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Reference Pricing Systems on the Pharmaceutical Market

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Constantly rising expenditures for pharmaceuticals require government intervention in firms' pricing decisions. To this end, reference pricing systems are a frequently employed regulatory mechanism. This paper considers a duopoly market with vertically differentiated firms under different competition types. Starting from the existing literature it can be confirmed that the introduction of a reference price leads to lower equilibrium prices and induces fiercer competition between firms. Further, it can be shown that reference pricing promotes generic usage and leads to an increased market coverage. Hence, an improved provision of medical supply is achieved due to the lower prices and the stimulated demand for drugs. The paper demonstrates that even under the increased demand consumer and insurance expenditures are reduced. The model isolates the mechanisms of reference pricing and shows the effects on the consumer decisions. Lastly, consumer surplus increases when implementing the regulation.

Keywords: reference pricing · pharmaceutical market · copayment · price cap · price competition · expenditures · consumer surplus

JEL Classification: I11, I18, L51

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1 Introduction and Literature Review

Worldwide, the market for pharmaceuticals is subject to various regulations. Rising expenditures of statutory health insurances and increasing fees for patients due to high drug prices have led to a multitude of regulatory instruments. The pharmaceutical market is highly innovative and always subject to change: a variety of new drugs is introduced continually to the market, bringing therapeutic advantages for the patients. Besides the original drugs there exist cheaper alternatives as generics or branded copies. The former can enter the market after patent expiry only, while the latter via "inventing" around can directly enter. Generics as well as branded copies treat the same diseases as the associated original drug. Generics are (more or less exact) copies of the original brand-name drug - containing the same active substance with varying additive components (therapeutic and chemical equivalence) - while branded copies consist of different active substances (only therapeutic equivalence). Consequently, they are not violating the patent protection ("inventing" around) and can enter the market at the same time (simultaneous price competition). Generic versions due to their chemical equivalence have to wait for the patent expiry for market entry (sequential price competition). Patients often do not know about these cheaper alternatives or believe that they are of inferior quality. Therefore, patients tend to purchase high-priced brand-name drugs instead of their alternatives.
In order to handle the increase in expenditures and to overcome the high price difference between these drug types, reference pricing systems are implemented in several countries (i.a., Germany, France, Spain). Patients insured via a statutory health insurance only have to bear a (percentage) part of the drug price ("copayment") in addition to their (fixed) insurance premium while the remaining amount is funded by their insurance. Consequently, patients do not fully consider the high price difference between the brand-name drug and its therapeutic alternatives. Here intervenes the reference price by imposing a further payment for the consumers when purchasing the brand-name drug. Additionally to their copayment they have to pay the amount by which the brand-name's price is higher than the respective reference price.
This type of regulation has been analyzed in theoretical and empirical work. The first relevant contribution concerning the competition between brand-name drugs and generic versions was contributed by Grabowski and Vernon (1992). They derived that while brand-name prices steadily increase, the prices of generic versions will remain low due to the competition among them. Scherer (1993) found that after generic entry when the original product's patent expired the brand-name producers maintained their high-price-strategy ("generic competition paradox"). This finding was confirmed by Frank and Salkever (1997). These results reveal the need for regulation. More recently Pavcnik (2002) found in an empirical study that reference pricing leads to lower prices for both firms, while the decrease was even stronger for the brand-name firm. Various academic works found that besides of decreasing prices, reference pricing intensifies competition (Brekke et al. 2007, 2009, 2011, 2016, Pavcnik 2002). Recently, Antoñanzas et al. (2017) analyzed the effect of reference pricing under exogenous and endogenous reference pricing systems on the price setting.
Building on the existing literature, this paper identifies the mechanisms of reference pricing in stimulating generic market shares and reducing consumer and insurance expenditures. Further, reference pricing increases market coverage while simultaneously reducing expenditures: the increase in demand is compensated by a sufficiently large decrease in prices. The improved medical supply in combination with lower prices lead to an increase in con-

sumer surplus. Furthermore, the paper points out the shortcomings of reference pricing and depicts where the regulation fails to accomplish its objectives.
Adopting a similar market set-up as Merino-Castelló (2003), this paper differs from the consisting literature in several ways. Simultaneous and sequential price competition will be analyzed alongside, emphasizing the differences and clarify the economic relevance of both competition types. The effects of the copayment rate and especially of the mechanism of the reference price on the market outcomes will be assessed. Also the effect on the market coverage and consumers' and insurance expenditures will be analyzed and the results for consumer and producer surplus are derived. Besides, by means of an exogenously given price cap (i.a. Brekke et al. (2011)) the superiority of reference pricing is proven. Hereafter, the paper is organized as follows: the second part deals with the model set-up and then introduces the reference price under sequential and simultaneous competition. The third part shortly considers a price cap to show that exogenous regulation cannot achieve a satisfactory solution. The last part concludes.

2 Reference Pricing

2.1 Set-up

The paper examines a duopolistic market with a brand-name firm ($i = 1$) producing an original drug and a firm ($i = 2$) producing either a generic version or a branded copy depending on the considered competition type.[1] A constant copayment rate, $k \in [0, 1]$, which the consumers face when purchasing a drug is assumed. Thus, the patients bear a proportional part of the drug costs while the remaining amount is covered by the statutory health insurance. The brand-name drug 1 and the drug of firm 2 differ in their perceived[2] quality θ_i, with $i = 1, 2$ and $0 < \theta_2 < \theta_1 \leq 1$. To enter the market the drugs are required to provide a minimum quality level, i.e. some bioequivalence criteria. The upper quality bound can be interpreted as the current research status ("state-of-the-art").
The consumers are uniformly distributed according to their drug valuation $\tau \in [0, 1]$. Consumers with a relatively high valuation prefer the brand-name drug, those are willing to pay a higher price for the high (perceived) quality. Consumers with a lower drug valuation are not committed to purchasing a specific drug and, therefore, will decide to purchase the alternative drug due to its lower price.
The utility from buying one unit of the drug is given by the direct utility from drug consumption (as the product of the consumers' valuation and the quality) minus the consumer's copayment, i.e. c_i. The consumers' utility is defined as

$$U(\tau, \theta_i) = \begin{cases} \tau\theta_i - c_i & \text{if consumer buys one unit} \\ 0 & \text{otherwise.} \end{cases}$$

With the copayment

$$\mathrm{c}_i = \begin{cases} kp_1 + (p_1 - p_R) & \text{for } i = 1 \\ kp_2 & \text{for } i = 2. \end{cases}$$

[1] The analysis applies only to drugs which are available on prescription and therefore covered by the statutory health insurance. Over-the-counter products are not included.
[2] Uninformed consumers might perceive the alternative drug as being of inferior quality.

With both firms charging positive prices p_i, $i = 1, 2$. The endogenous reference price is defined as a linear combination of the two drug prices

$$p_R = \alpha p_2 + (1 - \alpha) p_1$$

where $\alpha \, \epsilon \, [0, 1]$. The limit case of $\alpha = 0$ in the subsequent results describes the unregulated situation. The higher the weight the more restrictive the regulation and, hence, the lower the implemented reference price. It has to hold for each consumer that the utility from purchasing drug i has to be higher than the utility from purchasing drug j, i.e. $U(\tau, \theta_i) \geq U(\tau, \theta_j)$, with $i, j = 1, 2$, $i \neq j$. Consumers only buy a drug if their utility is non-negative. When a consumer decides to buy the brand-name drug, he is additionally charged the difference between the brand-name drug's price and the reference price. The consumer indifferent between the brand-name drug and its alternative is located at $\tau_1 \geq \frac{(k+\alpha)(p_1 - p_2)}{\theta_1 - \theta_2}$ and the consumer indifferent between the alternative drug and no purchase is located at $\tau_2 \geq \frac{k p_2}{\theta_2}$[3]. The demand system follows as depicted in Figure 1.

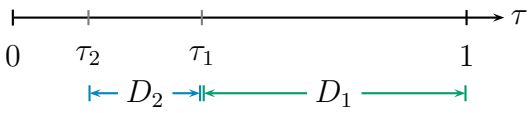

Figure 1: Demand System

Hence, the demand functions read $D_1 = 1 - \tau_1$ and $D_2 = \tau_1 - \tau_2$. The demand for drug 2 reacts more sensitive to price changes than the demand for the brand-name drug, i.e. $\frac{\partial D_2}{\partial p_2} < \frac{\partial D_1}{\partial p_1}$. The firms' profits are given by the sum of the direct revenues obtained from the consumers and the revenues obtained from the statutory health insurance. Production costs are assumed to be zero.[4] Then the firm profit is

$$\max_{p_i} \pi_i \; = \; \underbrace{k p_i D_i}_{\text{consumers}} \; + \underbrace{(1 - k) p_i D_i}_{\text{insurance}} \; = \; p_i D_i \, , \qquad i = 1, 2. \tag{1}$$

2.2 Sequential Price Competition

Sequential price competition depicts the competition between a brand-name drug and its generic version, which can enter the market with a time delay after patent expiry only. Firm 1 (brand-name firm as market leader) anticipates the reaction of the follower given by the reaction function of firm 2

$$R_2^S(p_1) \equiv p_2^S = \frac{(k + \alpha)\theta_2}{2(k\theta_1 + \alpha\theta_2)} p_1^S. \tag{2}$$

Resulting in the reduced-form optimization problem for firm 1:

$$\max_{p_1^S} \pi_1^S = p_1^S \left[1 - \frac{(k + \alpha)(2k\theta_1 + (\alpha - k)\theta_2)}{2(\theta_1 - \theta_2)(k\theta_1 + \alpha\theta_2)} p_1^S \right]$$

[3] It is assumed that $\tau_1 > \tau_2$, the proof can be given by substituting the prices calculated in the following and is robust for each competition type.

[4] Further, the costs for the quality development and R& D expenditures are assumed to be sunk and are neglected here.

The resulting equilibrium prices are

$$p_1^S = \frac{(\theta_1 - \theta_2)(k\theta_1 + \alpha\theta_2)}{(k+\alpha)(2k\theta_1 + (\alpha - k)\theta_2)} \qquad \text{and} \qquad p_2^S = \frac{\theta_2(\theta_1 - \theta_2)}{2(2k\theta_1 + (\alpha - k)\theta_2)}.$$

The lower the reference price, the more the firms will decrease their prices, i.e. $\frac{\partial p_i^S}{\partial \alpha} < 0$. The brand-name firm is directly affected via the additional copayment. Firm 2 realizes an indirect effect. Since prices are strategic complements, firm 2's price decreases under a more restrictive reference price, too. Nevertheless, the decrease in the price of firm 2 is comparably small, i.e. $\frac{\partial p_1^S}{\partial \alpha} < \frac{\partial p_2^S}{\partial \alpha}$. Figure (5) in the appendix reveals that firm 1 reacts stronger to the implementation of the reference price. The copayment rate negatively affects the pricing decision of both firms, i.e. $\frac{\partial p_i^S}{\partial k} < 0$. The relative price ratio decreases in the weight of the reference price, hence, fiercer price competition can be induced by the regulation:

$$\frac{\partial(p_1^S/p_2^S)}{\partial \alpha} = \frac{2k\theta_2^2 - 2k\theta_1\theta_2}{(k+\alpha)^2\theta_2^2} < 0$$

In contrast the influence of the copayment rate on the relative price ratio is positive - a higher copayment decreases the competition intensity between the two firms:

$$\frac{\partial(p_1^S/p_2^S)}{\partial k} = \frac{2\alpha\theta_1\theta_2 - 2\alpha\theta_2^2}{(k+\alpha)^2\theta_2^2} > 0$$

The generic market share under sequential competition results in equilibrium as

$$\gamma^S = \frac{\sum_{i=1}^{2} D_i}{D_2} = \frac{k\theta_1 + \alpha\theta_2}{3k\theta_1 + 2\alpha\theta_2 - k\theta_2}$$

with $i = 1, 2$. The more restrictive the reference price is, the higher the generic market share will be:

$$\frac{\partial \gamma^S}{\partial \alpha} = \frac{k\theta_1\theta_2 - k\theta_2^2}{(3k\theta_1 + 2\alpha\theta_2 - k\theta_2)^2} > 0$$

Consumers tend to purchase more of the generic drug when a low reference price is implemented. However, the higher demand for generic drugs is not due to a switch of the consumers from the brand-name drug to the generic version. The consumption decision can be analyzed when examining the location of the respective indifferent consumer. When substituting for the equilibrium prices, the consumer who is indifferent between the two drug types is not affected by the reference price, i.e. $\tau_1^S = 1/2$. The higher generic usage results from a movement of the location of the second indifferent consumer to the left, i.e. $\frac{\partial \tau_2^S}{\partial \alpha} < 0$. The fraction of consumers who do not purchase decreases. So while consumers cannot be incentivized to switch from the brand-name drug to its generic version, nevertheless, a higher market coverage is induced by the reference price

$$Q^S = \sum_{i=1}^{2} q_i = \frac{3k\theta 1 + 2\alpha\theta_2 - k\theta_2}{2(2k\theta_1 + (\alpha - k)\theta_2)}$$

with $i = 1, 2$ and $\frac{\partial Q^S}{\partial \alpha} > 0$, $\frac{\partial Q^S}{\partial k} < 0$. So while prices are lower when firms are regulated, the demand for drugs increases since consumers have to pay less for their drugs. Hence, it

is possible to identify two contrary effects on consumer expenditures: lower prices decrease expenditures, while higher demanded quantities increase those. Consumer expenditures are defined as

$$CE = \sum_{i=1}^{2} kp_i q_i \tag{3}$$

with $i = 1, 2$. The effect of the price decrease dominates the higher demand, therefore, consumer expenditures unambiguously decrease under reference pricing. The same holds true for insurance expenditures

$$IE = \sum_{i=1}^{2} (1-k)p_i q_i. \tag{4}$$

with $i = 1, 2$. Hence, overall expenditures incurred by consumers and insurance decrease under regulation. Figure (2) depicts the expenditures, i.e. $E^S = CE + IE$. Assuming that the brand-name drug's quality is state-of-the-art, i.e. $\theta_1 = 1$, and the copayment rate is $k = 0.1$, which resembles the German copayment rate, the development of the expenditures in dependence of the reference price and the difference in perceived quality can be shown. Expenditures are the highest when no regulation is applied ($\alpha = 0$) and when consumers perceive a high qualitative difference between the drugs ($\theta_2 = 0$). When implementing the reference price a huge decrease in expenditures appears, visible in the kink at $\alpha = 0.2$. So even a relatively high reference price leads to a sharp cut in expenditures.

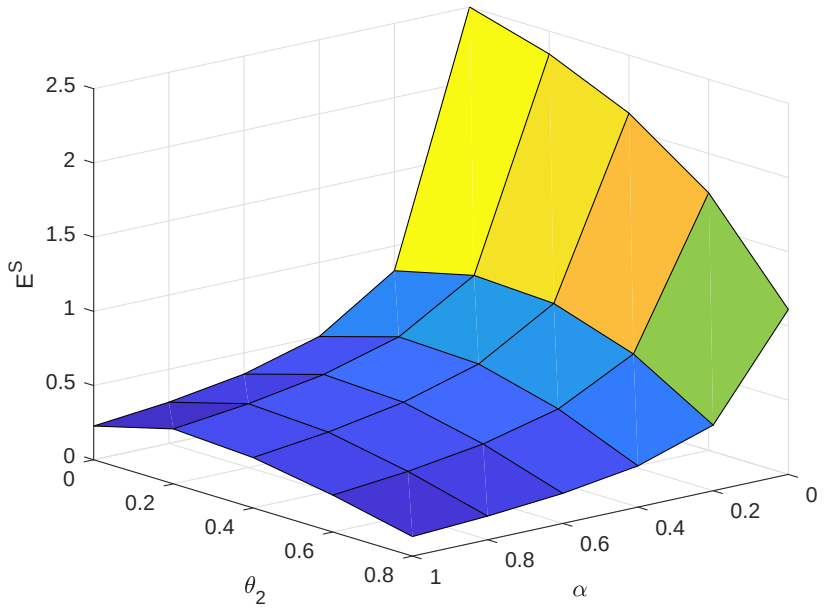

Figure 2: Expenditures, sequential competition, $\theta_1 = 1$, $k = 0.1$

Resulting from the decrease in consumer expenditures consumer surplus increases:

$$CS = \int_{\tau_1}^{1} (\tau\theta_1 - kp_1)\mathrm{d}\tau + \int_{\tau_2}^{\tau_1} (\tau\theta_2 - kp_2)\mathrm{d}\tau \tag{5}$$

The more restrictive the regulation the better the situation for consumers. Figure (3) depicts the development in consumer surplus for varying reference pricing and perceived quality difference. As expected consumer surplus increases as the regulation becomes stricter and the perceived quality difference decreases. Hence, to obtain a higher consumer surplus regulators should inform the patients about the non-existence of a quality difference. If consumers perceive the generics as being of high quality the consumer surplus could be increased. As in the case of expenditures the introduction of a reference price (moving from $\alpha = 0$ to $\alpha = 0.2$) leads to a strong increase in consumer surplus.

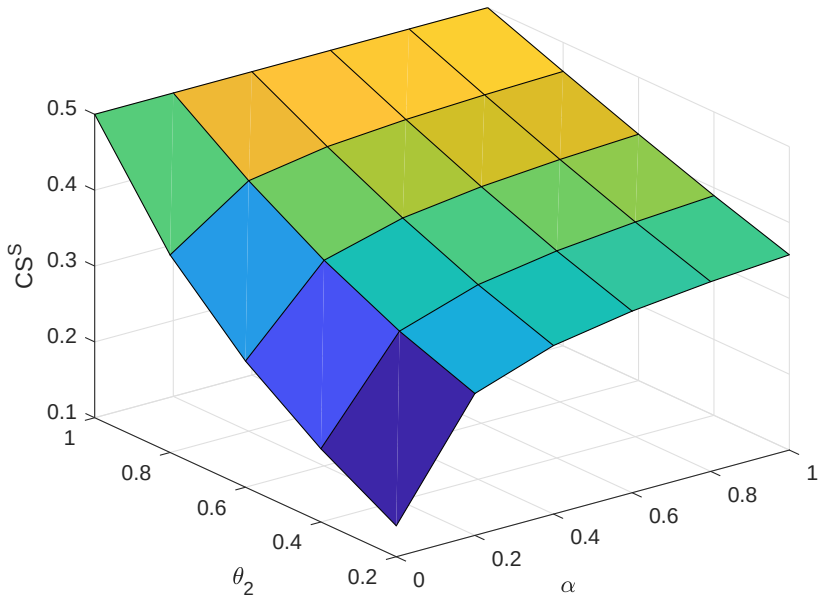

Figure 3: Consumer Surplus, sequential competition, $\theta_1 = 1$, $k = 0.1$

Finally, it remains to calculate the profits of the two firms as their producer surplus:

$$\pi_1^S = \frac{(\theta_1 - \theta_2)(k\theta_1 + \alpha\theta_2)}{2(\alpha + k)(2k\theta_1 + (\alpha - k)\theta_2)}$$
$$\pi_2^S = \frac{\theta_2(\theta_1 - \theta_2)(k\theta_1 + \alpha\theta_2)}{4(2k\theta_1 + (\alpha - k)\theta_2)^2}$$

In contrast to the consumer surplus, the producer surplus, $\Pi^S = \pi_1^S + \pi_2^S$, decreases if a more restrictive reference price is implemented. The increase demand cannot compensate for the loss due to the lower prices, the profits of both firms decrease. Figure (4) provides the development of producer surplus. Producers undergo a huge loss in surplus when reference pricing is introduced. On behalf of the brand-name firm it is preferable that the original drug is perceived as being of high-quality in comparison to the generic version. The high level of differentiation would facilitate the high-price-strategy of firm 1. The

larger share of the loss in producer surplus originates from firm 1, see figure (6) in the appendix. The brand-name producer's profits undergo a larger loss due to the stronger decrease in the price of the original drug.

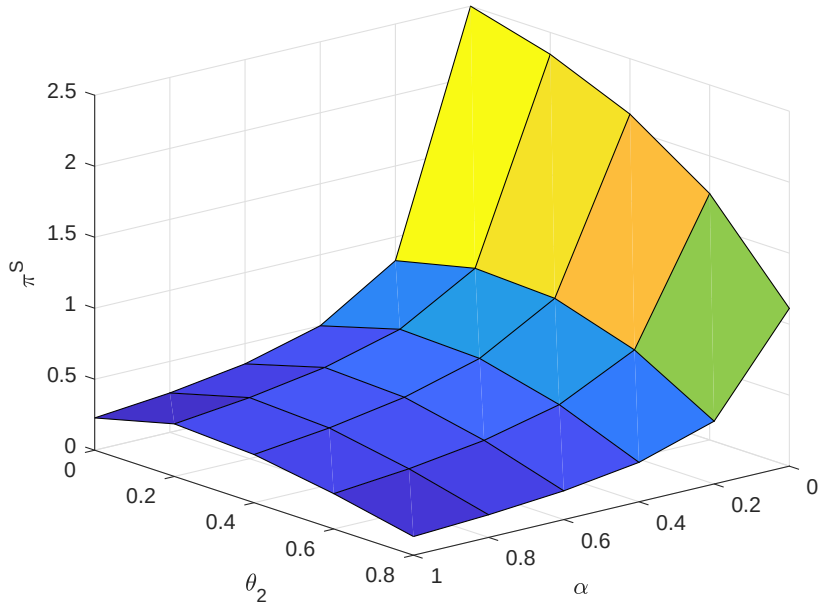

Figure 4: Producer Surplus, sequential competition, $\theta_1 = 1$, $k = 0.1$

2.3 Simultaneous Price Competition

Due to the minor economic relevance the findings from simultaneous price competition will only be shortly summarized. The situation of competition between brand-names and branded copies is less common. Only a comparably small share of drugs is categorized as branded copies. From the optimization problem (1) result the equilibrium prices of the two firms:

$$p_1^B = \frac{2(\theta_1 - \theta_2)(k\theta_1 + \alpha\theta_2)}{(k+\alpha)(4(k\theta_1 + \alpha\theta_2) - (k+\alpha)\theta_2)}$$
$$p_2^B = \frac{\theta_2(\theta_1 - \theta_2)}{4(k\theta_1 + \alpha\theta_2) - (k+\alpha)\theta_2},$$

A more restrictive reference price leads to lower prices of both firms, i.e. $\frac{\partial p_i^{RB}}{\partial \alpha} < 0$, $i = 1, 2$. The direction of the effect of the copayment on the prices under reference pricing is unchanged, i.e. $\frac{\partial p_i^B}{\partial k} < 0$, $i = 1, 2$.
A lower reference price induces fiercer price competition by reducing the relative price ratio:

$$\frac{\partial (p_1^B / p_2^B)}{\partial \alpha} = \frac{2k\theta_2^2 - 2k\theta_1\theta_2}{(\alpha + k)^2\theta_2^2} < 0$$

A higher copayment for the patients leads to weaker price competition between the two firms, i.e. $\frac{\partial (p_1^B / p_2^B)}{\partial k} > 0$. The crucial difference to sequential competition is that the market

share of the branded copy is constant under simultaneous price competition, i.e. $\gamma_R^B = \frac{1}{3}$. The reference price cannot induce a higher usage of the alternative to the brand-name drug. The constant share of the branded copy is due to a parallel movement to the left of both indifferent consumers, which is reflected in $\frac{\partial \tau_i^B}{\partial \alpha} < 0$, $i = 1, 2$. Nevertheless, this leftward shift of both locations of indifferent consumers results in an increased market coverage

$$Q^B = \frac{3(k\theta_1 + \alpha\theta_2)}{4(k\theta_1 + \alpha\theta_2) - (k + \alpha)\theta_2}$$

with $\frac{\partial Q^B}{\partial \alpha} > 0$ and $\frac{\partial Q^B}{\partial k} < 0$. Both drug types face an increased demand, due to the lower prices more consumers decide to purchase. Still, the decrease in prices is high enough to compensate for the higher demand and leads to a decrease in consumer (3) and insurance expenditures (4) respectively. Consequently, consumer surplus, as given by equation (5), increases due to their lower expenditures for the drugs. On the contrary producer surplus, Π^B, of both firms decrease under more restrictive reference pricing:

$$\pi_1^B = \frac{4(\theta_1 - \theta_2)(k\theta_1 + \alpha\theta_2)^2}{(k + \alpha)(4(k\theta_1 + \alpha\theta_2) - (k + \alpha)\theta_2)^2}$$
$$\pi_2^B = \frac{\theta_2(\theta_1 - \theta_2)(k\theta_1 + \alpha\theta_2)}{(4(k\theta_1 + \alpha\theta_2) - (k + \alpha)\theta_2)^2}$$

The effects of the interaction between the intensity of regulation and the perceived quality difference are qualitatively comparable to those under sequential price competition. The key difference between the two competition types is the independence of the branded-copy's market share of the reference price.

3 Price Cap

Reference pricing might not achieve all desired regulative outcomes, but to show that an exogenous regulation of prices performs even poorer, an exogenously given and binding price cap for the brand-name drug 1, $p_1 = \bar{p}_1$ is assumed. Substituting this price cap $\bar{p}_1$ into the price reaction function of firm 2 yields the generic price $p_2^{PC} = \frac{\theta_2}{2\theta_1}\bar{p}_1$.
A first shortcoming of this kind of regulation becomes visible in the price ratio which does not change in comparison to the benchmark case ($\alpha = 0$), i.e. $\frac{\bar{p}_1}{p_2^{PC}} = \frac{2\theta_1}{\theta_2}$. Hence, the price cap cannot induce fiercer competition. Further, it is sufficient to solve for the generic market share

$$\gamma_{PC} = \frac{k\theta_1\bar{p}_1}{(\theta_1 - \theta_2)(2\theta_1 - k\bar{p}_1)}.$$

The generic market share is increasing in the price cap, i.e. $\frac{\partial \gamma_{PC}}{\partial \bar{p}_1} > 0$. Consequently, decreasing the price cap leads to a lower generic market share, which constitutes a second shortcoming. A regulator would implement the lowest possible price cap to induce low prices, but this does not stimulate generic usage. A change in the price cap of a regulated product leads to a change in the same direction for the non-regulated product since prices are strategic complements. The price cap directly reduces prices but cannot overcome the price difference between the two drugs.

4 Conclusion

By shortly considering a price cap regulation it could be shown that it leads to lower prices, but it is neither capable of introducing fiercer price competition, nor promoting generic usage. Hence, applying a price cap will not lead to the intended results of the market regulation.
Applying reference pricing proves more useful in achieving the intentions of the regulation. While the brand-name drug's quantity stays constant under reference pricing (sequential price competition), the quantity of the generic drug increases. Consequently, this leads to a higher generic market share and an increased market coverage. This is due to the effect of the reference pricing on the location of the consumer indifferent between purchasing the generic drug and no purchase at all. The lower prices shift the location of the indifferent consumer to the left: the higher the weight of the reference price the more the location shifts to the left. Turning to the expenditures it could be shown that the consumer expenditures as well as the insurance expenditures can be reduced when implementing a reference pricing system. Thus, the price decrease is sufficiently large to offset the effect of the increased demand on expenditures.
When introducing the regulation (from $\alpha = 0$ to $\alpha = 0.2$) especially the brand-name's price drops crucially, whereas a further tightening of the regulation only leads to moderate decreases. This drop in prices drastically reduces expenditures and leads to an increase in consumer surplus. Clearly firms suffer under the regulation, whereby the reduction in producer surplus mainly originates from the loss in profits of the brand-name firm.
The decrease in prices and the intensified price competition are also visible under simultaneous price competition. The equilibrium quantities increase, since more consumers decide to buy a drug due to lower prices. Nevertheless, the reference price is not able to induce a higher market share of firm 2. The usage of the branded-copy cannot be stimulated. The reference price influences the locations of both indifferent consumers (via α). Both locations shift to the left, hence, increasing market coverage. But since this shift is parallel, the market share of firm 2 stays constant. The effects on expenditures and surpluses are similar to those under sequential price competition.
This paper confirmed the advantage of a reference pricing system in introducing fiercer price competition. Additionally, it demonstrated that under sequential price competition the generic market share increased as a consequence of the reference price. Sequential price competition is the more common type of competition on the pharmaceutical market. After patent expiry brand-name drugs are more often followed by generic versions instead of being threatened by firms inventing around the patent and coming up with branded copies. Furthermore, the improved market coverage shows that a reference price ensures that more consumers have access to medical treatment. Additionally, it could be shown that consumer and insurance expenditures decrease crucially under regulation - even when considering the increase in demand. Consequently, this leads to increased consumer surplus.
Of course introducing reference prices might lead to further changes in the insurance system, like an adjustment of the fixed health care contributions, as well as to effects on the firms' R& D investment decisions. However, these issues are beyond the scope of this paper.

Appendix

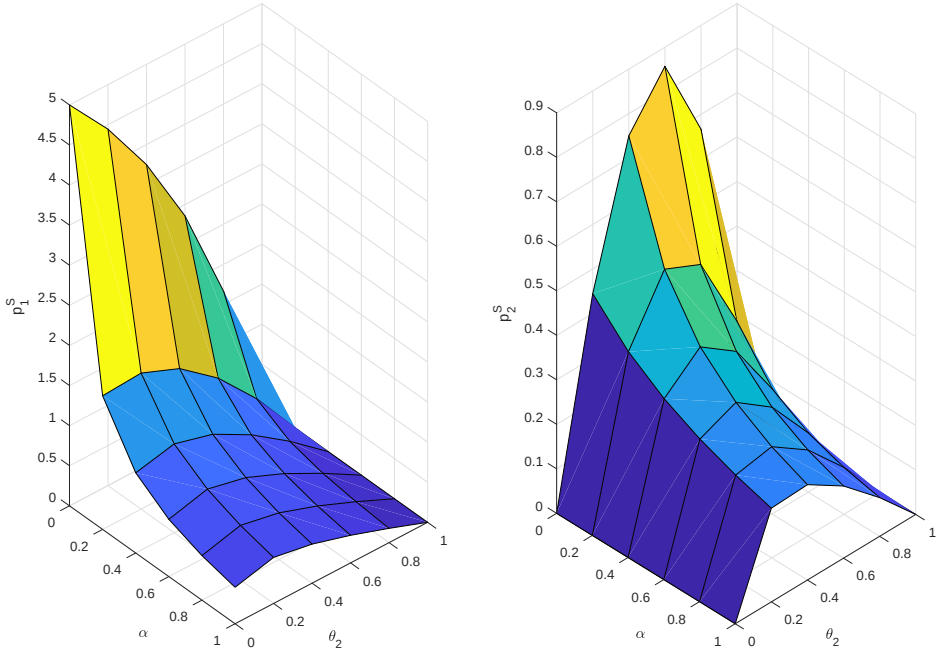

Figure 5: Prices, sequential competition, $\theta_1 = 1$, $k = 0.1$

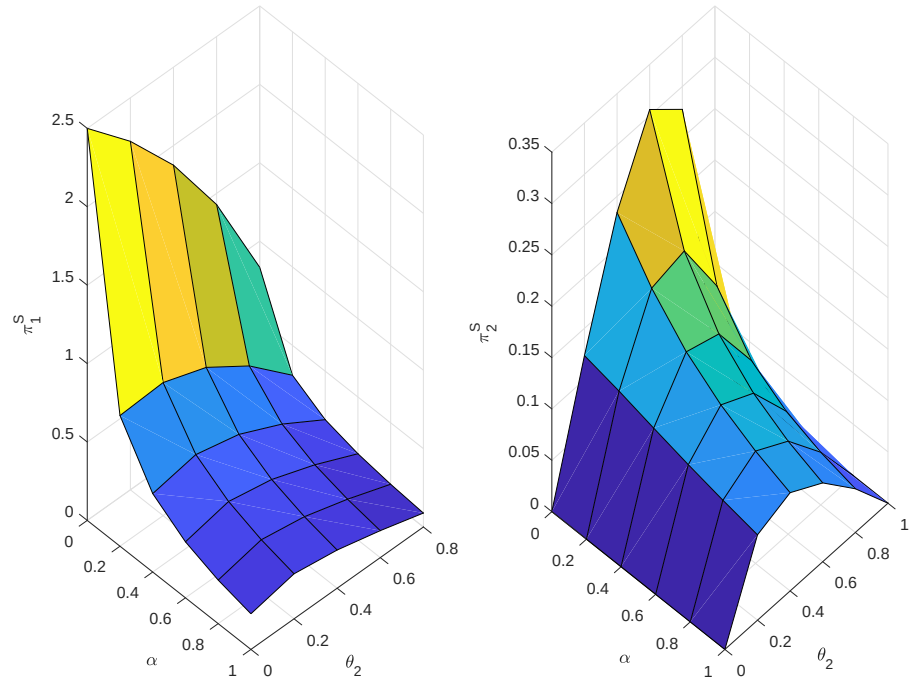

Figure 6: Profits, sequential competition, $\theta_1 = 1$, $k = 0.1$

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