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Two tales on resale[☆]

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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.

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 resell 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 anti-competitive, 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.[2] 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

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[2] 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).

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main purpose of forcing companies to supply is to improve the competitive situation in the downstream market".[3]

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 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 it may 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 types of 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 Hotelling (1929)/Salop (1979) models 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. Furthermore, if a regulator forces the integrated firms to charge resellers prices that are lower than their retail prices minus retail cost may make matters worse. We show that if the number of integrated firms is small, imposing "retail minus *X*" regulation may induce the integrated firms to increase their prices.

Our results demonstrate 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.

In most of the paper we assume that the mapping of resellers to integrated firms is exogenously given, so integrated firms do not compete to attract resellers. Absence of competition for the reseller might be due to diversified inputs by the integrated firm. For instance, the firm with a reseller could be a telecommunications company, the reseller a telecommunications service provide using telephony infrastructure, while the competing integrated firm might be a cable company which also offers voice telephony. Or the two integrated companies could be mobile network providers using different standards for voice telephony (like GSM and CDMA). There may be competition for resellers at an ex ante stage, but once a reseller is committed to one of the two technologies he may not be able to use inputs of both suppliers (at least not without incurring large adjustment costs). In other cases, however, competition for resellers is possible. Therefore, we extend the model to the case of competition for resellers in Section 5.

Despite its importance and its popularity with regulators and legislators, the economic literature on resale used to be relatively small. Burton et al. (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.[4] 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.

There are a few recent papers using models similar to ours but focusing on different questions. Ordover and Shaffer (2007) consider a non-spatial linear demand model and analyze whether an integrated firm would supply a downstream entrant. They show that the integrated firm will not supply the entrant if the entrant's product is a close substitute to its own downstream product. Brito and Pereira (2006) look at a Hotelling–Salop model with spatial competition and show that whether an entrant is foreclosed depends on the positions of the incumbents and the entrant on the circle. Bourreau et al. (2007) use a similar non-spatial linear demand framework in which the integrated firms compete upstream for resellers and downstream for final consumers. They provide necessary and sufficient conditions under which a "monopolistic outcome" where integrated firms do not compete for resellers can

[3] 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.

[4] 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).

obtain. We discuss the relation to their work in more detail in Section 5.

We add two main points to this literature. First, we focus on the effects of resale on downstream competition and the impact on prices and consumer surplus. Second, we compare the two types of models discussed in the literature (spatial and non-spatial) and find that resale tends to be more problematic with spatial competition.

A related but clearly distinct literature is the literature on vertical integration and vertical contractual relations (for surveys see Perry, 1989; 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[5]) 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 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 investigates competition for resellers. Section 6 concludes. All proofs can be found in the Appendix.

2. The general model

There are m vertically integrated firms, indexed by $i=1,\dots,m$ and $n-m$ resellers indexed by $r=m+1,\dots,n$. Resellers require one unit of the good from a vertically integrated firm to sell one unit on the downstream market. Let $m_i(r)$: $\{m+1,\dots,n\}\mapsto\{0,1\}$ 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 $i\in\{1,\dots,m\}$. Furthermore, we assume that $\sum_i m_i(r)=1$ for all $r\in\{m+1,\dots,n\}$, i.e., if a reseller r is supplied, it is exclusively supplied by one integrated firm. The mapping of resellers to integrated firms is assumed to be exogenously given, so integrated firms do not compete to attract resellers. However, in Section 5 we extend the model to the case of competition for resellers.

At the second stage, all firms compete in retail prices p_j, $j\in\{1,\dots,n\}$. We consider a general demand system $D(p)$ for the n varieties of the good that satisfies the following assumptions:

$$\frac{\partial D_j}{\partial p_j}\leq 0, \tag{1}$$

$$\frac{\partial D_j}{\partial p_k}\geq 0, j\neq k, \tag{2}$$

$$\frac{\partial^2 D_j}{\partial p_j \partial p_k}>0, j\neq k, \tag{3}$$

for all j, $k\in\{1,\dots,n\}$, 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 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 firm i, $i=1,\dots,m$, sets a wholesale price w_i, $i=1,\dots,m$ which it charges its reseller. At the second stage, all firms (integrated firms and resellers) compete in retail prices p_j, $j\in\{1,\dots,n\}$. 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 the following questions:

1. Consider an unregulated market with m integrated firms. 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? Note that falling prices is a sufficient but not a necessary condition for consumers to benefit from resale: If prices fall, consumers must be at least weakly better off because they can still afford the old consumption bundle. However, if prices increase, consumers may still be better off, because resellers offer additional varieties. Thus, if the answer to the first question is negative, the second question has to be addressed separately.
2. Consider a market with m integrated firms and $n-m$ resellers. If a regulator imposes a price cap that requires $w_i\leq p_i$, does this reduces prices, or is it possible that prices go up. Note that here an increase in prices must make consumer worse off, because no additional varieties are introduced. Note further that a price cap $w_i\leq p_i$, $i\in\{1,\dots,m\}$, reflects the standard "retail price minus retail cost" regulation because retail costs are assumed to be linear and normalized to zero.

We have 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 $i\in\{1,\dots,m\}$ is given by:

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

All integrated firms set their prices simultaneously to maximize

$$\max\ p_i D_i.$$

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

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

[5] 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."

Suppose now that in addition to the integrated firms $n-m$ resellers serve the market. Reseller $r \in \{m+1,\ldots, n\}$ is supplied by integrated firm $i \in \{1,\ldots, m\}$ at wholesale price w_i if and only if $m_i(r)=1$. At stage 2, the wholesale price w_i is given and each integrated firm maximizes:

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

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

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

At stage 1, the integrated firms choose w_i in order to maximize overall profits:

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

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

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

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 effect tends to decrease prices. However, if $w_i>0$ for some i there is a trade-off, because the integrated firm also cares about its wholesale revenues. Lowering $\hat{p}_i$ 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 that this is indeed possible we have to consider more specific models.

3. Resale, prices and consumer welfare

In this section we consider two standard types of models of price competition with horizontally differentiated products: A non-spatial Shubik and Levitan (1971) model with linear demand functions, and spatial models a la Hotelling (1929) and Salop (1979) model with linear-quadratic transport costs. Both types of models have the property 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, can increase profits of the integrated firms and may even make 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]

Consider first the situation where only the two integrated firms are active, i.e. $q_3=0$ by assumption Then the consumer's optimization problem yields[8]:

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

Firm 1 maximizes $D_1(p_1, p_2)\, p_1$ with respect to p_1. Firm 2's profit maximization problem is symmetric. It is straightforward to show that this game has a unique Nash equilibrium given by:

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

[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 $(\sum_j q_j)^2$, 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.

[8] It is important to note that if only two varieties are available, the resulting demand system is *not* $D_1 = \frac{1}{2}(1 - p_1 - \gamma(p_1 - \frac{p_1+p_2}{2}))$. Such a demand function would result if the representative consumer would have preferences only over two varieties, i.e. it would stem from a different utility function; hence the results of the cases with two varieties would not be comparable in terms of welfare to the case with three varieties. See Höffler (2007).

Consider now the case where there is an additional reseller that is supplied by integrated firm 1 at wholesale price w_1. If all three firms have positive market shares the demand system is given by Eq. (8). For given wholesale tariff w_1, the reseller maximizes profit 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 second stage equilibrium prices:

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

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

$$w_1 = \frac{3(6+5\gamma)(18+18\gamma+5\gamma^2)}{B}, \tag{14}$$

$$p_1 = \frac{9(4+3\gamma)(18+21\gamma+5\gamma^2)}{2B}, \tag{15}$$

$$p_2 = \frac{3(216+378\gamma+213\gamma^2+35\gamma^3)}{2B}, \tag{16}$$

$$p_3 = \frac{3(3+\gamma)(108+150\gamma+55\gamma^2)}{2B} \tag{17}$$

with $B=648+1296\gamma+909\gamma^2+249\gamma^3+20\gamma^4$. Comparing Eqs. (15) and (16) to Eq. (10) and calculating and comparing the profits for both cases 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. Resale yields higher profits than upstream duopoly for the firm supplying the reseller for γ 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 increases if products are distant substitutes. To see this suppose that γ is close to 0. Without resellers prices are close to the monopoly prices charged on two separate markets. With resellers, prices of the integrated firms are still close to the prices in separate monopolies, because the new competitor serves an almost separate market. However, due to the usual double marginalization problem the reseller is supplied by the integrated firm almost at the monopolistic wholesale price to which he adds his own mark-up. Thus, the reseller sells at a higher price to final customers and average prices increase compared to the situation without resale; Note that the integrated firm with a reseller must benefits from resale, because it could always drive the reseller out of the market (by setting $w_1 \to \infty$), but chooses not to do so.

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

3.2.1. Asymmetric Hotelling model

Consider a Hotelling line of length one, where the two integrated firms are located at 0 and 1. Consumers are uniformly distributed on the line and have mass 1. Each consumer has a unit demand and a maximum willingness to pay υ but suffers from a "transport cost" reflecting that the horizontally differentiated brands offered by the different firms are not his most preferred variety. We assume υ to be sufficiently high such that all consumers always buy the product. In order to ensure existence of pure strategy equilibria and in order to circumvent well-known problems to establish equilibria which are characterized by the first order conditions of the firms' profit maximization, we assume linear-quadratic transport cost $T(\Delta)=t\Delta+(1-t)\,\Delta^2$ where Δ is the consumer's distance to its seller and the parameter $t\in[0, 1]$.[9]

At stage 0 firm 1 may sign an exclusive dealing contract with a reseller in which it agrees to supply the reseller at a linear wholesale price w and commits not to drive the reseller out of the market in the following pricing game. We assume that the reseller is located asymmetrically at 1/4.[10] The reseller offers a different brand of the good. He does not incur transport costs when he buys the upstream good from the integrated firm.

At stage 1 all firms compete in prices. If a consumer located at point x buys the brand offered from seller j located

[9] This specification of a linear-quadratic transport cost is frequently used in the literature, see e.g. Anderson (1988) or Hamoudi and Moral (2005). If transport costs are linear, the demand function of each firm is discontinuous if it sufficiently undercuts the price of its competitor. This leads to the well known problem of non-existence of a pure strategy equilibrium in the pricing game of Hotelling or Salop models (D'Aspremont et al., 1979). This problem can be avoided if the transport cost function is sufficiently convex. Note that the parameter t does not measure the transport cost but rather the convexity of the transport cost function.

[10] In the Hotelling model the asymmetric location and the commitment not to drive the reseller out of the market are necessary to ensure that it is profitable for firm 1 and the reseller that the reseller enters the market. In the Salop model with two resellers that is presented below these assumptions are not required.

at x_j (integrated firm or reseller) at price p_j her utility is given by

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

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

In a duopoly, i.e. in the absence of a reseller, the consumer indifferent between the two integrated firms is located at:

$$x = \frac{1}{2} + \frac{p_2 - p_1}{2}. \tag{19}$$

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

$$p_1 \in \arg\max_{p_1} p_1 x; \quad p_2 \in \arg\max_{p_2} p_2(1-x). \tag{20}$$

This yields:

$$p_1^D = p_2^D = 1; \quad \pi_1^D = \pi_2^D = \frac{1}{2}. \tag{21}$$

Total cost to the consumer is the sum of profits and transportation costs and equals:

$$\mathrm{TC}^D = \frac{13}{12} + \frac{t}{6}. \tag{22}$$

We compare this to a situation where firm 1 first decides on a wholesale tariff w_1 and afterwards all three firms compete in prices. With three active firms the consumer indifferent between firm 1 and the reseller and the consumer indifferent between the reseller and firm 2 are, respectively, located at:

$$x_1 = \frac{1}{8} + 2\frac{r - p_1}{1+3t}, \quad x_2 = \frac{5}{8} + 2\frac{p_2 - r}{3+t}, \tag{23}$$

where r denotes the reseller's retail price. Thus, each firm maximizes in the second stage its retail profits:

$$\begin{aligned} p_1 &\in \arg\max_{p_1} p_1 x_1 + w_1(x_2 - x_1), \\ p_2 &\in \arg\max_{p_2} p_2(1 - x_2), \\ r &\in \arg\max_{r} (r - w_1)(x_2 - x_1). \end{aligned} \tag{24}$$

Anticipating the unique Nash equilibrium of the pricing game at stage 1, firm 1 sets its optimal wholesale tariff w_i:

$$w_1 = \frac{1260 + 2670t + 1776t^2 + 342t^3}{4(261 + 470t + 213t^2)}, \tag{25}$$

implying

$$p_1 = \frac{1338 + 3015t + 2148t^2 + 459t^3}{4(261 + 470t + 213t^2)}, \tag{26}$$

$$p_2 = \frac{969 + 2150t + 1473t^2 + 288t^3}{4(261 + 470t + 213t^2)}, \tag{27}$$

$$r = \frac{1350.75 + 3046.75t + 2114.25t^2 + 416.25t^3}{4(261 + 470t + 213t^2)}. \tag{28}$$

For t not too large, the reseller sets the highest price, followed by the firm supplying the reseller. The firm without a reseller sets the lowest price. The following proposition characterizes the equilibrium outcome.

Proposition 2. *In the asymmetric Hotelling model, there exist $\tilde{t}$, t^* with $0 < \tilde{t} < t^* < 1$, such that for all $t \in (\tilde{t}, t^*)$ a unique pure strategy equilibrium in which all three firms serve the market exists. For all $t \in (\tilde{t}, t^*)$ (i) retail prices are higher, (ii) consumers are worse off (iii) profits of the integrated firm increase and (iv) overall surplus is higher, compared to the equilibrium of the game with no resellers.*

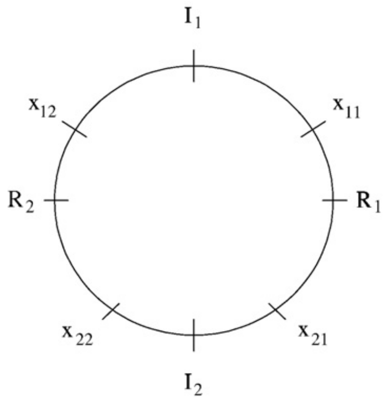

Fig. 1. Two vertically integrated firms and two resellers.

Thus, like in the non-spatial model, resale can increase the price level. Even though the firm with a reseller loses downstream sales to its reseller its profits can increase because prices and wholesale revenues on the upstream market increase. If t is sufficiently large, $t > \tilde{t}$, i.e. if the transport cost function is not too convex, this is indeed the case and firm 1 has a strict incentive to introduce the reseller. This is formally shown in the Appendix. The proof ensures that for all $t < t^*$ the transport cost function is sufficiently convex to guarantee existence of a pure strategy equilibrium. Furthermore, it is shown that $\tilde{t} < t^*$.

Not only firm 1 but also firm 2 benefits from introduction of the reseller. It can "free-ride" on the higher price level, but need not lose direct sales to the reseller. What is remarkable is that the price increase can be so strong that consumers are actually worse off — although total surplus always increases due to the reduction of total transportation cost.

3.2.2. Symmetric Salop model

Our result is not restricted to the asymmetric Hotelling setup. Let us briefly consider a symmetric specification where both integrated firms have a reseller. In this case consumers live on a Salop circle with two integrated firms located at 0 and 0.5, and two resellers, as depicted in Fig. 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 and is located at 0.75. The marginal consumer who is just indifferent between upstream firm i's and reseller j's offer is denoted by x_{ij}.

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

$$x_1 = \frac{1}{4} + \frac{p_2 - p_1}{1+t}, \tag{29}$$

$$x_2 = \frac{3}{4} + \frac{p_1 - p_2}{1+t}. \tag{30}$$

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

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

This yields:

$$p^D = p_1 = p_2 = \frac{1+t}{4}. \tag{31}$$

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 firm I_1 maximizes:

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

while the maximization problem of reseller R_1 is:

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

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:

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

Thus, the Nash equilibrium in retail prices of stage 2 is given by:

$$p_i = \frac{1}{48}(3 + 9t + 22w_i + 10w_j), \tag{33}$$

$$r_i = \frac{1}{48}(3 + 9t + 32w_i + 8w_j), \tag{34}$$

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

At stage 1, the integrated firms anticipate this continuation equilibrium and choose their wholesale, prices as to maximize their overall profits. In equilibrium the integrated firms choose:

$$w = w_1 = w_2 = 204\frac{(1+3t)}{1040}. \tag{35}$$

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

$$p = p_1 = p_2 = 201\frac{(1+3t)}{1040}, \tag{36}$$

$$r = r_1 = r_2 = 235\frac{(1+3t)}{1040}. \tag{37}$$

Note that prices of resellers are higher than prices of the integrated firms. Integrated firms set the wholesale tariff above their own retail price. Comparing the prices of Eq. (36) to the price of Eq. (31) in the absence of resellers yields the following result:

Proposition 3. *In the symmetric Salop model there exist $\hat{t}$, $\bar{t}$, with $0<\hat{t}<\bar{t}<1$, such that for all $t \in (\hat{t}, \bar{t})$ a unique pure strategy equilibrium in which all four firms serve the market exists. For all $t \in (\hat{t}, \bar{t})$, (i) retail prices are higher, (ii) consumers are worse off, (iii) profits of the integrated firms increase, and (iv) overall surplus is higher than in the equilibrium of the game with no resellers.*

Like in the asymmetric Hotelling game, there exists in intermediate range of t, such that an equilibrium exists and that prices increase so strongly that consumers are made worse off. Fig. 2 illustrates the effect for different levels of the parameter t, which measures the convexity of the transport cost function. If the cost function is very convex, i.e. t is close to zero, the integrated firms do not benefit from introducing resale because they are able to charge very high prices already in the absence of resale: If the transport cost function is not too convex, $t>0.169$, profits of the integrated firms increase when introducing reseller. Profits may increase even without increasing retail prices of the integrated firms because they charge wholesale prices above their own retail price (for $0.169<t<0.172$ the profit increase is fully due to wholesale profits). However, for sufficiently large t, $t>0.172$, also the price of the integrated companies increase compared to the situation without resellers. 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 prices in the case of resale. A price increase is a necessary but not sufficient condition to make consumers worse off, since they always benefit from resale in terms of saved transportation cost. Nevertheless, like in the previous example, for t sufficiently large, $0.189<t<0.456$, prices increase so much due to resale that the effect outweighs the benefit from reduced transportation cost for the consumers.

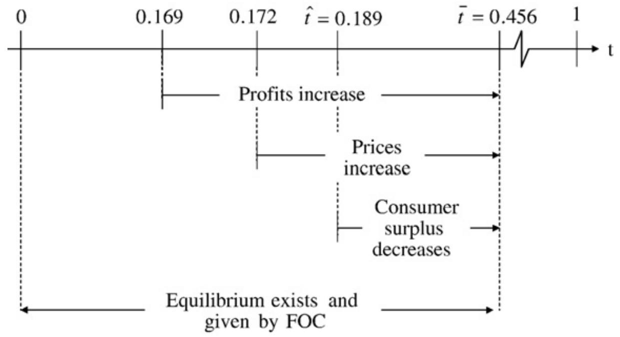

Fig. 2. Effects of resale in the Salop model.

With spatial competition the introduction of resale alters the mode of competition between integrated firms. They no longer compete directly with each other but only with the resellers who act as a "buffer". Note that resellers 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 induces the integrated firms to charge higher prices as well. The sum of additional revenues from the price increase plus the wholesale revenues leads to a higher profit level of the integrated firms, compared to an equilibrium without resale. Thus, the integrated firms have an incentive to supply the resellers instead of driving them out of the market by setting very high wholesale prices.

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 costs 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 not 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 1, the integrated firm has to announce a wholesale tariff w_1. At stage 2, all firms set retail tariffs, now with the additional restriction that $p_1 \leq w_1$. This implies that – to the extent that the price cap is binding – the wholesale tariff has a commitment effect with respect to firm 1's retail price.

Comparing Eq. (15) to Eq. (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 Eqs. (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 1:

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

Tedious but straightforward calculations yield:

$$p_1^R = \frac{3(6+5\gamma)}{F}, \text{ implying} \tag{38}$$

$$p_2^R = \frac{36+45\gamma+11\gamma^2}{(2+\gamma)F} \text{ and } p_3^R = \frac{54+66\gamma+17\gamma^2}{(2+\gamma)F}, \tag{39}$$

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

Proposition 4. *In the non-spatial model, the introduction of resale regulation has no effect for $\gamma \leq 3$. For $\gamma > 3$ it increases retail prices of the integrated firms and makes consumers worse off.*

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 asymmetric Hotelling model, the price cap is never binding (compare Eq. (25) to Eq. (26)). Therefore, resale regulation has no bite here and can not increase consumer surplus. The opposite is true in the symmetric Salop model; here, in the absence of regulation, the integrated firms always charge a wholesale price in excess of their own retail price (compare Eq. (35) to Eq. (36)). It can be shown (see Höffler and Schmidt, 2007), that for sufficiently large values of t, consumers are worse off under regulated resale compared to a situation where no resellers are active.

Summing up the results for both models, the assessment of regulated resale is largely negative. Essentially, regulated resale is a form of the ECPR (efficient component pricing rule), for which it is well known that it can yield undesirable results if applied in the "wrong" context (see e.g. the qualifications made by its main advocates in Ordover et al., 1997).[11] However, since many regulatory regimes use this form of regulation, our analysis points out that similar care has to be taken when applying "retail minus *X*" rules for regulated resale.

5. Competition for resellers

So far we assumed that the matching of resellers to integrated firms is exogenously given, so there is no competition for resellers on the upstream market. In this section we relax this assumption. One might expect that if integrated firms compete in wholesale prices to supply resellers, Bertrand competition must drive down wholesale prices to marginal cost. Thus, it seems that a market with resale must yield unambiguously lower prices and higher surplus for consumers than a market without resale. In turns out that this is indeed the case in our non-spatial model. In the spatial model, however, we find that prices can be higher and consumer surplus lower if resale is introduced even if integrated firms compete to supply the reseller in Bertrand fashion. This strengthens our previous results showing that the "buffer" effect of resellers is particularly strong and harmful to consumers if competition is spatial.

Consider first the non-spatial model with two symmetric integrated firms and one reseller. At stage 1 the two integrated firms choose wholesale prices w_i, $i \in [0, 1]$, simultaneously. The, reseller selects the supplier with the lowest wholesale price. At stage 2, all three firms compete in the downstream market. It is easy to see that in this model it is always an equilibrium if both integrated firms charge wholesale prices $w_1 = w_2 = 0$ and the reseller chooses each integrated firm with probability 0.5. In this equilibrium downstream prices are lower and consumer surplus is higher than in a market without a reseller. However, this need not be the only equilibrium. In a recent paper, Bourreau et al. (2007), analyze this model with general demand and profit functions and ask under what conditions a "monopolistic outcome" can be sustained, i.e. an outcome which would obtain in a situation where only integrated firm 1 can make an offer to the reseller (which is exactly the outcome that we characterized in Section 3). Bourreau et al. (2007) show that a monopolistic outcome can be sustained if and only if two conditions are satisfied.

(i) The maximum profit of firm 1 from supplying the reseller must exceed the profit it would get if it foreclosed the reseller by charging a prohibitively high price.

(ii) The profit of firm 2 if firm 1 supplies the reseller must be higher than the profit of firm 2 if firm 2 supplied the reseller (i.e., makes a wholesale offer that is more attractive for the reseller than the offer of firm 1).

Condition (ii) implies that firm 2 has no incentive to compete for the reseller, so it is optimal for firm 2 to charge a prohibitively high wholesale price that the reseller would never accept. In our symmetric setup, this requires that equilibrium profits of firm 2

[11] We are grateful to an anonymous referee for pointing out the relation to the ECPR.

when not supplying the reseller must exceed those of firm 1 (who supplies the reseller). Condition (i) requires that it is not profitable for firm 1 to get rid of the reseller by charging a prohibitively high price himself. Thus, if both conditions are satisfied, the monopolistic outcome is indeed an equilibrium. Furthermore, this equilibrium Pareto-dominates the competitive equilibrium from the perspective of the two integrated firms.

The question remains whether the two conditions can be satisfied simultaneously. For the non-spatial model of Section 3.1 the answer is negative. We know by Proposition 1 that condition (i) is satisfied if and only if γ is sufficiently small, i.e. the degree of product differentiation is sufficiently high. On the other hand, condition (ii) requires that firm 2's profits exceed the ones of firm 1 which is the case if and only if γ is sufficiently large. Comparing the two thresholds for γ one finds that the two conditions are mutually exclusive.

Proposition 5. *In the non-spatial model, if the two integrated firms compete for the reseller, there is a unique subgame perfect equilibrium with* $w_1=w_2=0$*. Compared to a situation without resale, prices are lower, consumers better off, and integrated firms are worse off.*

In the non-spatial model the tension between the two conditions is quite intuitive. If downstream competition is weak, i.e. if γ is close to zero, each firm serves essentially a different market. Therefore, the profits of firm 1 are higher when serving a reseller compared to a duopoly without a reseller (it gets – almost – its own monopoly profit in either case, but with resale also the profits from, selling to the reseller on the upstream market). But for exactly the same reason profits of firm 2 (that does not serve the reseller) are lower than profits of firm 1: it gets only the monopoly profit from its own market and therefore would like to undercut firm 1 in the wholesale market to appropriate firm 1's profit from supplying the reseller. Thus, condition (i) is satisfied, but not condition (ii). If γ is large (i.e. if products are not much differentiated), the opposite holds: firm 2 earns more than firm 1, because it free-rides on the high downstream price that firm 1 sets in order to be soft on its reseller. Thus, condition (ii) is satisfied. However, with intense downstream competition, it is very attractive for firm 1 to push the reseller out of the market, so condition (i) does not hold. Thus, in our model, only the competitive outcome where both integrated firms undercut each other until the wholesale price w_i equals marginal cost is an equilibrium.[12]

Consider now the case where competition is spatial. We have shown in Section 3.2 that in this case not only prices may increase if resale is possible, but also that consumer surplus may be reduced. It turns out that this result is robust to the introduction of wholesale competition.

[12] Bourreau et al. (2007) provide one example of a non-spatial model in which conditions (i) and (ii) can be satisfied simultaneously for some values of γ. Unfortunately, however, this example is flawed. The problem is that Bourreau et al. use demand functions that are derived from two different consumers for the case of a duopoly and for the case where three firms serve the downstream market. The demand function for the case where three firms serve the market is exactly the same one that we use in Section 3.1 and that is derived from the utility function (7) of, a consumer with preferences over three goods. The demand function for the duopoly case, however, is derived from a consumer who has preference over only two goods. It turns out that it makes a difference for the demand for goods 1 and 2 whether good 3 exists but is so expensive that the consumer does not want to buy it, or whether good 3 does not exist (see Höffler, 2007).

Proposition 6. *In the asymmetric Hotelling model, a monopolistic equilibrium, as characterized by* Proposition 2, *exists if the integrated firms compete for the reseller.*

For the asymmetric Hotelling model, we know from Proposition 2 already that condition (i) is satisfied for intermediate values of *t*. That also condition (ii) is satisfied for this parameter region, is at least partly due to the asymmetry of the model. Assume firm 2 would undercut firm 2 in the wholesale market. In this case, firm 1 no longer has a reason to be soft on the reseller, since it gets no wholesale revenues any longer. Therefore, firm 1 will be very aggressive against its nearby competitor, the reseller, and sets a low price; the competitor's best response is also to set a low price, which, in turn, leads to a low retail price also for firm 2. The deterioration of the retail profits is responsible for the fact that firm 2 has no incentive to undercut firm 1 in the wholesale market.

In addition, in the asymmetric Hotelling model, resale always benefits firm 2 more than firm 1; firm 2 free-rides, on the fact that firm 1 is soft on its reseller and thereby establishes a high retail price level. Although these effects are – in principle – also present in the non-spatial model, they are more pronounced in the spatial setup. The intuition is again the “buffer” effect of the reseller. In contrast to the non-spatial model, here the reseller fully suppresses the direct competition between the integrated firms, giving particular strength to the price and profit increasing effects of resale.

6. Conclusion

The conventional wisdom is that the introduction of resellers improves welfare 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 or (ii) if “retail minus *X*” regulation applies to wholesale prices.

Higher prices due to resale are driven by the fact that integrated firms care about their profits on the wholesale market which induces them to be soft on their resellers. However, in the non-spatial model there is a positive externality on all other firms who also benefit from higher downstream prices and gain market share. Thus, if the number of other firms in the downstream market 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. The same result obtains if there is competition on the upstream market.

In a spatial model each firm is in direct competition with a small number of neighbors, even if the total number of firms is large Furthermore, the introduction of resellers changes the nature of competition, because resellers act as buffers that separate the integrated firms. Therefore, our result that the introduction of resale may induce higher prices and less consumer surplus is more robust. It obtains even if there is competition in the wholesale market.

Our results show that the introduction of resale and of wholesale regulation is not in general beneficial. Therefore, regulators have to be 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 sufficiently large.

Appendix A. Proofs[13]

Proof of Proposition 1. Integrated firm 1's retail price increases due to resale:

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

where $F = 4\,(9\,(1+\gamma)+\gamma^2)$. The integrated firm without a reseller reduces the price due to resale:

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

Trade weighted average retail price:

$$p^{av} = \frac{D_1 p_1 + D_2 p_2 + D_3 p_3}{D_1 + D_2 + D_3};$$

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

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

Profits of firm 1

$$\pi_1 - \pi_1^D = \frac{11664 + 31104\gamma + 32076\gamma^2 + 15552\gamma^3 + 3249\gamma^4 + 123\gamma^5 - 10\gamma^6}{(3+2\gamma)(2592 + 5184\gamma + 3636\gamma^2 + 996\gamma^3 + 80\gamma^4)},$$

which is positive for γ sufficiently small. □

Proof of Proposition 2. Assume that a pure strategy equilibrium exists and that it is determined by the first order conditions.

(i) Prices:

$$p_1 - p_1^D = \frac{294 + 1135t + 1296t^2 + 459t^3}{4(261 + 470t + 213t^2)} > 0,$$
$$p_2 - p_2^D = \frac{3(-25 + 90t + 207t^2 + 96t^3)}{4(261 + 470t + 213t^2)} > 0 \text{ for } t > t',$$
$$r - p_1^D = \frac{1227 + 4667t + 5049t^2 + 1665t^3}{16(261 + 470t + 213t^2)} > 0,$$

where $t' = -23/32 + 19/(32 \cdot \sqrt[3]{3}) + 11 \cdot \sqrt[3]{3}/32 \approx 0.189$.

(iii) Profits:

$$\pi_1 = \frac{3(328 + 666t + 425t^2 + 81t^3)}{8(261 + 470t + 213t^2)},$$
$$\pi_1 - \pi_1^D = \frac{-60 + 118t + 423t^2 + 243t^3}{8(261 + 470t + 213t^2)} > 0 \text{ for } t > \tilde{t} = 0.251. \quad (40)$$

(ii) Total cost to consumers: Transport cost in case of resale:

$$\mathrm{Tr} = \frac{530865 + 2916195t + 6142250t^2 + 6289942t^3 + 3156693t^4 + 624087t^5}{96(261 + 470t + 213t^2)},$$

therefore, total cost to consumers, $\mathrm{TC} = \pi_1 + \pi_2 + \pi_R + \mathrm{Tr}$, raise due to the introduction of resale:

$$\mathrm{TC} = \frac{3750183 + 15462582t + 25141678t^2 + 20054324t^3 + 7789683t^4 + 1164366t^5}{48(261 + 470t + 213t^2)^2},$$
$$\mathrm{TC} - \mathrm{TC}^D = \frac{69297 + 719978t + 1970162t^2 + 2328732t^3 + 1276245t^4 + 267138t^5}{16(261 + 470t + 213t^2)^2} > 0. \quad (41)$$

To make sure that this is indeed an equilibrium we have to check profitable deviations for firm 1 and firm 2 by "undercutting" the reseller by discontinuously lowering the price. Consider firm 2. There are two possible types of deviation: First, a deviation that leaves some sales to the reseller, i.e. to choose p_2^{dev} such that x_2^{dev}, the consumer indifferent between firm 2 and the reseller, sits left of the reseller but $x_2^{dev} > x_1$. Second, the deviation might be such that the reseller is driven fully out of the market, and firm 2 would

[13] The derivation of most of the intermediate results is tedious but straightforward. Details are available from the authors upon request.

compete only with firm 1. However, it can be checked that in the latter case the deviation profit is increasing in x_2^{dev2} for $x_2^{dev2}<x_1$, thus optimum deviation would call for the corner solution $x_2^{dev2}=x_1$, implying that the second deviation can never be more profitable than the first. Call π_2^{dev1} the maximum profit from the first deviation:

$$\pi_2^{dev1} = \frac{(969+1367t+63t^2-351t^3)^2}{24(1-t)(261+470t+213t^2)^2}, \text{ implying:}$$
$$\pi_2 - \pi_2^{dev1} = \frac{t(265506+348107t-856764t^2-2073330t^3-1505790t^4-372033t^5)}{24(1-t)(261+470t+213t^2)^2},$$

which is positive for $t<t^*=0.446$. Finally, we need to check deviations by firm 1. We assumed that firm 1 is committed not to drive the reseller out of the market. It can be checked that if firm 1 undercuts the reseller to win customers to the right of the reseller's position, profits are increasing in x_1^{dev}, the consumer indifferent between firm 1's deviation offer and the reseller's offer. Thus, deviation profits have an upper bound where $x_1^{dev}=x_2$, i.e. where the reseller just makes zero sales. The resulting profit equals:

$$\pi_1^{dev} = \frac{(199+331t+138t^2)(1217+2706t+1773t^2+288t^3)}{8(261+470t+213t^2)^2}, \text{ implying:}$$
$$\pi_1 - \pi_1^{dev} = \frac{14641+42637t+64968t^2+70644t^3+45783t^4+12015t^5}{8(261+470t+213t^2)^2} > 0.$$

Thus, no profitable deviation from the solution characterized by the first order conditions exists for $t<t^*$. □

Proof of Proposition 3. Assume that a pure strategy equilibrium exists and that it is determined by the first order conditions. (i) Prices: The price without resale of Eq. (31) exceeds the one with resale of Eq. (36) if $t>59/343=0.172$. Therefore, for $t>59/343$ retail prices increase, since resellers always charge higher prices than integrated firms, Eq. (37)>Eq. (36). (ii) Profits: The profit of an integrated firm in the absence of resale equals $\pi^D=(1+t)/8$, while with resale they equal:

$$\pi_1 = \pi_2 = \pi = \frac{26223(1+3t)}{270400}, \text{ implying:} \tag{42}$$

$$\pi_1 - \pi^D = \frac{-41377+11069t}{270400} > 0 \text{ for } t > \frac{7577}{44869} \approx 0.169. \tag{43}$$

(iii) Total cost to consumers: Transport cost in the absence of resale equal $(1+5t)/48$, while with resale they are only $(7693+56879t)/811200$, implying an increase of total surplus. Total cost to consumers increase for the case without and with resale equal:

$$\mathrm{TC}^D = \frac{13+17t}{48} \text{ and } \mathrm{TC} = \frac{170797+546191t}{811200}, \text{ implying:}$$
$$\mathrm{TC} - \mathrm{TC}^D = \frac{16301-86297t}{270400} > 0 \text{ for } t > \hat{t} = \frac{16301}{86297} \approx 0.189.$$

Thus, if the solution is given by the first order conditions, for $t>\hat{t}$ prices increase, profits of the integrated firms increase, and consumers are worse off, due to the introduction of resale.

To check whether the solution is indeed given by the first order conditions, we proceed similar to the Proof of proposition 2. However, here the integrated firms are symmetric, thus it suffices to check deviations of firm 1. Again, we need to check whether optimum deviation implies that the reseller is fully driven out of the market or only partially, i.e. such that the consumer indifferent between firm 1's deviation offer and the reseller's is located at $x_{11}^{dev}>1/4$ and $x_{12}^{dev}<3/4$. It can be verified that, like in the case of proposition 2, optimum deviation (for the relevant parameter region $(\hat{t}, \bar{t})$) implies that the reseller is not fully driven out of the market. Deviation profits for this case equal:

$$\pi_1^{dev} = \frac{26223+40170t-47897t^2}{270400(1-t)}, \text{ implying:}$$
$$\pi_1 - \pi_1^{dev} = \frac{t(3069-7693t)}{67600(1-t)} > 0 \text{ for } t > \bar{t} = \frac{31}{68} \approx 0.456.$$

It is easily checked that undercutting is never profitable for the resellers (due to the wholesale cost, they always make losses when trying to gain customers located “on the other side” of the integrated firms' positions). Thus, no profitable deviation from the solution characterized by the first order conditions exists for $t<t^*$. □

Proof of Proposition 4. 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 2, the reseller maximizes

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

The integrated firm without a reseller maximizes:

$$\max_{p_2} p_2D_2\rightarrow p_2=\frac{3+\gamma(p_1+p_3)}{6+4\gamma}.$$

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

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

Using this in the integrated firm's optimization problem $\max_{p1} p_1 (D_1+D_3)$ 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, Eq. (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:

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

where $Z=288(2+\gamma)^2(9+9\gamma+\gamma^2)^2(648+1296\gamma+909\gamma^2+249\gamma^3+20\gamma^4)^2$. Thus ΔCS has a unique root,[14] which is at $\gamma=3$, implying $\Delta CS>0$ for $\gamma>3$. □

Proof of Proposition 5. We first show that the monopolistic outcome is not an equilibrium if there is competition for the reseller. Call π_1 (π_2) the profit of firm 1 (2) in the monopoly outcome and π_1^D the profit without a reseller, i.e. with a duopoly of both integrated firms. For the monopolistic outcome to be an equilibrium it must hold (see Bourreau et al., 2007, Proposition 1):

$$\pi_1^D\leq\pi_1\leq\pi_2. \tag{44}$$

For the second inequality, we find that:

$$\pi_2-\pi_1=-\frac{3(11664+46656\gamma+77112\gamma^2+67446\gamma^3+32850\gamma^4+8349\gamma^5+800\gamma^6-25\gamma^7)}{2(648+1296\gamma+909\gamma^2+249\gamma^3+20\gamma^4)^2}, \tag{45}$$

which is negative for $\gamma=0$ and has a unique root for $\gamma>0$. Numerical calculations show that this root must be in the interval (40.9, 41.0), thus $\pi_1>\pi_2$ for $\gamma<40$ 9 and Eq. (44) is violated. For the first part of the inequality, straightforward calculations yield

$$\pi_1-\pi_1^D=\frac{(11664+31104\gamma+32076\gamma^2+15552\gamma^3+3249\gamma^4+123\gamma^5-10\gamma^6)}{(6+\gamma)^2(3+2\gamma)(2592+5184\gamma+3636\gamma^2+996\gamma^4+80\gamma^4)}.$$

This expression is positive for $\gamma=0$ and has a unique root for $\gamma>0$. Numerical calculations show that this root must be in the interval (26.7, 26.8), thus $\pi_1<\pi_1^D$ and Eq. (44) is violated for $\gamma\geq26.8$. Therefore no $\gamma\geq0$ exists for which Eq. (44) can be satisfied. Thus, by Propositions 1 and 2 of Bourreau et al. (2007), the perfectly competitive outcome is the unique equilibrium of the game. It

[14] The function $f(t)=x_0t^0+x_1t^1+x_2t^2+\ldots+x_mt^m-x_{m+1}t^{m+1}-x_{m+2}t^{m+2}-\ldots-x_nt^n$ where $t>0$, $x_i>0$, $i=1,\ldots,m,\ldots,n$, has a unique root. We are grateful to Thomas Tröger who helped us to prove this statement.

is straightforward to verify that for the resulting second stage equilibrium – which is identical to a symmetric three firm equilibrium where all firms have marginal cost of zero — prices are lower and consumer surplus higher than in a duopoly. □

Proof of Proposition 6. Using the results of Bourreau et al. (2007), Proposition 1, we need to establish Eq. (44). First, we know from Proposition 2 that firm 1 indeed wants to introduce a reseller, $\pi_1 > \pi_1^D$. In equilibrium, firm 1 offers a wholesale tariff according to Eq. (25), firm 2 makes an unacceptable offer to the reseller and the reseller accepts firm 1's offer. In contrast to Bourreau et al. (2007) (and to our Proposition 5) we need to explicitly calculate the maximum deviation profit for firm 2, since our setup is not symmetric. Assume firm 2 would deviate and serve the reseller. To obtain an upper bound for the deviation profit, we neglect the condition that firm 2's offer must be such that the reseller is better off than when accepting firm 1's offer.

It can be checked that the optimum deviation implies that the consumer indifferent between firm 2's offer and the reseller's offer sits right of the reseller, i.e. at $\tilde{x}_2 > 1/4$ (one can check that the reseller makes sales, i.e. $\tilde{x}_1 > 1/4 > \tilde{x}_2$). This yields an optimum deviation wholesale price of

$$\tilde{w}_2 = \frac{198 - 165t + 16t^2 - t^3}{426 - 44t + 2t^2},$$

implying that the equilibrium profit π_2 minus the maximum deviation profit $\tilde{\pi}_2$ equals:

$$\pi_2 - \tilde{\pi}_2 = \frac{1}{Q}\big(-37237959 - 136991028t - 139957700t^2 + 46869772t^3 + 170615926t^4 + 99438372t^5 + 13589212t^6 \\ -2196732t^7 + 128313t^8 \big),$$

where $Q = 8(1-t)(-213+22t-t^2)(261+470t+213t^2)^2$. Since we are interested only in the parameter region $t \in (\tilde{t}, t^*)$, where $\tilde{t} \approx 0.251$ and $t^* \approx 0.446$, it suffices to show that this expression is positive for all $t < 0.5$, which is easily verified. Thus, the deviation in the wholesale market is never profitable in the parameter region of the equilibrium characterized in Proposition 2. □

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