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Complementarities, Below-Cost Pricing, and Welfare Losses*

Vanessa von Schlippenbach†

April 2008

Abstract

We analyze below-cost pricing in retail markets and examine its impact on social welfare as well as on suppliers' incentives to invest in quality. Considering negotiations about a linear wholesale price between the retailer and her suppliers, we find that below-cost pricing aggravates the double marginalization problem and causes welfare losses compared to a regime where below-cost pricing is banned. Furthermore, suppliers have stronger incentives to invest in high-quality products if a ban of below-cost pricing is enforced.

JEL-Classification: L22, L42

Keywords: Complementarities, Retailing, Below-Cost Pricing

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1 Introduction

Pricing and selling strategies in the retail sector are hotly debated in policy circles. One important issue constitutes the so-called loss-leader pricing which refers to retail prices below or just at marginal cost (OECD 2007). Below-cost pricing has gained in importance as consumers increasingly prefer one-stop shopping and, thus, tend to bundle their purchases in order to economize on their shopping time. From a retailer pricing perspective, one-stop shopping leads to complementarities among products even if they constitute substitutes, complements or independent goods from a consumption point of view (Holton 1957, Bliss 1988, Betancourt and Gautschi 1990, Beggs 1994). It is well known that firms offering at least two complementary goods may find it profitable to sell one of them below marginal costs in order to increase the demand for the other good (Ramsey 1927 and Robinson 1933). Accordingly, sales at a loss are not necessarily driven by the intention to exclude competitors but constitute a profit-maximizing strategy of the retailer and may increase social welfare.

This view typically ignores that the production structure consists of a vertical chain where both retailers and manufacturers have some degree of market power. Moreover, contracts in intermediate goods markets often rely on the result of negotiations, which are often not fully efficient.[1] Assessing sales at a loss, these vertical relations seem to be crucial. For example, Germany has recently enacted a general ban of selling food products at a loss. Among others, this has been forced by complaints of supplier associations.[2] They argue that competition between retailers is passed on to intermediate goods markets. Likewise, the German Federal Ministry of Food, Agriculture and Consumer Protection assesses below-cost pricing as an important driver for squeezing wholesale prices, damaging suppliers' image or jeopardizing quality assurance along the value chain.

One contributions of this paper is to show how bargaining in input markets may affect the

[1] For a discussion see Iyer and Villas-Boas (2003) as well as Inderst and Valetti (2008). Moreover, Rey and Tirole (1986) show the relevance of the double marginalization problem in a context of demand and cost uncertainty.

[2] In 2005, the German Farmer Association (*Deutscher Bauernverband*) pushed their members to protest against the decreasing prices for milk and in particular UHT milk at retail level. They directed their attention among others to the German chain store *Real* which offered dairy products at heavily reduced prices, and obviously below invoice prices in spring 2005. Such complains are not only confined to food only as the recent complaint by the German Association of Brand Manufacturers (*Deutscher Markenverband*) against below-cost prices by the third largest German drug store *Rossmann* shows (Press Release of the Federal Cartel Office (*Bundeskartellamt*) February 8th, 2007)

assessment of below-cost pricing as a socially beneficial retail strategy. In particular, we analyze below-cost pricing of retailers in a vertical setting and examine its impact on social welfare as well as on suppliers' incentives to invest in higher product quality. We consider a vertical structure with one retailer and several upstream manufacturers. With all her suppliers the retailer negotiates over a linear wholesale price. Consumers are supposed to have one-stop shopping preferences and buy different goods together in one single trip. Shopping baskets consist of particular core goods, such as staples, milk or tissue paper, which are bought by almost all consumers, while the remaining goods included in consumers' shopping baskets vary according to their individual preferences. We assume, therefore, that one product of the retail assortment is a core item. Due to consumers' one-stop shopping behavior, this product constitutes a complement to all other goods offered by the retailer. This coincides with products like milk which are both typical loss-leaders as well as part of almost all consumers' shopping baskets.

We find that the retailer sells the core good at a loss if consumers have strong preferences for one-stop shopping and their willingness to pay for the good is relatively low. The model also allows to examine how retail formats like hypermarkets and discounters affect the retailer's pricing strategy to be examined. We distinguish between the different formats by considering the overall size of the retail assortment as well as the characteristics of the retailer's product line. That is, the broadness of a product line refers to the number of different categories, while its depth stands for the variety of products within a particular category. The results show that prices below cost are more likely the broader the product line of the retailer, and thus the greater range of product categories the retailer sells to final consumers. The incentive to sell at a loss is less likely the deeper and the larger the retail assortment. The conditions determining below-cost pricing as a profit-maximizing strategy are best met by discounters whose small assortment consists of a broad product line with a low level of variety within each category. To the contrary, we find that loss-leader prices do not constitute a profit-maximizing strategy of hypermarkets or specialized retailers.

Those results are driven by the negotiations on a linear wholesale price between the retailer and her suppliers. Employing the symmetric Nash bargaining solution, we focus on the negotiations about a linear wholesale price between the retailer and the supplier of the core good. It turns out that a ban of below-cost pricing has two effects: A ban directly affects retailer's

price setting in downstream markets which in turn enhances the retailer's bargaining position vis-à-vis the supplier of the core good. Due to consumers' one-stop shopping preference, the retailer has an incentive to set a low price for the core good in order to stimulate demand for the other goods on which she can extract rents. Under a ban of below-cost pricing, however, the retailer has to sell at least at marginal costs. By this, the retailer cannot fully exploit the positive demand externalities resulting from one-stop shopping behavior. Correspondingly, the supplier's marginal contribution to the joint profit with the retailer decreases, which results in a lower wholesale price. Hence, a ban of below-cost pricing in retail markets serves as a vertical restraint that softens the double marginalization in the vertical relation between the supplier and the retailer. A ban of below-cost pricing is, therefore, socially beneficial. However, the supplier always looses if a ban is enacted. Instead the retailer and consumers gain from a ban. Furthermore, suppliers invest more and thus provide a higher quality under the ban.

The paper contributes to the literature on below-cost pricing. Beyond predation the economic literature identifies several reasons for selling a good at a loss: (i) multi-product retailing with complementary goods (Holton 1957, Hess and Gerstner 1987, Bliss 1988); (ii) price discrimination according to consumers' shopping baskets (DeGraba 2006, Jeuland and Narasimhan 1985); and finally (iii) the signaling and commitment role of price advertisements (Bagwell 1987, Simester 1995). Furthermore, there is a huge literature addressing price advertisements.[3] But so far, the economic literature has focused on the analysis of sales at a loss to their impact on horizontal competition, while vertical effects have been almost always neglected. In this regard, the paper of Allain and Chambolle (2005) is a notable exemption. They analyze below-cost pricing in downstream markets within a vertical setting with one upstream supplier and two competing retailers. They show that banning below-cost pricing in final consumer markets converts wholesale prices into floor prices inducing similar effects such as resale price maintenance. Since manufacturers may use the ban as a vertical restraint in order to raise profits at the expense of consumers and retailers, they benefit from the limitations in price setting. Given the different industry structure considered in our paper, we show the reverse: If below-cost pricing is prohibited, the retailer can commit to deviate from optimal pricing which implies a weaker

[3] Mostly price promotions are explained by a firm that sells one good to heterogeneous consumers. Thus, sales can be caused by differences in consumer search costs (Stigler 1961, Salop 1977, Salop and Stiglitz 1982), in their degree of price information (Varian 1980) or their store loyalty (Sobel 1984).

bargaining position of the supplier. Our paper also differs from Allain and Chambolle (2005) as we endogenize sales at a loss by modeling them as a result of a profit-maximizing strategy of the retailer.

The reminder of the paper is organized as follows: In Section 2, we present the model. In Section 3, we examine price-setting in downstream markets and negotiations in intermediate good markets when below-cost pricing is feasible and under a ban of below-cost prices. The implications of below-cost prices in retailing for social welfare are analyzed in Section 4. We extend the model in Section 5 and show how below-cost pricing affects upstream supplier incentives to invest in higher quality. Finally, in Section 6, we discuss some implications for competition policy and conclude.

2 The Model

We consider a vertical structure with one downstream retailer R and an upstream industry that provides $i = 0, 1, ..., n$ products. Hence, the upstream industry consists of $n + 1$ suppliers S_i. We assume that good 0 resembles one of the core products in consumption. Thus, the shopping basket of the representative consumer consists of good 0 plus an optimal combination of the goods $j = 1, .., n$. Since consumers bundle their purchases due to their preferences for one-stop shopping, good 0 is supposed to constitute a complement to all other goods in the retail assortment. We consider the following utility function for the representative consumer [4]

$$\begin{aligned} U(\cdot) &= v(\cdot) + \theta q_0 - \frac{1}{2}\left[v^2(\cdot) + q_0^2 - 2\sigma v(\cdot) q_0\right] - p_0 q_0 - \sum_{j=1}^{n} p_j q_j \qquad (1) \\ \text{with} \quad &: \quad v(\cdot) = \left(\sum_{j=1}^{n} q_j^{\alpha}\right)^{\frac{1}{a}}, \end{aligned}$$

where q_i denotes the quantity of good i and p_i denotes its price. This utility is in the spirit of the standard Dixit utility function, where $v(\cdot)$ indicates consumer's utility from the consumption of the goods $j = 1, ..., n$. $v(\cdot)$ has the form of a standard CES utility function with α denoting the constant elasticity of substitution. The extent of one-stop shopping preferences is represented by

[4] In order to simplify the notation, we omit the arguments of the functions where this does not lead to any confusion.

the degree of complementarity $\sigma \in [0,1]$ between good q_0 and $v(\cdot)$. Consumers' willingness to pay is positively correlated with the parameter θ which in turn depends on supplier's investments for quality improvements or promotional activities. On the supplier side, marginal costs of production c are the same for all products and supposed to be strictly positive. The retailer does not bear any distribution or storage costs.

In order to focus on the relationship between the retailer and supplier S_0, we assume that goods $j = 1, .., n$ are offered competitively, while good 0 is produced by one single firm. The retailer negotiates with all her suppliers on delivery contracts which are specified by a linear tariff w_i. Note that the suppliers S_j get each the wholesale price $w_j = c$.

We assume the following two-stage game and analyze subgame perfect equilibria: In the first stage of the game, the retailer negotiates with supplier S_0 on a linear wholesale price w_0. In stage two, the retailer sets prices in downstream markets. Within this framework, we compare the equilibrium prices without any restrictions on retail prices with the equilibrium prices under a general ban of below-cost pricing.

3 Consumer Prices and Negotiations

We first characterize optimal retail prices in downstream markets and examine the conditions under which below-cost pricing may be an optimal retail pricing strategy. We then solve for the negotiation outcome between the supplier S_0 and the retailer under both regimes, i.e. unrestricted price setting and a general ban of below-cost pricing. Given our results, we examine the implications a general ban has for social welfare. In particular, we consider consumer surplus as well as the supplier's and the retailer's profit.

3.1 Consumer Prices

In the second stage of the game, the retailer sets her prices in the downstream market. Defining $m = \sum_{j=1}^{n} p_j q_j$ and applying the composite commodity theorem, we decompose the represen-

tative consumer's decision into two problems, $P1$ and $P2$, with

$$\begin{aligned} \text{P1:} \quad & \min_{q_i} m \text{ subject to } v(\cdot) \geq \overline{v} && (2) \\ \text{P2:} \quad & \max_{q_0, v} \widetilde{u}\left(m\left(\overline{v}, p_0, p, \cdot\right), \cdot\right) && (3) \\ \text{with:} \quad & p = (p_1, ..., p_n), \end{aligned}$$

where $m\left(\overline{v}, p_0, p, \cdot\right)$ denotes the solution of P1 and $\widetilde{u}\left(\cdot, m\left(\overline{v}, p_0, p, \cdot\right)\right)$ is given by

$$\widetilde{u}\left(m\left(\overline{v}, p, \cdot\right), \cdot\right) = \overline{v}\left(\cdot\right) + \theta q_0 - \frac{\overline{v}^2\left(\cdot\right) + q_0^2 - 2\sigma\overline{v}\left(\cdot\right) q_0}{2} - p_0 q_0 - m\left(\cdot\right). \tag{4}$$

Solving first the problem P1, we obtain the standard conditional demand and expenditure functions

$$\begin{aligned} q_j\left(p_i, \cdot\right) &= \frac{p_j^{\rho-1} m\left(\overline{v}, \cdot\right)}{\sum_{i=1}^n p_j^\rho} && (5) \\ \text{with} \quad &: \quad m\left(\overline{v}, \cdot\right) = \overline{v}\left(\sum_{i=1}^n p_j^\rho\right)^{\frac{1}{\rho}} \\ \text{and} \quad &: \quad \rho = \frac{\alpha}{1-\alpha}. \end{aligned}$$

Note that $\rho \in (1, \infty)$ can be interpreted as the level of product differentiation: The higher ρ the more differentiated are the products offered by the retailer. The parameter n determines the size of the retail assortment as it stands for the number of products the retailer offers to final consumers.

Turning to $P2$ and differentiating $\widetilde{u}\left(\cdot, m\right)$ with respect to q and $\overline{v}$, we get

$$\begin{aligned} q_0^*(\cdot) &= \frac{\theta - p_0 + \left(1 - m_{\overline{v}}(\cdot)\right)\sigma}{1 - \sigma^2} && (6) \\ \overline{v}^*(\cdot) &= \frac{1 + \theta\sigma - m_{\overline{v}} - \sigma p_0}{1 - \sigma^2} && (7) \\ \text{with} \quad &: \quad m_{\overline{v}}(\cdot) = \left(\sum_{j=1}^n p_j^\rho\right)^{\frac{1}{\rho}}. && (8) \end{aligned}$$

Substituting (8) into (6) and (7), we obtain the demand for both the complement and each

substitutable good as

$$q_0^*(\cdot) = \frac{\theta - p_0 + [1 - m_{\overline{v}}]\,\sigma}{1 - \sigma^2} \tag{9}$$

$$q_j^*(\cdot) = \frac{[1 + \sigma\theta - \sigma p_0 - m_{\overline{v}}]\left[\sum_{i=1}^{n} p_j^{\rho}\right]^{\frac{1-\rho}{\rho}}}{(1 - \sigma^2)\, p_j^{1-\rho}}. \tag{10}$$

Using (9) and (10), the profits $\Pi^R(\cdot)$ and $\Pi_0^S(\cdot)$ of the retailer and the supplier S_0, respectively, are given by

$$\Pi^R(\cdot) = (p_0 - w_0)\, q_0^*(\cdot) + \sum_{j=1}^{n} (p_j - c)\, q_j^*(\cdot) \tag{11}$$

$$\Pi_0^S(\cdot) = (w_0 - c)\, q_0^*(\cdot). \tag{12}$$

Maximizing (11) with respect to p_0 and p_j with $j = 1, ..., n$, we obtain

$$p_0^*(\cdot) = \frac{\theta + w_0}{2} \tag{13}$$

$$p_j^*(\cdot) = \frac{1}{2}\left(c + n^{-1/\rho}\right). \tag{14}$$

The results show that the retailer sets the standard monopoly price for the complementary good. The retail prices for the other goods decrease in the size of the retail assortment, while they increase the more differentiated the products are.

Note that we can describe different types of retail formats by using the parameter n and ρ. The profound consolidation process in retailing has come along with the creation of a wide range of different store formats like discounters and hypermarkets. Discounters sell a broad product line with a multitude of different product categories, whereas the variety of products within each product category is rather low. Hence, discounters' assortment is characterized by a high degree of product differentiation, i.e. ρ relatively high, and a limited size of products, i.e. n rather low. While discounters offer only a poor selection of substitutable products, hypermarkets satisfy a wide range of different consumer tastes. That is, hypermarkets offer a deeper product line with a large number of substitutes within each category. Compared to discounters, hypermarkets are determined by a lower level of product differentiation, i.e. a lower level of ρ. In terms of size, the hypermarket largely exceeds the discounter. Hence, it accounts for a higher n. A further

store format that is still relatively common constitutes the specialized retailer. Her assortment is characterized by a limited product line, which implies a small overall size and a low degree of product differentiation. Accordingly, this type of retail format is represented by low n and low ρ.

3.2 Bargaining without a Ban

Turning to the first stage of the game, the retailer agrees with supplier S_0 on a delivery contract in the form of a linear wholesale price w_0. The wholesale price w_0 is determined according to the symmetric Nash Bargaining Solution so that joint surplus is equally shared. Both, the retailer and the supplier, receive their disagreement payoffs plus a share of the joint profit. However, negotiations on a linear price induce a trade-off: A higher wholesale price increases supplier's profit but decreases the total pie to be shared because of the induced problem of double marginalization.

We assume that supplier S_0's disagreement payoff is equal to zero. The retailer, however, may still sell the goods $j = 1, ..., n$ in the case of negotiation breakdown with supplier S_0. If the retailer fails to achieve an agreement with supplier S_0, the demand $\widehat{q}_j(\cdot)$ can be simply derived by setting $q_0 = 0$ in the Dixit utility function (see (1)) and maximizing consumers' utility which leads to

$$\widehat{q}_j(\cdot) = \frac{\left[\sum_{j=1}^{n} p_j^{\rho}(\cdot)\right]^{\frac{1-\rho}{\rho}} \left[1 - \left[\sum_{j=1}^{n} p_j^{\rho}(\cdot)\right]^{\frac{1}{\rho}}\right]}{p_j^{1-\rho}(\cdot)}. \tag{15}$$

Using (15) and assuming no renegotiation in the case of negotiation breakdown with supplier S_0, retailer's disagreement payoff is given by

$$\widehat{\Pi}^R(\cdot) = \sum_{i=1}^{n} (p_j(\cdot) - c)\, \widehat{q}_j(\cdot). \tag{16}$$

The optimal price that the retailer sets in downstream markets if she fails to find an agreement with supplier S_0 refers again to

$$\widehat{p}_j(\cdot) = \frac{1}{2}\left(c + \frac{1}{n^{1/\rho}}\right). \tag{17}$$

Given (13) and (14), let $\Pi^{R*}(w_0, \cdot)$ and $\Pi_0^{S*}(w_0, \cdot)$ denote the reduced profit functions of the

retailer and the supplier respectively. Hence, the Nash Product can be written as

$$NP = \left[\Pi^{R*}(\cdot) - \widehat{\Pi}^{R}(\cdot)\right] \Pi_0^{S*}(\cdot). \tag{18}$$

Maximizing (18) with respect to w_0, the optimal wholesale price is given by

$$w_0^* := \frac{\theta + \sigma(1 - cn^{1/\rho}) + 3c}{4}. \tag{19}$$

Lemma 1 *The wholesale price negotiated between the retailer and supplier S_0 is increasing in consumers' preferences for one-stop shopping, i.e. σ, their willingness to pay θ as well as in the degree of product differentiation ρ. However, it is decreasing in the size of the retail assortment n.*

The stronger consumers' preferences for one-stop shopping the more supplier S_0 contributes to the joint profit with the retailer. Accordingly, the wholesale price $w_0^*(\theta, \cdot)$ increases in σ. The same holds for θ indicating consumers' willingness to pay for the complementary product. Likewise the joint profit of the retailer and supplier S_0 increases, if the goods $j = 1, ..., n$ become more differentiated. Thus, the wholesale price is increasing in ρ. However, the larger the size of the assortment the higher the retailer's profit if no agreement is achieved with supplier S_0. As a consequence, the marginal contribution of supplier S_0 is decreasing in the number of additional products the retailer offers to final consumers. This in turn leads to a lower wholesale price in equilibrium.

In order to assess the conditions under which below-cost pricing in retailing occurs, (13) already shows that

$$p_0^*(\theta, \cdot) \gtrless w_0 \Longleftrightarrow \theta \gtrless w_0. \tag{20}$$

Using (13) and (19), we can define

$$\theta_1^c(n, \sigma, \rho) = \frac{\sigma}{3}(1 - cn^{1/\rho}) + c. \tag{21}$$

Proposition 1 *Sales at a loss constitute a profit maximizing strategy in retailing if consumers' willingness to pay is sufficiently low, i.e. $\theta < \theta_1^c(\cdot)$. Below-cost pricing becomes more likely the higher consumer preferences for one-stop shopping and the higher the differentiation of the*

additional goods included in the shopping basket, i.e. $d\theta_1^c(\cdot)/d\sigma > 0$ *and* $d\theta_1^c(\cdot)/d\rho > 0$. *However, retailer's incentives for selling at a loss decrease if the size of the assortment increases, i.e.* $d\theta_1^c(\cdot)/dn < 0$.

Our results show that sales at a loss may constitute a profit-maximizing strategy of the retailer without being driven by anti-competitive behavior. That is, by selling goods at a loss the retailer does not necessarily aim at driving competitors out of the market. In fact, the retailer reacts to the increasing one-stop shopping preferences of consumers when she sells below-cost. By offering a wide range of different products, the retailer allows consumers to bundle their purchases and thus to reduce their shopping time. This in turn induces positive demand externalities. As particular goods like milk, eggs, meat or other frequently purchased items are more important to consumers than others, the retailer attracts a large number of consumers by selling these products at a low price or even at a loss. Accordingly, these products serve as driver of "store-traffic". And the more consumers enter the store outlet, the higher the retailer's opportunity to extract rents on the other goods included in consumers' shopping basket.

However, we find that the retailer has an incentive to sell core products at a loss, only if consumers' willingness to pay is relatively low. This can also be observed in real life where milk or vegetable oil are typical loss-leaders. We further show that the incentives to sell at a loss become stronger if the other products the retailer offers are sufficiently differentiated. That is, if the retailer offers a wide range of different categories. Below-cost pricing becomes even more likely the fewer products the retail assortment includes. Hence, discounters, which are particularly characterized by a small size but a high number of different product categories, have the strongest incentives to sell at a loss. In contrast, very specialized retailers offer a large range of less differentiated products and hypermarkets' assortment is characterized by a larger number of products which makes sales at a loss less likely.

Our model, therefore, generates a number of relevant predictions concerning the pricing behavior of particular retail markets. Although there is some research on the impact of the market structure on retail pricing, most of the literature is salient about the relation between retail format and retail pricing. One notable exception are Cataluna et al. (2005) who show that price discount offered by discounters are in some cases higher than price discounts offered by hypermarkets.

Note further that below-cost pricing does not result from the strong bargaining position retailers may have vis-à-vis suppliers. The more bargaining power the retailer has, the lower the wholesale prices negotiated with suppliers. However, wholesale prices increase if suppliers have full take-it or leave-it power. As a consequence, below-cost pricing becomes more likely as the retailer has a stronger incentive to soften the double mark-up problem. Thus, an increase in buyer power may decrease the likelihood of sales at a loss.

3.3 Bargaining under a Ban

If a per-se ban of below-cost pricing is put into force, prices have to be at least equal to wholesale prices. The retailer has to maximize her profit Π^R such that $p_0 \geq w_0$, i.e.

$$\max_{p_0,p} \Pi^R \text{ subject to } p_0 \geq w_0. \tag{22}$$

Apparently, the constraint is only binding if $\theta \leq \theta_1^c(\cdot)$. Since the retailer's profit is strictly decreasing in p_0 as long as $p_0 > p_0^*$, the retailer increases p_0 such that the constraint is just binding, i.e. $p_0 = w_0$. Solving (22), we obtain the following pair of retail prices with

$$\widetilde{p}_0^* = \begin{cases} \frac{\theta + w_0}{2} & \text{if } \theta > \theta_1^c(\cdot) \\ w_0 & \text{otherwise} \end{cases} \tag{23}$$

$$\widetilde{p}_j^* = \begin{cases} \frac{c + n^{-1/\rho}}{2} & \text{if } \theta > \theta_1^c(\cdot) \\ \frac{c + n^{-1/\rho}[1 + \sigma(\theta - w_0)]}{2} & \text{otherwise.} \end{cases} \tag{24}$$

Compared to the case of unrestricted retail prices, equilibrium prices for the substitutable goods $\widetilde{p}_j^*$ are reduced as long as the ban is binding, i.e. $w_0 > \theta$. Given (23) and (24), let $\widetilde{\Pi}^{R*}(\widetilde{w}_i, \cdot)$ and $\widetilde{\Pi}_0^{S*}(\widetilde{w}_0, \cdot)$ denote the reduced profit functions of the retailer and the supplier respectively. Since the disagreement payoffs are not affected by the ban, the optimal wholesale price negotiated between the retailer and the supplier is given by

$$\begin{aligned} \widetilde{w}_0^*(\theta, \cdot) &: = \arg\max_{w_0} \widetilde{NP} \\ \text{with} &: \widetilde{NP} = \left[\widetilde{\Pi}^{R*}(w_i, \cdot) - \widehat{\Pi}^R(\cdot)\right] \widetilde{\Pi}_0^{S*}(w_0, \cdot). \end{aligned} \tag{25}$$

Analyzing $\widetilde{w}_0^*(\theta,\cdot)$, there exists a threshold $\theta_2^c(\cdot)$ indicating that $\widetilde{w}_0^* > \theta$ for all $\theta < \theta_2^c(\cdot)$. This holds since

$$\begin{aligned}\widetilde{NP}_{w_0}\Big|_{w_0=\theta} &= \frac{(1-cn^{1/\rho})^2\sigma^2\left[-(4-\sigma^2)(\theta-c)+\sigma(1-cn^{1/\rho})\right]}{8(1-\sigma^2)} \geq 0 \text{ if } \theta \leq \theta_2^c(\cdot) \\ \text{with} \quad &: \quad \theta_2^c(\cdot) = \frac{\sigma(1-cn^{1/\rho})}{4-\sigma^2} + c.\end{aligned}$$

Note that $\theta_2^c(\cdot)$ is strictly lower than $\theta_1^c(\cdot)$. Hence, the optimal wholesale prices under a ban are given by

$$\begin{aligned}&\widetilde{w}_0^*(\theta,\cdot) > \theta && \text{if } \theta \leq \theta_2^c \\ &\widetilde{w}_0^*(\theta,\cdot) = \theta && \text{if } \theta \in [\theta_2^c, \theta_1^c] \\ &\widetilde{w}_0^*(\theta,\cdot) = w_0^*(\theta,\cdot) && \text{if } \theta \geq \theta_1^c.\end{aligned} \tag{26}$$

If a ban of below-cost pricing is enforced and the ban is binding, the retailer has to deviate from the optimal pricing rule. That is, $\widetilde{p}_0^*$ increases for $\theta < \theta_3^c(\cdot)$ that is implicitly given by

$$\widetilde{p}_0^*(\theta_3^c,\cdot) \equiv \widetilde{w}_0^*(\theta_3^c,\cdot) \text{ with } \theta_2^c(\cdot) > \theta_3^c(\cdot). \tag{27}$$

In the interval $[\theta_3^c, \theta_1^c]$ $\widetilde{p}_0^*$ decreases as a result of a ban. Inspection of (24) and (14) shows that the retailer lowers the prices $\widetilde{p}_j^*$ for the remaining goods as a consequence of a ban if $\theta < \theta_2^c(\cdot)$. In the interval $[\theta_2^c, \theta_1^c]$, $\widetilde{p}_j^*$ remains equal. Therefore, the retailer cannot fully exploit the one-stop shopping externality by first attracting consumers and then extracting rents on the remaining goods. Our results are illustrated by a numerical example for $c = 0.1, n = 20, \sigma = 0.5$, and $\rho = 20$ (see Figure 1). Correspondingly, we can state that a core good plays a notable role in the increase in overall sales, as long as it serves as a loss-leader. However, under a ban the importance of these core goods is reduced. As a consequence, the supplier S_0 contributes less to the joint surplus with the retailer. This in turn leads to a lower wholesale price, i.e. $\widetilde{w}_0^* < w_0^*$. Summarizing our results, we get the following proposition:

Proposition 2 *If a ban of below-cost pricing is binding, i.e. $\theta < \theta_1^c(\cdot)$, the retailer sets $\widetilde{p}_0^* = \widetilde{w}_0^*$ and reduces the prices for all remaining goods, i.e. $\widetilde{p}_j^* < p_j^*$, if $\theta < \theta_2^c(\cdot)$. As a consequence of the ban, the negotiated wholesale price is reduced, i.e. $\widetilde{w}_0^*(\theta,\cdot) < w_0^*(\theta,\cdot)$.*

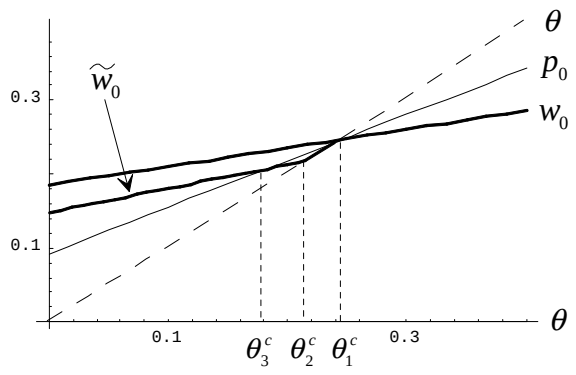

Figure 1: Downstream and Wholesale Prices under both Regimes

Proof. In the interval $[\theta_2^c, \theta_1^c]$, $\widetilde{w}_0^* < w_0^*$ holds since $\widetilde{w}_0^* = \theta$ (see (26)) and $w_0^* > \theta$. For $\theta < \theta_2^c$, it is easy to show that $\partial \widetilde{NP}/\partial w_0\Big|_{w_0=w_0^*} < 0$ as long as

$$\theta < \theta_4^c = \theta_1^c + \frac{4\sqrt{(1-cn^{1/\rho})^2\sigma^2(4-3\sigma^2)}}{4-3\sigma^2}.$$

Since $\theta_4^c > \theta_1^c$, $\partial \widetilde{NP}/\partial w_0\Big|_{w_0=w_0^*} < 0$ is fulfilled for all $\theta < \theta_2^c$. Hence, we get that $\widetilde{w}_0 < w_0$ for all $\theta < \theta_1^c$. ■

Since a ban results in a lower wholesale price, it reduces the double mark-up externality in the vertical relationship between the retailer and her supplier. This is a first hint of the negative impact below-cost pricing may have on social welfare as it strengthens the problem of double marginalization.[5]

4 Implications for Social Welfare

A ban of sales at a loss has two different effects on consumer prices. First of all, the retailer has to deviate from the prices she would set without a ban. This in turn implies that the retailer cannot fully exploit the externalities resulting from consumers' shopping behavior. Therefore the marginal contribution of the supplier is reduced which leads to a lower wholesale price negotiated in intermediate good markets. Hence, a ban of below-cost pricing changes prices in

[5] Note, however, that the problem of double marginalization vanishes if more complex contracts are negotiated in intermediate good markets.

final consumer markets and lowers wholesale prices. Before assessing the overall welfare effect, we analyze how a ban affects the distribution of rents.

Comparing consumer utility under both regimes, it is easy to show that consumer surplus under a ban is always higher than without a ban.

Lemma 2 *Consumers always benefit from a ban of below-cost pricing.*

Proof. In order to prove Lemma 2, we compare $U(\cdot)$ and $\widetilde{U}(\cdot)$ with

$$\begin{aligned} U(\cdot) &= \frac{4(1-m_{\overline{v}})^2 + (\theta - w_0^*)\left[\theta - w_0^* + 4\sigma(1-m_{\overline{v}})\right]}{8(1-\sigma^2)} && (28) \\ \widetilde{U}(\cdot) &= \frac{4(1-\tau)^2 + 4\left(\theta - \widetilde{w}_0^*\right)\left[\theta - \widetilde{w}_0^* + 2\sigma(1-\tau)\right]}{8(1-\sigma^2)} && (29) \\ \text{with} \quad &: \quad \tau = \left[2^{-\rho} n \left[c + n^{-1/\rho}\left[1 - \sigma(\widetilde{w}_0^* - \theta)\right]\right]^{\rho}\right]^{\frac{1}{\rho}} \leq m_{\overline{v}}. \end{aligned}$$

Since $\widetilde{w}_0^* < w_0^*$ always holds, consumers always benefit from the ban. ■

The supplier, however, loses if a ban of below-cost pricing is enforced. This comes due to the fact that her bargaining position is weakened by the ban such that she receives a lower wholesale price. On the contrary, the retailer always benefits from a ban. Obviously, retailer's profit is not affected by the ban at θ_1^c where $w_0^* = \widetilde{w}_0^* = \theta$ is fulfilled. Moreover, it is easy to show that a retailer benefits from a ban at θ_3^c where prices under both regimes are equal, i.e. $\widetilde{p}_0^* = \widetilde{w}_0^* = p_0^*$, and wholesale prices are lower due to the ban, i.e. $\widetilde{w}_0^* < w_0^*$. For all other values $\theta < \theta_1^c$ the retailer benefits from the ban as the reduced wholesale price she has to pay for the core product fully compensates her losses induced by her deviation from optimal wholesale prices.

Lemma 3 *A ban of sales at a loss in downstream markets harms the supplier, while the retailer benefits.*

Proof. See Appendix. ■

Denoting $W(\cdot) = U^*(\cdot) + \Pi^{R*}(\cdot) + \Pi_0^{S*}(\cdot)$ and $\widetilde{W}(\cdot) = \widetilde{U}^*(\cdot) + \widetilde{\Pi}^{R*}(\cdot) + \widetilde{\Pi}_0^{S*}(\cdot)$ the social welfare under both regimes and evaluating $\Delta W(\cdot) = \widetilde{W}(\cdot) - W(\cdot)$ for $c = 0$, we obtain

$$\begin{aligned} \Delta W(\cdot)|_{c=0} &= \frac{1 - \eta + 2\sigma(\theta + w_0^* - 2\widetilde{w}_0^*\eta) + (\theta + w_0^*)^2 - 4\widetilde{w}_0^{*2}}{8(1-\sigma^2)} > 0 && (30) \\ \text{with} \quad &: \quad \eta = \left[1 + \sigma(\theta - \widetilde{w}_0^*)\right]. \end{aligned}$$

Hence, social welfare increases under a ban if marginal costs of production are normalized to zero. Note that the impact of the number of products included in the retail assortment disappears with $c = 0$. Evaluating the first derivative of $\Delta W(\cdot)$ with respect to c for $c = 0$, we obtain

$$\left.\frac{\partial \Delta W(\cdot)}{\partial c}\right|_{c=0} = \frac{n^{\frac{1}{\rho}} + (w_0^* - \widetilde{w}_0^*)\,(2 + \sigma n^{\frac{1}{\rho}}) + 2\,(\theta - \widetilde{w}_0^*)\,\left(1 - \sigma^2\right)}{4\,(1 - \sigma^2)} > 0. \tag{31}$$

Our result shows that the higher the marginal costs, the more increases the difference in social welfare.

Proposition 3 *For given θ and marginal costs of production sufficiently low, social welfare is increasing if a ban of below-cost pricing is enforced. In particular, consumers and the retailer always gain from the ban, while the supplier loses.*

While the supplier benefits if her good is sold at a loss, the increasing wholesale price results in a welfare loss. In particular, consumers lose if the retailer sells at a loss since this enhances the problem of double marginalization.

5 Investment Decision

In this section we add an additional stage where the supplier S_0 decides about her investment for quality improvements or promotional activities. These investments lead to an increase of consumers' willingness to pay θ, whereas we assume that θ is common knowledge. For the investment, the supplier S_0 bears costs $C(\theta)$ with $C', C'' > 0$. We compare the optimal investment decision of supplier S_0, if the retailer does not underlie a restriction in downstream price setting, with the investment decision if a ban is put into force.

The optimal levels of investment under both regimes, i.e. θ^* and $\widetilde{\theta}^*$, are given by

$$\theta^* := \arg\max_{\theta} \Pi_0^S(w_0^*, \cdot) \tag{32}$$

and

$$\widetilde{\theta}^* := \arg\max_{\theta} \widetilde{\Pi}_0^S(\widetilde{w}_0^*, \cdot) \tag{33}$$

In the case of relatively low investment costs $C(\theta)$, a ban does not affect supplier's investment

decision as long as $\widetilde{\theta}^* > \theta_1^c$. However, for intermediate or high levels of investment costs, it can be shown that the supplier always extends her investments if a ban of below-pricing is put into force. On the one hand, a ban of below-cost pricing weakens the bargaining position of supplier S_0 which in turn leads to a lower wholesale price (see Proposition 2). On the other hand, a higher θ improves her bargaining position vis-à-vis the retailer leading to a higher wholesale price.

Lemma 4 *In the case of intermediate or high levels of fixed investment costs $C(\theta)$ and c sufficiently low, the supplier's investment increases under a ban, i.e. $\theta^* < \widetilde{\theta}^* < \theta_1^c$.*

Proof. See Appendix. ■

Taking corner solution into account, the supplier S_0 may even have an incentive to excessively invest by increasing $\widetilde{\theta}^*$ up to θ_1^c. With sufficiently low investment costs and consumers' preference for one-stop shopping relatively strong, the supplier chooses a level of θ where the ban is not binding. With higher costs, the supplier also tends to invest in order to avoid the ban. However, the positive effect of circumventing the ban is compensated by increasing fixed costs. Assuming $\rho = 2$, $n = 10$, $c = 1/10$ and $C(\theta) = k\theta^2$, we get the numeric results for supplier's investment decision as indicated in Table 1.

If we suppose that θ is endogenously chosen by the supplier, the higher investment of supplier S_0 also implies a higher level of social welfare. But a ban may also lead to excessive investments at the supplier side which may negatively affect social welfare.

Table 1: Supplier's Investment Decision

k		0.3	0.4	0.5	0.6	0.7	0.8
$\sigma = 0.3$	$\widetilde{\theta}^*$	0.02	0.01	0.01	0.004	0.003	0.003
		$\widetilde{\theta}^* < \theta_1^c$	$\widetilde{\theta}^* < \theta_1^c$	$\widetilde{\theta}^* < \theta_1^c$	$\widetilde{\theta}^* < \theta_1^c$	$\widetilde{\theta}^* < \theta_1^c$	$\widetilde{\theta}^* < \theta_1^c$
$\sigma = 0.7$	$\widetilde{\theta}^*$	4.4	0.689	0.352	0.26	0.175	0.139
		$\widetilde{\theta}^* > \theta_1^c$	$\widetilde{\theta}^* > \theta_1^c$	$\widetilde{\theta}^* > \theta_1^c$	$\widetilde{\theta}^* = \theta_1^c$	$\widetilde{\theta}^* < \theta_1^c$	$\widetilde{\theta}^* < \theta_1^c$

Accordingly, our numeric results show (see Table 2) that welfare effects with endogenously chosen θ are ambiguous. That is, suppliers excessively invest if costs for investment are sufficiently low and consumers have only weak preferences for one-stop shopping.

Hence, our results can be summarized as follows:

Table 2: Welfare Effects of Excessive Investments

k		0.3	0.4	0.5	0.6	0.7	0.8
$\sigma = 0.3$	$\widetilde{W}(\widetilde{\theta}^*, \cdot)$	0.182	0.181	0.181	0.181	0.181	0.181
	$W(\theta^*, \cdot)$	0.183	0.182	0.181	0.18	0.18	0.18
$\sigma = 0.7$	$\widetilde{W}(\widetilde{\theta}^*, \cdot)$	$\widetilde{\theta}^* > \theta_1^c$	$\widetilde{\theta}^* > \theta_1^c$	$\widetilde{\theta}^* > \theta_1^c$	0.3786	0.342	0.324
	$W(\theta^*, \cdot)$	0.679	0.427	0.365	0.337	0.320	0.31

Proposition 4 *Below-cost pricing by retailers reduces supplier's incentives to invest in quality improvements of their products.*

The negative effects below-cost pricing has on social welfare are robust in a dynamic setting. Moreover, our findings approve that sales at a loss negatively affect the quality provided by upstream suppliers. This fear has been expressed by the German Federal Ministry of Food, Agriculture and Consumer Protection in the recent debate on the general ban of selling food products at a loss. But in contrast to the common reasoning, we show that higher investment incentives are due to a weakened bargaining position of the supplier and the fact that the marginal impact of θ in w_0 is higher under a ban.

6 Conclusion

In this paper, we have shown that below-cost pricing is not necessarily driven by predatory purposes. To the contrary, sales at a loss may rather constitute an optimal pricing strategy which replies to the increasingly observed one-stop shopping behavior of consumers. Furthermore, our model allows us to relate the retail format in terms of size and product differentiation to the chosen pricing strategy. That is, the stronger consumers' preference for one-stop shopping, the more likely are sales at a loss at downstream retailers. Retailer's incentives to sell at a loss also increase if she offers a broad product line allowing for one-stop shopping, while her incentives decrease the more products her assortment includes and the deeper her product line. These results explain why sales at a loss more likely to prevail at discounters than at hypermarkets or specialized retailers.

Although below-cost pricing is not intended to harm competitors, it negatively affects social welfare by enhancing the double marginalization in the vertical relation between the retailer and

the supplier. That is, a retailer uses core products of consumers' shopping basket like milk as a loss-leader in order to increase store traffic and thus overall sales at the retail outlet. As a consequence, the supplier contributes more to the joint surplus with the retailer which leads to a higher wholesale price. If the retailer is forced to set prices at least equal to marginal costs, the supplier's marginal contribution decreases resulting in a lower wholesale prices. A ban, therefore, serves as a vertical restraint which lowers the problem of double marginalization. Hence, our results imply that below-cost pricing can be detrimental to social welfare. Therefore, it seems to be appropriate to assess below-cost pricing by a rule of reason approach that considers the market structure explicitly.

Appendix

Proof of Lemma 3

Starting with the supplier and comparing the supplier's profits under both regimes, i.e. Π_0^{S*} and $\widetilde{\Pi}_0^{S*}$ with

$$\Pi_0^{S*} = \frac{(w_0^* - c)\left[\theta + 2(1 - m_{\overline{v}}) - w_0^*\right]}{2(1-\sigma^2)} \tag{34}$$

$$\widetilde{\Pi}_0^{S*} = \frac{(\widetilde{w}_0^* - c)\left[2\theta + 2(1-\mu) - 2\widetilde{w}_0^*\right]}{2(1-\sigma^2)}, \tag{35}$$

and rearranging terms, we get

$$\Pi_0^{S*} > \widetilde{\Pi}_0^{S*} \Leftrightarrow \tag{36}$$

$$w_0^*\left[\theta + w_0^* + 2(1 - m_{\overline{v}})\right] + 2\mu\widetilde{w}_0^* >$$

$$-2\widetilde{w}_0^*\left(\widetilde{w}_0^* + \mu - \theta\right) - c\left[2\left(m_{\overline{v}} - \mu\right) + \left(w_0^* + \theta - 2\widetilde{w}_0^*\right)\right]. \tag{37}$$

Obviously, the inequality (37) is always fulfilled such that the supplier gains less if price setting in downstream markets is restricted. Turning to the retailer and defining the difference in retail profits under both regimes as $\Delta\Pi^R(\cdot) = \widetilde{\Pi}^{R*}(\cdot) - \Pi^{R*}(\cdot)$, we obtain

$$\Delta\Pi^R(\cdot) = \frac{\sigma^2(\widetilde{w}_0^* - \theta)^2 + 2\sigma(1 - cn^{1/\rho})(w_0^* - \widetilde{w}_0^*) - (w_0^* - \theta)^2}{4(1-\sigma^2)}. \tag{38}$$

$\Delta\Pi^R(\cdot)$ becomes zero when $w_0^* = \widetilde{w}_0^* = \theta$, i.e. $\Delta\Pi^R(\cdot)\big|_{\theta=\theta_1^c} = 0$. In order to prove that $\Delta\Pi^R(\cdot)$

is also positive for all $\theta < \theta_1^c$ if production costs are sufficiently low, we define a threshold $\widetilde{w}_0^c$ that solves $\Delta\Pi^R(w_0^*, \widetilde{w}_0^c, \cdot)\big|_{c=0} = 0$ with

$$\widetilde{w}_0^c = \theta + \frac{1}{\sigma} - \frac{\sqrt{9(\theta+\sigma)^2 + 16(1-\sigma^2)}}{4\sigma}. \tag{39}$$

It can be numerically shown that

$$\widetilde{NP}(\cdot)_{w_0}\Big|_{w_0=\widetilde{w}_0^c} < 0 \tag{40}$$

for all $\sigma \in [0,1]$ and $\theta \in [0, \sigma/3]$. Hence, $\widetilde{w}_0 < \widetilde{w}_0^c$ the difference of retail profits $\Delta\Pi^R(\cdot)$ is always positive if production costs c are sufficiently low.

Proof of Lemma 4

In order to prove $\widetilde{\theta}^* > \theta^*$, we show that $d\widetilde{\Pi}_0^{S*}/d\theta > d\Pi_0^S/d\theta$ with

$$\frac{d\Pi_0^{S^*}}{d\theta} = \frac{3\left[\theta - c + \sigma(1 - cn^{1/\rho})\right]}{16(1-\sigma^2)} \text{ and } \frac{d\widetilde{\Pi}_0^{S*}}{d\theta} = \frac{\partial\widetilde{\Pi}_0^{S*}}{\partial\theta} + \frac{\partial\widetilde{\Pi}_0^{S*}}{\partial\widetilde{w}_0^*}\frac{d\widetilde{w}_0^*}{d\theta}.$$

First of all, we characterize $d\widetilde{w}_0^*/d\theta$. Since $sign[d\widetilde{w}_0^*/d\theta] = sign\widetilde{NP}_{w_0\theta}$, we evaluate $\widetilde{NP}_{w_0\theta}\Big|_{c=0,\widetilde{w}_0=\widetilde{w}_0^*}$ with

$$\widetilde{NP}_{w_0\theta}\Big|_{c=0,\widetilde{w}_0=\widetilde{w}_0^*} = \frac{\sigma\left[3(2-\sigma^2)(\theta^2 - 4\theta\widetilde{w}_0^* + 3\widetilde{w}_0^{*2}) + (4-\sigma^2)(2\theta + \sigma - 4\widetilde{w}_0^*)\right]}{8(1-\sigma^2)^2}. \tag{41}$$

Using that $\theta < \widetilde{w}_0^* < w_0^*$ holds under a ban and showing that $(2\theta + \sigma - 4\widetilde{w}_0^*)|_{\widetilde{w}_0^*=w_0^*} = 2\theta + \sigma - (\theta+\sigma) > 0$ and $(\theta^2 - 4\theta\widetilde{w}_0^* + 3\widetilde{w}_0^{*2})\big|_{\widetilde{w}_0^*=\theta+\varepsilon} = \theta^2 - 4\theta(\theta+\varepsilon) + 3(\theta+\varepsilon)^2 = 3\varepsilon^2 + 2\theta\varepsilon > 0$, we can show that $\widetilde{NP}_{w_0\theta}\Big|_{c=0,\widetilde{w}_0=\widetilde{w}_0^*}$ is strictly positive. Hence, $d\widetilde{w}_0^*/d\theta > 0$ if production costs c are sufficiently low. Knowing that $\partial\widetilde{\Pi}_0^S/\partial\widetilde{w}_0 > 0$ as well as $d\widetilde{w}_0/d\theta > 0$ for c sufficiently low, we simply assess

$$\eta = \frac{\partial\widetilde{\Pi}_0^{S*}}{\partial\theta} - \frac{d\Pi_0^{S*}}{d\theta}. \tag{42}$$

Evaluating η for $c = 0$, we obtain

$$\eta|_{c=0,w_0=w_0^*,\widetilde{w}_0=\widetilde{w}_0^*} = \frac{8(2-\sigma^2)\widetilde{w}_0^* - 3(\theta+\sigma)}{16(1-\sigma^2)} > 0. \tag{43}$$

Since $\partial\eta/\partial c = -(13 - 3\sigma n^{1/\rho} - 8\sigma^2)/\left[16(1-\sigma^2)\right] < 0$, $\widetilde{\theta}^* > \theta^*$ holds for sufficiently low levels of c.

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