brien and Shaffer, 1992; Rey and Vergé, 2004; Gabrielsen and Johansen, 2017). Moreover, min RPM can benefit downstream firms by making it harder for entrants to steal business through undercutting them (Shaffer, 1991). Min RPM can also eliminate all effective competition—at the interbrand level as well as at the intrabrand level—through networks of interlocking RPM agreements in a setting with two manufacturers and common retailers (Dobson and Waterson, 2007; Rey and Vergé, 2010). In this setup, Hunold and Muthers (2017) also challenge the service argument as an efficiency defense for minimum RPM by showing that if manufacturer market power is asymmetric, minimum RPM may distort the allocation of services toward the high-

⁶The ETP is reinforced by cost substitutability (Hotelling, 1932; Coase, 1946; Vickrey, 1960; Selten, 1970) and is then also possible under conditions of perfect competition (Hotelling, 1932; Vickrey, 1960).

⁷The prediction goes back to Salinger (1991) which is the only work we are aware of which applied the ETP to analyze vertical integration, here in a context with two upstream suppliers and a common retailer.

priced products of the manufacturer with more market power.⁸ Moreover, for a broad range of products the service-based justification for RPM is simply not plausible, as for instance noted by Ippolito (1991). Our explanation for min RPM can be empirically distinguished from all the preceding explanations as it (i) does neither rely on competition on the side of the retailers nor on retailer pre-sale services, so prevails absent intrabrand competition, and (ii) does not rely on manufacturers using it as some coordination device by implementing it mutually.

Thus, our contribution is to show that a min RPM can occur in the archetypical bilateral trading model—that is, in a successive monopoly model as proposed by Spengler (1950)—, which we augment by a substitute good the downstream firm has at hand. Referring to retailing, this substitute good can be interpreted as a retail brand or private label good. Such private-label substitute products are widespread, as discussed in the growing literature on multi-product retailing (see, e.g., Ezrach and Bernitz, 2009). Moreover, we adopt the assumption of a linear wholesale price, an assumption that is widely shared both in the theoretical (e.g., Dobson and Waterson, 1997; Iozzi and Valletti, 2015; Gaudin, 2015, 2016) as well as the empirical (e.g., Gowrisankaran et al., 2015; Draganska et al., 2010; Grennan, 2013, 2014) industrial economics literature, and which is natural in particular when analyzing vertical restraints (see Rey and Tirole, 1986). Moreover, linear wholesale prices are not necessary for our results to hold: it is straightforward to show that they also emerge in the case of two-part tariffs when the fixed fee is constrained in such a way that the manufacturer also wants to extract a margin through the wholesale price. Thus, we view the constituents for the emergence of the ETP in vertical relations as quite weak.

2 A Case for Min RPM in Hotelling’s Discrete Example

We first restate the original example for the Edgeworth taxation paradox (ETP) proposed by Hotelling (1932), and then apply it to a vertical manufacturer-retailer relation. Building on the original example, we show that min RPM allows a brand manufacturer to prevent a multi-product retailer from charging lower prices for all his products and thereby shifting demand towards the substitute product with a relatively higher profit margin.

⁸Other arguments for the anticompetitiveness of min RPM exist for very different setups as they refer to two-sided markets (Gabrielsen et al., 2018a), to setups where shelf-space is costly (Gabrielsen et al., 2018b) or settings where retailers can third-degree price discriminate depending on consumers’ ability to switch retailers (Chen, 1999).

2.1 The Example for the ETP by Hotelling (1932)

Hotelling (1932) offers a discrete example to show the existence of the ETP whereby an increase in an input price (e.g., because of an excise tax increase) decreases all final goods prices. The example is instructive because it highlights that the multi-product pricing problem of the retailer critically affects the vertical relation with an upstream supplier.

Table 1: The Example by Hotelling (1932)

Consumers	Group Size	Willingness-to-pay for good 1	Willingness-to-pay for good 2
Group 1	450	$\min\{12, p_2 + 5\}$	$\min\{7, p_1 - 5\}$
Group 2	40	11	0
Group 3	900	8	8
Group 4	200	6	6

There are two goods, 1 and 2, with prices p_1 and p_2 , and four consumer groups in the market (see Table 1). All consumers have unit demand; i.e., they demand only one of the products to fulfill their needs. For instance, Edgeworth (1925) referred to first- and second-class railway tickets, where this assumption is natural. Consumers of group 1 buy good 2 when they are indifferent between goods 1 and 2; that is, if p_1 is equal or below 12 and $p_2 = p_1 - 5$, then group 1 consumers buy good 2. All other consumers buy, when indifferent, good 1. Production costs are zero. A tax of t_1 is imposed on good 1. The firm's profit is then given by

$$\pi_R(p_1, p_2, t_1) = (p_1 - t_1)D_1(p_1, p_2) + p_2D_2(p_1, p_2),$$

where $D_1(p_1, p_2)$ and $D_2(p_1, p_2)$ are the demands for goods 1 and 2, which follow from Table 1.

To derive the ETP, Hotelling compared the optimal prices under the no-tax situation ($t_1 = 0$) with the one when the unit tax on good 1 is $t_1 = 7$. In the former case the profit-maximizing prices are $p_1(t_1 = 0) = 12$ and $p_2(t_1 = 0) = 8$, so that group 1 buys good 1 and group 3 buys good 2, while groups 2 and 4 do not buy good 1 or good 2. In the latter case, the optimal prices are $p_1(t_1 = 7) = 11$ and $p_2(t_1 = 7) = 6$, so that group 2 buys good 1 and all remaining consumers buy good 2. Amazingly, the tax leads to an outcome which Pareto-dominates the no-tax outcome from a consumer perspective.

The result follows from noticing that—*ceteris paribus*—the tax dramatically reduces the margin of good 1 from 12 to 5. This margin decrease gives an incentive to shift consumers to good 2, for which the attainable margin is higher. It turns out that a price reduction of p_2 alone (holding $p_1 = 12$ fixed) is not optimal. Rather, the multi-product firm will lower both prices down

to $p_1 = 11$ and $p_2 = 6$, which allows to shift consumers of group 1 toward good 2 and to gain additional revenues from selling good 1 and good 2 also to consumer groups 2 and 4, respectively.⁹

In the course of the retailer's optimal pricing response to the tax increase, high value consumers are shifted from good 1 (the "high-value" good) to good 2 (the "low-value" good), while the downward adjustment of the price architecture allows the retailer also to sell goods 1 and 2 to consumers with lower willingness-to-pay. Clearly, the result is unfortunate from good 1's perspective. Even though its price is reduced from 12 to 11, its overall sales decline from 450 to 40 as all consumers of group 1 turn to good 2. In the next section, we show in a vertical extension of Hotelling's example how a brand manufacturer of the high-value good (good 1) can use min RPM to achieve an outcome with a high retail price and a relatively high sales volume.

2.2 Extending the ETP Toward a Vertical Manufacturer-Retailer Relation

We extend Hotelling's example by imposing a vertical structure, where an upstream manufacturer sells good 1 via a linear wholesale price w_1 to a downstream multi-product firm (the retailer). The retailer also offers a second good as in the Hotelling example. As we will show, in such a setting the manufacturer can increase its profits through minimum resale price maintenance (min RPM).

We analyze the following game. In the first stage, the upstream (brand) manufacturer of good 1 sets a contract that consists of a wholesale price w_1 and possibly a minimum final good price imposed on the retailer. In the second stage, the retailer decides whether to accept or reject the contract, and at which prices to sell to consumers.

The retailer incurs no additional costs than the costs of acquiring good 1 from manufacturer 1; as in the Hotelling example, all production costs are set to zero. The retailer's profit is then given by $\pi_R(p_1, p_2, w_1) = (p_1 - w_1)D_1(p_1, p_2) + p_2D_2(p_1, p_2)$, while the manufacturer's profit is given by $\pi_M = w_1\hat{q}_1$, where \hat{q}_1 is the retailer's derived demand for good 1, which follows from Table 1.

First, suppose the manufacturer can only set a wholesale price. The manufacturer wants

⁹To see the ETP logic, note first that the taxed firm's profit at the pre-tax prices is $\pi_R(12, 8, 7) = (12 - 7) \cdot 450 + 8 \cdot 900 = 9,450$. Reducing the price p_2 down to 7, gives $\pi_R(12, 7, 7) = 7 \cdot (900 + 450) = 9,450$, which is not strictly profitable. Given $p_2 = 7$, reducing p_1 down to 11 allows to capture group 2 consumers, but drives the consumers of group 1 back to good 1, so that the associated profit is lower than before, $\pi_R(11, 7, 7) = (11 - 7) \cdot 490 + 7 \cdot 900 = 8,260$. However, given the reduced price, $p_1 = 11$, it becomes profitable to reduce p_2 down to 6, which gives a profit of $\pi_R(11, 6, 7) = (11 - 7) \cdot 40 + 6 \cdot (900 + 450 + 200) = 9,460$, which is higher than the taxed firm's profit at the pre-tax prices.

group 1—which is large in size and has a high valuation for product 1—to buy the product. To achieve that, the manufacturer has to leave the retailer a sufficiently high margin that prevents him from serving group 1 with good 2 and selling the brand product only to group 2. Precisely, the manufacturer has to ensure that the retailer earns weakly more from setting $p_1 = 12$ and $p_2 = 8$ than setting what is optimally otherwise, which is $p_1 = 11$ and $p_2 = 6$. It turns out that this is the case when the manufacturer sets $w_1 = \frac{286}{41} < 7$.

Suppose now the manufacturer can also set a min RPM. In this case, the retailer cannot threaten to “lower all prices” by setting $p_1 = 11$ and $p_2 = 6$. As the min RPM at $p_1 = 12$ restrains effectively the price choices of the retailer, the manufacturer can raise the wholesale price to $w = 7$ without losing group 1 consumers. This gives the following Corollary 1.

Corollary 1. *In the vertical extension of the Hotelling example, the manufacturer of good 1 sets a linear wholesale price $w_1 = 7$ and a min RPM of $p_1 = 12$.*

Proof. See Appendix.

2.3 Modification of Hotelling’s Example

We modify the Hotelling example to show that, unlike in the original Hotelling example discussed above, ETP-driven min RPM can have strictly negative effects on social and consumer welfare. The only difference from the original Hotelling example lies in the assumption that consumer group 2 is of size 45 instead of 40 (see Table 1). With this change, the retailer optimally chooses prices $(p_1, p_2) = (11, 8)$ if $w_1 = 0$. Unlike in the original example by Hotelling, here group 2 is sufficiently large such that absent a min RPM the retailer charges a strictly lower retail price for good 1 in order to serve group 2. Solving the game without an RPM clause, the manufacturer optimally charges $w_1 = \frac{19}{3}$ and the retailer sets prices $p_1 = 11$ and $p_2 = 8$. The manufacturer’s profit is then $\pi_M(w_1 = \frac{19}{3}) = \frac{19}{3} \cdot (450 + 45) = 3,135$. Thus, if the manufacturer only sets a linear wholesale price, both consumer groups 1 and 2 buy good 1, while group 3 buys good 2 and group 4 is excluded.

With a min RPM the manufacturer sets wholesale price $w_1 = 7$ and a min RPM of $p_1 = 12$, which induces retail prices $p_1 = 12$ and $p_2 = 8$. Thus, min RPM increases p_1 from 11 to 12, which excludes group 2 consumers. The manufacturer realizes then a higher profit level $\pi_M(w_1 = 7, p_1 = 12) = 3,150$. Overall, consumers are clearly worse off under the min RPM.

3 A Case for Min RPM with Continuous Demands

In this section, we establish a relation between the ETP and the strict profitability of min RPM for the manufacturer. In line with the literature, we understand under the ETP that the retail price decreases when the input price increases. In Section 3.1, we establish for general demands that the ETP arises whenever the retailer's derived demand for the manufacturer's product increases in the good's retail price set by the manufacturer. This gives a necessary and sufficient for the ETP and the optimality of a min RPM, while a max RPM is optimal if the reverse of the ETP-case holds. In Section 3.2, we provide a linear demand example, where the optimality of min RPM follows directly from the parameters of the demand functions. The example shows that consumers are harmed by use of min RPM.

3.1 General Model

Consider the contracting problem between a manufacturer M ("she") and a retailer R ("he"). M produces a single good, good 1, at marginal costs $c_1 \geq 0$ and sells it via R to final consumers. The retailer also sells a good 2 to final consumers which he produces inhouse at marginal costs $w_2 \geq 0$.¹⁰ Consumer demands for goods 1 and 2 are given by the continuously differentiable functions $q_1 = D_1(p_1, p_2)$ and $q_2 = D_2(p_1, p_2)$. Demand for good $i = 1, 2$ is decreasing in its own price ($\frac{\partial D_i}{\partial p_i} < 0$) and increasing in the other good's price ($\frac{\partial D_i}{\partial p_j} > 0, i \neq j$). We assume that c_1 is sufficiently small, so that there is a gain from trade between M and R .¹¹

We suppose that the wholesale price is the only instrument the manufacturer has to extract rents from the retailer. On top of the wholesale price the manufacturer can impose an RPM-clause as a vertical restraint on the retailer. The game is, therefore, as follows. In the first stage, M sets the wholesale price w_1 and a retail price ceiling (max RPM) or a retail price floor (min RPM) for good 1 to the buyer firm. In the second stage, the retailer decides whether to procure good 1 at the posted terms and sets the prices of both goods, accordingly.

We solve for the subgame-perfect Nash equilibrium in two steps. In step 1, we solve the game for a price-fixing RPM, so that the manufacturer determines the retail price p_1 . We here first solve the second stage of the game to obtain the derived demand of the retailer for good 1 (step 1a). Secondly, we solve the manufacturer's maximization problem for the optimal wholesale and retail price of good 1 (step 1b). In step 2, we show that the same solution can be implemented with the weaker min RPM or max RPM restraint.

¹⁰Alternatively, we may assume that good 2 is supplied at a linear wholesale price w_2 under conditions of perfect competition with constant returns to scale, so that its wholesale price is equal to marginal costs; i.e., $w_2 = c_2$ holds.

¹¹We thereby assume that the vertically integrated solution is interior with $q_1, q_2 > 0$.

Step 1a: Derivation of the derived demand for good 1. In the second stage of the game, the retailer decides whether to procure good 1 at the posted terms. If the retailer wants to procure good 1, then the retailer chooses p_2 optimally given p_1 and given that the retailer incurs costs of w_i for each unit of good $i = 1, 2$. The retailer's profit is given by

$$\pi_R = (p_1 - w_1)D_1(p_1, p_2) + (p_2 - w_2)D_2(p_1, p_2), \quad (1)$$

while its outside option profit is $\pi_R^0 := \max_{p_2 \geq 0} (p_2 - w_2)D_2(p_1 \rightarrow \infty, p_2)$. We assume that standard second-order conditions hold.

Assumption 1 (Second-order Conditions). *Standard second-order conditions of the retailer's (unconstrained) problem, $\max_{p_1, p_2 \geq 0} \pi_R$, hold for all w_1 not prohibitively large; i.e., $\frac{\partial^2 \pi_R}{\partial p_1^2} < 0$, $\frac{\partial^2 \pi_R}{\partial p_2^2} < 0$, and $\frac{\partial^2 \pi_R}{\partial p_1^2} \frac{\partial^2 \pi_R}{\partial p_2^2} - \left(\frac{\partial^2 \pi_R}{\partial p_1 \partial p_2} \right)^2 > 0$.*

Assumption 1 ensures—besides other things—that the first-order condition with respect to p_2 must hold as an equality, i.e.,

$$\frac{\partial \pi_R}{\partial p_2} = \frac{\partial D_1}{\partial p_2}(p_1 - w_1) + \frac{\partial D_2}{\partial p_2}(p_2 - w_2) + D_2 = 0. \quad (2)$$

The retailer's profit-maximizing price for good 2 then follows from (2) and can be written as a function of p_1 and w_1 , that is, $\hat{p}_2 := p_2(p_1, w_1)$. Given the retailer's optimal price response for good 2, \hat{p}_2 , the retailer's derived demand for good 1 is also a function of p_1 and \hat{p}_2 ; i.e.,

$$\hat{q}_1(p_1, w_1) = D_1(p_1, \hat{p}_2). \quad (3)$$

Taking the total derivative of (3) with respect to p_1 yields

$$\frac{d\hat{q}_1}{dp_1} = \frac{\partial D_1}{\partial p_1} + \frac{\partial D_1}{\partial p_2} \cdot \frac{d\hat{p}_2}{dp_1}, \quad (4)$$

so that the total demand effect of a price change of good 1 is given by the sum of the direct effect on demand (first term on the right-hand side of (4)) and the indirect effect, which works via the retailer's optimal adjustment of price p_2 (second term on the right-hand side of (4)).

Applying the implicit function theorem to (2) gives the optimal adjustment of p_2 in response to a marginal change of p_1 ; that is,

$$\frac{d\hat{p}_2}{dp_1} = - \frac{\frac{\partial^2 \pi_R}{\partial p_2 \partial p_1}}{\frac{\partial^2 \pi_R}{\partial p_2^2}}, \quad (5)$$

so that (4) can be written as

$$\frac{d\hat{q}_1}{dp_1} = \frac{\partial D_1}{\partial p_1} - \frac{\partial D_1}{\partial p_2} \cdot \frac{\frac{\partial^2 \pi_R}{\partial p_2 \partial p_1}}{\frac{\partial^2 \pi_R}{\partial p_2^2}}. \quad (6)$$

Thus, the sign of (6) depends on the slope of the retailer's reaction function, $\frac{d\hat{p}_2}{dp_1}$, which in turn depends on the sign of $\frac{\partial^2 \pi_R}{\partial p_2 \partial p_1}$,¹² with

$$\frac{\partial^2 \pi_R}{\partial p_2 \partial p_1} = \frac{\partial D_1}{\partial p_2} + \frac{\partial D_2}{\partial p_1} + \frac{\partial^2 D_1}{\partial p_2 \partial p_1}(p_1 - w_1) + \frac{\partial^2 D_2}{\partial p_2 \partial p_1}(p_2 - w_2). \quad (7)$$

The first two terms are positive, while the remaining terms are ambiguous. Thus, a necessary condition for a positive marginal own (derived) demand effect of a small price change of p_1 is that the retailer's reaction function, $\frac{d\hat{p}_2}{dp_1}$, has positive slope, which holds if and only if (7) is strictly positive. Note, if demand functions are linear, the derivative (7) is always strictly positive, because the derivatives in the last two summands are then zero. In the following, we invoke the assumption that the derived demand, \hat{q}_1 , is monotone in p_1 in the relevant range from the manufacturer's perspective.

Assumption 2 (Monotonicity of the derived demand function). *Derived demand, \hat{q}_1 , is either strictly monotonically increasing in p_1 for all $p_1 \geq w_1 \geq c_1$ (i.e., the "ETP-case" with $\frac{d\hat{q}_1}{dp_1} > 0$ holds according to (6)) or it is strictly monotonically decreasing in p_1 for all $p_1 \geq w_1 \geq c_1$ (i.e., the "reverse ETP-case" with $\frac{d\hat{q}_1}{dp_1} < 0$ holds according to (6)).*

We maintain Assumption 2 throughout the remaining analysis. Before proceeding with the analysis, we shortly divert to the formulation of the original ETP condition (see Bailey, 1954, p. 74, eq. 9),¹³ which helps to understand the intuition behind the ETP-case, when the derived retailer demand for good 1 increases in its retail price. In the original ETP analysis the wholesale price w_1 is fixed exogenously, while the retailer sets both prices to maximize its profit (1). Accordingly, the retailer solves $\max_{p_1, p_2} \pi_R$, so that the optimal retail prices fulfill the first-order conditions $\frac{\partial \pi_R}{\partial p_i} = 0$ for $i = 1, 2$. Applying the implicit function theorem, one gets the optimal price effects of a marginal change of the exogenous wholesale price; i.e., $\frac{dp_i}{dw_1}$. The original ETP condition is that " $\frac{dp_1}{dw_1} < 0$ " holds, in which case $\frac{dp_2}{dw_1} < 0$ must also hold. Comparing the original ETP condition with our ETP-case, it is easily checked that our ETP-case with $\frac{d\hat{q}_1}{dp_1} > 0$ holds if and only if the original ETP condition $\frac{dp_1}{dw_1} < 0$ holds. If, to the contrary, $\frac{dp_1}{dw_1} > 0$ holds, then the reverse ETP-case must apply.

Lemma 1. *The "ETP-case" with $\frac{d\hat{q}_1}{dp_1} > 0$ holds according to (6) if and only if the original ETP condition $\frac{dp_1}{dw_1} < 0$ holds; in this case $\frac{dp_2}{dw_1} < 0$ must also hold. The "reverse ETP-case" with $\frac{d\hat{q}_1}{dp_1} < 0$ holds according to (6) if and only if the reverse of the original ETP condition, i.e., $\frac{dp_1}{dw_1} > 0$ holds; in this case, $\frac{dp_2}{dw_1} < 0$ or $\frac{dp_2}{dw_1} > 0$ are both possible.*

¹²Note that $\frac{\partial D_1}{\partial p_1} < 0$ as demand is downward sloping in its own price, $\frac{\partial D_1}{\partial p_2} > 0$ as products are substitutable, and $\frac{\partial^2 \pi_R}{\partial p_2^2} < 0$ by the second-order condition.

¹³The same formula can be found in Selten (1970) and Salinger (1991).

Proof. See Appendix.

Thus, the retailer's derived demand is upward sloping whenever the retailer's optimal price setting response to an exogenous wholesale price increase w_1 is to lower *all* prices. As in Hotelling's discrete example, by lowering all retail prices relatively high-value consumers are driven to the substitute good, which ultimately reduces consumer demand for good 1 and, with that, the retailer's derived demand for good 1. Notably, this logic applies even though the price of good 1 is reduced in the optimal downward adjustment of the retailer's price architecture. Thus, the retailer's demand for good 1 must be upward sloping in its retail price, whenever the ETP holds.

While a change of p_1 affects the retailer's derived demand for good 1 both directly and indirectly (see (6)), a marginal change of w_1 can only affect the derived demand for good 1, \hat{q}_1 , indirectly via the price for good 2, i.e., according to $\frac{d\hat{q}_1}{dw_1} = \frac{\partial D_1}{\partial p_2} \cdot \frac{d\hat{p}_2}{dw_1}$. Applying the implicit function theorem to (2) to get $\frac{d\hat{p}_2}{dw_1}$, yields

$$\frac{d\hat{q}_1}{dw_1} = -\frac{\partial D_1}{\partial p_2} \cdot \frac{\frac{\partial^2 \pi_R}{\partial p_2 \partial w_1}}{\frac{\partial^2 \pi_R}{\partial p_2^2}} = \frac{\left(\frac{\partial D_1}{\partial p_2}\right)^2}{\frac{\partial^2 \pi_R}{\partial p_2^2}} < 0,$$

so that the retailer's derived demand for good 1 is strictly decreasing in the linear wholesale price w_1 . With those results at hand, we have enough information to turn to step 1b. In particular, the equilibrium profit function of the manufacturer is given by $\hat{\pi}_M(p_1, w_1) := \hat{q}_1(w_1 - c_1)$ and the retailer's equilibrium profit function is $\hat{\pi}_R(p_1, w_1) := \pi_R(p_1, \hat{p}_2, w_1)$.

Step 1b: The manufacturer's problem. The manufacturer's maximization problem is

$$\max_{w_1, p_1 \geq 0} \hat{\pi}_M \quad \text{subject to} \quad \hat{\pi}_R \geq \pi_R^0. \quad (8)$$

We assume $\hat{\pi}_M(p_1, w_1)$ to be quasi-concave. An interior solution, in which the retailer's constraint is not fulfilled as an equality, can be ruled out because even if there is such a candidate outcome, then for a higher or lower value of p_1 the demand for good 1 must increase strictly in one of the directions according to (6). Thus, the manufacturer will end up on the retailer's isoprofit curve, where $\hat{\pi}_R = \pi_R^0$ holds.

As the retailer's participation constraint must hold as an equality in the optimal solution, $d\hat{\pi}_R = d\pi_R^0 = 0$ must also hold, as π_R^0 is a constant. Hence,

$$\frac{\partial \hat{\pi}_R}{\partial w_1} dw_1 + \frac{\partial \hat{\pi}_R}{\partial p_1} dp_1 = 0,$$

which yields

$$\left. \frac{dp_1}{dw_1} \right|_{\hat{\pi}_R = \pi_R^0} = - \left. \frac{\frac{\partial \hat{\pi}_R}{\partial w_1}}{\frac{\partial \hat{\pi}_R}{\partial p_1}} \right|_{\hat{\pi}_R = \pi_R^0}. \quad (9)$$

Note that $\frac{\partial \hat{\pi}_R}{\partial w_1} = \frac{\partial \pi_R}{\partial w_1} \Big|_{p_2=\hat{p}_2} + \frac{\partial \pi_R}{\partial p_2} \frac{d\hat{p}_2}{dw_1} = -\hat{q}_1 < 0$, as $\frac{\partial \pi_R}{\partial p_2} = 0$ follows from (2). Thus, the sign of (9) is given by the sign of $\frac{\partial \hat{\pi}_R}{\partial p_1} = \frac{\partial \pi_R}{\partial p_1} \Big|_{p_2=\hat{p}_2}$ (again, using (2)).

In the optimal constrained solution the total differential of the manufacturer's profit fulfills $\frac{\partial \hat{\pi}_M}{\partial w_1} dw_1 + \frac{\partial \hat{\pi}_M}{\partial p_1} dp_1 = 0$, subject to $\hat{\pi}_R = \pi_R^0$, which gives

$$\frac{dp_1}{dw_1} \Big|_{\hat{\pi}_R=\pi_R^0} = - \frac{\frac{\partial \hat{\pi}_M}{\partial w_1}}{\frac{\partial \hat{\pi}_M}{\partial p_1}} \Big|_{\hat{\pi}_R=\pi_R^0}. \quad (10)$$

In the constrained solution it must hold that the marginal effect of a wholesale price change on the manufacturer's profit is strictly positive; i.e., $\frac{\partial \hat{\pi}_M}{\partial w_1} > 0$. Suppose otherwise: if it is negative, then the manufacturer will lower w_1 , which is then always feasible as this would increase both the profit of the retailer and the manufacturer; if it is zero, then $\frac{\partial \hat{\pi}_M}{\partial p_1} \neq 0$ (otherwise, we would be in an interior solution), so that the manufacturer has a strict incentive to lower w_1 (which does not affect the manufacturer's profit much and is feasible because this increases the retailer profit) and at the same time to change the price p_1 into the direction of $\text{sign}\left(\frac{d\hat{q}_1}{dp_1}\right)$. For the manufacturer the latter effect is of first-order and the former is of second-order. The manufacturer, therefore, can clearly increase her profit while she could keep the retailer indifferent. Thus, we have

$$\frac{\partial \hat{\pi}_M}{\partial w_1} \Big|_{\hat{\pi}_R=\pi_R^0} > 0.$$

It follows that the sign of (10) depends on the sign of $\frac{\partial \hat{\pi}_M}{\partial p_1}$. The marginal profit effect of a retail price change p_1 on the manufacturer's profit is given by

$$\frac{\partial \hat{\pi}_M}{\partial p_1} = \frac{d\hat{q}_1}{dp_1} (w_1 - c_1),$$

so that

$$\text{sign} \left(\frac{\partial \hat{\pi}_M}{\partial p_1} \Big|_{\hat{\pi}_R=\pi_R^0} \right) = \text{sign} \left(\frac{d\hat{q}_1}{dp_1} \right), \quad (11)$$

because $w_1 > c_1$ is obviously a property of the optimal contract. We will use the relations (9), (10), and (11) in the next step.

Step 2: From price-fixing RPM to min RPM and max RPM. In the constrained solution of the price-fixing RPM contract, the right-hand side of (9) must be equal to the right-hand side of (10), which gives the optimality condition

$$- \frac{\frac{\partial \hat{\pi}_R}{\partial w_1}}{\frac{\partial \hat{\pi}_R}{\partial p_1}} \Big|_{\hat{\pi}_R=\pi_R^0} = - \frac{\frac{\partial \hat{\pi}_M}{\partial w_1}}{\frac{\partial \hat{\pi}_M}{\partial p_1}} \Big|_{\hat{\pi}_R=\pi_R^0}. \quad (12)$$

Suppose the ETP-case applies (i.e., $\frac{d\hat{q}_1}{dp_1} > 0$), then $\frac{\partial \hat{\pi}_M}{\partial p_1} \Big|_{\hat{\pi}_R=\pi_R^0} > 0$ must hold because of (11) and $\frac{\partial \hat{\pi}_R}{\partial p_1} \Big|_{\hat{\pi}_R=\pi_R^0} < 0$ because of the optimality condition (12). As we assumed that $\frac{\partial^2 \pi_R}{\partial p_1^2} < 0$

holds (Assumption 1), it follows that the retailer only wants to lower the retail price p_1 below the price-fixing solution. Thus, a min RPM suffices to implement the optimal price-fixing contract.¹⁴ If, to the contrary, the reverse ETP-case applies (i.e., $\frac{d\hat{q}_1}{dp_1} < 0$), then the retailer only wants to increase the price p_1 above the price-fixing solution, because now $\frac{\partial \hat{\pi}_M}{\partial p_1} \Big|_{\hat{\pi}_R = \pi_R^0} < 0$, and thus, $\frac{\partial \hat{\pi}_R}{\partial p_1} \Big|_{\hat{\pi}_R = \pi_R^0} > 0$ holds by the optimality condition (12); i.e., a max RPM suffices to sustain the optimal solution. The following proposition summarizes the preceding results.

Proposition 1. *The manufacturer's profit maximizing price-fixing contract (w_1, p_1) satisfies $\hat{\pi}_R = \pi_R^0$ and the optimality condition (12). Depending on whether or not the ETP-case applies according to Assumption 2, either a min RPM or a max RPM suffices to sustain the profit maximizing price-fixing solution:*

- i) *If the ETP-case holds, then $\frac{\partial \hat{\pi}_R}{\partial p_1} = \frac{\partial \pi_R}{\partial p_1} \Big|_{p_2 = \hat{p}_2} < 0$ follows from (12); i.e., a min RPM is used to sustain the manufacturer's profit maximizing solution.*
- ii) *If the reverse ETP-case holds, then $\frac{\partial \hat{\pi}_R}{\partial p_1} = \frac{\partial \pi_R}{\partial p_1} \Big|_{p_2 = \hat{p}_2} > 0$ follows from (12); i.e., a max RPM is used to sustain the manufacturer's profit maximizing solution.*

Thus, we have shown that a manufacturer selling its good via a multi-product downstream firm to final consumers has a strict incentive to either set a min RPM or a max RPM. Which vertical restraint is optimal depends on the sign of the slope of the derived demand for good 1 with respect to p_1 . If the ETP-case applies, so that the derived demand for good 1, \hat{q}_1 , increases in p_1 , then the optimal solution is obtained in a point (w_1, p_1) on the retailer's isoprofit curve, $\hat{\pi}_R = \pi_R^0$, where both the retailer's isoprofit curve and the manufacturer's isoprofit curve have negative slope; i.e., $\frac{dp_1}{dw_1} \Big|_{\hat{\pi}_R = \pi_R^0} < 0$ holds for both curves. In such a point, the retailer only wants to lower the retail price of good 1, because the retailer's marginal profit with respect to p_1 must be strictly negative; i.e., $\frac{\partial \hat{\pi}_R}{\partial p_1} \Big|_{\hat{\pi}_R = \pi_R^0} < 0$. At the same time, the manufacturer wants to further increase p_1 , because the manufacturer's marginal profit still increases strictly in p_1 ; i.e., $\frac{\partial \hat{\pi}_M}{\partial p_1} \Big|_{\hat{\pi}_R = \pi_R^0} > 0$ holds.

In other words, given the optimally chosen wholesale price w_1 (as part of the manufacturer's optimal price-fixing solution), the retailer wants to lower all prices p_1 and p_2 if the ETP-case applies: p_1 , because $\frac{\partial \hat{\pi}_R}{\partial p_1} \Big|_{\hat{\pi}_R = \pi_R^0} < 0$ and accordingly p_2 , because $\frac{d\hat{p}_2}{dp_1} > 0$ is a prerequisite of the ETP-case. Whenever the converse holds, the manufacturer sets a max RPM, as in the classical successive monopoly model with a single-product downstream firm.¹⁵

¹⁴Note that the assumption that the retailer's profit is strictly concave in p_1 (by the second-order condition) ensures that the retailer's isoprofit curve is always connected (i.e., there cannot be two unconnected isoprofit curves for the same profit level). There could be, however, more than one point of tangency for the same isoprofit curve.

¹⁵Of course, this only holds under the assumption of a downward sloping consumer demand. If consumer demand

3.2 Linear Demands

Suppose the inverse demands are given by

$$p_1 = \max\{a_1 - b_1q_1 - d_1q_2, 0\} \text{ and} \quad (13)$$

$$p_2 = \max\{a_2 - d_2q_1 - b_2q_2, 0\}, \quad (14)$$

for two goods 1, 2 with parameters $b_i > d_i > 0$ for $i = 1, 2$. We assume in the following a parameter range which ensures existence and uniqueness of the (interior) equilibrium solutions under both contracting regimes, where the manufacturer can only set a wholesale price and where the manufacturer can, in addition, set a min or max RPM. Inverting the (inverse) demand system (13)-(14) to get the demand functions $q_1 = D_1(p_1, p_2)$ and $q_2 = D_2(p_1, p_2)$, it is straightforward to get the derivatives

$$\frac{\partial D_1}{\partial p_1} = -\frac{b_2}{b_1b_2 - d_1d_2}, \quad \frac{\partial D_1}{\partial p_2} = \frac{d_1}{b_1b_2 - d_1d_2}, \quad \frac{\partial^2 \pi_R}{\partial p_2 \partial p_1} = \frac{d_1 + d_2}{b_1b_2 - d_1d_2}, \text{ and } \frac{\partial^2 \pi_R}{\partial p_2^2} = -\frac{2b_1}{b_1b_2 - d_1d_2}.$$

Substituting into (6) gives

$$\frac{d\hat{q}_1}{dp_1} = \frac{d_1^2 + d_2d_1 - 2b_1b_2}{2b_1(b_1b_2 - d_1d_2)}.$$

Note that $2b_1(b_1b_2 - d_1d_2) > 0$. Thus, $\frac{d\hat{q}_1}{dp_1} > 0$ holds if¹⁶

$$d_1^2 + d_2d_1 - 2b_1b_2 > 0. \quad (15)$$

If and only if this condition holds, the manufacturer wants to set a min RPM according to Proposition 1.¹⁷

Proposition 2. *If the demand functions are linear, the manufacturer sets a min RPM when the ETP condition (15) holds, that is, $d_1^2 + d_2d_1 - 2b_1b_2 > 0$. When the reverse ETP condition holds, that is, $d_1^2 + d_2d_1 - 2b_1b_2 < 0$, she sets a max RPM.*

We can compare the “price-fixing regime” according to Proposition 1 with the successive monopoly outcome in the absence of RPM (to which we refer as the “linear wholesale pricing regime”); that is, when the manufacturer can only set a linear wholesale price w_1 , while the

is upward sloping one can construct a case for a min RPM with increasing marginal production costs.

¹⁶Notably, the integrability condition $\partial p_1 / \partial q_2 = \partial p_2 / \partial q_1$ does not hold here, so these demand functions cannot be derived from a representative-agent model; but with non-linear demand curves, Edgeworth’s paradox can also arise when the integrability conditions holds (see Hotelling, 1932). This is closely related to the discussion on symmetry of the Slutsky matrix: while Slutsky symmetry is predicted by the classical model, it is rejected by a large body of empirical literature (see for instance the thorough discussion of Slutsky symmetry in Gabaix, 2014).

¹⁷Condition (15) is compatible with Assumption 1.

retailer sets both retail prices p_1 and p_2 to maximize his profits (1). We then get the following result.

Proposition 3. *The manufacturer charges the same wholesale price under the price-fixing and the linear wholesale pricing regimes.*

i) *If the ETP condition holds, the manufacturer sets a min RPM such that all market prices increase above the prices that prevail under the linear wholesale pricing regime. In this case, consumers are worse off.*

ii) *If the reverse ETP condition holds, the manufacturer sets a max RPM such that the price of good 1 decreases while the price for good 2 can increase or decrease when compared with the linear wholesale pricing regime.*

The proof to this proposition is straightforward along the following lines. Solving the game for the case that the manufacturer sets only a linear wholesale price and for the case that the manufacturer can also fix the retail price, we get the same wholesale price¹⁸

$$w_1 = \frac{1}{2}(a_1 + c_1) - \frac{d_1 + d_2}{4b_2}(a_2 - w_2). \quad (16)$$

It then follows that all final good prices increase if condition (15) holds by use of min RPM relative to the case that the manufacturer can only set a linear wholesale price. This also implies that by use of min RPM consumers are clearly worse off (simply by revealed preferences).

4 Conclusion

We have uncovered a relation between the economics of the ETP and min RPM which went unnoticed so far; astonishingly, even though the academic debates circling around both topics started around the turn of the next-to-last century.¹⁹ Augmenting the archetypical successive monopoly model by a substitute product the retailer has at hand, we could show that a min RPM is optimal for the manufacturer whenever the ETP-case applies. Only in this case, the retailer's derived demand for the manufacturer's good is increasing in its retail price from which the incentive to impose a min RPM follows. By use of min RPM the manufacturer deters the retailer from lowering all its retail prices to drive relatively high value consumers away from the manufacturer's brand to its substitute good, which is the optimal retailer pricing strategy under ETP conditions.

¹⁸The manufacturer's profit maximizing price-fixing contract (w_1, p_1) satisfies $\hat{\pi}_R = \pi_R^0$ and the optimality condition (12), from which we get the wholesale price as stated in (16).

¹⁹For historical surveys of the ETP and RPM see Moss (2010) and Breit (1991), respectively, and the therein cited references.

We, therefore, have shown that the ETP could become relevant in a vertical relation between a manufacturer and a multi-product retailer, which gives a novel explanation for the widespread observation that manufacturers impose min RPM on retailers. Understanding the precise reasons for the implementation of RPM clauses is important for a correct assessment of the welfare effects of such practices. Unlike other reasons for RPM—such as the prevention of double marginalization or protection of service provision—the channel for min RPM that we delineate is, at least in the case of linear demand functions, always to the detriment of consumers, as it prevents *all* prices from falling.

Interestingly, by our channel min RPM is detrimental for welfare even though it can increase sales volume for the respective product. This is in contrast to what the literature stated, whereby min RPM should be beneficial as long as it does not lower sales (see, e.g., Posner, 1981, or Elzinga and Mills, 2008, that sum up on p.9: “If putting an RPM policy in place boosts total sales noticeably, this strongly suggests that consumers, on net, have benefited.”).

Taking a dynamic perspective, the availability of min RPM should enhance manufacturers’ incentives to invest into branded goods when the brands are sold via multi-product retailers to final consumers. With a min RPM the manufacturer can realize higher sales volumes and profits, so that incentives to develop new branded goods and to invest into “brand image” are strengthened. The min RPM achieves this because it ensures that the brand manufacturer can, in fact, reach the targeted “high-value” consumers by effectively countering the multi-product retailer’s incentive to drive them to the “low-value” substitute good (e.g., the retail brand) for which the attainable retail profit margin is relatively high.

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Appendix

Proof of Corollary 1. Suppose the manufacturer sets only a wholesale price. Two outcomes are then possible. Either the manufacturer sets a relatively high wholesale which induces the

retailer to shift group 1 consumers to good 2, or the manufacturer sets a relatively low wholesale price, so that the retailer indeed wants to sell good 1 to group 1 consumers. In the first case, given that the retailer shifts group 1 consumers to good 2, the manufacturer cannot do better than setting $w_1 = 11$. The retailer then sets $p_1 = 11$ and the manufacturer earns $11 \cdot 4 = 440$. In the second case, the retailer sets a price of $p_1 = 12$ for good 1. Group 2 consumers will never be served by the retailer because lowering the price p_1 from 12 to 11 does not pay off (assuming that the retailer does not want to shift group 1 consumers to good 2). Thus, when the manufacturer wants to sell to group 1 consumers, she sets the highest possible w_1 such that the retailer does not want to shift this group to product 2.

We can directly use Hotelling's example to determine the optimal wholesale price the manufacturer will charge. Hotelling has shown that a wholesale price of $w_1 = 7$ will induce the retailer to set prices $p_1 = 11$ and $p_2 = 6$, so that only group 2 consumer will buy good 1. To avoid being "undercut" this way, the manufacturer is constrained to set a wholesale price w_1 such that

$$\begin{aligned} \pi_R(12, 8, w_1) &\geq \pi_R(11, 6, w_1) \text{ or} \\ (12 - w_1) \cdot 450 + 8 \cdot 900 &\geq (11 - w_1) \cdot 40 + 6 \cdot (900 + 450 + 200), \end{aligned}$$

which is fulfilled for all $w_1 \leq w'_1 := \frac{286}{41} < 7$. Thus, given the manufacturer sets $w_1 = w'_1$ the retailer cannot do strictly better than setting $p_1 = 12$ and $p_2 = 8$, which induces consumer group 1 to buy good 1, yielding a profit of $\pi_M(w'_1) = \frac{286}{41} \cdot 450 \approx 3,139$ to the manufacturer.

It is now easily checked that other wholesale prices than w'_1 are not optimal for the manufacturer. Given that the manufacturer sets a wholesale price such that it is optimal for the retailer to sell product 1 to consumer group 1, it must be optimal for the retailer to set prices $(p_1, p_2) = (12, 8)$ rather than, what can be otherwise optimal, which is either $(12, 7)$ or $(11, 6)$; i.e.,

$$\pi_R(12, 8, w_1) \geq \max\{\pi_R(12, 7, w_1), \pi_R(11, 6, w_1)\}$$

must hold. It then follows that the manufacturer's maximal wholesale price which ensures that the retailer sets $(12, 8)$ is given by w'_1 . For wholesale prices $w_1 \in (w'_1, \frac{29}{4}]$ the retailer undercuts the manufacturer with a joint price reduction $(11, 6)$ and for wholesale prices $w_1 > \frac{29}{4}$, the retailer undercuts with a unilateral reduction of good 2 $(12, 7)$. In both cases the retailer induces group 1 consumers to buy good 2. In the former case the manufacturer can still sell to group 2 consumers, while in the latter case the manufacturer is foreclosed from the market. Thus, it is optimal to set the wholesale price w'_1 .

Now suppose that the manufacturer can set a min RPM in addition to the wholesale price. Again, we can make use of Hotelling's analysis to find the optimal contract. We know already that at $w_1 = 7$ it is strictly optimal for the retailer to undercut the manufacturer with prices (11, 6), leaving the manufacturer with group 2 only. A min RPM of $p_1 = 12$ obviously counters a joint price reduction from (12, 8) to (11, 6) by the retailer. At $w_1 = 7$ the retailer is also indifferent between (12, 8) and (12, 7) while for all $w_1 > 7$ such a unilateral undercutting with the price of good 2 is always strictly optimal for the retailer. Thus, with a min RPM the manufacturer can charge $w_1 = 7$ to obtain a profit of $7 \cdot 450 = 3150$, which is strictly larger than the profit earned absent a min RPM. \square

Proof of Lemma 1. In the original formulation of the ETP, the wholesale price w_1 is exogenous. The retailer solves $\max_{p_1, p_2 \geq 0} \pi_R$, where π_R is given by (1). Given Assumption 1, the optimal retail prices follow from the retailer's first-order conditions, $\frac{\partial \pi_R}{\partial p_i} = 0$, for $i = 1, 2$. Totally differentiating the first-order conditions with respect to w_1 and solving for $\frac{dp_1}{dw_1}$, one gets the original formulation of the ETP condition (see Bailey, 1954; Selten, 1970; Salinger, 1991)

$$\frac{dp_1}{dw_1} = \frac{\frac{\partial D_1}{\partial p_1} \frac{\partial^2 \pi_R}{\partial p_2^2} - \frac{\partial D_1}{\partial p_2} \cdot \frac{\partial^2 \pi_R}{\partial p_2 \partial p_1}}{\frac{\partial^2 \pi_R}{\partial p_1^2} \frac{\partial^2 \pi_R}{\partial p_2^2} - \left(\frac{\partial^2 \pi_R}{\partial p_1 \partial p_2} \right) \left(\frac{\partial^2 \pi_R}{\partial p_2 \partial p_1} \right)} < 0. \quad (17)$$

The denominator is positive (second-order condition, see Assumption 1), so that $\frac{dp_1}{dw_1} < 0$ holds if and only if the numerator is negative. We can re-write $\frac{d\hat{q}_1}{dp_1}$ (see (6)) as

$$\frac{d\hat{q}_1}{dp_1} = \frac{1}{\frac{\partial^2 \pi_R}{\partial p_2^2}} \left(\frac{\partial D_1}{\partial p_1} \cdot \frac{\partial^2 \pi_R}{\partial p_2^2} - \frac{\partial D_1}{\partial p_2} \cdot \frac{\partial^2 \pi_R}{\partial p_2 \partial p_1} \right), \quad (18)$$

so that the sign of $\frac{d\hat{q}_1}{dp_1}$ is given by the reverse sign of the term in brackets on the right-hand side of (18), which is the same term as the term in the numerator of (17) (note that $\frac{\partial^2 \pi_R}{\partial p_2^2} < 0$; Assumption 1). It is then straightforward to see that $\text{sign} \left(\frac{d\hat{q}_1}{dp_1} \right) = -\text{sign} \left(\frac{dp_1}{dw_1} \right)$. \square