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Does the Service Argument Justify Resale Price Maintenance?

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by

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Abstract

Proponents of RPM argue that RPM helps to sustain a high level of service at the point of sale and that such a high level is efficient. This paper provides a simple model which leads to the following conclusions: 1) RPM may increase or decrease the level of service. 2) Whether the service level is more efficient under RPM does not depend on the fact that service increases due to RPM. It may be lower under RPM and more efficient. 3) Whether the service level is more efficient depends on the characteristics of the heterogeneous consumers. A feature of the model which deviates from those found in the literature is the introduction of a class of consumers who do not search but decide on a purchase spontaneously.

Keywords: resale price maintenance, quality, efficiency

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Does the Service Argument Justify Resale Price Maintenance?

The issue of resale price maintenance (RPM) has a long history. In the English-speaking world one attributes its beginning to the pricing of Alfred Marshall's Principles of Economics (Breit (1991)). However, the evidence for RPM reaches back for a considerably longer time (Picot (1991)). But it is not merely a greeting from the distant past. Every once in while it becomes a hot topic. In March 2005 the Swiss Competition Commission (WeKo) prohibited a RPM arrangement of the Swiss book trade (WeKo (2005)). Germany had recently a debate on resale price maintenance in the book trade which led to the remarkable situation that resale price maintenance is mandatory by law in this sector (since 2002), while it is forbidden per se for all other sectors. These decisions are obviously in considerable conflict to each other. Of course, the issue of RPM is not restricted to the book trade. The literature has pointed to a vast array of industries where RPM takes the form of price floors, price ceilings or stipulated prices (e.g. Winter (1993), Chen (1999)). The U.S. policy towards RPM and more generally towards vertical restraints is reported to have shifted over time and to be not very consistent (Comanor and Rey (1997)).

Theoretically, this could reflect the ambivalent evaluation of RPM by the profession, where a positive attitude on the grounds of efficiency within a supply chain is counterbalanced by concerns about competition impeding effects. Quite a number of explanations have been provided for the existence of RPM. This specific form of a vertical restraint is said to overcome the double marginalization problem (e.g. Tirole (1988), to aid collusion (e.g. Jullien and Rey (2000)), to enhance the service level of retailers (e.g. Telser (1960), Winter (1993)), to provide incentives to retailers to hold sufficient inventories (Deneckere et al. (1996)), to overcome a commitment problem (e.g. Hart and Tirole (1990)), to suppress price discrimination by retailers (Chen (1999)), to name a few. Some of these explanations speak for positive efficiency effects of RPM other for negative effects. Excellent recent surveys can be found e.g. in Motta (2004) or in Rey and Vergé (2005).

This paper focuses exclusively on the suggested justification of RPM by the service argument. Unconstrained price competition is said to lead to an inadequate supply of service. The free rider argument which posits that a customer may ask for product information (service) in one shop and than buy at a different shop which does not provide such information and can therefore offer the product at a cheaper price is one – albeit an extreme - variant of the efficiency argument. Indeed, in its extreme form this argument is not convincing in the book trade nor is it convincing in other sectors, where the price of a commodity is low relative to search costs (Winter (1993)). However, as Mathewson and Winter (1998) have stressed, the service argument is more general. Unconstrained price competition can erode the financial capability to provide high quality service. If service is valuable to consumers they might get hurt by abolishing RPM. Hence, there is scope for an efficiency rationale for RPM based on the service argument. Nevertheless it has long been acknowledged that RPM may induce such a high level of service that corresponding costs are not worth the potentially increased utility of consumers.

Much of the literature relevant to this topic has stressed the situation where firms use RPM to induce higher prices and higher service. Comanor (1985) provides an analysis showing that such increases in price and service may be in the interest of a manufacturer but may decrease social surplus. He also provides a case where social surplus is increased. He argues that social surplus increases if the increased level of service shifts the (linear) demand curve in a parallel manner and if there is perfect competition on the retail side. The present paper shows that this conclusion is not warranted once oligopolistic interactions of the retailers are taken into account.

Perry and Porter (1990) analyze the case where the service provided by one retailer has positive spillover effects on the demand faced by each retailer. Obviously, this models the free rider argument. They consider free entry of retailers and investigate the effect of a two part tariff of the manufacturer and RPM on retail prices, on the level of service, on the number of retailers, and on social surplus. They employ an isoelastic demand system and a model of monopolistic competition rather than oligopolistic competition (in order to render their model tractable). Their results show that – given that the manufacturer uses a two part tariff – RPM increases the level of service and social surplus, if the spillovers are sufficiently strong, and decreases the level of service and social surplus in the opposite case.

Inspired by Mathewson and Winter (1984), Motta (2004) deals with the same case (positive spillovers) in an oligopolistic setting. He compares a situation where the manufacturer uses a linear whole sale price and a situation where he uses a two part tariff and RPM (which induces the vertical integration outcome). He finds that social surplus is higher under the vertical integration regime. With a fixed number of retail firms service is also higher in this case. Obviously, these results are not consistent with those of Perry and Porter.

As is documented e.g. in Winter (1993) the case of positive spillover effects of service is not the most relevant case empirically. Usually retailers *compete* not only by offering low prices but also *by providing high quality service*. This implies that the service provided by one retailer attracts away customers from other retailers. The externality is thus negative rather than positive. From the point of view of a manufacturer the service of retailers has two effects. If all retailers jointly increase their level of service, this enhances the demand for the product. This may increase the profit opportunities of the manufacturer. But retailers care for their own demand. Their incentive to increase service will also be determined by their aim to steal business from their competitors. This not necessarily in the interest of the manufacturer. Hence, a manufacturer does not have an unambiguous incentive to encourage higher levels of service. This argument should not be understood as saying that retailers have always an incentive to excessively provide services. Note that retailers have two instruments to attract customers, given RPM is not practiced: price and service. It may be easier to attract customers by low prices which renders service less profitable. From this perspective the level of service may be excessively high or low in the eyes of a manufacturer.

It is known (e.g. R. Winter (1993)) that a manufacturer has the incentive to align the interests of retailers and his own by RPM. This instrument may be used to increase or to decrease the level of point of sales service together with prices in such a context. Winter shows that price and service will increase due to RPM, if consumers are more sensitive to price competition than to service competition, but that price and service will decrease, if consumers are more sensitive to service competition than to price competition (this argument will be made more explicit in the main body of the paper). Winter's paper is the only one which allows for service competition (negative spillover) to the best of my knowledge. He also provides a specific model of the demand side which supports the view that consumers are more sensitive to price competition – thus fuelling the predominant view that RPM increases prices and the level of service.

A model of demand which allows for both cases is lacking so far. It seems desirable to have such a model, because otherwise price ceilings are left unexplained. Note that the practice of recommended prices which is common in many markets can be seen as a form of a price ceiling (Chen (1999)). Moreover, when the British RPM arrangement in the book trade (the net book agreement (NBA)) broke down around 1995, commentators reported that the prices for some books increased while prices decreased for other types of books (Monopolkommission (2000)). It is therefore one aim of the present paper to provide a simple parsimonious model of the demand side which allows for both consequences of RPM to occur.

The main contribution of the paper, however, is contained in the results on the effects of RPM on social surplus in a context, where the service spillover is negative which appears to be the empirically prevalent case. To the best of my knowledge, no other work has provided any results on these effects derived analytically from a rigorous model (rather than by numerical examples in Winter (1993) which point at a negative impact of RPM on social surplus).

Although the model of the demand side is linear and therefore quite simple, it allows for several partly sobering insights: 1) Whether RPM increases or decreases social surplus and whether RPM increases or decreases the level of service are entirely different questions. Social surplus may increase due to RPM independently of whether the impact on service is positive or negative. The same holds true for a decline of social surplus. This is bad news to competition authorities. Fuelled by the academic literature on positive spillovers of service, they try to find out whether RPM is expected to increase service and demand and consider this a necessary condition for RPM to have positive efficiency effects. The case of the Swiss book trade mentioned above is a case in point. But our results show that an increased level of service is neither necessary nor sufficient for an increase of the social surplus. This is very different from the results in the literature which stress a positive spillover effect of service.

2) This finding is derived in a model of the demand side which corresponds to the “parallel shifting of linear demand curves” case in Comanor (1985). This point has some relevance as the Swiss case in the book trade suggests that competition authorities use the logic inherent in Comanor’s arguments. As pointed out in 1) this leads to questionable implications with oligopolistic retailers. The main point here is that our results are not derived via an abstrusely modeled demand side but by one which is similar to the models of demand existing in the literature on this subject.

3) Despite the simple nature of the demand system the results on the impact of RPM on social surplus depend in subtle ways on the parameters of the model. Critical values of parameters distinguishing domains leading to a positive impact of RPM from those with a negative impact can be determined in the present model. But even in this “simple” specification of demand the critical levels depend in a nonlinear and not very transparent manner on the remaining parameters. This would make it very difficult for a competition authority to assess the efficiency impact of RPM. It would need a very precise estimate of the parameters of the demand system. It seems save to conclude

from this observation that the situation of a competition authority is worse, if the demand system is more complex in practice than in our theoretical model.

4) Obviously these results do not speak for any per se rule (in contrast to what we find in reality). But 3) suggests that an argument for a rule of reason is weak as well. Based on these findings the best policy option seems to be that RPM should not be challenged by competition authorities grounded on the service argument alone. While this conclusion could also be drawn from the main thrust of the recent (post 1990) literature on the service argument, the logic is different. This literature (with the exception of Perry and Porter) supports the point that the use of RPM improves efficiency and should therefore not be challenged. Even Winter argues in this direction despite his numerical example for negative efficiency effects. In the context of the present paper it is admitted that RPM may improve or endanger efficiency, but there are big doubts concerning the ability of competition authorities to tell these cases apart. Of course, this does not say anything about different arguments - favorable or unfavorable to RPM.

The general modeling approach underlying these results follows closely Winter (1993). In technical terms the demand system is specified such that an analytical treatment of the social surplus becomes possible. In this point the model is different from Winter's. As noted before, this is achieved by specifying a linear demand structure. In order to analyze social surplus a link between demand and preferences is needed. Going through the examples of products which are deemed relevant for RPM (provided e.g. in Winter (1993) or Chen (1999)) suggests a discrete choice approach (which is employed by these authors well) rather than a representative consumer approach. To that end two types of consumers are introduced.

Consumers of the first type choose the retail outlet which promises the best mix of service, price, and other characteristics of the outlet. These are modeled similarly to the demand side in Winter (1993). The second type consists of consumers who spontaneously decide to visit a store. They do not reason where to shop and do not compare retail outlets before a potential purchase. They just want to see whether there is something on offer which is worth its price. A considerable part of demand in many retail sectors is said to be due to this type of consumers. In the model of the present paper their presence is responsible for the fact that prices and service may decline due to RPM.

The remaining parts of the paper are organized as follows. Section 1 provides the model used in this paper together with some supporting arguments as to the modeling approach. Section 2 establishes the equilibrium result and section 3 establishes results on consumer surplus and welfare.

Section 4 concludes, discusses omissions, and relates the results to different additional contributions in the literature.

1. The model

The general modeling approach follows closely that of R. Winter (1993). One monopolistic manufacturer produces goods which are sold by two sellers to the consumers. This fits the situation in the book trade quite well. The product is a book title and its copyright belongs to exactly one publisher. The retail sector of this trade is not particularly concentrated but some (local) market power is certainly relevant. Modeling competition as a duopoly without much bargaining power vis à vis the manufacturer seems therefore adequate. Again this is not only a valid model for the book trade only. Whenever manufacturers distribute a branded product via retailers this modeling strategy has been the prevalent standard in the relevant literature. We follow this strategy although we can easily think of examples where the role of the retailer and the manufacturer are reversed or where retailers and the manufacturer bargain on approximately equal terms.

From this it should be clear that interbrand competition is not modeled. We add some remarks on this obvious omission in section 4. This section will also comment on the relative bargaining strength of retailers and manufacturers and on the fact that we abstract from endogenous entry of retailers. It should be recalled that the results of the present work have the nature of counterexamples to views held up to now. It seems safe to hypothesize that the results will be even be more ambiguous, if more aspects are taken into account.

The demand faced by retailer i is modeled as

$$D_i(p_i, p_j, s_i, s_j) = a + (l + w)s_i - ws_j - (1 + d)p_i + dp_j$$

where a, l, w, d are non negative parameters and p_i denotes the price charged by retailer i and s_i denotes the level of service of retailer i. Note that in this specification service provided by the other retailer j induces a negative externality on the demand faced by retailer i. Obviously, this is not compatible with a positive spillover which is exclusively modeled in the literature analyzing the service argument (with the exception of Winter). Service should be interpreted in fairly broad terms. It may include well organized shelf space, properly trained personnel, pleasant ambience of the store etc.

As mentioned in the introduction we employ a discrete choice approach in order to link the demand system to preferences of consumers. Hence, each of the potential customers purchases one unit of the product or none.

According to many observers goods like textiles or books are often bought by incidence. A consumer strolling through a city may suddenly decide to visit a store and to find out what is on offer, although he had no intent to do so, when he decided to go downtown. Customers of this type typically do not actively search. Once a store is entered he only decides whether or not a good that he finds promising is worth its price. But he will not visit another store in order to search for a better price (in a world without RPM) or better service. To introduce such a type of consumers is not new to the literature. E.g. Chen (1999) introduces a similar category (while not considering the quality of service) and calls them "local shoppers". If all consumers were of this type there would be no essential role for competition among retailers but for showy appearances in order to attract the consumers attention. A retailer could more or less act like a local monopolist. In the framework of our model this would have the consequence that non linear prices and RPM are perfect substitutes for the manufacturer. This will become clear in a moment.

Certainly, not all consumers are of this type. Some decide to go downtown in order to buy e.g. a specific item (e.g. a novel or a textbook). These consumers will also decide ex ante where to buy. They may prefer one store to another because it is closer in distance or because they prefer certain retail brand names to others. But they may also decide on the grounds of information about price and service quality at that store. Again, Chen (1999) introduces this category of consumers as well (without considering the quality of service) and calls them "comparison shoppers".

Our model (as the one in Chen) allows for both types of consumers. In principle it would be possible to model both types of consumers in a joint framework with different search costs. "Local shoppers" who are called *spontaneous consumers* in the present paper could be modeled with prohibitively high search costs. However, it is far from clear what the advantage from this modeling strategy would be. In addition, the same consumer might find himself sometimes in a "spontaneous purchase" situation and sometimes in a "comparison shopper" situation. This would be obscured by attaching fixed search costs to each consumer.

This modeling strategy deviates from the demand model in R. Winter (1993) which only captures the second type (comparison shopper) of consumers. We follow Winter to a large extent in modeling this type of consumers which we call *choosey consumers*. But we simplify his model by assuming that these consumers will buy one unit of the good in any case which seems adequate in this context. Stores are modeled as being located at the end points of a Hotelling line of length 1. There is a continuum of consumers each characterized by his location on the line. As usual the location can be interpreted geographically or in terms of product differentiation (appearance, internet shop versus mortar and brick store etc.). The distribution of consumers with respect to their location is assumed to be uniform (another simplification compared with Winter). The mass of these consumers is denoted by β.

The utility of a consumer located at α when patronizing store 1 (which is located at 0) is assumed to be

$$B + es_1 - p_1 - b\alpha$$

An analogous expression denotes the utility of this consumer when he purchases the good at store 2 (which is located at 1 and therefore α has to be replaced by $1 - \alpha$). Demand for store 1 stemming from this type of consumers is

$$\frac{\beta}{2} + \frac{e\beta}{2b}(s_1 - s_2) + \frac{\beta}{2b}(p_2 - p_1)$$

with an analogous expression for the demand facing store 2. This presupposes that B is large enough such that all consumers of this type buy one unit of the good.

The class of spontaneous consumers which end up patronizing retailer i is characterized by the utility

$$A + ls_i - p_i$$

when a consumer visits store i. These customers differ in their reservation utility A_0 which is distributed uniformly in [0, A^*], where A^* is large enough, such that the demand at store i from spontaneous customers is equal to the expression denoting the utility of a customer. Hence demand from both types of consumers patronizing store i is:

$$D_i(p_i, p_j, s_i, s_j) = A + ls_i - p_i + \frac{\beta}{2} + \frac{e\beta}{2b}(s_i - s_j) + \frac{\beta}{2b}(p_j - p_i)$$

The first specification of demand is linked to this one by denoting $A + \beta/2$ by a, $e\beta/2b$ by w and $\beta/2b$ by d.

As for the cost structure of the firms we assume that the manufacturer has constant marginal cost which we normalize to 0 and some fixed cost which are sufficiently small to not influence the decision variables of the publisher.

Therefore the fixed cost will be neglected in the following. The provision of service is costly to the stores. Providing the level of s_i costs $cs_i^2/2$.

The pricing behavior of the manufacturer vis à vis the sellers follows again Winter (1993). The manufacturer charges store i a price q_i per unit of the good and a fee F_i independently of the volume of sales. This captures among other things the use of rebates which are quite common in the relationship between manufacturers and retailers. It also provides the manufacturer with an instrument to work against the problem of double marginalization.

The profit of store i is therefore:

$$\pi_i(p_i, p_j, s_i, s_j) = (p_i - q_i)D_i(p_i, p_j, s_i, s_j) - cs_i^2/2 - F_i$$

Without RPM stores choose their level of price and service given q_i and F_i. With RPM the price is fixed by the manufacturer and the stores can only choose their level of service. In slight misuse of notation we denote the equilibrium choices as $p_i(\cdot)$ and $s_i(\cdot)$ in both cases.

The manufacturers profit is

$$\Pi = \sum_{i=1}^{2}(q_i D_i(p_i(\cdot), p_j(\cdot), s_i(\cdot), s_j(\cdot)) + F_i)$$

where under RPM $p_i(\cdot)$ equals the price which the manufacturer chooses.

In order to guarantee that all profit functions are concave in their respective choice variables we impose the assumption that the cost of service provision is high enough. More precisely:

$$\textit{Assumption}\,(A1): \quad c(1+d) > \max(l, w)(l+w)$$

It is immediate that this assumption can be met by sufficiently large values of c for any values of d, l, and w.

As the manufacturer has the possibility of charging non linear prices to retailers, it should be clear that he cannot gain anything if only spontaneous consumers exit ($\beta = 0$). Both retailers are just (local) monopolists in this case and RPM and nonlinear prices are perfect substitutes to the manufacturer.

2. The consequences of RPM for prices and service

Given the complete symmetry of the stores we will concentrate on symmetric equilibrium configurations. Hence prices and service levels are equal for both stores. Under RPM prices are of course equal by definition of RPM.

The demand system as modeled by Winter (1993) yields a clear answer with respect to the consequences of RPM for prices and service: It increases both prices and service. This is not the case in our model: With RPM the price and the service level turns out to be

$$p_{RPM} = \frac{ac}{2c - l^2} \qquad s_{RPM} = \frac{al}{2c - l^2}.$$

The appendix provides a proof of this result as well as proofs for all other assertions in this and the following section. Assumption A1 also implies that all prices are positive.

With RPM the parameters reflecting some competition among the stores, w and d, play no role. This is to be expected. RPM eliminates any role for price competition. Equal prices imply that the manufacturer is exclusively interested in aggregate demand which does not depend on w.

If RPM is not an option for the manufacturer, prices and service turn out to be

$$p_c = \frac{a(c(1+d)^2 - dl(l+w) + w(l+w))}{2c(1+d)^2 - (1+2d)l(l+w) + w(l+w)}$$

$$s_c = \frac{a(1+d)(l+w)}{2c(1+d)^2 - (1+2d)l(l+w) + w(l+w)}$$

As is evident from these expression, p_{RPM} and p_c do not coincide in general and the same is true for s_{RPM} and s_c. It is also clear that the publisher's profit will be less in general, if RPM is not available. With RPM he could otherwise choose p_c as retail price and ask a price q_i such that stores would choose s_c. As the optimal decision under RPM differs from these levels it must be true that the profit of the manufacturer is smaller without RPM.

In terms of comparison we can state the following proposition, which turns out to be more transparent, if we return to the notation used in the discrete choice description of the demand system:

Proposition 1: (a) If $e < l$ then $p_{RPM} > p_c$ and $s_{RPM} > s_c$.
(b) If $e > l$ then $p_{RPM} < p_c$ and $s_{RPM} < s_c$.

Hence depending on the parameter values prices and service may move in different directions if RPM is enabled. Only if $e = l$ nothing changes. Note that $e > l$ means that an increase in service increases the utility of choosey consumers by more than the utility of spontaneous consumers. An increase in service attracts more choosey consumers than spontaneous consumers. Without RPM this is more attractive, as stores can set higher prices to cover the increased cost of service.

This result may help to explain why prices of different types of books developed in different directions when the NBA broke down. The demand for scientific literature could be argued to be quite insensitive to service for those customers who visit a book store based on an conscious ex ante decision to buy a specific title. Well trained personnel in the content or prominent shelf space for this title should play a very minor role for those customers. For spontaneous customers a prominent presentation may be a welcome reminder that they always wanted to buy this book. Hence $e < l$ captures this situation and in line with our result the prices of scientific books are reported to have declined after the NBA breakdown. The price of pocket books on the other hand increased. At least for novels this is also consistent with our theoretical result. Think of the situation that a consumer consciously decides to by a novel as a present to a friend and that he only knows that he wants to buy a novel of a specific genre. Then well trained personnel becomes important as well as the presentation in the store which speaks for a high e. For spontaneous customer who browses around without a specific purpose the advice of trained personnel is not that important. This speaks for a relatively small l. Proposition 1 predicts in this case that prices and service increase when RPM is no longer possible. It is not claimed here that these arguments explain the movement of prices in Great Britain fully. There are many more influences than we capture in this simple model. But the facts seem quite consistent with the result.

Winter (1993) points out that RPM will increase prices if and only if

$$\frac{\varepsilon_p^r}{\varepsilon_p^M} > \frac{\varepsilon_s^r}{\varepsilon_s^M}$$

where ε_p denotes the price elasticity and ε_s denotes the service elasticity of demand. The index M relates to the elasticities at the market level while the index r relates to the elasticities at the level of one retailer. One way of interpreting this equality is thus: If at the level of one retailer consumers are easier attracted by a decrease in price than by an increase in service, than competition among stores will drive down prices. As service is worth less it will also decrease. RPM can than be used to stabilize a higher level of service. In Winter's model the demand system satisfies this inequality.

Given that this characterization for a price increasing effect of RPM is quite general (at least locally) it is not surprising that Proposition 1 is fully consistent with this inequality. The condition in part (a) can easily be checked to be a special case of the above inequality. But – deviating from Winter - our demand system is flexible enough to allow for the reversed inequality to hold, which is the case in part (b). As we have seen, casual empirical evidence supports the view that both directions of prices can be observed after RPM is no longer practiced.

As the level of demand plays an important role in some arguments on the efficiency of the service level due to RPM it seems adequate to note the following corollary:

Corollary : Market demand increases due to RPM if and only if $e \neq l$.

Moreover market demand has the form $2(a + ls - p)$. Hence it has the parallel shifting property mentioned in Comanor (1985). Note also that the fact that market demand increases due to RPM (for $e \neq l$) does not depend on the fact that RPM induces a higher level of service.

3. The consequences of RPM on consumer surplus and welfare

If we want compare welfare under RPM with welfare without RPM, this is extremely easy for $e = l$. In this case the same prices and service levels obtain whether RPM is an option of the manufacturer or not. Hence, profits, consumer surplus of both types of customers, and (therefore) welfare are not affected by RPM. For all other parameter constellations a direct comparison turns out to be very messy. However, consumer surplus and welfare can be taken as functions of the taste parameter e. Using the mathematical properties of these functions provides some clear characterizations.

It is convenient to analyze the surplus of both types of customers first. For the type of spontaneous consumers we find that they are always better off under RPM, as long as $e \neq l$:

Proposition 2: For $e \neq l$ consumer surplus of spontaneous consumers; CS^{sp}, is always larger with RPM than without RPM.

Intuitively, this is due to the fact that without RPM retailers have more freedom to adapt the service levels to the wishes of the choosey consumers. If these consumers derive a higher utility from service ($e > l$), it is possible to pass the increased costs on to higher prices (as we have seen in the last section). The same holds true if choosey consumers derive less utility. Then prices will decrease. Hence, without RPM service and price will be more aligned with the wishes of the choosey customers and less so with the wishes of the spontaneous customers (relative to the RPM choices). Therefore spontaneous customers suffer from the prohibition of RPM. This same intuition helps also explain why choosey consumers suffer from RPM:

Proposition 3: For $e \neq l$ consumer surplus of choosey consumers; CS^{ch}, is always smaller with RPM than without RPM.

While profits are always higher under RPM (for $e \neq l$), consumer surplus of both types of consumers are inversely affected by RPM. From what we developed so far, we cannot say whether the loss of consumer surplus of one type is dominated by gains of the other type of consumers and firms. Intuitively one might think that RPM is welfare reducing if the group of choosey consumers is large enough (β). But this turns out not to be true. The number of choosey consumers has an impact on prices and service which is to the detriment of the other groups if RPM is not allowed. Hence RPM may profit these groups too much to render welfare smaller under RPM.

Fortunately, it possible to derive a local result at $e = l$:

Proposition 4: In a neighborhood of $e = l$ welfare is
(a) higher under RPM (for $e \neq l$), if A is large enough and
(b) lower under RPM (for $e \neq l$), if b is large enough.

Part (a) of proposition 4 is intuitive given the results obtained so far. A is the basic utility of spontaneous consumers. If A increases demand more spontaneous consumers will purchase a unit of the good. Hence, the utility of this group will increase if A does. As this group becomes more important and as this group profits from RPM, part (a) does not come as surprise.

Part (b) is bit more subtle. Suppose we are in situation without RPM. Let us start with the reaction of price and service to an increase of e, starting from $e = l$. As is clear from proposition 1 price and service will both increase. Now b decreases the service and the price elasticity of demand. Hence cet. par. retailers have an incentive to charge higher prices and offer lower service, if b is increased. As in the double marginalization problem this is not in the interest of the manufacturer. Hence he will decrease his wholesale price to counteract this effect. In the present model the combined effect is that prices and service will increase more due to an increase in e, if b is larger.

Furthermore price and service changes are such that the utility of spontaneous consumers is not affected locally. But the choosey customers gain for $e > l$, as they value the increased service higher. As due to an increased b this increase in service is higher, choosey costumers gain more. If this gain is sufficiently large, welfare increases if RPM is not allowed or phrased otherwise, welfare decreases under RPM.

Note that the result does not depend on whether RPM induces higher or lower levels of service. Rather it depends on which group of consumers is more affected by RPM.

4 Concluding remarks

The paper introduces a specification of the demand side which allows RPM to have different effects on prices and on service, which may increase or decrease due to RPM.

A feature of the model which deviates from those found predominantly in the literature is that service of one retailer exerts a negative rather than positive externality on the other retailer. It is also distinguished from the model of Winter (1993) in that it introduces a class of customers who do not search but decide on a purchase spontaneously. This is certainly an adequate modeling strategy with respect to the book trade. But it is also adequate for other product markets, especially those where the price of the commodity represents a relatively small fraction of the consumer's budget.

While the prices and the service level are influenced by the relative importance of those consumers who do search, the qualitative effect of RPM on prices and service are not affected, as can be easily checked.

The findings of the paper support the view that RPM may have an efficiency enhancing potential which always sheds doubt on a per se prohibition of RPM – especially when other forms of vertical restraints are not prohibited per se. But the opposite effect may also arise. RPM may be efficiency reducing. Moreover, even in the restricted environment of the model, the judgment of whether RPM is detrimental to efficiency or not depends on much more delicate tradeoffs as found in the literature. Simple indications such as an increased demand due to higher service are found to provide neither a necessary nor a sufficient condition for RPM to enhance efficiency. Indeed, in the context of our model RPM always increases aggregate demand, whether service is increased or not. As increased demand due to increased service can therefore not serve as an easy indicator for improved efficiency via RPM and as critical values for positive rather than negative efficiency effects seem hard to handle in practice, our results render a rule of reason objectionable. Neither in the case of positive spillovers (Perry and Porter) nor in the case of negative spillovers (present model) challenging RPM seems warranted on the merits of the service argument alone.

The most serious omission of the model concerns the absence of competition among manufacturers. Even in the case of the book trade where it is true that a publisher usually holds an exclusive copyright on a book title, books of similar types are substitutable to a certain extent. It is a frequent result in the study of vertical restraints that negative efficiency effects are weakened by interbrand competition (cp. Winter (1993) or Motta (2004)). But usually these negative effects remain in existence whenever competition is not very intense. And thus the warning included in proposition 4 that RPM may have negative consequences in terms of efficiency seems justified from this perspective.

Moreover in a recent paper Rey and Vergé (2004) show in a context of two manufacturers and two retailers that the manufacturers can use two part tariffs plus RPM to reach the collusive outcome. This does not speak for the generality of the argument according to which interbrand competition reduces the problems which arise with respect to efficiency in an intrabrand context. Interestingly enough, they also consider a variant where retailers provide service. This variant renders the collusive outcome as the unique equilibrium. However, in their set up service provided by one retailer for a specific product has no spillover effects to other products and retailers. It would be interesting to see what the consequence of spillovers would be in this context. But this is beyond the scope of the present paper.

Another shortcoming of our model consists in the assumption of a fixed number retailers rather than allowing for free entry of retailers (as in Perry and Porter). In a context of entry a manufacturer can use vertical restraints such as two part tariffs and RPM to induce the number of retailers which is most profitable to him. Depending on the love for variety of consumers this may very much deviate from the efficient number of retailers thus inducing another concern for efficiency due to RPM. Allowing for such an analysis would require a different modeling strategy as it is not straightforward to integrate love for variety in the present model. Therefore this issue is also beyond the scope of this paper.

It should be noted that competition is very loosely incorporated in the model as the cost of service can be interpreted as the opportunity cost of not providing prominent shelf space or informational service for other goods (of a rival manufacturer). Given the vast number of retail items, available shelf space is certainly scarce and it also impossible for the personnel to be properly informed about all items of certain group of products.

There are some contributions to the literature dealing with the scarcity of shelf space in the retail sector, most prominently by Shaffer (1991a, 1991b). However, both papers give a minor role to retail competition. In Shaffer (1991b) a multi-product monopolist tries to convince retailers (which all enjoy a local monopoly) to stock their full line of products. It is shown that one possibility of reaching the full integration result consists in imposing RPM and paying a flat fee for shelf space. Competition is only present, as retailers have the option to use their shelf space for presentation of commodities of another competitive industry which is not specified more precisely. In Shaffer (1991a) manufacturers are perfectly competitive and sell to retailers with considerable market power. It remains unclear whether these results are robust to oligopolistic interactions.

The success of new goods, such as books, is usually very uncertain at the time of production. The management of the corresponding risk is therefore an important part of the strategy of manufacturers and retailers alike. Deneckere et al. (1996, 1997) have taken up demand uncertainty and its relationship to RPM in two remarkable papers. They show that a monopolistic manufacturer has an incentive to impose RPM on its sales to perfectly competitive retailers and that this imposition may (but need not) improve welfare and even expected consumer surplus. One driving force of the result is that retailers have to order inventories before uncertainty unveils and that the costs of these inventories are completely sunk. Again while a very interesting result by itself it fits many sectors less well, the book trade being one example. The uncertainty in those papers deals with the demand of one specific homogenous commodity. If a manufacturer produces essentially one product this is a suitable modeling strategy. A publisher, however, produces a whole line of new books each year. Possibilities to form a less risky portfolio of titles are open to a publisher. In addition, it is quite common that publishers take back unsold inventories. Hence costs related to inventories are not completely sunk. But this drives the results of those papers. Hence, it is not clear how the results would change if both aspects would be incorporated, let alone the main issue of the present paper: the service argument.

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Appendix A1: Prices and Service with RPM

Recall that demand can be written as

$$D_i(p_i, p_j, s_i, s_j) = a + ls_i - p_i + w(s_i - s_j) + d(p_j - p_i)$$

and that the aim of the manufacturer is

$$\Pi = \sum_{i=1}^{2}(q_i D_i(p_i(\cdot), p_j(\cdot), s_i(\cdot), s_j(\cdot)) + F_i)$$

The usual argument applies to show that F_i will be set such that retailers obtain a reservation profit of 0. This implies

$$F_i = (p_i - q_i)D_i(p_i, p_j, s_i, s_j) - cs_i^2/2$$

and the profit of the manufacturer becomes:

$$\Pi = \sum_{i=1}^{2}(p_i D_i(p_i(\cdot), p_j(\cdot), s_i(\cdot), s_j(\cdot)) - cs_i^2/2)$$

As prices are equal for both retailers with RPM, this reads in more specific terms:

$$\Pi = p(2a + l(s_1 + s_2) - 2p) - c(s_1^2 + s_2^2)/2$$

Suppose the manufacturer could directly set p and both s_i. Then maximizing the profit would yield the first order conditions:

$$2a + l(s_1 + s_2) - 4p = 0$$

$$pl - cs_i = 0$$

Solving this system gives the expressions for p_{RPM} and s_{RPM}.

For these expressions to make sense, c has to be large enough which is satisfied due to assumption A1.

In our setup the manufacturer cannot directly set s_{RPM}. It remains to be shown that he can implement this level of service by charging a suitable price q_i to the retailers. In the RPM context the profit of retailer i is:

$$\pi_i = (p - q_i)(a + ls_i - p + w(s_i - s_j)) - cs_i^2/2 - F_i$$

Maximizing with respect to s_i gives the first order condition:

$$(p - q_i)(l + w) = cs_i$$

In order to obtain the service level s_{RPM}, the manufacturer should therefore set q_i according to

$$q_i = p_{RPM} - \frac{cs_{RPM}}{l+w} = \frac{ac}{2c-l^2} - \frac{acl}{(2c-l^2)(l+w)} = \frac{acw}{(2c-l^2)(l+w)}$$

which establishes the result.

Appendix A.2 Prices and service without RPM

If retailers choose their price as well as the service level the profit takes the form

$$\pi_i = (p_i - q_i)(a + ls_i - p_i + w(s_i - s_j) + d(p_j - p_i)) - cs_i^2/2 - F_i$$

which is concave in the retailers own price and service level, if c is large enough. This is satisfied due to assumption A1:

$$(A1) \qquad c(1+d) > \max(l, w)(l + w)$$

The first order conditions can be written as:

$$(1) \qquad a + q_i(1+d) + (l+w)s_i - ws_j - 2(1+d)p_i + dp_j = 0$$

$$(2) \qquad (p_i - q_i)(l+w) - cs_i = 0$$

Solving (2) for s_i and inserting the result in (1) gives:

$$(3)\ a + q_i(1+d) - q_i\frac{(l+w)^2}{c} + q_j\frac{w(l+w)}{c} - \left(2(1+d) - \frac{(l+w)^2}{c}\right)p_i + \left(d - \frac{w(l+w}{c}\right)p_j = 0$$

As announced in the main body of the paper we will concentrate on the symmetric solutions. Hence we posit $q_1 = q_2 = q$ and this implies $p_1 = p_2 = p$. Then (3) becomes:

$$ac + q((1+d)c - l(l+w)) = ((2+d)c - l(l+w))p$$

which gives

$$(4) \quad p(q) = \frac{ac + q((1+d)c - l(l+w))}{(2+d)c - l(l+w)}$$

Inserting this back into the solution of (2) gives

$$(5) \quad s(q) = \frac{(a-q)(l+w)}{(2+d)c - l(l+w)}$$

For the same reasons as in appendix A.1 the profit of the manufacturer can now be written as

$$\Pi = p(q)(D_1(p(q), s(q)) + D_2(p(q), s(q))) - cs^2(q)$$

Note that the first order conditions for the retailers' equilibrium have the form:

$$(1a) \quad (p_i - q)\frac{\partial D_i}{\partial p_i} + D_i = 0$$

$$(2a) \quad (p_i - q)\frac{\partial D_i}{\partial s_i} - cs_i = 0$$

This form will be used in a moment. Consider now the first order condition for maximizing the manufacturer's profit with respect to q:

$$\frac{\partial p}{\partial q}\left(\left[D_1 + p\frac{\partial D_1}{\partial p_1} + p\frac{\partial D_2}{\partial p_1}\right] + \left[D_2 + p\frac{\partial D_2}{\partial p_2} + p\frac{\partial D_1}{\partial p_2}\right]\right) +$$
$$\frac{\partial s}{\partial q}\left(\left[p\frac{\partial D_1}{\partial s_1} + p\frac{\partial D_2}{\partial s_1} - cs\right] + \left[p\frac{\partial D_2}{\partial s_2} + p\frac{\partial D_1}{\partial s_2} - cs\right]\right) = 0$$

Using ($1a$) and ($2a$) this yields:

$$\frac{\partial p}{\partial q}\left(\left[q\frac{\partial D_1}{\partial p_1}+p\frac{\partial D_2}{\partial p_1}\right]+\left[q\frac{\partial D_2}{\partial p_2}+p\frac{\partial D_1}{\partial p_2}\right]\right)+$$
$$\frac{\partial s}{\partial q}\left(\left[q\frac{\partial D_1}{\partial s_1}+p\frac{\partial D_2}{\partial s_1}\right]+\left[q\frac{\partial D_2}{\partial s_2}+p\frac{\partial D_1}{\partial s_2}\right]\right)=0$$

and using the specific expressions for the demand system gives:

$$2\left(\frac{\partial p}{\partial q}\left[-q(1+d)+dp\right]+\frac{\partial s}{\partial q}\left[q(l+w)-pw\right]\right)=0$$

Inserting the derivatives of (4) and (5) this condition now reads:

$$((1+d)c-l(l+w))(-q(1+d)+dp)-(l+w)(q(l+w)-pw)=0$$

Next insert p according to (4). After a series of rearrangements this can be rewritten as.

$$a\left[(1+d)cd-l(l+w)d+w(l+w)\right]-\left[2(1+d)^2c-(1+2d)l(l+w)+w(l+w)\right]q=0$$

Note that under assumption (A1) the second expression in brackets is positive. It follows that the profit function of the publisher is concave in q.

Hence, the publisher will charge each bookseller a price of

$$(6)\quad q=\frac{a\left[(1+d)cd-l(l+w)d+w(l+w)\right]}{2(1+d)^2c-(1+2d)l(l+w)+w(l+w)}$$

The remaining steps are conceptually simple: just insert (6) into (4) and (5). As doing these steps and getting the result in the main part of the paper is not that straightforward we offer some details here. Let us start with the price. Inserting (6) into (4) gives

$$((2+d)c-l(l+w))p/a=$$
$$c+((1+d)c-l(l+w))\frac{(1+d)cd-l(l+w)d+w(l+w)}{2(1+d)^2c-(1+2d)l(l+w)+w(l+w)}$$

The right hand side of the equation above can therefore be written as:

$$\frac{c(2c(1+d)^2-(1+2d)l(l+w)+w(l+w))}{2(1+d)^2-(1+2d)l(l+w)+w(l+w)}$$
$$+\frac{((1+d)c-l(l+w))((1+d)cd-l(l+w)d+w(l+w)}{2(1+d)^2-(1+2d)l(l+w)+w(l+w)}$$

Next we focus on the numerator of this expression. Note that

$$2c(1+d)^2 = (1+d)(2+d)c + (1+d)cd$$

Therefore we can write the numerator as follows:

$$c(1+d)((2+d)c - l(l+w)) + cd((1+d)c - l(l+w)) + cw(l+w) + c^2 d(1+d)^2 - \\ 2cdl(l+w) - 2cd^2 l(l+w) + dl^2(l+w)^2 + c(1+d9w(l+w) - lw(l+w)^2$$

$$= c(1+d)\left[(2+d)c - l(l+w)\right] + w(l+w)\left[(2+d)c - l(l+w)\right] + \\ c^2 d(1+d)(2+d) - 3cdl(l+w) - 2cd^2(l+w) + dl^2(l+w)^2$$

$$= c(1+d)\left[(2+d)c - l(l+w)\right] + w(l+w)\left[(2+d)c - l(l+w)\right] + \\ c^2 d(1+d)(2+d) + dl(l+w)\left[l(l+w) - (2+d)c\right] - (1+d)cdl(l+w)$$

$$= \left[(2+d)c - l(l+w)\right]\left((1+d)c + w(l+w) - dl(l+w) + (1+d)cd\right)$$

From this expression the result for the price in the main body of the paper follows immediately. Deriving the result for *s* poses no problems.

Appendix A3 Comparison of prices and service levels

Let us start with a comparison of the service levels:

$$s_c = \frac{a(1+d)(l+w)}{2c(1+d)^2 - (1+2d)l(l+w) + w(l+w)} < s_{RPM} = \frac{al}{2c - l^2}$$

$$\Leftrightarrow (1+d)(l+w)(2c - l^2) < l\left[2c(1+d)^2 - (1+2d)l(l+w) + w(l+w)\right]$$

$$\Leftrightarrow 2c(1+d)(w - dl) < l(l+w)(w - dl)$$

Because of assumption A1 this is equivalent to $w < dl$.

The price with RPM is higher than the price without RPM iff

$$p_{RPM} = \frac{ac}{2c - l^2} > p_c = \frac{a\left[c(1+d)^2 - dl(l+w) + w(l+w)\right]}{2c(1+d)^2 - (1+2d)l(l+w) + w(l+w)}$$

$$\Leftrightarrow c\left[l^2(1+d)^2 - (l+w)^2\right] > l^2(l+w)(dl - w)$$

$$\Leftrightarrow (dl - w)\left[l((2+d)c - l(l+w)) + cw\right] > 0$$

Again given assumption A1 this is equivalent to $w < dl$. Using the definition w and d, this establishes proposition 1.

Market demand is in the absence of RPM $a + ls_c - p_c$. Inserting the expressions for s_c and p_c gives:

$$ac\frac{(1+d)^2}{2c(1+d)^2 - (1+d)l(l+w) + (w-dl)(l+w)}$$

Note that $s_c = s_{RPM}$ and $p_c = p_{RPM}$ for $e = l$. e enters the demand only via w. As s_{RPM} and p_{RPM} do not depend on w market demand under RPM is constant in e. Consider now market demand without RPM as given above. Market demand depends on w and thus on e. The monotonicity properties of market demand with respect to e are the same as with respect to w. Therefore we will look at the derivative market demand with respect to w:

$$\frac{ac(1+d)^2 2(dl-w)}{\left[2c(1+d)^2 - (1+d)l(l+w) + (w-dl)(l+w)\right]^2}$$

Hence market demand increases iff $dl > w$ or equivalently $l > e$. This implies that market demand as function of e increases up to l and decreases from this value onwards. Its maximum is attained at $e = l$ where it reaches its RPM level. This proves the Corollary.

Appendix A4 Consumer and Social surplus effects

The aggregate gross utility of spontaneous customers patronizing bookstore i is

$$\int_0^{A+ls_i-p_i} (A + ls_i - A_0)dA_0 = \frac{1}{2}(A + ls_i - p_i)(A + ls_i + p_i)$$

Consumer surplus of these consumers is

$$\frac{1}{2}(A + ls_i - p_i)^2$$

Hence, given the symmetry of the model total consumer surplus is

$$CS_c^{sp}(e) = (A + ls_c - p_c)^2$$

without RPM and

$$CS_{RPM}^{sp}(e) = (A + ls_{RPM} - p_{RPM})^2$$

with RPM. Again CS_{RPM}^{sp} does not depend on *e*. CS_c^{sp} depends on *e* via prices and service levels and attains the same value as CS_{RPM}^{sp} at *e* = *l*. This function will rise and fall iff the expression in parentheses rise and fall. In turn this expression rises and falls at same conditions as market demand. From this it follows that is CS_c^{sp} quasi-concave attaining its maximum at *e* = *l*. This proves proposition 2.

Given the symmetric configurations the aggregate gross utility of the choosey type of customers patronizing bookstore *i* is

$$\beta\int_0^{0,5}(B + es_i - b\alpha)d\alpha = \frac{\beta B}{2} + \frac{\beta es_i}{2} - \frac{\beta b}{8}$$

This implies that total consumer surplus is

$$\beta B - \beta b/4 + \beta(es - p)$$

CS_c^{ch} denotes consumer surplus of choosey consumers, if RPM does not prevail and CS_{RPM}^{ch} if it does. We will look at the properties of CS_c^{ch} - CS_{RPM}^{ch} :

$$CS_c^{ch}(e) - CS_{RPM}^{ch}(e) = \beta e(s_c - s_{RPM}) - \beta p_c + \beta p_{RPM}$$

We will check the monotonicity properties of this function. Therefore we differentiate this function with respect to *e*:

$$(7) \quad \beta(s_c - s_{RPM}) + \beta\left(e\frac{\partial s_c}{\partial w} - \frac{\partial p_c}{\partial w}\right)\frac{\beta}{2b}$$

Note that the first term is positive iff *e*> *l*. Differentiating s_c with respect to *w* gives:

$$\frac{\partial s_c}{\partial w} = \frac{a(1+d)(2c(1+d)^2 - (l+w)^2)}{\left[2c(1+d)^2 - (1+d)l(l+w) + (w-dl)(l+w)\right]^2}$$

Differentiating p_c with respect to *w* gives :

$$\frac{\partial p_c}{\partial w} = \frac{a(l+w)(2c(1+d)^2 - (1+d)l(l+w))}{\left[2c(1+d)^2 - (1+d)l(l+w) + (w-dl)(l+w)\right]^2}$$

Inserting these expression into the bracket in the second expression in (7) gives:

$$\frac{a(1+d)(e-l)(2c(1+d) - (l+w)^2)}{\left[2c(1+d)^2 - (1+d)l(l+w) + (w-dl)(l+w)\right]^2}$$

Given assumption A1 this expression is positive iff $e > l$. Hence, CS_c^{ch} - CS_{RPM}^{ch} decrease for $e < l$ and increases for $e > l$. At the minimum at $e = l$ the function attains the value of 0. For all other values of e it must therefore attain positive values. This proves proposition 3.

Given the expressions for the aggregate utility for both types of consumers social surplus at symmetric solutions is therefore

$$W(p,s) = (A + ls - p)(A + ls + p) + \beta B + \beta es - \beta b/4 - cs^2$$

which can be rewritten as

$$W(p,s) = A^2 + \beta B - \beta b/4 + 2(Al + bw)s + (l^2 - c)s^2 - p^2$$

As at $e = l$ prices and service levels are same under RPM and without RPM, it is obvious that the social surplus is also the same in both situations. We denote by W_c resp. W_{RPM} the value of W, if the arguments (p_c, s_c) resp. (p_{RPM}, s_{RPM}) are inserted.

We consider now an increase in e which induces an increase in w without changing any of the remaining parameters. As monotonicity and concavity properties are preserved whether e or w are taken as variables, we will use w as this entails a more convenient notation.

$$(7) \quad \frac{\partial W}{\partial w} = 2bs + 2(Al + bw)\frac{\partial s}{\partial w} + (l^2 - c)2s\frac{\partial s}{\partial w} - 2p\frac{\partial p}{\partial w}$$

Note that (p_{RPM}, s_{RPM}) do not depend on w. Therefore

$$\frac{\partial W_{RPM}}{\partial w} = 2b\frac{al}{2c - l^2}$$

While this derivative is independent of the value of w, the derivative of W_c will in general depend on w. In order to calculate the derivative of W_c at $w = dl$ ($e = l$) we need the derivative of s with respect to w at dl:

$$\frac{\partial s}{\partial w} = \frac{a}{(1+d)(2c-l^2)}$$

The derivative of *p* with respect to *w* at *dl* is :

$$\frac{\partial p}{\partial w} = \frac{al}{(1+d)(2c-l^2)}$$

Inserting these values in (7) yields at $w = dl$

$$\frac{\partial W_c}{\partial w} = 2b\frac{al}{2c-l^2} + 2(Al+bw)\frac{a}{(1+d)(2c-l^2)} + (l^2-c)\frac{2al}{2c-l^2}\frac{a}{(1+d)(2c-l^2)} - \frac{2ac}{2c-l^2}\frac{al}{(1+d)(2c-l^2)}$$

$$= \frac{2bal}{2c-l^2} + \frac{2a(Al+bdl)}{(1+d)(2c-l^2)} - \frac{2a^2 l}{(1+d)(2c-l^2)}$$

Recalling that *bd* equals $\beta/2$ and $a = A + \beta/2$ this can be simplified to

$$\frac{\partial W_c}{\partial w} = \frac{2bal}{2c-l^2}$$

From this it follows that

$$\left.\frac{\partial(W_c - W_{RPM})}{\partial w}\right|_{w=dl} = 0\ .$$

Therefore we need the second derivative of W_c with respect to *w*. As W_{RPM} is linear in *w*, its second derivative is 0. The second derivative of W_c has the following form:

$$(8)\quad \frac{\partial^2 W_c}{\partial w^2} = 4b\frac{\partial s_c}{\partial w} + (2Al+2bw)\frac{\partial^2 s_c}{\partial w^2} + 2(l^2-c)\left[\left(\frac{\partial s_c}{\partial w}\right)^2 - s_c\frac{\partial^2 s_c}{\partial w^2}\right]$$

$$-2\left[\left(\frac{\partial p_c}{\partial w}\right)^2 + p_c\frac{\partial^2 p_c}{\partial w^2}\right]$$

At $w = dl$ the second derivative of p_c and s_c with respect to w are:

$$\frac{\partial^2 p_c}{\partial w^2} = \frac{2a(c - l^2)}{(1+d)^2 (2c - l^2)^2} \quad \frac{\partial^2 s_c}{\partial w^2} = \frac{-2al}{(1+d)^2 (2c - l^2)^2}$$

Inserting all of these expressions into (8) gives:

$$\frac{\partial^2 W_c}{\partial w^2} = \frac{2a}{(1+d)^2 (2c - l^2)^3} \left[2b(2c - l^2)^2 + \beta(2c^2 - 3{,}5cl^2 + l^4) + Ac(l^2 - 4c) \right]$$

The sign of this expression is obviously the sign of the expression in brackets. As the last term is negative according to assumption A1, sufficiently large A will yield a negative sign. In this case W_c is locally concave. And so is W_c - W_{RPM}. It has a maximum at $e = l$ where it attains the value of 0. This proves part (a) of proposition 4.

Conversely, if b is sufficiently large, then the expression in brackets becomes positive. Hence W_c - W_{RPM}. is locally convex and attains its minimum at $e = l$ where it attains the value of 0. This proves part (b) of proposition 4.

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