Deutsches Institut für
Wirtschaftsforschung

DIW BERLIN

Discussion Papers

782

Pio Baake

Accidents, Liability Obligations and Monopolized Markets for Spare Parts: Profits and Social Welfare

Berlin, April 2008

IMPRESSUM

DIW Berlin
German Institute for Economic Research
Mohrenstr. 58
10117 Berlin
Tel. +49 (30) 897 89-0
Fax +49 (30) 897 89-200
http://www.diw.de

ISSN print edition 1433-0210
ISSN electronic edition 1619-4535

Available for free downloading from the DIW Berlin website.

Discussion Papers of DIW Berlin are indexed in RePEc and SSRN.
Papers can be downloaded free of charge from the following websites:

http://www.diw.de/english/products/publications/discussion_papers/27539.html
http://ideas.repec.org/s/diw/diwwpp.html
http://papers.ssrn.com/sol3/JELJOUR_Results.cfm?form_name=journalbrowse&journal_id=1079991

Accidents, Liability Obligations and Monopolized Markets for Spare Parts: Profits and Social Welfare*

Pio Baake†

April 2008

Abstract

We analyze the effects of accidents and liability obligations on the incentives of car manufacturers to monopolize the markets for their spare parts. We show that monopolized markets for spare parts lead to higher overall expenditures for consumers. Furthermore, while the manufacturers invest more in order to offer cars with higher qualities, monopolization tends to reduce social welfare. Key for these results is the observation that high prices for spare parts entail a negative external effect inasmuch as liability obligations imply that consumers of competing products have to pay the high prices as well.

JEL-Classification: L13, L42, D43

Keywords: aftermarkets, monopolization, liability

*I would like to thank Rainald Borck, Justus Haucap and Christian Wey for valuable comments and suggestions.

†Deutsches Institut für Wirtschaftsforschung (DIW) Berlin; e-mail: pbaake@diw.de

1 Introduction

The optimal extent of design protection has been extensively discussed during the last years. This is especially true for the protection of spare parts for motor vehicles. 'Must-match' restrictions with respect to the exact look of visible spare parts in combination with strict design protection imply that car manufacturers and their component suppliers have almost perfect monopoly power for visible replacement parts. Concerning the economic effects of such consequences, there are essentially two different views. First, monopoly power due to design protection should be evaluated in the same manner as patent protection for innovations. Furthermore, applying the Chicago argument that there is only one monopoly rent leads to the conclusion that monopoly power on secondary markets is not detrimental for social welfare.[1] According to the second view this conclusion is, however, premature. Monopoly power on secondary markets may well lead to additional distortions and may thus increase allocative inefficiencies.

The actual policy in the European Union seems to follow the second line of reasoning. Based on the Design Directive of 1998 (Directive 98/71/EC) and the proposal for the amendment on that Directive of September 2004 (COM (2004) 582 final), the parliament of the European Union backed a proposed directive which aims at liberalizing secondary markets for spare parts in December 2007. The proposed directive limits design protection for visible parts to primary markets by referring to a 'repair clause'. This clause allows competitive suppliers to produce spare parts for secondary markets, i.e., markets for repair and maintenance services. Thus, design protection is to be reduced such that market entry and competition on secondary markets is possible.

The model presented in this paper supports the approach taken by the European Union. The focus of our model is on the possibility that consumers, i.e. car drivers, cause accidents with other cars and that they are reliable for the entailed damage. Analyzing the implied economic effects shows that car manufacturers have in fact strong incentives to monopolize the markets for their spare parts: monopolized markets for spare parts lead to higher overall expenditures for consumers. Although the manufacturers have stronger incentives to choose high qualities, monopolized markets for spare parts nevertheless tend to increase the manufacturers' profits. On the other hand, social welfare tends to be lower

[1] See Posner (1976) and Bork (1978).

with monopolized markets. More specifically, social welfare is always lower with monopolized markets for spare parts if primary markets for cars are covered and if costs for producing spare parts are relatively high.

Key for these results is the observation that high prices for spare parts do not only harm a manufacturer's own consumers but also entail a negative external effect for other consumers. With strictly positive probabilities of causing accidents, high prices for spare parts increase expected expenditures for all consumers. Using this correlation, each manufacturer has an incentive to choose rather high prices for spare parts but relatively low prices for cars. By increasing the relation between the prices for spare parts and cars each manufacturer can increase his own market share without lowering the overall revenue he gets from his customers. In contrast to the simple Chicago school argument the relation between the prices for spare parts and cars is therefore not neutral with respect to the manufacturers' market shares. Furthermore, the intensity of competition between manufacturers is reduced when markets for spare parts are monopolized. Since high prices for spare parts have to be paid by all consumers who cause accidents, each manufacturers' demand is relatively inelastic with respect to his price for spare parts. Overall it turns out that monopolized markets for spare parts lead to less intense competition between manufacturers.

In contrast to main parts of the literature on secondary markets, these results are based on external effects. While we assume that consumers are locked-in with respect to the possible choices of spare parts, we also assume that consumers have perfect foresight and that there are no commitment problems concerning future prices. More precisely, we analyze a simple three stage game where two manufacturers choose the qualities of their cars first. In the second stage, the manufacturers decide on their prices for cars and spare parts. Consumers decide in the third stage. Their decisions are based on the (given) prices and the overall expenditures they expect to incur if they buy a car. Expected expenditures comprise the price for the car bought as well as expected payments due to accidents caused. For simplicity, we assume that consumers always replace broken parts.

This setting does not entail any aspect of price discrimination between consumers who differ with respect to their willingness to pay (see for example Chen et al. (1993) and Emch (2003)). Furthermore, with perfect foresight of consumers manufacturers cannot economize on lock-in effects or information costs (see Borenstein et al. (1995); Shapiro (1995) provides a critical discussion of monopolization incentives based on information costs). Our assumption that all prices are chosen in the second stage rules out any commitment problem (see Blair and Herndorn (1996)). Additionally there is no imperfect information with respect to the manufacturers' qualities (see Schwarz and Werden (1996) who show that tying of goods and service in combination with low prices for services can be used to signal high qualities).

Our results concerning social welfare are contrary to the findings of Carlton and Waldman (2006). Their approach focuses on durable goods in conjunction with maintenance, remanufactured parts and product improvements. Carlton and Waldman show that in all these cases monopolization of the respective aftermarkets can enhance efficiency. In contrast to competitive markets, monopolization allows for pricing structures that resemble Ramsey prices and thus lead to more efficient allocations when maintenance versus replacement decisions or the purchase of either improved or upgraded products are analyzed. In the case of remanufactured parts, competition may harm social welfare because of potential cost disadvantages of competing suppliers. Compared to the models analyzed by Carlton and Waldman our model is much simpler, because we assume that demand for spare parts is completely inelastic. Moreover, our model does not contain any dynamic aspects with respect to future quality improvements.

In the following, we first describe the model. Section 3 focuses on the relation between the prices for cars and spare parts and the induced effects on the manufacturers' market shares. Pricing decisions are analyzed in section 4, while quality decisions are discussed in section 5. Using two specific examples, we illustrate our results in section 6 where we also consider social welfare. The final section concludes.

2 The Model

We consider a rather simple model with two firms $i = 1, 2$ producing cars of type 1 and 2. Both firms can choose the qualities q_i and the prices p_i for their cars. To incorporate the possibility of accidents and to analyze the resulting demand for spare parts, we assume that each accident leads to the same damage. This allows us to restrict the analysis to just one spare part, the price of which is denoted by $\widetilde{p}_i$ with $i = 1, 2$. Considering the markets for spare parts, we will compare the case in which $\widetilde{p}_1$ and $\widetilde{p}_2$ can be chosen by firm 1 and 2 with the case where these prices are determined by competitive suppliers using the same technologies as firms 1 and 2. Finally, we assume that both firms have the same marginal cost functions $c(q_i)$ and $\widetilde{c}(q_i)$ for producing cars and spare parts, respectively. Marginal costs are increasing and strictly convex in qualities, i.e., $c'(q_i), \widetilde{c}'(q_i) > 0$ and $c''(q_i), \widetilde{c}''(q_i) > 0$. Additionally, we make the natural assumption that $c(q_i) > \widetilde{c}(q_i)$ and $c'(q_i) \geq \widetilde{c}'(q_i)$.

There is a continuum of consumers the number of which is normalized to one. Furthermore, we assume that the firms' cars are imperfect substitutes and that the (aggregate) demand functions for both types of cars are the same. Letting m_i denote the overall expected expenditures which consumers have to incur if they buy a type i car, consumers' demand D_i for type i cars is given by $(i, j = 1, 2; i \neq j\ )$[2]

$$D_i(\cdot) \quad : \quad = D(m_i, m_j, q_i, q_j) \text{ with } \frac{\partial D_i(\cdot)}{\partial m_j} > 0 > \frac{\partial D_i(\cdot)}{\partial m_i},\ \frac{\partial^2 D_i(\cdot)}{\partial m_i^2} \leq 0 \tag{1}$$

$$\text{and} \quad : \quad \frac{\partial D_i(\cdot)}{\partial q_i} > 0 > \frac{\partial D_i(\cdot)}{\partial q_j}. \tag{2}$$

Overall expected expenditures m_i are determined by the price p_i as well as the prices $\widetilde{p}_1$ and $\widetilde{p}_2$ in combination with the probabilities that a consumer causes an accident. Each consumer who has bought a car may cause two different kinds of accidents. First, there are accidents where no other cars are involved, second the consumer can cause accidents with other cars. We assume that accidents are independent events which implies that the expected number of accidents caused with other cars is linearly increasing in the number of cars sold. Finally, we assume that consumers always replace broken parts and that they are liable for damages caused to other cars. Let $\rho \geq 0$ denote the probability that a consumer causes an accident where no other car is involved and let $\sigma \geq 0$ denote the probability that a consumer causes an accident with another car of either type. Furthermore, let x_i denote the quantity of type i cars which have actually been sold. Then, total expected expenditures m_i for buying a car of type i can be written as

$$m_i(\cdot) \quad = \quad p_i + \rho\widehat{p}_i + \phi_i(\widehat{p}_i, \widehat{p}_j, x_i, x_j) \text{ with } \widehat{p}_i := \min\{p_i, \widetilde{p}_i\} \tag{3}$$

$$\text{where} \quad : \quad \phi_i(\cdot) = 2\sigma\widehat{p}_i x_i + (\widehat{p}_i + \widehat{p}_j)\sigma x_j \text{ denotes the expected payments} \tag{4}$$

$$: \quad \text{due to accidents caused with other cars}$$

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

Note that (4) is based on the assumption that accidents lead to damages on all cars involved and that spare parts are incompatible. Note further that a consumer would buy a new car instead of the spare part if $\widetilde{p}_i > p_i$. Since we also have $c(q_i) > \widetilde{c}(q_i)$, it is never optimal for a firm to choose $\widetilde{p}_i > p_i$.

Combining (1) and (3) and restricting the further analysis to $\widetilde{p}_i \leq p_i$, firms' demand functions $X_i(p_i, p_j, \widetilde{p}_i, \widetilde{p}_j)$ for cars are implicitly given by

$$X_1(\cdot) \equiv D_1(p_1 + \rho\widetilde{p}_1 + \phi_1(\cdot, X_1(\cdot), X_2(\cdot)), p_2 + \rho\widetilde{p}_2 + \phi_2(\cdot, X_2(\cdot), X_1(\cdot)), \cdot) \quad (5)$$

$$X_2(\cdot) \equiv D_2(p_2 + \rho\widetilde{p}_2 + \phi_2(\cdot, X_2(\cdot), X_1(\cdot)), p_1 + \rho\widetilde{p}_1 + \phi_1(\cdot, X_1(\cdot), X_2(\cdot)), \cdot) \quad (6)$$

whereas expected demand $\widetilde{X}_i(p_i, p_j, \widetilde{p}_i, \widetilde{p}_j)$ for spare parts can be written as

$$\widetilde{X}_1(\cdot) = \rho X_1(\cdot) + \Phi_1(X_1(\cdot), X_2(\cdot)) \quad (7)$$

$$\widetilde{X}_2(\cdot) = \rho X_2(\cdot) + \Phi_2(X_2(\cdot), X_1(\cdot)) \quad (8)$$

$$\text{with} : \Phi_i(\cdot) = X_i(\cdot)\left[2\sigma X_i(\cdot) + 2\sigma X_j(\cdot)\right]. \quad (9)$$

Employing (5)—(8) and the assumptions on the firms' costs leads to the following expressions for the firms' profits $\Pi_1(\cdot)$ and $\Pi_2(\cdot)$

$$\Pi_1(\cdot) = (p_1 - c(q_1))X_1(\cdot) + (\widetilde{p}_1 - \widetilde{c}(q_1))\widetilde{X}_1(\cdot) \quad (10)$$

$$\Pi_2(\cdot) = (p_2 - c(q_2))X_2(\cdot) + (\widetilde{p}_2 - \widetilde{c}(q_2))\widetilde{X}_2(\cdot). \quad (11)$$

We will analyze a three stage game where firms first decide on their qualities. In the second stage firms choose their prices while demand and profits are realized in the last stage. We assume perfect information and simultaneous decisions in all stages and solve the game by backward induction.

3 Prices and market shares

Before turning to the firms' pricing decisions let us first consider the impact which accidents and liability obligations have on consumers' demand and firms' market shares. Focusing on the relation between p_i and $\widetilde{p}_i$ and assuming $\sigma = 0$ and thus $\phi_i(\cdot) = 0$, firms' demand functions are given by $X_i(\cdot) = D_i(p_i + \rho\widetilde{p}_i, p_j + \rho\widetilde{p}_i, \cdot)$ and $\widetilde{X}_i(\cdot) = \rho X_i(\cdot)$. Therefore, the standard Chicago school argument applies because consumers' demand depends only on the weighted sum of prices. The relation between p_i and $\widetilde{p}_i$ has no effect on demand and thus on the firms' profits.

However, taking into account that consumers have to pay the damages they may have caused to other consumers, it turns out that the relation between p_i and $\widetilde{p}_i$ plays a crucial rule for the firms' market shares. To see this more precisely, assume $\sigma > 0$ and consider a change in p_i and $\widetilde{p}_i$ with $\widetilde{p}_i < p_i$ such that overall expenditures of consumers who buy type i cars remain constant. That is, let $p_i^k(\widetilde{p}_i, \cdot)$ be defined such that

$$m_i(\cdot) = p_i^k(\widetilde{p}_i, \cdot) + \rho\widetilde{p}_i + \phi_i(\widetilde{p}_i, \widetilde{p}_j, X_1(\cdot), X_2(\cdot)) = const. \tag{12}$$

Using $p_i^k(\widetilde{p}_i, \cdot)$ and evaluating the change in the firms' demands if $\widetilde{p}_i$ is varied leads to the following proposition

Proposition 1 *Starting from $\widetilde{p}_i < p_i$ and changing $\widetilde{p}_i$ and p_i such that total expenditures $m_i(\cdot)$ remain constant, the market share of firm i increases with $\widetilde{p}_i$ while the market share of firm j decreases as long as*

$$1 - \sigma\left((\widetilde{p}_i + \widetilde{p}_j)\frac{\partial D_i(\cdot)}{\partial m_j(\cdot)} + 2\widetilde{p}_j\frac{\partial D_j(\cdot)}{\partial m_j(\cdot)}\right) > 0$$

holds.

Proof. Using (12), the partial derivative of $p_i^k(\widetilde{p}_i, \cdot)$ with respect to $\widetilde{p}_i$ satisfies

$$\frac{\partial p_i^k(\widetilde{p}_i, \cdot)}{\partial \widetilde{p}_i} + \rho + \frac{\partial \phi_i(\cdot)}{\partial \widetilde{p}_i} + \sum_{j=1}^{2}\frac{\partial \phi_i(\cdot)}{\partial X_j(\cdot)}\left[\frac{\partial X_j(\cdot)}{\partial p_i}\frac{\partial p_i^k(\widetilde{p}_i, \cdot)}{\partial \widetilde{p}_i} + \frac{\partial X_j(\cdot)}{\partial \widetilde{p}_i}\right] = 0 \tag{13}$$

Employing (13), using (5) and (6) as well as the implicit function theorem to calculate $\partial X_i(\cdot)/\partial p_i$ and $\partial X_j(\cdot)/\partial p_i$ leads to

$$\frac{\partial X_i(\cdot)}{\partial p_i}\frac{\partial p_i^k(\widetilde{p}_i, \cdot)}{\partial \widetilde{p}_i} + \frac{\partial X_i(\cdot)}{\partial \widetilde{p}_i} = \frac{1}{\Theta}\frac{\partial \phi_j(\cdot)}{\partial \widetilde{p}_i}\frac{\partial D_i(\cdot)}{\partial m_j(\cdot)} \tag{14}$$

$$\frac{\partial X_j(\cdot)}{\partial p_i}\frac{\partial p_i^k(\widetilde{p}_i, \cdot)}{\partial \widetilde{p}_i} + \frac{\partial X_j(\cdot)}{\partial \widetilde{p}_i} = \frac{1}{\Theta}\frac{\partial \phi_j(\cdot)}{\partial \widetilde{p}_i}\frac{\partial D_j(\cdot)}{\partial m_j(\cdot)} \tag{15}$$

where Θ is given by

$$\Theta := 1 - \frac{\partial \phi_j(\cdot)}{\partial X_i(\cdot)}\frac{\partial D_i(\cdot)}{\partial m_j(\cdot)} - \frac{\partial \phi_j(\cdot)}{\partial X_j(\cdot)}\frac{\partial D_j(\cdot)}{\partial m_j(\cdot)} \tag{16}$$

Using (4) we get

$$\frac{\partial \phi_j(\cdot)}{\partial \widetilde{p}_i} = \sigma X_j(\cdot) \text{ and } \Theta = 1 - \sigma\left((\widetilde{p}_i + \widetilde{p}_j)\frac{\partial D_i(\cdot)}{\partial m_j(\cdot)} + 2\widetilde{p}_j\frac{\partial D_j(\cdot)}{\partial m_j(\cdot)}\right). \tag{17}$$

■

The intuitive explanation for proposition 1 is based on the observation that an increase in $\widetilde{p}_i$ also leads to higher expected expenditures for consumers who buy type j cars. Hence, assuming $\Theta > 0$, increasing $\widetilde{p}_i$ and adapting p_i such that expected expenditures $m_i(\cdot)$ remain constant implies that type j cars become relatively more expensive. Therefore, the market share of firm i increases while the market share of firm j decreases. In other words, low prices for cars but high prices for spare parts ensure a competitive advantage as far as market shares are concerned. This is especially true, if symmetric prices are considered:

Corollary 1 *With $\partial D_i(\cdot)/\partial m_j(\cdot) \leq |\partial D_j(\cdot)/\partial m_j(\cdot)|$ and symmetric prices, i.e. $\widetilde{p}_i = \widetilde{p}_j$ with $p_i > \widetilde{p}_i$, increasing $\widetilde{p}_i$ and decreasing p_i such that that total expenditures $m_i(\cdot)$ remain constant leads to a higher market share of firm i.*

4 Firms' pricing decisions

In the following, we will first analyze the firms' pricing decisions if markets for spare parts are monopolized, i.e., if firms can decide on both the price of their cars as well the price of their spare parts. We show that the economic reasoning which leads to proposition 1 can also be applied to the firms' pricing strategies. That is, in a symmetric equilibrium firms will choose their prices such that $p_i = \widetilde{p}_i$.

We will then turn to the case where markets for spare parts are perfectly competitive, i.e., where we have $\widetilde{p}_i = \widetilde{c}(\cdot)$. Comparing the two regimes and assuming covered markets shows that monopolized markets for spare parts lead to higher overall expenditures for consumers.

Assuming that markets for spare parts are monopolized and using the same approach as employed for proposition 1, equal prices for cars and spare parts are optimal if

$$\frac{d\Pi_i(p_i^k(\widetilde{p}_i,\cdot),\widetilde{p}_i,\cdot)}{d\widetilde{p}_i} = \frac{\partial \Pi_i(\cdot)}{\partial p_i^k(\widetilde{p}_i,\cdot)} \frac{\partial p_i^k(\widetilde{p}_i,\cdot)}{\partial \widetilde{p}_i} + \frac{\partial \Pi_i(\cdot)}{\partial \widetilde{p}_i} > 0 \quad (18)$$

for all $p_i^k(\widetilde{p}_i,\cdot) \geq \widetilde{p}_i$. Evaluating (18) and focusing on symmetric situations, i.e., $p_i = p_j$, $\widetilde{p}_i = \widetilde{p}_j$ and $q_i = q_j$, we obtain the following lemma

Lemma 1 *With equal qualities and*

$$\frac{\partial D_i(\cdot)}{\partial m_j(\cdot)} \leq \left|\frac{\partial D_i(\cdot)}{\partial m_i(\cdot)}\right|$$

any symmetric equilibrium implies $p_i = p_j = \widetilde{p}_i = \widetilde{p}_j$.

Proof. Starting with $p_i^k(\widetilde{p}_i, \cdot) \geq \widetilde{p}_i$, using (14)–(15) and simplifying (18) by employing symmetry as well as (4) and (9) we get

$$\begin{aligned}
\frac{d\Pi_i(p_i^k(\widetilde{p}_i,\cdot),\widetilde{p}_i,\cdot)}{d\widetilde{p}_i} &= \frac{X_i(\cdot)}{\Theta_1}\Bigg[X_i(\cdot)\left(1-2(\widetilde{p}_i+\widetilde{c}(q_i))\frac{\partial D_i(\cdot)}{\partial m_i(\cdot)}\right) \\
&\quad + \left(p_i^k(\widetilde{p}_i,\cdot)-c(q_i)+(\widetilde{p}_i-\widetilde{c}(q_i))(\sigma+2X_i(\cdot))-\widetilde{c}(q_i)4X_i(\cdot)\right)\frac{\partial D_i(\cdot)}{\partial m_j(\cdot)}\Bigg] \qquad (19) \\
\text{with} &: \Theta_1 = 1-2\widetilde{p}_i\left(\frac{\partial D_i(\cdot)}{\partial m_j(\cdot)}+\frac{\partial D_i(\cdot)}{\partial m_i(\cdot)}\right)
\end{aligned}$$

Solving $d\Pi_i(p_i^k(\widetilde{p}_i,\cdot),\widetilde{p}_i,\cdot)/\,d\widetilde{p}_i = 0$ for $p_i^k(\widetilde{p}_i,\cdot)$ and substituting the solution into $\Pi_i(\cdot)$ reveals that any prices $p_i^k(\widetilde{p}_i,\cdot) > \widetilde{p}_i$ that satisfy $d\Pi_i(p_i^k(\widetilde{p}_i,\cdot),\widetilde{p}_i,\cdot)/\,d\widetilde{p}_i = 0$ and $\widetilde{p}_i \geq 0$ lead to negative profits $\Pi_i(\cdot)$ as long as $\partial D_i(\cdot)/\,\partial m_j(\cdot) \leq |\partial D_i(\cdot)/\,\partial m_i(\cdot)|$. Similarly, assuming $\widetilde{p}_i = 0$ and solving $\partial\Pi_i(\cdot)/\,\partial p_i = 0$ for p_i we get $\partial\Pi_i(\cdot)/\,\partial\widetilde{p}_i > 0$. Together these results imply that we must have $p_i = p_j = \widetilde{p}_i = \widetilde{p}_j$ in any symmetric equilibrium. ■

Lemma 1 and Proposition 1 are based on the same economic reasoning. While an increase in $\widetilde{p}_i$ may lower overall demand, this negative effect can be compensated by reducing p_i such that the positive effects due to an increased market share dominate.

Applying lemma 1 and focusing again on symmetric equilibria, the firms' maximization problem can be written as

$$\max_{p_i} \Pi_i(\cdot) = (p_i - c(q_i))X_i(\cdot) + (p_i - \widetilde{c}(q_i))\left[\rho X_i(\cdot) + \Phi_i(X_i(\cdot), X_j(\cdot))\right] \qquad (20)$$

Solving the first-order condition aligned with (20) shows that the equilibrium price $p^*(q_i, q_j, \cdot)$ in any symmetric equilibrium with $q_i = q_j$ is implicitly given by

$$\begin{aligned}
\frac{p_i - c(q_i) + \rho(p_i - \widetilde{c}(q_i))}{p_i} &= -\frac{1}{\eta_{X_i p_i}}\left[1+\rho+\frac{1}{X_i(\cdot)}\left(\Phi_i(\cdot)+(p_i-\widetilde{c}(q_i))\Theta_2\right)\right] \qquad (21) \\
\text{with} \quad \eta_{X_i p_i} &= \left[\frac{\partial X_i(\cdot)}{\partial p_i}+\frac{\partial X_i(\cdot)}{\partial \widetilde{p}_i}\right]\frac{p_i}{X_i(\cdot)} \\
\text{and} \qquad \Theta_2 &= \frac{\partial \Phi_i(\cdot)}{\partial X_i(\cdot)}\left[\frac{\partial X_i(\cdot)}{\partial p_i}+\frac{\partial X_i(\cdot)}{\partial \widetilde{p}_i}\right]+\frac{\partial \Phi_i(\cdot)}{\partial X_j(\cdot)}\left[\frac{\partial X_j(\cdot)}{\partial p_i}+\frac{\partial X_j(\cdot)}{\partial \widetilde{p}_i}\right]
\end{aligned}$$

While (21) does not allow a straightforward interpretation, it indicates that there are two major factors which determine the firms' pricing decisions. First and the most obvious, with $p_i = \widetilde{p}_i$ the relevant price-cost margin depends on the cost for cars as well as the cost for spare parts (see the LHS of (21)). Second, firms have to take into account that demand for cars and spare parts are closely related not only to the firms' prices but also to their market shares. This fact is captured by the last term on the RHS of (21) where Θ_2 represents the change in the demand for spare parts if the firms increase their prices.

Turning to the case in which spare parts can be offered competitively, firms' profits Π_i simplify to (in the following the superscript c serves to indicate competitive markets for spare parts)

$$\Pi_i^c(\cdot) = (p_i - c(q_i))X_i^c(\cdot) \tag{22}$$

where $X_i^c(\cdot)$ is given by (5) or (6) evaluated at $\widetilde{p}_i = \widetilde{c}(\cdot)$. Differentiating (22) with respect to p_i and solving the respective first-order condition, the equilibrium price $p_i^c(\cdot)$ for cars satisfies

$$\frac{p_i - c(q_i)}{p_i} = -\frac{1}{\eta^c_{X_i p_i}} \text{ with } \eta^c_{X_i p_i} = \frac{\partial X_i^c(\cdot)}{\partial p_i}\frac{p_i}{X_i^c(\cdot)}. \tag{23}$$

Combining (20), (21) and (23) in order to compare overall expenditures with and without competition in the markets for spare parts, we obtain

Proposition 2 *Assume that there exists a unique symmetric equilibrium in both cases, i.e. if the markets for spare parts are monopolized and if these markets are competitive. With covered markets, i.e.*

$$D_i(\cdot) + D_j(\cdot) = const.,$$

total consumer expenditures are higher if markets for spare parts are monopolized.

Proof. We first derive the prices $p_i = \widetilde{p}_i$ which lead to the same overall consumer expenditures as $p_i = p^c$ and $\widetilde{p}_i = \widetilde{c}(q_i)$. Using (4) and the assumption that markets are covered we thus start from a situation in which $p_i = \widetilde{p}_i$ are equal to p^k given by

$$p^k = \widetilde{c}(q_i) + \frac{p^c - \widetilde{c}(q_i)}{1 + \rho + 2\sigma(X_i(\cdot) + X_j(\cdot))}. \tag{24}$$

Evaluating $\partial\Pi_i(\cdot)/\partial p_i$ at $p_i = \widetilde{p}_i = p^k$ and again using (4) and (8) leads to

$$\left.\frac{\partial\Pi_i(\cdot)}{\partial p_i}\right|_{p_i = p_i^k} = 2X_i(\cdot)^2 > 0. \tag{25}$$

Therefore, starting with $p_i = \widetilde{p}_i = p^k$ both firms would have an incentive to increase their prices which also leads to higher consumer expenditures if the markets for spare parts are monopolized. ■

Note that while proposition 2 is based on the assumption that markets are covered, the strict inequality in (25) indicates that the result continues to hold if the difference between $|\partial D_i(\cdot)/\partial m_i(\cdot)|$ and $\partial D_i(\cdot)/\partial m_j(\cdot)$ is positive but small enough. Thus, strictly positive probabilities of causing accidents and liability obligations do not only imply that firms have an incentive to increase the prices for their spare parts, we also find that competition in the markets for spare parts can decrease overall expenditures. Hence, monopolization of markets for spare parts can indeed increase prices and may thus serve as a collusive device.

5 Quality decisions

Turning to the first stage of the game, we again start with the case in which the markets for spare parts are monopolized. Analyzing the impact of σ on the firms' qualities and focusing on symmetric equilibria, comparative statics at $\sigma = 0$ show that the firms may choose even higher qualities if σ increases. This is the case as long as $\widetilde{c}'(q_i)$ is relatively low. On the other hand, with competitive markets for spare parts firms will always decrease their qualities if σ is increased. Therefore, monopolized markets for spare parts tend to lead to higher qualities as compared to the case in which spare parts are competitively supplied.

Let $\Pi_i^*(\cdot)$ denote the firms' reduced profit function if markets for spare parts are monopolized, i.e.

$$\Pi_i^*(\cdot) = (p_i^*(q_i, q_j, \cdot) - c(q_i))X_i(\cdot) + (p_i^*(q_i, q_j, \cdot) - \widetilde{c}(q_i))\left[\rho X_i(\cdot) + \Phi_i(X_i(\cdot), X_j(\cdot))\right]. \quad (26)$$

Applying the envelope theorem, the first-order condition for the optimal quality $q_i^*(\cdot)$ can be written as

$$\frac{d\Pi_i^*(\cdot)}{dq_i} = \frac{\partial \Pi_i^*(\cdot)}{\partial q_i} + \frac{\partial \Pi_i^*(\cdot)}{\partial p_j^*}\frac{\partial p_j^*(\cdot)}{\partial q_i} \quad (27)$$

where $\partial\Pi_i^*(\cdot)/\partial q_i$ is given by

$$\begin{aligned}\frac{\partial\Pi_i^*(\cdot)}{\partial q_i} &= (p_i^*(q_i,q_j,\cdot)-c(q_i))\frac{\partial X_i(\cdot)}{\partial q_i}-c'(q_i)X_i(\cdot) \\ &+(p_i^*(q_i,q_j,\cdot)-\widetilde{c}(q_i))\left[\rho\frac{\partial X_i(\cdot)}{\partial q_i}+\frac{\partial\Phi_i(\cdot)}{\partial X_i}\frac{\partial X_i(\cdot)}{\partial q_i}+\frac{\partial\Phi_i(\cdot)}{\partial X_j}\frac{\partial X_j(\cdot)}{\partial q_i}\right] \\ &-\widetilde{c}'(q_i)\left[\rho X_i(\cdot)+\Phi_i(X_i(\cdot),X_j(\cdot))\right]\end{aligned} \tag{28}$$

Analyzing $\partial X_i(\cdot)/\partial q_i$ in greater detail, comparative statics based on (5)–(6) as well as (4) lead to

$$\frac{\partial X_i(\cdot)}{\partial q_i} = \frac{1}{\Theta_3}\left[\frac{\partial D_i(\cdot)}{\partial q_i}-2p_i\sigma\sum_{k=1}^{2}\frac{\partial D_k(\cdot)}{\partial m_i}\left[\frac{\partial D_i(\cdot)}{\partial q_i}-\frac{\partial D_j(\cdot)}{\partial q_i}\right]\right] \tag{29}$$

$$\frac{\partial X_i(\cdot)}{\partial q_i}+\frac{\partial X_j(\cdot)}{\partial q_i} = \frac{1}{\Theta_3}\left[\frac{\partial D_i(\cdot)}{\partial q_i}+\frac{\partial D_j(\cdot)}{\partial q_i}\right] \tag{30}$$

$$\text{with} \; : \; \Theta_3 = 1-4p_i\sigma\left[\frac{\partial D_i(\cdot)}{\partial m_i}+\frac{\partial D_j(\cdot)}{\partial m_i}\right]$$

for $p_i = p_j$ and $q_i = q_j$. Combining (29) and (30) shows that while the shift in the firms' market shares due to an increase of q_i does not depend on σ, a positive probability for causing accidents tends to lower the positive effects of higher qualities on overall demand (see (30)).

In view of (28) there are thus two opposing effects on the firms' incentives to invest in qualities. While the term in the second line of (28) points to a positive effect, an increase in σ decreases $\partial X_i(\cdot)/\partial q_i$ but does not imply any additional effects with respect to the relation between the firms' qualities and their market shares. Evaluating these effects more carefully, we obtain

Lemma 2 *Assume that consumers' demand functions $D_i(\cdot)$ are linear in m_i and m_j, that markets are covered and that the markets for spare parts are monopolized. Assume further that there exists a symmetric equilibrium in which both firms choose the same qualities $q^*(\sigma,\cdot) = q_i^*(\sigma,\cdot) = q_j^*(\sigma,\cdot)$. Then,*

$$\left.\frac{\partial q^*(\sigma,\cdot)}{\partial\sigma}\right|_{\sigma=0} \gtreqless 0 \Leftrightarrow c'(q^*(0,\cdot))-(2+\rho)\widetilde{c}'(q^*(0,\cdot)) \gtreqless 0$$

Proof. The proof is based on simple but tedious comparative statics. Using (3)—(8) and (21) we get

$$p^*(q_i,q_j,\cdot)|_{\sigma=0} = \frac{X_i(\cdot)-(c(q_i)+\rho\widetilde{c}(q_i))\,\partial D_i(\cdot)/\partial m_i(\cdot)}{(1+\rho)\,\partial D_i(\cdot)/\partial m_i(\cdot)} \text{ and} \tag{31}$$

$$\left.\frac{\partial\Pi_i^*(\cdot)}{\partial q_i}\right|_{\sigma=0} = 0 \Leftrightarrow \frac{\partial D_i(\cdot)}{\partial q_i} = -(c'(q_i)+\rho\widetilde{c}'(q_i))\frac{\partial D_i(\cdot)}{\partial m_i}. \tag{32}$$

Furthermore, comparative statics with respect to σ reveals

$$\left.\frac{\partial}{\partial\sigma}p^*(q_i, q_j, \cdot)\right|_{\sigma=0} = \frac{2X_i(\cdot)\left[X_i(\cdot) - (c(q_i) - \widetilde{c}(q_i))\,\partial D_i(\cdot)/\,\partial m_i(\cdot)\right]}{(1+\rho)^2\,\partial D_i(\cdot)/\,\partial m_i(\cdot)} \tag{33}$$

Employing (31)—(33), totally differentiating (27) with respect to σ and evaluating the respective expression at $\sigma = 0$ and $q^*(0,\cdot) = q_i^*(0,\cdot) = q_j^*(0,\cdot)$ we obtain

$$\left.\frac{\partial}{\partial\sigma}\left[\frac{\partial\Pi_i^*(\cdot)}{\partial q_i}\right]\right|_{\sigma=0} = \frac{4\left[c'(q^*(0,\cdot)) - (2+\rho)\widetilde{c}'(q^*(0,\cdot))\right]X_i(\cdot)^2}{3(1+\rho)} \tag{34}$$

■

The economic intuition for lemma 2 is based on two counteracting effects. On the one hand, the higher σ the higher are the consumers' total expected expenditures and the lower their willingness to pay for additional quality enhancements. On the other hand, by increasing its quality q_i and adapting the prices for cars and spare parts correspondingly, firm i gets an additional competitive advantage inasmuch as cars of type i become more attractive while total expected expenditures $m_j(\cdot)$ increase as well. Lemma 2 shows that this second effect dominates as long as long as $\widetilde{c}'(q_i)$ is small enough.

Turning to the case in which markets for spare parts are competitive, let $\Pi_i^{c*}(q_i, q_j)$ denote the firms' reduced profit functions. Using the same approach as in lemma 2 leads to

Lemma 3 *Assume that consumers' demand functions $D_i(\cdot)$ are linear in m_i and m_j, that markets are covered and that the markets for spare parts are competitive. Assume further that there exists a symmetric equilibrium in which both firms choose the same qualities $q^c(\sigma,\cdot) = q_i^c(\sigma,\cdot) = q_j^c(\sigma,\cdot)$. Then,*

$$\left.\frac{\partial q^c(\sigma,\cdot)}{\partial\sigma}\right|_{\sigma=0} < 0.$$

Proof. Again, the proof is based on simple but tedious comparative statics. Employing (3)—(6) and (22) we get

$$\frac{\partial\Pi_i^{c*}(\cdot)}{\partial q_i} = (p_i^c - c(q_i))\left[\frac{\partial X_i^c(\cdot)}{\partial q_i} + \frac{\partial X_i^c(\cdot)}{\partial p_j^c(\cdot)}\frac{\partial p_j^c(\cdot)}{\partial q_i} + \frac{\partial X_i^c(\cdot)}{\partial\widetilde{p}_i}\widetilde{c}'(q_i)\right] - c'(q_i)X_i^c(\cdot) \tag{35}$$

Simplifying (35) shows that with $\sigma = 0$ the firms would in fact choose the same qualities as with monopolized markets (see (32)), i.e.,

$$\left.\frac{\partial\Pi_i^{c*}(\cdot)}{\partial q_i}\right|_{\sigma=0} = 0 \Leftrightarrow \frac{\partial D_i(\cdot)}{\partial q_i} = -(c'(q_i) + \rho\widetilde{c}'(q_i))\frac{\partial D_i(\cdot)}{\partial m_i}. \tag{36}$$

Additionally, assuming covered markets implies $\partial p^c(q_i, q_j, \cdot)/\,\partial\sigma = 0$. Using (23) and (35), employing comparative statics with respect to σ and evaluating the respective expressions at $\sigma = 0$ and $q^c(0, \cdot) = q_i^c(0, \cdot) = q_j^c(0, \cdot)$ leads to

$$\frac{\partial}{\partial\sigma}\left[\frac{\partial\Pi_i^{c*}(\cdot)}{\partial q_i}\right]\Bigg|_{\sigma=0} = -\frac{4}{3}\widetilde{c}'(q^c(0, \cdot))X_i^c(\cdot)^2 < 0. \tag{37}$$

■

Lemma 3 confirms the intuition provided for lemma 2. With competitive markets for spare parts, the additional strategic effects implied by higher qualities and prices for cars and spare parts are always dominated by the negative effects due to increased total expected expenditures. Since the firms cannot use the prices for spare parts in order to exploit the negative effects on the other firm's demand, their willingness to invest in higher qualities is lower the higher σ. Summarizing these findings we get

Proposition 3 *Assume that consumers' demand functions $D_i(\cdot)$ are linear in m_i and m_j and that markets are covered. Assume further that $\sigma = 0$ and that there exists a symmetric equilibrium in which both firms choose the same qualities. Then, an increase in σ implies that the firms' incentive to exploit the external effects induced by liability obligations lead to comparatively higher qualities if the markets for spare parts are monopolized, that is,*

$$\frac{\partial q^c(\sigma, \cdot)}{\partial\sigma}\Bigg|_{\sigma=0} < \frac{\partial q^*(\sigma, \cdot)}{\partial\sigma}\Bigg|_{\sigma=0}.$$

Proof. Using $c'(q) \geq \widetilde{c}'(q)$ and comparing (34) and (37) leads to the result. ■

Propositions 1—3 show that the relation between prices for cars and spare parts is not neutral with respect to the equilibrium allocation. Monopolized markets for spare parts tend to imply higher overall expenditures and stronger incentives for providing higher qualities. Considering social welfare, it is, however, not clear whether or not monopolized markets for spare parts are detrimental for welfare. On the one hand, high overall expenditures tend to lower welfare. On the other hand, positive probabilities of causing accidents and the implied negative externalities lead to inefficient consumer decisions. Similarly, while high qualities of cars are beneficial for consumers, high qualities also tend to raise the expected costs due to accidents caused. In order to evaluate these countervailing effects, we will now turn to two simple examples.

6 Examples

The first example is based on a Hotelling model with covered markets. It mainly illustrates the results presented in the preceding section and shows that while firms are strictly better off with monopolized markets for spare parts, social welfare is higher with competitive markets. The second example is more involved inasmuch as it builds on uncovered markets where consumers are assumed to have a Dixit utility function. In contrast to the Hotelling model it turns out that firms may be better off with competitive markets for spare parts. While monopolized markets for spare parts again lead to higher expenditures for the consumers, the implied increase in the firms' profits is the lower the lower the substitutability between the firms' products. Moreover, equilibrium qualities continue to be higher with monopolized markets for spare parts which may ultimately lead to lower profits as compared to the case with competitive markets.

6.1 Covered markets

Following the standard Hotelling model, we assume that consumers are uniformly distributed on the $[0, 1]$ interval. The mass of consumers is normalized to one. Let ν denote a consumer's location and let firm 1 be located at 0 and firm 2 at 1. Assuming linear transportation cost $t > 0$, a consumer's utility when he buys from firm 1 or 2, respectively, is given by

$$u(\cdot) = \begin{cases} v(q_1) - m_1(\cdot) - t\nu & \text{if he buys from firm 1} \\ v(q_2) - m_2(\cdot) - t(1-\nu) & \text{if he buys from firm 2} \end{cases} \tag{38}$$
$$\text{with} : v'(q) > 0 \text{ and } v''(q) \leq 0$$

With respect to the firms' cost, we rely on the general assumptions $c'(q_i), \widetilde{c}'(q_i) > 0$ and $c''(q_i), \widetilde{c}''(q_i) > 0$ as well as $c(q_i) > \widetilde{c}(q_i)$ and $c'(q_i) > \widetilde{c}'(q_i)$.

Using (38), solving for the indifferent consumer and taking into account that $m_1(\cdot)$ and $m_2(\cdot)$ are given by (3), the firms' demands $X_1(\cdot)$ and $X_2(\cdot)$ can be written as

$$X_1(\cdot) = \frac{1}{2t}\left[v(q_1) - v(q_2) - (p_1 - p_2) - (\widetilde{p}_1 - \widetilde{p}_2)(\rho + \sigma) + t\right] \tag{39}$$

$$X_2(\cdot) = 1 - X_1(\cdot) \tag{40}$$

Starting with the case of monopolized markets, it is easy to verify that both firms will in fact choose $p_i = \widetilde{p}_i$. Furthermore, solving $\partial\Pi_i(\cdot)/\partial p_i = 0$ for the equilibrium prices

$p_i^*(q_i, q_j, \cdot)$ and differentiating the reduced profit functions $\Pi_i^*(\cdot)$ with respect to q_i, it is straightforward to show that there is a unique symmetric equilibrium $p^*(\cdot)$ and $q^*(\sigma, \cdot)$ implicitly given by

$$p_i = \widetilde{c}(q_i) + \frac{c(q_i) - \widetilde{c}(q_i)}{1+\rho+2\sigma} + \frac{t}{1+\rho+\sigma} \text{ and} \quad (41)$$

$$c'(q_i) = -\widetilde{c}'(q_i)(\rho+2\sigma) + \frac{(1+\rho+2\sigma)}{1+\rho+\sigma} v'(q_i) \quad (42)$$

Turning to the case of competitive markets for spare parts we get

$$X_1^c(\cdot) = \frac{1}{2t}\left[v(q_1) - v(q_2) - (p_1 - p_2) - (\widetilde{c}(q_1) - \widetilde{c}(q_2))(\rho+\sigma) + t\right] \quad (43)$$

$$X_2^c(\cdot) = 1 - X_1^c(\cdot) \quad (44)$$

Again, maximizing the firms' profit functions $\Pi_i^c(\cdot)$ with respect to the firms' prices and differentiating the reduced profit functions with respect to the firms' qualities, the unique symmetric equilibrium $p^c(\cdot)$ and $q^c(\sigma, \cdot)$ is implicitly given by

$$p_i = c(q_i) + t \text{ and} \quad (45)$$

$$c'(q_i) = -\widetilde{c}'(q_i)(\rho+\sigma) + v'(q_i) \quad (46)$$

Comparing (42) and (46) and using simple comparative statics leads to $q^*(\sigma, \cdot) > q^c(\sigma, \cdot)$ for all $\sigma > 0$. Furthermore, (41) and (45) reveal that the firms' profits are strictly higher with monopolized markets for spare parts:

$$\Pi_i^*(q^*(\sigma, \cdot), \cdot) = \frac{1+\rho+2\sigma}{2(1+\rho+\sigma)} t > \frac{1}{2} t = \Pi_i^{c*}(q^c(\sigma, \cdot), \cdot) \ \forall \ \sigma > 0 \quad (47)$$

Finally, analyzing social welfare and focusing on competitive markets for spare parts we get

$$W^c(\cdot) = \sum_{i=1}^{2} X_i^c(\cdot)\left[v(q_i) - m_i(\cdot)\right] + \sum_{i=1}^{2} \Pi_i^{c*}(q_i, \cdot) - \frac{1}{2}\left[1 + X_1^c(\cdot)(X_1^c(\cdot) - 2(1-t))\right] \quad (48)$$

and

$$\left.\frac{\partial W^c(\cdot)}{\partial q_i}\right|_{q_1=q_2=q^c} = -\frac{1}{2}\sigma \widetilde{c}'(q^c) < 0 \quad (49)$$

Inequality (49) together with $q^*(\sigma, \cdot) > q^c(\sigma, \cdot)$ implies that social welfare is lower with monopolized markets for spare parts as compared to the case in which spare parts can be supplied competitively.

6.2 Uncovered markets

In contrast to the Hotelling model we now assume that markets are not covered. We assume that there is a continuum of homogeneous consumers the number of which is normalized to 1. Consumers have a Dixit utility function given by

$$u(\cdot) = q_1 x_1 + q_2 x_2 - \frac{1}{2}(x_1^2 + 2\mu x_1 x_2 + x_2^2) - m_1(\cdot)x_1 - m_2(\cdot)x_2 \tag{50}$$

where $\mu \in [0, 1)$ measures the degree of substitutability between the firms' cars. The firms' marginal costs are given by

$$c(q_i) = c_a q_i^2 \text{ and } \widetilde{c}(q_i) = c_s q_i^2 \tag{51}$$

Maximizing (50) with respect to x_i $(i = 1, 2)$ and assuming interior solutions leads to

$$x_i(q_i, q_j, m_i(\cdot), m_j(\cdot)) = \frac{1}{1-\mu^2}\left[q_i - m_i(\cdot) - \mu(q_j - m_j(\cdot))\right] \tag{52}$$

To simplify the analysis further, let $\rho = 0$. Then, expected overall expenditures $m_i(\cdot)$ can be written as

$$m_i(\cdot) = p_i + 2\sigma\widetilde{p}_i x_i + (\widetilde{p}_i + \widetilde{p}_j)\sigma x_j. \tag{53}$$

Solving the system of equations implied by (52) and (53), firms' market demands with $p_i = \widetilde{p}_i$ are given by

$$X_i(\cdot) = \frac{q_i(1 + 2\sigma p_j) + (p_j - q_j)(\mu + \sigma p_j) - p_i\left[1 + \sigma(p_j + q_j)\right]}{1 - \sigma\left[\sigma(p_i - p_j)^2 - 2(p_i + p_j)\right] - \mu\left[\mu + 2\sigma(p_i + p_j)\right]} \tag{54}$$

Using (54) and focusing on symmetric equilibria, (21) and (32) together with the assumptions on the firms' costs lead to

$$p^*(q^*(0, \cdot), \cdot) = \frac{q^*(0, \cdot)(1 + q^*(0, \cdot)c_a - \mu)}{2 - \mu}, \; q^*(0, \cdot) = \frac{1}{2c_a} \text{ and} \tag{55}$$

$$\frac{\partial}{\partial\sigma}\left[\frac{\partial\Pi_i^*(\cdot)}{\partial q_i}\right]\Bigg|_{q_i = q^*(0,\cdot)} \gtreqless 0 \Leftrightarrow c_a \gtreqless \frac{8 - (5 - \mu)\mu^2}{2 + \mu - 3\mu^2 + 2\mu^3} c_s \tag{56}$$

Since $(8-(5-\mu)\mu^2)/(2+\mu-3\mu^2+2\mu^3)$ is strictly decreasing in μ, (56) indicates that the firms' incentives to increase their qualities are decreased if the probability of accidents caused raises when markets are uncovered and competition becomes less intense, i.e. when μ decreases.

Turning to the case of competitive markets for spare parts we obviously get $p^c(q^c(0, \cdot), \cdot) = p^*(q^*(0, \cdot), \cdot)$ as well as $q^c(0, \cdot) = q^*(0, \cdot)$. Additionally, simple comparative statics reveal

$$\frac{\partial}{\partial\sigma}\left[\frac{\partial\Pi_i^{c*}(\cdot)}{\partial q_i}\right]\Bigg|_{q_i = q^c(0,\cdot)} = -\frac{(6 - \mu(1 + \mu)^2)c_s}{8(2 - \mu)^3(1 + \mu)^2(2 + \mu)c_a} < 0 \tag{57}$$

Hence, with competitive markets for spare parts firms unambiguously reduce their qualities if the probability of accidents caused and thus the consumers' overall expenditures increase.

Evaluating the impact of these different comparative static results on the firms' profits and overall welfare, consider first the special case with rather low costs for spare parts, i.e.,

$$c_s := \alpha c_a \text{ with } \alpha = 0.1 \tag{58}$$

Solving for the equilibrium prices and quantities, it turns out that there exists a unique symmetric equilibrium. Figure 1 assumes $\mu = 0.2$ and shows the graphs for $q^*(\sigma, \cdot)$ and $q^c(\sigma, \cdot)$ as well as the differences between the firms' profits, $\Pi_i^*(q^*(\cdot), \sigma, \cdot) - \Pi_i^{c*}(q^c(\cdot), \sigma, \cdot)$, and between social welfare, $W^*(q^*(\cdot), \sigma, \cdot) - W^c(q^c(\cdot), \sigma, \cdot)$ ($W^*(q^*(\cdot), \sigma, \cdot)$ denotes social welfare with monopolized markets for spare parts).

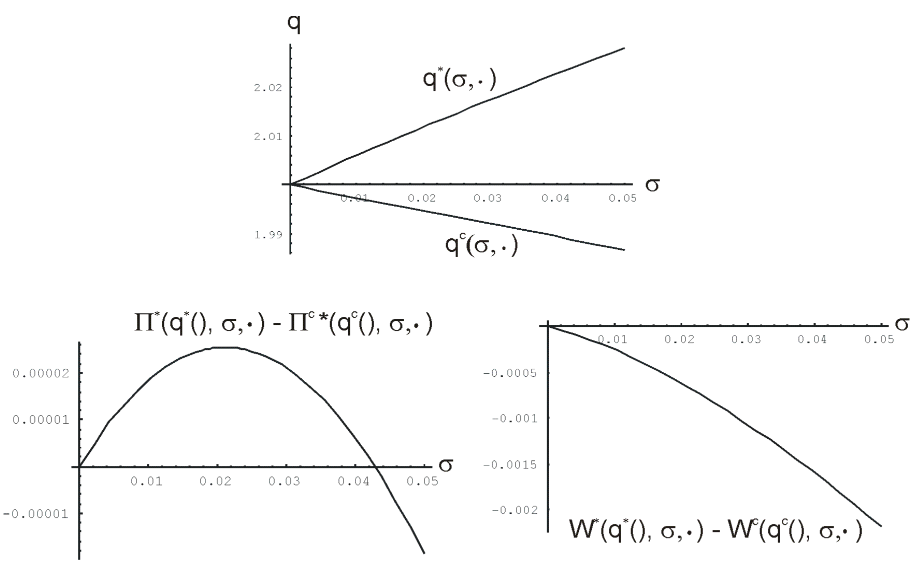

Figure 1: Qualities, profits and social welfare with $\mu = 0.2$ and $\alpha = 0.1$

Figure 1 indicates that the comparative static results derived for covered markets continue to hold in this example. Furthermore, monopolization leads to higher equilibrium profits as long as σ is not too high. Although higher qualities tend to reduce the firms' profits, the positive effect from the increase in overall consumer expenditures dominates if σ is rather low. This result is reversed when σ is high enough. Then, the firms' incentives to exploit the external effects by choosing higher qualities are such that their equilibrium profits are lower as compared to the case with competitive markets for spare parts. Finally, figure 1 also reveals that social welfare is always lower with monopolized markets for spare parts. The increase in overall expenditures under monopolization as well as the higher qualities reduce social welfare unambiguously.

The last result does not hold if the degree of substitutability between the firms' products is high. Figure 2 shows the critical values $\sigma^W(\mu, \alpha)$ and $\sigma^\pi(\mu, \alpha)$ at which social welfare and the firms' profits are the same with monopolized and competitive markets for spare parts. More precisely, with $\alpha = 0.2$ we have $W^*(q^*(\sigma, \alpha), \cdot) < W^c(q^c(\sigma, \alpha), \cdot)$ ($\Pi^*(q^*(\sigma, \alpha), \cdot) < \Pi^{c*}(q^c(\sigma, \alpha), \cdot)$) for all (μ, σ) with $\sigma > \sigma^W(\mu, \alpha)$ ($\sigma > \sigma^\pi(\sigma, \alpha)$). With $\alpha = 0.5$ we obtain $W^*(q^*(\sigma, \alpha), \cdot) < W^c(q^c(\sigma, \alpha), \cdot)$ for all $(\mu, \sigma) > 0$ and $\Pi^*(q^*(\sigma, \alpha), \cdot) > \Pi^{c*}(q^c(\sigma, \alpha), \cdot)$ for all (μ, σ) with $\sigma < \sigma^\pi(\mu, \alpha)$.

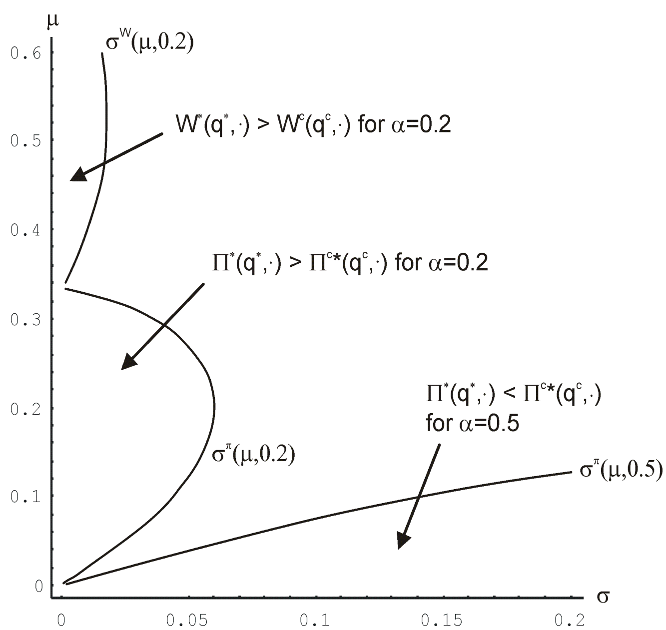

Figure 2: Comparison of profits and social welfare for low and high costs for spare parts

To give an intuitive explanation for these results, consider first the case of relatively low costs for spare parts, i.e., $\alpha = 0.2$. In this case monopolization can be beneficial for social welfare because *i*) high values of μ imply that competition between the firms is rather fierce and *ii*) consumers do not internalize the negative external effects they impose on other consumers when they decide to buy a car. Therefore, an increase in overall expenditures due to monopolized markets for spare parts can in fact lead to higher social welfare. On the other hand, with relatively high costs for spare parts, monopolization is always detrimental for social welfare because higher qualities lead to significantly higher costs and overall expenditures for consumers. Turning to the firms' profits and again starting with $\alpha = 0.2$, note first that high values of μ lead to rather strong incentives for the firms to invest in their qualities. Hence, firms' profits may be higher with competitive markets if μ is high. With relatively high costs for spare parts, i.e., $\alpha = 0.5$, monopolized markets for spare parts are beneficial for the firms as long as the relation between the degree of substitutability and the probability for accidents caused is high enough. The intuition for this finding is based on the fact that the higher the costs for spare parts the lower are the firms' incentives to increase their qualities.

7 Conclusion

The results presented in the last section clearly indicate that monopolization of markets for spare parts can be detrimental for social welfare. Positive probabilities of causing accidents together with liability obligations imply that high prices for spare parts do not only harm the firms' own consumers but also the consumers of other firms. The relation between the prices for the firms' cars and the respective spare parts is not neutral with respect to the firms' market shares. By choosing a relatively high price for spare parts but a relatively low price for cars each firm can increase its own market share without decreasing its overall revenues. Hence, the firms' incentives to choose high prices are stronger with monopolized markets for spare parts compared to the case in which these markets are competitive. Ultimately, competition is weakened and the firms' profits tend to be higher with monopolized markets for spare parts.

While endogenous quality decisions can imply that the firms' profits are higher with competitive markets for spare parts, covered markets and relatively high costs for spare parts ensure that firms are better off with monopolized markets. Considering social welfare, an increase in overall expenditures may serve as a mechanism to get socially more efficient consumption decisions. However, our examples have shown that the overall effects implied by monopolized markets for spare parts reduce social welfare for a broad range of parameter values. This is especially true if markets are covered or the costs for spare parts are relatively high.

Although these results are based on a rather simple model, the underlying reasoning should continue to hold under more general assumptions. Most obviously, considering the possibility that consumers can refrain from repairing damaged cars would alter the demand for spare parts but would not lead to other conclusions with respect to the external effects implied by accidents caused and liability obligations. While a consumer can decide not to repair his own car, he has to pay the damage caused to other consumers. Hence, the relation between the prices for cars and spare parts would not be neutral with respect to the firms' market shares and the firms would again have an incentive to increase the relative price of their spare parts. Similarly, while analyzing risk averse consumers and their demand for liability insurance would lead to a more complicated model, it would not alter the firms' pricing strategies. Since insurance rates are positively correlated with expected payments for accidents caused the basic strategic effects implied by high prices for spare parts and low prices for cars would continue to hold in a model which incorporates liability insurances.

References

[1] Blair, R.D. and Herndorn, J.B. (1996): "Restraints of Trade by Durable Goods Producers", *Review of Industrial Organization,* 11, 339-353

[2] Borenstein, S, Mackie-Mason, J.K. and Netz, J.S. (1995): "Antitrust Policy in Aftermarkets", Antitrust Law Journal, 63, 455-482

[3] Bork, R.H. (1978): *The Antitrust Paradox,* New York: Free Press

[4] Carlton, D.W. and Waldman, M. (2006): "Competition, Monopoly, and Aftermarkets", Johnson School Research Paper Series No. 10-06

[5] Chen, Z., Ross, T.W. and Stanbury, W.T. (1993): "Refusal to Deal, Price Discrimination, and Independent Service Organizations", *Journal of Economics and Management Strategy,* 2, 593-614

[6] European Commission: "Proposal for a Directive of the European Parliament and of the Council amending Directive 68/71/EC on the Legal Protection of Design", *Commission Staff Working Paper, COM (2004) 582 final*

[7] European Commission: "Directive 98/71/EC of the European Parliament and of the Council of 13 October 1998 on the legal protection of designs", *Directive 98/71/EC*

[8] Emch, E. (2003): "Price Discrimination via Proprietary Aftermarkets", *Contributions to Economic Analysis & Policy,* 2 (1), Article 4, 1-32

[9] Posner, R. (1976): *Antitrust Law: An Economic Perspective*, University of Chicago Press

[10] Shapiro, C. (1995): "Aftermarkets and Consumer Welfare: Making Sense of *Kodak*", *Antitrust Law Journal*, 63, 483-611

[11] Schwartz, M. and Werden, G. (1996): "A Quality-Signalling Rationale for Aftermarket Tying", *Antitrust Law Journal*, 64, 387-404