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Max Planck Institute for
Research on Collective Goods
Bonn 2007/16

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March 2007

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March 13, 2007.

Abstract

In some markets vertically integrated firms sell directly to final customers but also to independent downstream firms with whom they then compete on the downstream market. It is often argued that resellers intensify competition and benefit consumers, in particular when wholesale prices are regulated. However, we show that (i) resale may increase prices and make consumers worse off and that (ii) standard "retail minus X regulation" may increase prices and harm consumers. Our analysis suggests that this is more likely if the number of integrated firms is small, the degree of product differentiation is low, and/or if competition is spatial.

JEL-Classification: D43, L11, L42, L51

Keywords: Resale regulation, wholesale, spatial product differentiation, non-spatial product differentiation, vertical restraints

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Financial support from Deutsche Forschungsgemeinschft through SFB-TR 15 is gratefully acknowledged.

1 Introduction

This paper analyzes a market structure where several vertically integrated firms produce a horizontally differentiated product that they sell directly to final customers. In addition they may sell the product to independent intermediaries. These "resellers" may further differentiate the product and re-sell it on the final customer market. Thus, vertically integrated firms compete not only with each other, but also with the resellers they supply.

One leading example for resale are telecommunications markets. Many companies offer fixed or mobile services without an own infrastructure, by just reselling capacity of network operators. The perceived wisdom is that resellers increase competition in such markets and that therefore resale is to the benefit of consumers. Hence, refusal of integrated firms to make wholesale offers to reseller is often regarded as anticompetitive, and regulators frequently force integrated firms to make regulated wholesale offers to resellers.

The FCC obliged the US fixed line telecommunications operators to make wholesale offers until 2002[1]. In the European Union, the Access Directive (2002/19/EC, Article 12 (1d)) prescribes that national regulators must have the opportunity to mandate resale, and many national legislators have implemented this (e.g. §30 (5) of the German Telecommunications act allows for ex ante price regulation of resale offers). More generally, the EU Commission discusses "refusal to supply" as an anti-competitive practice, in particular, if refusal is used to make downstream competition impossible, i.e. as an instrument for vertical foreclosure. The EU clearly spells out the aim of regulatory intervention in such cases: "The main purpose of forcing companies to supply is to improve the competitive situation in the downstream market".[2]

We challenge the perceived wisdom by arguing that, generally, resale has an ambiguous effect on price levels in the final customer market. While, indeed, introducing resellers increases the number of firms and thereby tends to intensify competition, there are also counteracting effects. With resale, an integrated firm is also interested in its sales on the wholesale market. In order not to reduce its

[1] 60 FCC 2d 261 (1976), recon granted in part, 62 FCC 2d 588 (1977), aff'd sub nom. AT&T v. FCC, 572 F. 2d 17 (2d Cir), cert Denied, 439 US 875 (1978).

[2] See DG Competition discussion paper on the application of Article 82 of the Treaty to exclusionary abuses, Brussels December 2005, par. 207-242, in particular par. 209; quote from par. 213.

wholesale revenues too much, it competes less aggressively with its resellers on the downstream market. If firms compete in prices, this implies an incentive to raise prices compared to a situation without resellers. Furthermore, resellers are high cost competitors, because their costs are determined by the wholesale prices charged by the integrated firms. Thus, if prices are strategic complements, the higher the prices charged by resellers the higher are the prices charged by the integrated firms.

Regulators often try to reduce the price increasing effect from high wholesale tariffs by imposing a so called "retail minus X" regulation. This requires the integrated firms to charge a wholesale price that does not exceed their own retail price minus the cost of retail. However, it is not clear that this regulation reduces retail prices. An integrated firm might rather increase its own retail price instead of reducing its wholesale price in order to satisfy the price cap.

In this paper we address two questions: First, does the introduction of resale always reduce prices and benefit consumers? Second, does regulating resale according to a “retail minus X” rule always reduce prices on the downstream market? We show that the answer to both questions is negative. Introducing resale may increase the price level and make consumers worse off. This is remarkable because resellers add new varieties to the market which is always beneficial to consumers. However, the increase in prices may be so large that consumers are worse off despite the benefit of more product variety. Furthermore, imposing a “retail minus X” regulation may make things worse by inducing the integrated firms to increase prices even further.

We use two simple and frequently used models of price competition with horizontally differentiated products to show that this may indeed be the case: A Shubik and Levitan (1971) linear demand model of non-spatial competition and a Salop (1979) model of spatial competition with linear-quadratic transport costs. For each of these models we construct examples showing that the conventional wisdom may be wrong.

The intuition for our results is best seen if competition is spatial. Consider two integrated firms located at opposite positions on a Salop circle and competing in prices. Suppose now that two resellers are introduced and located in between them. The resellers act as “buffers”: The integrated firms no longer compete directly with each other but only with the resellers. But resellers are high cost competitors because they have to buy the product from the integrated firms. Furthermore, the integrated firms do not want to compete too aggressively against their own resellers because this cuts into their wholesale profits. Both effects tend to increase prices and are further aggravated by the fact that prices are strategic complements. There is a range of parameters in which the price increase is so strong that total consumer surplus is reduced even though many consumers benefit from reduced transport costs.

If the number of integrated firms is small, imposing “retail minus X” regulation may induce the integrated firms to increase their prices in both the spatial and the non-spatial model. In our example of the spatial model the effect is extreme and may lead to very high prices, prices that are even in excess of the prices that would result if the integrated firms would choose the wholesale prices collusively.

Our results show that the conventional wisdom on the positive effects of resale is not always correct and has to be seen with suspicion. In particular if the number of integrated firms is small and if competition is spatial it is well possible that the negative effects on prices dominate and that “resale minus X” regulation is inadequate to solve this problem.

Despite its importance and its popularity with regulators and legislators, the economic literature on resale is relatively small. Burton, Kaserman, and Mayo (2000) highlight three positive effects of resale. First, resale may allow to exploit different scale economies along the value chain, an argument first analyzed in the context of vertical integration by Stigler (1951). Second, resale may inhibit price discrimination.[3] Third, resale may allow for low cost market entry. While all of these effects are clearly important, our research question is focused on the effects of resale on price competition.

A related but clearly distinct literature is the literature on vertical integration and vertical contractual relations (for surveys see Perry (1989) and Katz (1989), respectively). The first line of research typically asks: Is it optimal to own one or several downstream firms (which then would no longer be independent[4]) and thereby to become directly active on the final product market? The second line of research assumes that the downstream firm is independent, and analyzes the optimal contractual relations between the up- and downstream firms. However, it presumes that the upstream firm itself is not directly active in the final product

[3] This is reflected in discussion on "re-imports", e.g. of cars or pharmaceuticals within the European Union. For this and related competition issues regarding attempts to hamper "parallel trade" in order to support price discrimination see e.g. Szymanski and Valletti (2005).

[4] As Perry (1989), p. 185, notes: "...inherent in the notion of vertical integration is the elimination of contractual or market exchanges, and the substitution of internal exchanges within the boundaries of the firm."

market. Our research question is in-between: We are interested in the case where the integrated firms can (or in case of regulation: must) sell their products upstream to independent intermediaries and, at the same time, sells directly downstream to final customers.

The remainder of the paper is organized as follows. Section 2 develops the basic trade-offs resulting from resale in a general framework. Section 3 introduces a spatial and a non-spatial model of price competition with horizontal product differentiation and offers one example for each model in which resale increases prices and makes consumers worse off (despite the additional product variety). Section 4 analyzes the effects of "retail minus X" regulation. Section 5 concludes.

2 The General Model

There are m vertically integrated firms, indexed by $i = 1, ..., m$ and $n-m$ resellers indexed by $r = m+1, ..., n$. Resellers require one unit of the good from a vertically integrated firm to sell one unit on the downstream market. Let $m_i(r) : \{m+1, ..., n\} \mapsto \{0, 1\}$ denote the supply mapping of integrated firm i, i.e. $m_i(r) = 1$ if integrated firm i is the supplier of reseller r, and 0 otherwise. Each vertically integrated firm may supply none, one, or several resellers, i.e. $0 \leq \sum_r m_i(r) \leq n - m$, for all $i \in \{1, ..., m\}$. Furthermore, we assume that $\sum_i m_i(r) = 1$ for all $r \in \{m+1, ..., n\}$, i.e., if a reseller r is supplied, it is exclusively supplied by one integrated firm, and that the mapping of resellers to integrated firms is exogenously given.[5] Note that in this model integrated firms do not compete to attract resellers. At the second stage, all firms compete in retail prices $p_j, j \in \{1, ..., n\}$.

We consider a general demand system $D(p)$ for the n varieties of the good that

[5] A model that endogenizes the mapping of resellers to integrated firms, including cases were one reseller can be supplied by several integrated firms, is significantly more complex and beyond the scope of the present paper, but it would be an interesting topic for future research.

satisfies the following assumptions:

$$\frac{\partial D_j}{\partial p_j} \leq 0, \tag{1}$$
$$\frac{\partial D_j}{\partial p_k} \geq 0, \tag{2}$$
$$\frac{\partial^2 D_j}{\partial p_j \partial p_k} > 0, \tag{3}$$

for all , $j, k \in \{1, ..., n\}$, i.e., demand for the good decreases with its own price (ordinary goods), goods are substitutes, and demand exhibits increasing differences which implies that prices are strategic substitutes.

We compare two situations. In the first situation there are no resellers. Only the m integrated firms are active on the downstream market and set their prices simultaneously. In the second situation resellers are introduced. In this case the game has two stages. At the first stage integrated firms set wholesale prices w_i, $i = 1, ..., m$. At the second stage, all firms (integrated firms and resellers) compete in retail prices p_j, $j \in \{1, ..., n\}$. The integrated firms have to supply any quantity on the wholesale market that the resellers demand at stage 2.

As noted in the introduction already we want to address two main questions:

1. Does the introduction of resellers increase competition in the sense that retail prices of the integrated firms decrease? Do consumers necessarily benefit from the introduction of resale?

2. Consider a situation in which resellers are active. If a price cap is imposed that requires $w_i \leq p_i$, does this reduces prices, or is it possible that prices go up and consumer are worse off?

With respect to the first question note that, if the introduction of resale induces falling prices, then consumers must be better off (if all prices fall they can still afford the varieties offered by the integrated firms, so they cannot be worse off. If they choose to consume different varieties, they must be at least weakly better off). Concerning the second question note further that a price cap $w_i \leq p_i$, $i \in \{1, ..., m\}$, reflects the standard "retail price minus retail cost" regulation because retail costs are normalized to zero in our model.

We want to compare two situations with different product varieties. Therefore, we have to specify the model such that consumers have preferences over all varieties, i.e. also over those which become available only with the introduction of resellers. Thus, we assume that in the situation without resellers, the varieties offered by the resellers are prohibitively costly. Therefore, in the case without resale we set the prices of the varieties offered by the resellers to infinity, so the demand function for the good of integrated firm $i \in \{1, ..., m\}$ is given by:

$$D_i = D_i \left(p_1, ..., p_m, p_{m+1} = ... = p_n = \infty\right).$$

All integrated firms set their prices simultaneously. A pure strategy equilibrium in which all integrated firms supply the downstream market is characterized by the first order conditions which imply, for all $i \in \{1, ..., m\}$:

$$p_i = \frac{D_i}{-\frac{\partial D_i}{\partial p_i}} \tag{4}$$

Suppose now that in addition to the integrated firms $n-m$ resellers serve the market as well. Reseller $r \in \{m+1, ..., n\}$ is supplied by integrated firm $i \in \{1, ..., m\}$ if and only if $m_i\left(r\right) = 1$. Thus, at stage 2, an integrated firm maximizes:

$$\max_{p_i} \widehat{p}_i \widehat{D}_i + w_i \sum_{r=m+1}^{n} m_i\left(r\right) \widehat{D}_r,$$

where we use a hat to distinguish this problem from the problem without resale. In a pure strategy equilibrium in which all firms (integrated firms and resellers) supply the downstream market the first order conditions of profit maximization imply

$$\widehat{p}_i = \frac{\widehat{D}_i + w_i \sum_{r=m+1}^{n} m_i\left(r\right) \frac{\partial \widehat{D}_r}{\partial \widehat{p}_i}}{-\frac{\partial \widehat{D}_i}{\partial \widehat{p}_i}}. \tag{5}$$

At stage one, the upstream firms choose w_i in order to maximize overall profits:

$$\max_{w_i} \widehat{p}_i \widehat{D}_i + w_i \sum_{r=m+1}^{n} m_i\left(r\right) \widehat{D}_r.$$

Comparing (4) and (5) it is straightforward that the introduction of resale decreases retail prices if for all $i \in \{1, ..., m\}$:

$$\frac{D_i}{-\frac{\partial D_i}{\partial p_i}} - \frac{\widehat{D}_i}{-\frac{\partial \widehat{D}_i}{\partial \widehat{p}_i}} > \frac{w_i \sum_{r=m+1}^{n} m_i(r) \frac{\partial \widehat{D}_r}{\partial \widehat{p}_i}}{-\frac{\partial \widehat{D}_i}{\partial \widehat{p}_i}}. \tag{6}$$

To interpret this expression, suppose that for all integrated firms $w_i = 0$: Then the strategic complementarity of prices implies that if prices of resellers fall (from infinity to some finite level), prices of the vertically integrated firms also decrease. This suggests that resale tends to decrease prices.

However, this is not necessarily the case if $w_i > 0$ for some i: In this case there is a trade off. If the price of reseller r falls, the integrated firm i wants to reduce its price in order to protect its own downstream market. On the other hand, the integrated firm also cares about its wholesale revenues. Lowering $\widehat{p}_i$ reduces the demand of its resellers and therefore its wholesale revenues. If there are many vertically integrated firms in the market and if the price reduction of the integrated firms affects all other firms more or less symmetrically, the latter effect can be expected to be small. However, if the number of firms is small, or if competition is spatial and a price increase affects only the demand of i's neighbors, the second effect may dominate. To show this we have to consider more specific models.

3 Resale, Prices and Consumer Welfare

In this section we consider two standard models of price competition with horizontally differentiated products: A non-spatial Shubik and Levitan (1971) model with linear demand functions, and a spatial Salop (1979) model with linear transport costs. Both models have the properties that an increase in the number of firms does not extend the market: if the number of firms increases while the (identical) price charged by all firms remains constant, then the total quantity sold on the market remains constant. Thus, if there are more firms, the sum of all firms' profits is unaffected while consumers benefit because of more product variety. Therefore, integrated firms can benefit from the introduction of additional resellers only if the (average) price increases and if this price increase is sufficiently strong to compensate them for lost market shares. Furthermore, consumer surplus is reduced only if the price increase is sufficiently high to overcompensate the benefits of more product variety. In this section we will show that there are parameter ranges such that the introduction of resale increases prices, raises profits of the integrated firms and makes consumers worse off.

3.1 Non-Spatial Competition

Consider a demand system which can be derived from a representative consumer with a symmetric quasi-linear utility function of the following quadratic specification for the utility from the differentiated product:[6]

$$U^n = \sum_{j=1}^{n} q_j - \frac{1}{2}\left(\sum_{j=1}^{n} q_j\right)^2 - \frac{n}{2(1+\gamma)}\left[\sum_{j=1}^{n} q_j^2 - \frac{\left(\sum_{j=1}^{n} q_j\right)^2}{n}\right]. \tag{7}$$

If the consumer buys positive amounts of all goods, the demand for variety j is given by:

$$D_j(p) = \frac{1}{n}\left(1 - p_j - \gamma\left(p_j - \frac{1}{n}\sum_k p_k\right)\right). \tag{8}$$

The parameter γ describes the level of product differentiation. $\gamma = 0$ implies that products are no substitutes, $\gamma \to \infty$ implies perfect substitutability.

Let $n = 3$. We compare a situation with two integrated firms and no reseller to a situation with an additional reseller who is exclusively supplied by integrated firm 1.[7]

If only the two integrated firms are active, $q_3 = 0$, by assumption. Then the consumer's optimization problem yields:

$$D_1(p_1, p_2) = \frac{1+\gamma}{3+2\gamma}\left(1 - p_1 - \gamma\frac{p_1 - p_2}{3}\right). \tag{9}$$

Firm 1 maximizes $D_1(p_1, p_2)\, p_1$ with respect to p_1. Firm 2's profit maximization

[6] See Vives (2001), p. 163, for this specification of the Shubik-Levitan model. Note that there is a typo, where for the last term in the utility function it reads $\sum_j q_j$, while correctly it should be $\left(\sum_j q_j\right)^2$, since only the latter results in the demand functions derived by Vives.

[7] This resembles the situation in fixed line telephony in the US before 2002. Cable companies and telephone companies acted as integrated firms, while (only) telephone companies were forced to make wholesale offers to resellers.

problem is symmetric. It is straightforward to show that this game has a unique Nash equilibrium given by:

$$p^D = p_1 = p_2 = \frac{3}{6+\gamma}. \tag{10}$$

Suppose now that, additionally, there is a reseller who is supplied by integrated firm 1 at wholesale price w_1. The demand system is now given by (8) for $n = 3$. For given wholesale tariff w_1, the reseller maximizes with respect to its retail price p_3:

$$\max_{p_3} D_3(p)(p_3 - w_1). \tag{11}$$

The integrated firm 1 maximizes the sum of its retail and its wholesale profits:

$$\max_{p_1} D_1(p)\, p_1 + D_3(p)\, w_1, \tag{12}$$

while firm 2 (who does not supply a reseller) maximizes:

$$\max_{p_2} D_2(p)\, p_2. \tag{13}$$

This yields as second stage equilibrium prices:

$$\begin{aligned} p_1 &= \frac{18 + 15\gamma + 9\gamma w_1 + 5\gamma^2 w_1}{A}, p_2 = \frac{18 + 15\gamma + 3\gamma w_1 + 3\gamma^2 w_1}{A} \\ p_3 &= \frac{18 + 15\gamma + 18 w_1 + 21\gamma w_1 + 7\gamma^2 w_1}{A}. \end{aligned}$$

where $A = 36 + 42\gamma + 10\gamma^2$. Anticipating this, at stage one firm 1 chooses w_1 to maximize $D_1(p(w_1))\, p_1(w_1) + D_3(w_1)\, w_1$. Tedious but straightforward calculations show that there is a unique subgame perfect equilibrium with:

$$
\begin{aligned}
w_1 &= \frac{3(6+5\gamma)(18+18\gamma+5\gamma^2)}{B}, &(14)\\
p_1 &= \frac{9(4+3\gamma)(18+21\gamma+5\gamma^2)}{2B}, &(15)\\
p_2 &= \frac{3\left(216+378\gamma+213\gamma^2+35\gamma^3\right)}{2B}, &(16)\\
p_3 &= \frac{3\left(3+\gamma\right)\left(108+150\gamma+55\gamma^2\right)}{2B} &(17)
\end{aligned}
$$

with $B = 648 + 1296\gamma + 909\gamma^2 + 249\gamma^3 + 20\gamma^4$. Comparing (15) and (16) to (10) yields the following result:

Proposition 1 *In the non-spatial model with two integrated firms the introduction of a reseller leads to an increase of the retail price of the integrated firm that supplies the reseller. Furthermore, the trade weighted average retail price increases if γ is sufficiently small.*

This proves that the counteracting effect, stemming from the fact that an integrated firm with a reseller cares also about wholesale revenues, can outweigh the effect of additional competition. In this example, the retail price of the firm with a reseller increases independent of the level of product differentiation.

The retail price of the other integrated firm, which has no reseller in our example, however, always decreases. For this firm, no counteracting effect works against the effect that with resale there is an additional competitor in the market. The effect on the average price level therefore is ambiguous. The average price in the industry will however increase if products are distant substitutes. If $\gamma \to 0$, without resellers prices will be close to the monopoly prices charged in two separate markets. With resellers, prices of the integrated firms will still be close to the prices in separate monopolies: The integrated firms react only very little to the new competitor because he serves an almost separate market. However, the reseller sells at a higher price to final customers due to the usual double marginalization problem. The integrated firm sells to its reseller almost at the monopolistic retail price, and the reseller then adds his own mark-up. Thus, average prices increase compared to the situation without resale for small values of γ.

It can be shown that for all $\gamma \geq 0$ consumers benefit from the introduction of resale. However, our analysis shows that for small values of γ this effect must stem from the underlying preferences for variety, because the price effect harms consumers. The next example shows that the introduction of resale may make consumers strictly worse off.

3.2 Spatial Competition

Consider a Salop circle of length 1. Consumers are uniformly distributed and have mass 1. Each consumer has a unit demand and a maximum willingness to pay of v but suffers from having to subscribe to a firm with a brand that she does not like, modeled as linear-quadratic transport cost $T(\Delta) = t\Delta + (1-t)\Delta^2$, where Δ is the consumer's distance to its seller. We assume v to be sufficiently high such that all consumers always buy the product.

Integrated firms and resellers are located at exogenously given positions on the circle. Resellers do not have to pay any transport cost if they buy the upstream good from the integrated firms. The idea is that resellers offer a different branding of the good. If a consumer located at point x buys the brand offered from seller j located at x_j (integrated firm or reseller) at price p_j, his utility is given by

$$U = v - p_j - t\Delta(x, x_j) - (1-t)\Delta(x, x_j)^2, \tag{18}$$

where $\Delta(x, x_j)$ is the shortest distance along the circle between x and x_j.

We consider an example with two integrated firms and two resellers as in Figure 1. R_1 is a reseller that sells only I_1's products and is located at 0.25. R_2 is a reseller who sells only I_2's products. x_{ij} is the consumer indifferent between upstream firm i's and reseller j's offer.

If no resellers are present, the locations of the consumer indifferent between firm I_1 and I_2 are:

$$x_1 = \frac{1}{4} + \frac{p_2 - p_1}{1+t}, \tag{19}$$

$$x_2 = \frac{3}{4} + \frac{p_1 - p_2}{1+t}. \tag{20}$$

Each firm chooses its retail price to maximize the retail profits, i.e.

$$\begin{aligned} p_1 &\in \arg\max_{p_1} (x_1 + (1 - x_2))\, p_1, \\ p_2 &\in \arg\max_{p_2} (x_2 - x_1)\, p_2. \end{aligned}$$

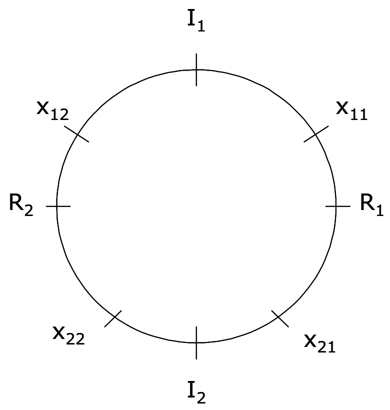

Figure 1: Two vertically integrated firms and two resellers

This yields:

$$p^D = p_1 = p_2 = \frac{1+t}{4}. \tag{21}$$

Now consider a situation where both integrated firms I_1 and I_2 supply the respective resellers, R_1 and R_2, at prices w_1 and w_2, respectively. At the second stage, the retail competition, firm I_1 maximizes:

$$\max_{p_1} \left(x_{11} + (1 - x_{12})\right) p_1 + w_1 \left(x_{21} - x_{11}\right),$$

while the maximization problem of reseller R_1 is:

$$\max_{r_1} \left(r_1 - w_1\right)\left(x_{21} - x_{11}\right),$$

where r_1 is his retail price. The objectives of firms I_2 and R_2 are determined analogously. If all firms serve the market, the reaction functions derived from the first order conditions are:

$$p_i = \frac{1+3t}{32} + \frac{r_i + r_j + w_i}{4}, r_i = \frac{1+3t}{32} + \frac{p_i + p_j + 2w_i}{4}. \tag{22}$$

Thus, the Nash equilibrium in retail prices of stage two is given by:

$$p_i = \frac{1}{48}(3 + 9t + 22w_i + 10w_j), \tag{23}$$

$$r_i = \frac{1}{48}(3 + 9t + 32w_i + 8w_j), \tag{24}$$

for $i, j \in \{1, 2\}, i \neq j$.

At stage one, the integrated firms anticipate this continuation equilibrium and choose their wholesale prices as to maximize their overall profits. In equilibrium the integrated firms choose:

$$w = w_1 = w_2 = 204 \frac{(1+3t)}{1040}. \tag{25}$$

Thus, on the equilibrium path, retail prices are given by:

$$p = p_1 = p_2 = 201 \frac{(1+3t)}{1040}, \tag{26}$$

$$r = r_1 = r_2 = 235 \frac{(1+3t)}{1040}. \tag{27}$$

The price of the reseller is higher than the price of the integrated firms. Integrated firms set the wholesale tariff above their own retail price. Comparing the prices (26) to the price (21) in the absence of resellers yields the following result:

Proposition 2 *In the spatial model, there exist $\widehat{t}, \bar{t}$, with $0 < \widehat{t} < \bar{t} < 1$, such that for all $t \in \left(\widehat{t}, \bar{t}\right)$ a unique pure strategy equilibrium in which all four firms serve the market exists. Compared to the equilibrium with just two integrated firms, for $t \in \left(\widehat{t}, \bar{t}\right)$, (i) prices for consumers are higher and (ii) consumers are worse off, while (iii) overall surplus is always higher.*

Proof. See Appendix. ■

The cutoff value of t for which (26) yields higher prices than (21) is $\widehat{t} = 59/343$. In the Salop model there is the well known problem of non-existence of a pure strategy equilibrium if the transport cost function is not sufficiently convex. The proof ensures that for all $t < \bar{t}$ the transport cost function is sufficiently convex to guarantee existence of a pure strategy equilibrium. Furthermore, it is shown that $\widehat{t} < \bar{t}$.

Note that in our model the social surplus must increase if additional resellers enter the market. This is because additional firms reduce transport costs while price increases do not affect social welfare given our assumption of unit demand. It is therefore even more surprising that resale can make consumers worse off. Figure 2 illustrates the effect for the different levels of the parameter t, which measure the convexity of the transport cost. If only the transport cost function is not too convex,

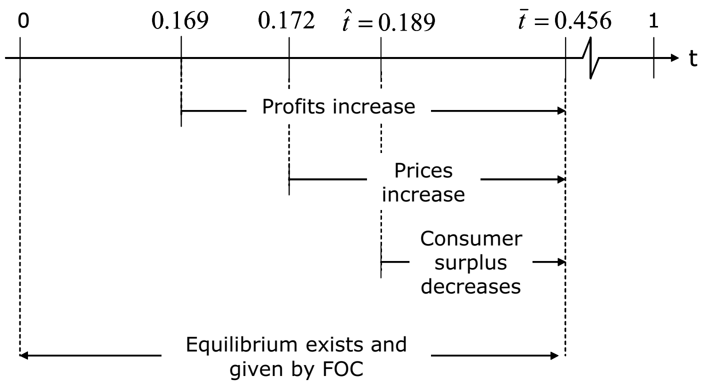

Figure 2: Effects of resale in the Salop model

the prices of the integrated firms increase when introducing resale. From (27) we know that this implies that also the price of the resellers is higher than the prices of the integrated firms in the absence of resale. The reason is – as in the non-spatial model – that the integrated firms want to be soft on their resellers, and therefore set relatively high price in the case of resale.

Furthermore, with spatial competition the introduction of resale alters the competition between the integrated firms. Since resellers act as a "buffer", they no longer compete directly with each other; rather, they compete only with the resellers. Resellers, however, are high cost competitors who must demand high retail prices in order to cover the wholesale tariff w_i. Since prices are strategic complements, this allows also the integrated firms to demand high prices.

As in the non-spatial example, higher retail prices are not a sufficient condition to make consumers worse off, since consumers benefit from the saving of transport cost due to resale. The effect from saved transport cost is most pronounced if the transport cost function is very convex. Thus, with decreasing convexity, i.e. increasing t, saved transport cost play less of a role for the customers. This explains why for t sufficiently large, consumers are made worse off by the introduction of resale.

The same argument explains why prices (and integrated firms' profits) increase due to resale only if the transport costs are not too convex. If they are very convex, i.e. if t is close to zero, integrated firms are able to set very high retail prices already in the duopoly situation. At the same time, introducing resellers saves a lot of transport cost with a very convex cost function, thus, the competitive effect from resellers is strongest with very convex transport cost.

4 Resale Regulation

Regulators frequently use “retail minus X” regulation, i.e. they impose a price cap on the wholesale price of the integrated firms that is equal to their retail price minus retailing cost. In our model, retailing cost are normalized to zero, so “retail minus X” regulation requires $w_i \leq p_i$. Note that if this form of regulation induces integrated firms to lower their wholesale prices, then retail prices are also reduced: resellers have lower per unit costs, which shifts their reaction functions downwards. Given that prices are strategic complements this implies that retail prices go down. This reasoning is reflected in the perceived wisdom that resale regulation should reduce prices.

However, integrated firms may react to retail minus X regulation by increasing their retail prices in order to meet the requirement $w_i \leq p_i$. Once they have chosen a wholesale tariff w_i, they are committed no to be too aggressive in the retail market because they cannot charge prices $p_i < w_i$. Thus, the introduction of resale regulation may increase rather than decrease retail prices and make consumers worse off.

4.1 Non-spatial model

To see that this may indeed happen under natural circumstances consider again the non-spatial model with $n = 3$ firms. The timing is as follows: At stage one, the integrated firm has to announce a wholesale tariff w_1. At stage two, all firms set retail tariffs, now with the additional restriction that $p_1 \leq w_1$.

Comparing (15) to (14), it is easy to see that for $\gamma \leq 3$ the price cap regulation has no bite. Even without the regulation the integrated firm sets $w_1 \leq p_1$. For low values of γ goods are poor substitutes. Therefore, an integrated firm does not see its reseller as a competitor but rather as a separate market. In the limit, as $\gamma \to 0$, the integrated firm charges the optimum wholesale price of a two stage monopoly.

Therefore, we can restrict attention to the case of $\gamma > 3$ where the price cap is binding, implying $w_1 = p_1$. At the second stage, the maximization problems of the reseller and the integrated firm without a reseller are still given by (11) and (13).

The integrated firm supplying the reseller anticipates the resulting solutions $p_3(p_1)$ and $p_2(p_1)$, and maximizes in stage one:

$$\max_{p_1} p_1 \left[D_1 \left(p_1, p_2(p_1), p_3(p_1)\right) + D_3 \left(p_1, p_2(p_1), p_3(p_1)\right) \right].$$

Tedious but straightforward calculations yield:

$$p_1^R = \frac{3(6+5\gamma)}{F}, \text{ implying} \tag{28}$$

$$p_2^R = \frac{36+45\gamma+11\gamma^2}{(2+\gamma)F} \text{ and } p_3^R = \frac{54+66\gamma+17\gamma^2}{(2+\gamma)F}, \tag{29}$$

where $F = 4\left(9(1+\gamma)+\gamma^2\right)$. Using these expressions and comparing them to the case without regulation yields the following results:

Proposition 3 *In the non-spatial model, the introduction of resale regulation has no effect for* $\gamma \leq 3$. *For* $\gamma > 3$ *it increases prices of the integrated firms and makes consumers worse off.*

Proof. See Appendix. ■

The proposition shows that it may indeed happen that the integrated firm increases its retail prices in order to meet the regulatory requirement. Actually, it does both: it increases the retail price and decreases the wholesale price to meet the price cap. Since it increases the retail price, due to the strategic complementarity, the other integrated firm also increases the retail price compared to the unregulated case. Only the reseller (slightly) reduces its retail price due to the decreased input cost, compared to the unregulated case. However, it can be shown that the total effect on consumer surplus (and total surplus) is always negative.

4.2 Spatial Model

In the spatial model, the price cap is always binding (compare (25) to (26)). It can be shown that if a pure strategy equilibrium exists $\left(t < \bar{t}\right)$, regulation always yields the desired results: retail prices decrease and consumers are better off.

For less convex transport costs there does not exist a pure strategy equilibrium in the unregulated market with resale, so we lack a point of reference. However, we can compare the outcome of the model with regulated resale to the outcome of the market without resale. With regulated resale, the integrated firms, when determining their wholesale tariffs, anticipate the pricing behavior of the resellers in stage two according to (22). Since the price cap is binding, we can set $p_1 = w_1$ and solve the first stage equilibrium. Denote by D_{iI} the quantity of the integrated firm i and by D_{iR} the quantity of firm i's reseller, $i = 1, 2$. Then, firm i maximizes:

$$\max_{p_i} p_i \left(D_{iI} + D_{iR}\right), \tag{30}$$

which, by symmetry, yields

$$p_i^R = \frac{1 + 3t}{6}, i = 1, 2. \tag{31}$$

Comparing this to (21) and calculating the total cost to consumers as the sum of payments and transport cost, we find:

Proposition 4 *In the spatial model, compared to a situation without resale, regulated resale yields (i) higher prices for* $t > 1/3$, *and (ii) lower consumer surplus for* $t > 67/183$.

Similar to the non-spatial model, integrated firms have an incentive to set high retail prices in order to satisfy the price cap. If transport costs are very convex (i.e. if t is small), the introduction of resellers saves a lot of transport costs. Furthermore, in this case integrated firms charge high prices already in the absence of resellers. Therefore, the introduction of regulated resale is harmful to consumers only if transport costs are not too convex (i.e. if t is sufficiently large).

A second interesting comparison relates regulated resale to a situation where the integrated firms collude on the wholesale tariff (but not on the retail prices). A cartel on the wholesale tariffs must not set w too high, since otherwise resellers would be driven out of the market and could not have the (from the integrated firms' perspective) desired "buffer" function. Furthermore, the wholesale tariff must be relatively low in order to ensure sufficient sales for the resellers. If their sales were too small, the integrated firms would have an incentive to "undercut" the resellers in stage two and drive them out of the market.

Regulation helps to circumvent this problem. Though firms cannot collude on w, the price cap again acts as a commitment device not to undercut in the second stage. This implies that retail prices under regulation can exceed unregulated retail prices resulting from collusion on the wholesale tariff.

Proposition 5 *Compared to collusion on the wholesale tariff, regulated resale yields higher retail prices and lower consumer surplus for* $t > 0.7$.

Proof. See Appendix. ■

Proposition 5 shows that regulation may help to stabilize high wholesale prices if transport costs are not too convex, i.e. if t is sufficiently close to 1. In this case the problem of a cartel is that it has to set low wholesale prices in order to deter the integrated firms from undercutting the resellers at stage 2. Retail minus regulation solves this problem. Once the wholesale price is fixed, the integrated firms are required by regulation not to undercut their wholesale prices.

As in the spatial model, resale regulation tends to lead to undesired results if the level of product differentiation is low. With low levels of product differentiation, price competition is intense, hence, firms have a strong incentive to reduce competition, and use the "commitment effect" of wholesale regulation to do so. At the same time, consumers gain very little from additional varieties.

5 Conclusion

The conventional wisdom of resale is that the introduction of resellers is beneficial because it increases price competition on the retail market. Furthermore, it is often argued that retail minus X regulation reduces prices even further because it forces integrated firms to supply resellers at lower wholesale prices. However, in this paper we have shown that this need not be the case in general. Prices may increase and consumer surplus may decrease if (i) resale is introduced and (ii) if retail minus X regulation applies to wholesale prices.

Higher prices due to resale are driven by the fact that integrated firms want to be soft on their resellers. This results in an externality: an integrated firm sets a high price to enable its reseller to make sales. However, all other firms in the industry also benefit from this, in particular, if competition is symmetric in the sense of our non-spatial model. Therefore, if the number of firms increases, the benefits of an integrated firm from raising its price are diminished. Indeed, if we add a second reseller to our non-spatial model, resale no longer increases prices.

In the spatial model the effect is somewhat more robust because the introduction of resellers changes the nature of competition. In a spatial model resellers may act as buffers that separate the integrated firms.

Our results show that the introduction of resale and of wholesale regulation is not in general beneficial. Therefore, regulators have to be very careful when employing these instruments, in particular if the number of firms in the industry is small and/or if competition is spatial in the sense that firms compete directly only with their "neighbors". Furthermore, resale regulation tends to be beneficial only if the level of product differentiation provided by the resellers is sufficiently large.

Appendix A: Proofs

Proof of Proposition 2: Assume that a pure strategy equilibrium exists and that it is determined by the first order conditions, i.e. by (25), (26), and (27); we later check for which parameter constellation this assumption holds. This implies $x_{11} = 99/520$ and $x_{21} = 161/520$.

The price without resale (21) exceeds the one with resale (26) if $t > 59/343 = 0.172$. Therefore, for $t > 59/343$ consumer prices increase, since resellers always charge higher prices than integrated firms, $(27) > (26)$.

We assume that consumers always buy the good. Thus, resale makes them worse off if it increases the sum of payments plus the transport cost T. Denote the total cost by C. Payments equal the sum of profits of all firms. In the absence of resale, i.e. with a duopoly of two integrated firms, this can be calculated from (21) to be $\pi_i^D = (1+t)/8$. Transport cost in the absence of resale equal

$$T^D = 4\int_0^{\frac{1}{4}} tx + (1-t)\, x^2 dx = \frac{1+5t}{48}.$$

Thus, total cost in the absence of resale are

$$C^D = \frac{13+17t}{48}. \tag{32}$$

With resale, it follows from (25) to (27) that integrated firms' profits equal

$$\pi_{integrated} = \frac{26223\,(1+3t)}{270400}, \tag{33}$$

while profits of resellers are

$$\pi_{reseller} = \frac{961\,(1+3t)}{270400}.$$

Note that integrated firms' profits are higher with resale compared to no resale for $t > 7577/44869 = 0.169$. Transport cost in the case of resale equal:

$$\begin{aligned} T &= 4\left(\int_0^{x_{11}} tx + (1-t)\, x^2 dx + \int_0^{\frac{1}{4}-x_{11}} tx + (1-t)\, x^2 dx\right) \\ &= \frac{7693+56879t}{811200}. \end{aligned} \tag{34}$$

Thus, total cost to consumers in the case of resale equal:

$$C = 2\left(\pi_{integrated} + \pi_{reseller}\right) + T = \frac{7693 + 56879t}{811200}, \tag{35}$$

which is higher than the total cost in the absence of resale (32) if $t > 16301/86297 = 0.189$. Therefore, if the solution is given by the first order conditions, for $t > \widehat{t} = 0.189$, prices increase and consumers surplus decreases, proving claims (i) and (ii). Claim (iii) is immediate since we assume that consumer always buy the good, so that the only effect on the overall surplus results from a reduction of transport cost due to the introduction of resellers.

It is left to show for which values of t a pure strategy equilibrium, which is determined by the first order conditions, exists. Therefore, we need to consider possible non-marginal deviations from the claimed equilibrium in the case of resale.[8] Consider the following deviation from the claimed equilibrium: After having chosen w_1 and w_2, an integrated firm (say, firm I_1) may deviate by choosing $\widetilde{p}_1 < p_1$ to undercut the resellers. Optimum deviation implies the following profits:[9]

$$\widetilde{\Pi}_1 = \begin{cases} \frac{26223+40170-47897t^2}{270400(1-t)} & \text{if} \quad t < \frac{31}{99}, \\ \frac{161(139+541t)}{270400} & \text{if} \quad \frac{31}{99} \leq t \leq \frac{61}{73}, \\ \frac{(461+863t)^2}{2163200(1+t)} & \text{if} \quad t > \frac{61}{73}. \end{cases} \tag{36}$$

The first part of the function stems from an undercutting in which the resellers still make sales, but the indifferent consumer $\widetilde{x}_{11} > 1/4$, the position of the reseller R_1. The second part reflects the payoffs resulting from the corner solution in which the reseller is just driven out of the market and x_1, the customer indifferent between I_1 and I_2, is at x_{21}. The third part results if $x_1 > x_{21}$ and I_1's optimum behavior is given by the best response function in the case of a duopoly. It is easily checked that for $t < \bar{t} = 31/68 = 0.456$ the profit in the claimed equilibrium (33) exceeds the deviation profit, proving that $\left(\widehat{t}, \bar{t}\right)$ is non-empty, such that equilibria with the

[8] Note that in the absence of resale, i.e. with only two integrated firms, the usual undercutting argument which is responsible for the non-existence of pure strategy equilibria with more than two firms on the Salop circle, does not apply. The reason is that undercutting can not discontinuously increase the number of customers if there are only two firms.

[9] The deviation of this function is tedious but straightforward. Details are available from the authors upon request.

claimed properties (i) - (iii) exists. ■

Proof of Proposition 3: Note first that

$$w_1 - p_1 = \frac{3\gamma(5\gamma^2 - 9\gamma - 18)}{2F}$$

is negative for $0 < \gamma < 3$ and positive for $\gamma \geq 3$. Thus, the regulatory constraint is binding only for $\gamma > 3$.

Assume $\gamma > 3$. Set $w_1 = p_1$. At stage two, the reseller maximizes

$$\max_{p_3} D_3 (p_3 - p_1) \to p_3 = \frac{3 + 3(1+\gamma)p_1 + \gamma p_2}{6 + 4\gamma}.$$

The integrated firm without a reseller maximizes:

$$\max_{p_2} p_2 D_2 \to p_2 = \frac{3 + \gamma(p_1 + p_3)}{6 + 4\gamma}.$$

Therefore, the integrated firm with a reseller anticipates a second stage outcome as a function of its choice of $w_1 = p_1$:

$$\begin{aligned} p_2 &= \frac{18 + 15\gamma + 9\gamma p_1 + 7\gamma^2 p_1}{36 + 48\gamma + 15\gamma^2} \\ p_3 &= \frac{18 + 15\gamma + 18p_1 + 30\gamma p_1 + 13\gamma^2 p_1}{36 + 48\gamma + 15\gamma^2}. \end{aligned}$$

Using this in the integrated firm's optimization problem

$$\max_{p_1} p_1 (D_1 + D_3)$$

yields

$$p_1^R = \frac{3(6 + 5\gamma)}{4(9 + 9\gamma + \gamma^2)}.$$

This is higher than the price in the absence of resale regulation, (15), since for $\gamma > 3$:

$$p_1 = \frac{9(4 + 3\gamma)(18 + 21\gamma + 5\gamma^2)}{2(648 + 1296\gamma + 909\gamma^2 + 249\gamma^3 + 20\gamma^4)} < \frac{3(6 + 5\gamma)}{4(9 + 9\gamma + \gamma^2)} = p_1^R$$

What is left to show is that consumers are made worse off from regulated resale.

In the case of regulated resale, the utility level of the representative consumer, given prices and the resulting quantities, is:

$$U^R = \frac{30132 + 97848\gamma + 123417\gamma^2 + 75636\gamma^3 + 22947\gamma^4 + 3112\gamma^5 + 144\gamma^6}{288(2+\gamma)^2(9+9\gamma+\gamma^2)^2}.$$

Comparing the resulting consumer surplus CS^R to the consumer surplus CS in the absence of regulation yields:

$$\begin{aligned}\Delta CS &= CS - CS^R = \frac{\gamma}{Z}[-272097792 - 1587237120\gamma - 4043675520\gamma^2 - 5859314172\gamma^3 \\ &\quad -5234838192\gamma^4 - 2867552847\gamma^5 - 826786602\gamma^6 + 3997836\gamma^7 \\ &\quad +98637426\gamma^8 + 37585323\gamma^9 + 6839640\gamma^{10} + 628260\gamma^{11} + 23200\gamma^{12}],\end{aligned}$$

where

$$Z = 288(2+\gamma)^2(9+9\gamma+\gamma^2)^2(648 + 1296\gamma + 909\gamma^2 + 249\gamma^3 + 20\gamma^4)^2 > 0.$$

Thus, ΔCS is positive if and only if the numerator is positive. Note first that the numerator is equal to zero at $\gamma = 3$, and that the first derivative of the numerator at $\gamma = 3$ is positive. Taking the second derivative we get:

$$\begin{aligned}&[-673945920 - 2929657086\gamma - 5234838192\gamma^2 - 4779254745\gamma^3 - 2066966505\gamma^4 \\ &+\gamma^5(13992426 + 460307988\gamma + 225511938\gamma^2 + 51297300\gamma^3 + 5759050\gamma^4 \\ &+255200\gamma^4\gamma)]12.\end{aligned}$$

For $\gamma > 3$, this is larger than:

$$\begin{aligned}
& [-673945920 - 2929657086\gamma - 5234838192\gamma^2 - 4779254745\gamma^3 - 2066966505\gamma^4 \\
& +243 \cdot (13992426 + 460307988\gamma + 225511938\gamma^2 + 51297300\gamma^3 + 5759050\gamma^4 \\
& +255200\gamma^5)]12 \\
= & [2726213598 + 108925183998\gamma + 49564562742\gamma^2 + \\
& \gamma^3\{7685989155 - 667517355\gamma + 62013600\gamma^2\}]12,
\end{aligned}$$

which is positive, since the term in the braces is positive for $\gamma > 0$. Thus, the first derivative is increasing and it must be the case that $\Delta CS > 0$ for $\gamma > 3$. ■

Proof of Proposition 5:

We first show that the results are not given by the first order conditions for the maximization of the joint profits of the integrated firms.

The cartel's maximization problem is:

$$\max_{w} p_1(w) D_{1I}(w) + wD_{1R}(w) + p_2(w) D_{2I}(w) + wD_{2R}(w) \tag{37}$$

From (23) and (24) we can use that in stage two:

$$p_i = \frac{3 + 9t + 32w}{48}, \tag{38}$$

$$r_i = \frac{3 + 9t + 40w}{48}, \tag{39}$$

such that the first order conditions of (37) yield $w = \frac{33}{32}(1 + 3t)$. This, however implies $D_{iR} = -7/16$.

The optimum collusive wholesale tariff is therefore given by a "No deviation condition": Integrated firms choose w as high as possible, but sufficiently low such that resellers make positive sales which are sufficiently large that in stage two it is not worthwhile for an integrated firm to undercut the resellers and drive them out of the market.

The cartel has to ensure that in stage two undercutting the resellers is not profitable. For a given choice of w, consider a deviation that just drives out the resellers and attracts customer x_{21} to the integrated firm I_1 :

$$x_{21} = \frac{3}{8} + 2\frac{p_2 - r_1}{1+3t}, \tag{40}$$

which, using (38) and (39) implies:

$$x_{21} = \frac{9 + 27t - 8w}{24 + 72t}. \tag{41}$$

To attract this customer, firm I_1 must chose

$$\widetilde{p}_1 = \frac{-3 + 9t^2 + 48w + 2t(-3 + 56w)}{48\,(1+3t)}, \tag{42}$$

implying (due to symmetry) a deviation profit of

$$\begin{aligned} \widetilde{\pi}_i &= 2\widetilde{p}_1 x_{21} \\ &= \frac{9 + 54t + 81t^2 + 264w + 792tw - 128w^2}{576 + 1728t}. \end{aligned} \tag{43}$$

Comparing this to the profit from the collusive outcome, for collusion to be stable, w must not be larger than:

$$\overline{w} = \frac{3 + 9t}{8 + 16t}. \tag{44}$$

Since we know that collusion profits are increasing in w for the relevant parameter region, the profit maximizing choice of w is $\overline{w}$. Thus,

$$p_1^{Coll} = \frac{5 + 17t + 6t^2}{16 + 32t}. \tag{45}$$

Comparing this to the price from regulated resale (31),

$$\begin{aligned} p_1^{Coll} &= \frac{5 + 17t + 6t^2}{16 + 32t} > \frac{1+3t}{6} = p_1^R \\ \text{if } t &< -1/3 \ \text{ and } t > 7/10. \end{aligned} \tag{46}$$

The total cost to the consumer are given by

$$C^{Coll} = \textstyle\sum_{i=1}^{2} p_{iI1} D_{iI} + p_{iR} D_{iR} + C^{Tranpsport} \tag{47}$$

where

$$C^{Transport} = 4\left(\int_0^{x_{11}} ty + (1-t)\, y^2 dy + \int_0^{\frac{1}{4}-x_{11}} ty + (1-t)\, y^2 dy\right).$$

Since p_1^{Coll} implies $x_{11} = (1+t) / (4+8t)$,

$$C^{Coll} = \frac{16 + 90t + 141t^2 + 47t^3}{48\,(1+2t)^2}. \tag{48}$$

Comparing this to C^R, the total cost to consumers in the case of regulated resale, defined in a similar way, yields:

$$C^{Coll} - C^R = \frac{115 + 421t - 128t^2 - 1068t^3}{768\,(1+2t)^2}, \tag{49}$$

which is negative for $t > 0.7$. ■

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Appendix B (not intended for publication)

Here we document how the explicit results have been derived for the non-spatial and the spatial model.

B.1 Non-spatial model

B.1.1 No resale

If only two varieties are available although the consumer has preferences for three varieties, her utility is given by:

$$U = D_1 + D_2 - \frac{1}{2}(D_1 + D_2)^2 - \frac{3}{2(1+\gamma)}\left(q_1^2 + q_2^2 - \frac{(D_1 + D_2)^2}{3}\right),$$

since, by assumption, $D_3 = 0$. Setting marginal utility equal to the price of each variety yields:

$$D_1 = \frac{(1+\gamma)(3 - (3+\gamma)p_1 + \gamma p_2)}{9 + 6\gamma},$$

which, by rearranging terms, yields (9) in the paper. Maximizing profits yields:

$$\begin{aligned} & \max_{p_1} D_1(p_1, p_2)\, p_1 \\ p_1 &= \frac{3 + p_2\gamma}{6 + 2\gamma}, \end{aligned}$$

which, by symmetry, implies

$$p_1 = p_2 = \frac{3}{6+\gamma},$$

as given in (10) in the paper. Using this, we can derive:

$$D_1^D = D_2^D = \frac{(1+\gamma)(3+\gamma)}{(6+\gamma)(3+2\gamma)}$$

$$U^D = \frac{27 + 39\gamma + 13\gamma^2 + \gamma^3}{(6+\gamma)^2(3+2\gamma)}$$

$$CS^D = U^D - 2D^D p^D = \frac{(1+\gamma)(3+\gamma)^2}{(6+\gamma)^2(3+2\gamma)}.$$

B.1.2 Resale

Since now all three varieties are available, demand for variety i is given by:

$$D_i = \frac{1}{3}\left(1 - p_i - \gamma\left(p_i - \frac{\sum_{j=1}^{3} p_j}{3}\right)\right).$$

The reseller maximizes:

$$\max_{p_3} D_3\left(p_3 - w_1\right) \rightarrow p_3 = \frac{3\left(1 + w_1\right) + \gamma\left(p_1 + p_2 + 2w_1\right)}{6 + 4\gamma}.$$

The integrated firm without a reseller maximizes:

$$\max_{p_2} D_2 p_2 \rightarrow p_2 = \frac{3 + \gamma\left(p_1 + p_3\right)}{6 + 4\gamma}.$$

The integrated firm with a reseller maximizes:

$$\max_{p_1} D_1 p_1 + w_1 D_3 \rightarrow p_1 = \frac{3 + \gamma\left(p_2 + p_3 + w_1\right)}{6 + 4\gamma}.$$

Solving the resulting system of three equations for the prices then yields the terms after equation (13) in the paper.

Maximizing the profits of firm 1 with respect to w_1 then yields:

Wholesale price

$$w_1 = \frac{3(6 + 5\gamma)(18 + 18\gamma + 5\gamma^2)}{F},$$

where $F = 648 + 1296\gamma + 909\gamma^2 + 249\gamma^3 + 20\gamma^4$. This implies:

$$\begin{aligned}
p_1 &= \frac{9(4 + 3\gamma)(18 + 21\gamma + 5\gamma^2)}{2F} \\
p_2 &= \frac{3\left(216 + 378\gamma + 213\gamma^2 + 35\gamma^3\right)}{2F} \\
p_3 &= \frac{3\left(3 + \gamma\right)\left(108 + 150\gamma + 55\gamma^2\right)}{2F}
\end{aligned}$$

$$
\begin{aligned}
D_1 &= \frac{648+1458\gamma+1179\gamma^2+393\gamma^3+40\gamma^4}{6F} \\
D_2 &= \frac{648+1566\gamma+1395\gamma^2+531\gamma^3+70\gamma^4}{6F} \\
D_3 &= \frac{324+702\gamma+549\gamma^2+165\gamma^3+10\gamma^4}{6F}.
\end{aligned}
$$

$$
\begin{aligned}
U &= \frac{1}{8F^2}\left[1084752+4583952\gamma+8272692\gamma^2+8257788\gamma^3+4930551\gamma^4\right. \\
&\quad \left.+1775322\gamma^5+368499\gamma^6+39240\gamma^7+1600\gamma^8\right]
\end{aligned}
$$

$$
\begin{aligned}
CS &= \frac{1}{8F^2}\left[314928+1434672\gamma+2827548\gamma^2+3133404\gamma^3\right. \\
&\quad \left.+2120229\gamma^4+888102\gamma^5+221769\gamma^6+29640\gamma^7+1600\gamma^8\right].
\end{aligned}
$$

B.1.3 Comparisons

Integrated firm 1's retail price:

$$
p_1 - p^D = \frac{3\gamma(108+90\gamma+21\gamma^2+5\gamma^3)}{2(6+\gamma)F} > 0.
$$

Integrated firm without a reseller:

$$
p_2 - p^D = -\frac{3\gamma\left(108+162\gamma+75\gamma^2+5\gamma^3\right)}{2\left(6+\gamma\right)F} < 0.
$$

Average prices:

$$
p^{av} = \frac{D_1p_1+D_2p_2+D_3p_3}{D_1+D_2+D_3};
$$

$$
\begin{aligned}
& p_1^D - p^{av} \\
= \; & \frac{3(-69984-268272\gamma-419904\gamma^2-336312\gamma^3-138996\gamma^4-23895\gamma^5+534\gamma^6+385\gamma^7)}{2(6+\gamma)FZ}
\end{aligned}
$$

where $Z = 540 + 1242\gamma + 1041\gamma^2 + 363\gamma^3 + 40\gamma^4$. Thus, the average price in case of resale is higher for γ sufficiently close to 0.

B.1.4 Regulated Resale

Demand for variety i is again given by:

$$D_i = \frac{1}{3}\left(1 - p_i - \gamma\left(p_i - \frac{\sum_{j=1}^{3} p_j}{3}\right)\right).$$

In the proof of Proposition 3 we show that the regulatory constraint is binding if and only if $\gamma > 3$. Investigate the case $\gamma > 3$. We can set $w_1 = p_1$. The solutions to the second stage optimization problems (22) then become:

$$\begin{aligned} p_3 &= \frac{3 + 3(1+\gamma)p_1 + \gamma p_2}{6 + 4\gamma} \\ p_2 &= \frac{3 + \gamma(p_1 + p_3)}{6 + 4\gamma}. \end{aligned}$$

This yields a second stage equilibrium as a function of p_1 :

$$\begin{aligned} p_3 &= \frac{18 + 15\gamma + 18p_1 + 30\gamma p_1 + 13\gamma^2 p_1}{36 + 48\gamma + 15\gamma^2}, \\ p_2 &= \frac{18 + 15\gamma + 9p_1 + 7\gamma^2 p_1}{36 + 48\gamma + 15\gamma^2}. \end{aligned}$$

Using this, the integrated firm with a reseller maximizes:

$$\max_{p_1} p_1 (D_1 + D_3),$$

which then yields (28) in the paper.

B.2 Spatial model

B.2.1 When are the equilibrium strategies under (unregulated) resale determined by the first order conditions?

To answer this we need to check the optimum deviation that "undercuts" the reseller. Assume the outcome to be determined by the first order conditions. Now consider a deviation of firm I_1. Three cases must be distinguished. First, an undercutting such that the resellers still make sales. Second, an undercutting which drives

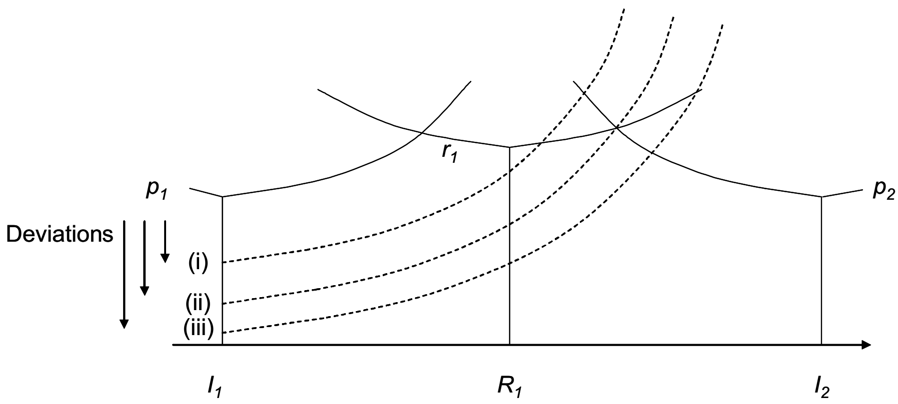

Figure 3: Possible deviations in the Salop model with resale

the resellers out of the market, and in which the deviator's price is determined by the first order conditions from a duopoly in which it competes only with the other integrated firm. Third, an intermediate case, where the deviator's price is determined by the constraint that the reseller makes no sales (i.e. where the first order conditions for a duopoly yields a relatively low optimum price for the deviator such that the reseller would make positive sales). Figure 3 illustrates the three cases. The problem stems from the kink of the "Hotelling umbrella" at the location of reseller R_1, due to the linear quadratic specification of the transport cost function.

(i) Consider a deviation to some $\widetilde{p}_1$ which implies that the resellers still makes sales. We know the pricing behavior of the reseller R_1 and the integrated firm I_2

$$\begin{aligned} r_1 &= r_2 = \frac{47}{208}(1+3t), \\ p_2 &= \frac{201}{1040}(1+3t), \\ w_1 &= w_2 = \frac{51}{260}(1+3t), \end{aligned}$$

implying $x_{21} = 161/520$. Thus, we consider $\widetilde{p}_1$ such that $1/4 < \widetilde{x}_{11} < 161/520$: (considerations for the cutoff customer x_{12} are identical due to symmetry):

$$\widetilde{x}_{11} = \frac{1-5t}{8(1-t)} + 2\frac{r_1 - \widetilde{p}_1}{1-t}.$$

Given this, the second stage profit maximization for the deviation

$$\max_{\widetilde{p}_1} 2\left(\widetilde{x}_{11}\widetilde{p}_1 + \left(\frac{161}{520} - \widetilde{x}_{11}\right) w_1\right),$$

we get

$$\widetilde{p}_1 = \frac{201 + 343t}{1040},$$

implying a deviation profit of:

$$\widetilde{\pi}_1 = \frac{26223 + 40170 - 47897t^2}{270400\,(1-t)}.$$

However, this result applies only if the resellers still make sales, i.e. $\widetilde{x}_{11} < 161/520$, i.e. if

$$t < \frac{31}{99},$$

otherwise, the constraint that resellers make non-negative sales becomes binding and the lowest price the deviator can set must be above

$$\overline{p}_1 = \frac{139 + 541t}{1040}.$$

However, the optimum deviation might well imply that resellers are driven out of the market such that the deviator competes only with the other integrated firm. Then we know the best response function from the duopoly situation to be:

$$\widetilde{\widetilde{p}}_1 = \frac{1}{4} + \frac{p_2 - \widetilde{\widetilde{p}}_1}{1+t}.$$

Using

$$p_2 = \frac{201}{1040}\left(1 + 3t\right),$$

immediately yields as the maximum deviation profit for this case:

$$\widetilde{\widetilde{\pi}}_1 = 2\widetilde{\widetilde{x}}_{11}\widetilde{\widetilde{p}}_1 = \frac{\left(461 + 863t\right)^2}{2163200\,(1+t)}.$$

However, we need to ensure that the resellers indeed make no sales, which, as we already know, requires that

$$\widetilde{\widetilde{p}}_1 < \frac{139 + 541t}{1040}.$$

This constraint becomes binding for[10]

$$t < \frac{61}{73}.$$

Therefore, the solution is given by the best response function for $t > 61/73$, and by the corner solution which ensures zero sales for the reseller for $t \leq 61/73$, implying

$$\widetilde{\widetilde{\pi}}_1 = \begin{cases} \frac{161(139+541t)}{270400} & \text{if} \quad t \leq 61/73, \\ \frac{(461+863t)^2}{2163200(1+t)} & \text{if} \quad t > 61/73. \end{cases}$$

Hence, depending on t, the profit resulting from the optimum deviation is a three step function:

$$\widetilde{\Pi}_1 = \begin{cases} \frac{26223+40170-47897t^2}{270400(1-t)} & \text{if} \quad t < \frac{31}{99}, \\ \frac{161(139+541t)}{270400} & \text{if} \quad \frac{31}{99} \leq t \leq \frac{61}{73}, \\ \frac{(461+863t)^2}{2163200(1+t)} & \text{if} \quad t > \frac{61}{73}. \end{cases}$$

Since the profit in the claimed equilibrium is

$$\pi_1 = \frac{26223}{270400}\left(1+3t\right),$$

it is easily checked that for $t < 31/99$ the deviation is never profitable. For higher values it is profitable if

$$\begin{aligned} \frac{161\left(139+541t\right)}{270400} &> \frac{26223}{270400}\left(1+3t\right) \\ t &> \frac{31}{68}. \end{aligned}$$

Thus, for $t < 31/68$ the solution of the two stage game is given by the first order conditions, as claimed in the proposition. For higher values of t no equilibrium in pure strategies exist due to the jump in the profit functions just derived.

B.2.2 Regulated Resale

Comparing (15) to (14) in the paper shows that the price cap is always binding. Thus, $p_i = w_i$ in the optimum. The best response functions of the resellers are

[10] The profits are increasing in p_1 for $p_1 < \frac{461+863t}{2080}$. Thus, for $\widetilde{\widetilde{p}}_1 < \frac{139+541t}{1040}$ and $t < \frac{61}{73}$ it is indeed optimal to choose $\widetilde{\widetilde{p}}_1$ als large as possible, i.e. equal to $\frac{139+541t}{1040}$, since $\frac{139+541}{1040} \leq \frac{461+863t}{2080}$ for $t \leq \frac{61}{73}$.

anticipated by the integrated firms. From (22), and setting $p_i = w_i$, we get:

$$\begin{aligned} r_1 &= \frac{1+3t+24p_1+8p_2}{32}, \\ r_2 &= \frac{1+3t+24p_2+8p_1}{32}. \end{aligned}$$

Denote by D_{iI} an integrated firm's quantity and by D_{iR} a reseller's quantity, $i = 1, 2$. An integrated firm, maximizes

$$\max_{p_i} p_i \left(D_{iI} + D_{iR}\right).$$

This yields:

$$p_i = \frac{1+3t+6p_j}{12},$$

implying by symmetry equilibrium prices for the case of regulated resale of:

$$\begin{aligned} p_i^R &= \frac{1+3t}{6}, \\ r_i^R &= \frac{19\left(1+3t\right)}{96}. \end{aligned}$$

Note that p_i^R is always lower than the price p_i in case of unregulated resale, provided a pure strategy equilibrium exists (see (26)):

$$p_i^R = \frac{1+3t}{6} < p_i = 201\frac{(1+3t)}{1040}.$$

The equilibrium prices with regulated resale imply:

$$\begin{aligned} x_{11}^R &= \frac{3}{16}, x_{21}^R = \frac{5}{16}, x_{22}^R = \frac{11}{16}, x_{12}^R = \frac{13}{16}, \\ D_{iI} &= \frac{3}{8}, D_{iR} = \frac{1}{8}, \\ \pi_{iI} &= \frac{1+3t}{6}, \pi_{iR} = \frac{1+3t}{256}. \end{aligned}$$

Hence, total payments for the consumers equal $2\left(\pi_{iI} + \pi_{iR}\right) = \frac{67(1+3t)}{384}$. Transport cost equal:

$$\begin{aligned}
T^R &= 4\left(\frac{t}{2}x_{11}^2 + \frac{1-t}{3}x_{11}^3 + \frac{t}{2}\left(\frac{1}{4} - x_{11}\right)^2 + \frac{1-t}{3}\left(\frac{1}{4} - x_{11}\right)^3\right) \\
&= \frac{7+53t}{768}.
\end{aligned}$$

Thus, total cost to consumers in case of regulated resale amount to:

$$C^R = \frac{141+455t}{768}.$$

This is strictly smaller than the total cost in the case of unregulated resale, given by (35). It is, however, higher than the total cost for consumers in the case without resale for $t > \frac{67}{183}$:

$$\begin{aligned}
C^R &= \frac{141+455t}{768} > C^D = \frac{13+17t}{48} \\
t &> \frac{67}{183}.
\end{aligned}$$