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REFERENCE PRICES: THE SPANISH WAY

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The aim of this paper is to analyse the effects of recent regulatory reforms implemented in the Spanish pharmaceutical market: the promotion of generic drugs and the implementation of reference prices. The objectives of such reforms are twofold: firstly, to increase price competition and secondly, to reduce public pharmaceutical costs. This paper shows that for the Spanish method of implementing reference prices to achieve these objectives, compared to a situation with copayments, requires the reference price to be set in a certain interval. In addition, the Spanish system may result in profits for the branded and generic producers being reduced.

Keywords: Reference prices, copayments, generics, pharmaceutical industry.

(*JEL* I18, L00, L50, L65)

1. Introduction

The aim of this work is to give some insights into the possible effects that recent regulatory reforms introduced by the Spanish Health Authorities might have on the pharmaceutical market. These reforms are the introduction and promotion of generic drugs coupled with the introduction of a reference price system. A generic drug is sold under generic denomination, once the patent of the branded (pioneer) good for the active ingredient expires. A reference price system is a reimbursement system that categorises drugs into groups with similar active

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ingredient(s). The health authorities set a maximum reimbursement (reference) price for each group. Firms are free to set their price. If the price they set is higher than this reference price, the consumer pays the difference. The interested reader can find a more detailed explanation of these reforms, and their relationship in Mestre-Ferrándiz (1999a).

Reference price systems are in place in various developed countries, such as Germany, Sweden, Denmark and Holland. Furthermore, in each country, this system is implemented in different ways. For example, in Germany, if the price set by pharmaceutical firms exceeds the reference price, the consumer pays the difference, but otherwise the patient does not need to copay (Pavcnik, 2000). In Spain, the reimbursement system most widely used is the copayment system, whereby the patient pays a proportion of the price, irrespective of the drug purchased (branded or generic). However, reference prices have been implemented for some medicines. The following mechanism has been enforced: if the physician prescribes a drug with a price higher than the reference price, then the consumer has two options: either(s)he buys the branded good, or a cheaper generic version. In the former case, the total payment results from the sum of the difference in price between the branded good and the reference price and the copayment associated with the *reference price* (El País, 21 July 2000). In the latter case, the copayment the consumer has to pay is unaffected by the introduction of reference pricing. Before this new system was introduced, patients only paid a copayment of the price. Now, the consumer has to pay the copayment plus an additional cost should he/she buy the branded version. Hence, to examine the impact of introducing reference pricing, the situation with copayments only will be compared with the combined copayments and reference prices system.

In Spain, the copayment system is universal, and on average, is 40 % of the price of the drug prescribed. Nevertheless some exemptions exist. For the treatment of chronic or acute diseases, patients contribute 10 % of the retail price, up to a maximum of 2.60 euros. Pensioners, disabled, and patients requiring treatment following a work-place accident or occupational disease are exempt from payment. The reference price system was set by Health Authorities and implemented in December 2000. As mentioned before, the aim is to define homogenous groups of drugs based on bio equivalence ratings of the active ingredients and each group must contain at least one generic drug. This currently applies to 74 active ingredients. The reference price is usually set in the range of 10-50 % below the most expensive drugs in each group, with the restriction that it cannot be set lower that the lowest-priced generic. In early 2002, new negotiation rounds between Farmaindustria (the association of the Spanish pharmaceutical industry) and Health Authorities agreed to impose more reference prices and identify other groups.

The main objectives of a reference price system are to increase price competition and ultimately, reduce public expenditure on pharmaceuticals. The first objective can in principle be achieved by giving some economic incentives to patients, who can then influence the prescriber in his/her therapeutic decision, and so achieve an efficient outcome. This could lead producers to reduce prices towards the reference price to maintain their market share. Consequently controlling public expenditure could be achieved by having lower unitary costs.

This paper analyses how firms respond to a change from a copayment system to a reference price system. The results show that implementing a reference price system can achieve lower supplier's prices and lower public pharmaceutical spending compared to a copayment regime, but only if the reference price is set in a certain interval. This is because implementing reference prices affects each producer differently. For the branded good producer the relationship between the reference price and the price set by this firm is positive while this relationship is negative for the generic producer. Under copayments, however, the relationship between the prices set for both products and the level of copayment is negative under certain conditions. However, in this interval, profits for both firms might be reduced.

The advantage of using the reference price system described here is that it can be easily generalised to take into account other methods used to define the net price paid by the consumer. For example, if the copayment is set to zero, it becomes equivalent to the German reference price system, where patients do not pay anything if the cheaper alternative is bought, or pay the difference between the price of the branded good and the reference price if the branded drug is purchased.

Few papers have tried to model theoretically the effects of introducing a reference price system, and most literature is mainly descriptive (López-Casanovas and Puig-Junoy, 1999). Zweifel and Crivelli (1997) use a duopoly model to analyse market reactions of pharmaceutical firms, by having a probability of such a system being implemented.

Woodfield *et al.* (1997) adapt a simple model of an oligopolistic pharmaceutical market, originally developed by Johnston and Zeckhauser (1991), where firms compete à la Bertrand. A recent paper by Pavcnik (2000) is a very interesting empirical analysis of Germany, comparing the situation before and after the implementation of the reference price system. Her results show producers responded by reducing prices after the introduction of such system, and that the existence of generic competition was a very important factor. When the competition faced by branded good producers is tougher, the reduction in price is higher.

Danzon and Liu (1997) use a kinked demand model in order to predict price responses to a reference price system. They do this based in the context of a model of physician decision making, using the assumption of imperfect agency between physician and patient. They find that under a kinked-demand curve model, prices will tend to converge to the reference price. Furthermore, they argue that it would never be optimal to set a price below the reference price. However, this result is driven by the fact that the copayment associated with the buying of the generic drug (with price below the reference price) is zero. The first difference of this paper with the Danzon and Liu's (1997) is the assumption of a perfect agency relationship between physician and the patient. Secondly, this paper also generalises the payment made by the consumer, should he/she purchase a generic or branded drug under reference prices. In the Danzon and Liu paper (1997), the consumer's copayment is zero if he/she decides to buy the generic drug. In this paper, as explained in the next section, this is not necessarily true, as under both the reference pricing and copayments systems, generic products have the same copayment element in its price (and is non-zero). Under this more general setting, it is not trivial that the price of the generic drugs tend to converge to the reference price.

The methodology of this paper is somewhat different from those mentioned above. Here it is assumed the market is a duopoly, each firm producing one good respectively, a branded medicine and its generic alternative. and firms know with a probability of one, which system is enforced. The objective is to compare the outcome under a copayment system with the outcome obtained with a reference price regime.

The structure of this paper is as follows. Section 2 presents the model before and after the introduction of a reference price system. Section 3 presents the equilibrium of the game for both cases when firms move simultaneously. Section 4 compares scenarios. Finally, Section 5 presents the conclusions and possible areas for future research.

2. The model

The market is composed of two differentiated duopolists, where the patent of the active ingredient for the branded good has expired, so that a generic alternative exists in the market. There is going to be a degree of (horizontal) differentiation between both goods, denoted as $\theta \in (0,1)$. This is because a generic product may not be a perfect substitute for the original brand due to both subjective and objective factors, which maintain sales of the original brand, despite the presence of low-price generic competition (Hudson, 2000). One of the reasons to choose this framework is because in some countries, generic drugs have entered the market with a price similar or higher than the original brand, and still gained a relatively high market share. This result can be achieved with a model of horizontal differentiation. Assumptions on underlying preferences are assumed such that partial equilibrium analysis can be undertaken.

The demand side is a simplified version of Singh and Vives (1984), but taking into account that under copayments and reference prices, the consumer does not pay the whole price. There is a continuum of consumers of the same type. The representative consumer maximises

$$U\left(q_B, q_G\right) - \sum_{i}^{B,G} \hat{p}_i, \qquad [1]$$

where $i = B, G$ denotes the branded good and the generic respectively, q_i is the amount of good i and $\hat{p}_i$ is the net price paid by the consumer for this good. $U\left(q_B, q_G\right)$ is assumed to be quadratic and strictly concave.

As mentioned in the introduction, the Spanish reference price system will be used. Hence, under *copayments*,

$$\hat{p}_i = \gamma p_i, \quad i = B, G, \qquad [2]$$

while under *reference prices*,

$$\hat{p}_i = \begin{cases} \gamma p_G \text{ if consumer buys generic,} \\ \gamma r + \left(p_B - r\right) \text{ if consumer buys branded,} \end{cases} \qquad [3]$$

with $\gamma \in (0,1)$ being the copayment and $r > 0$ is the reference price set[1]. Moreover, we need that $p_G \leq r < p_B$ for the system to be well defined. For this purpose, we will restrict the possible choice variable set for both firms, depending on whether it is a branded or generic producer, as mentioned before.

It is important to describe the time structure implicitly assumed in the setting of this paper. As previously explained, the idea of the paper is to compare equilibrium values obtained under reference prices with the ones that result under copayments. This has some consequences for the setting of the game. In the first period, the consumer faces a copayment regime; given this, firms choose prices simultaneously. In the second period, Health Authorities then decide to change the regime, and implement the reference price system described before, which has an implicit assumption underlying it: the reference price has to be set between the most expensive good (the branded drug) and the cheapest product (generic alternative). Hence, given r, the branded firm cannot set its price below this r, while the generic's price cannot exceed the reference price. This is a unique characteristic of the Spanish reference price system, since the government sets a different policy for generics and branded pharmaceuticals[2]. For this reason, the set of values that the firms can choose from when taking their pricing decision is restricted. Hence, since this is imposed by the system, the possibility of the branded firm setting its price below r, and the generic producer setting its price above r[3] is ignored.

Hence, the demand functions faced by both producers are:

$$q_{Bi} = \frac{(a_B - \theta a_G)}{b(1-\theta^2)} - \frac{1}{b(1-\theta^2)}\hat{p}_{Bi} + \frac{\theta}{b(1-\theta^2)}\hat{p}_{Gi}, \qquad [4]$$

$$q_{Gi} = \frac{(a_G - \theta a_B)}{b(1-\theta^2)} - \frac{1}{b(1-\theta^2)}\hat{p}_{Gi} + \frac{\theta}{b(1-\theta^2)}\hat{p}_{Bi}, \qquad [5]$$

[1] These two parameters are chosen by Health Authorities, and will be treated as exogenous throughout the whole analysis. However, we will carry out comparative static analysis to see how firms' decision variables are affected by the choice of these two parameters.

[2] I would like to acknowledge one referee for pointing this out.

[3] Note that we are not trying to endogenise the reference price system, or looking for the socially optimum method of implementing. We use the Spanish system as has been introduced, and take it as given.

where $\hat{p}$ denotes the net price paid as shown in [2] and [3], and $i = \gamma, r$ stands for the situation under copayments and reference prices respectively. This demand system is derived from the inverse demand functions of the following kind:

$$\hat{p_i} = a_i - bq_i - b\theta q_j; \; i = B, G, i \neq j. \qquad [6]$$

where $\hat{p_i}$ is the net price paid for good i by the consumer.

The difference between both scenarios is that the net price paid by the consumer for the branded good is now the sum of two elements: a proportion γ of the reference price, and the difference between the actual price set and the reference price.

There are some restrictions on the parameters, to take into account the special features of the pharmaceutical industry (see Mestre-Ferrándiz, 1999b, for more details). More precisely, and due to demand barriers to entry faced by generic producers, the following assumptions are made.

ASSUMPTION 1. $a_B \geq a_G > 0$.

Assumption 1 states the size of the market is greater for the branded good, since this implies that $a_B - \theta a_G \geq a_G - \theta a_B$. Moreover, both demand intercepts are positive.

With these demand functions, and assuming constant marginal costs for both firms (denoted by c_B and c_G for the branded and generic good producer respectively), the profit functions for each company become:

$$\pi_{Bi} = (p_{Bi} - c_B) \, q_{Bi}, \qquad [7]$$
$$\pi_{Gi} = (p_{Gi} - c_G) \, q_{Gi}, \qquad [8]$$

where $i = \gamma, r$ (the situation with copayment only and reference prices respectively).

ASSUMPTION 2. $a_i \geq c_i$, $i = B, G$.

This assumption ensures non-negative profits for all non-negative prices.

ASSUMPTION 3. $c_B \geq c_G$.

The marginal cost of production for the branded producer is greater or equal to the marginal cost for the generic producer, according to casual observation. The rationale underlying this assumption is the higher costs of packaging and labelling of branded drugs.

3. Equilibrium

The concept to be used is the Nash Equilibrium and it is assumed that firms decide prices simultaneously.

The model is solved, under copayments, in the next subsection, while subsection 3.2 shows the results when reference prices exist.

3.1. Copayments

For the case of copayments only, the profit functions for both firms are:

$$\pi_{i\gamma} = (p_{i\gamma} - c_i)\left(\frac{(a_i - \theta a_j)}{b(1-\theta^2)} - \frac{1}{b(1-\theta^2)}\gamma p_{i\gamma} + \frac{\theta}{b(1-\theta^2)}\gamma p_{j\gamma}\right). \quad [9]$$

Restricting to the analysis of interior solutions, the following first order condition (FOC) is obtained:

$$\frac{\partial \pi_{i\gamma}}{\partial p_{i\gamma}} = \frac{a_i - \theta a_j - 2\gamma p_{i\gamma} + \theta\gamma p_{j\gamma} + \gamma c_i}{b(1-\theta^2)} = 0, \quad [10]$$

with $i, j = B, G,\ i \neq j$.

Hence, from equation [10], and using the implicit function theorem, the following positive relationship between the two prices is obtained:

$$\frac{dp_{i,\gamma}}{dp_{j,\gamma}} = \frac{\theta}{2} > 0. \quad [11]$$

From [10], the best response functions for the two firms are derived, yielding the Nash Equilibrium in prices[4]. These are given by

$$p^*_{i\gamma} = \frac{\left(2-\theta^2\right)a_i - \theta a_j + \gamma(2c_i + c_j)}{\gamma(4-\theta^2)}, \quad [12]$$

with $i, j = B, G,\ i \neq j$.

It can be said that an increase in the copayment γ will decrease the equilibrium price for the branded good under Assumption 1. With regards to the response of the generic producer, it will depend on the relative magnitude of market sizes. More precisely,

$$\frac{\partial p^*_{B,\gamma}}{\partial \gamma} = -\frac{\left(2-\theta^2\right)a_B - \theta a_G}{(4-\theta^2)\gamma^2} < 0, \quad [13]$$

$$\frac{\partial p^*_{G,\gamma}}{\partial \gamma} = -\frac{\left(2-\theta^2\right)a_G - \theta a_B}{(4-\theta^2)\gamma^2} < 0 \Leftrightarrow \frac{\theta}{\left(2-\theta^2\right)} < \frac{a_G}{a_B} \leq 1. \quad [14]$$

[4] Second order conditions are satisfied.

Comparing equilibrium prices, the following lemma[5] is obtained:

LEMMA 1. *If Assumptions 1 to 3 hold, then under copayments, the price of the branded good is higher or equal to the price of its generic alternative; i.e.* $p^*_{B,\gamma} \geq p^*_{G,\gamma}$ *(with strict inequality if* $a_B > a_G$ *and/or* $c_B > c_G$*).*

The associated equilibrium quantities for the copayment system are,

$$q^*_{i\gamma} = \frac{(2-\theta^2)(a_i - \gamma c_i) - \theta\,(a_j - \gamma c_j)}{b(4-\theta^2)(1-\theta^2)}, \qquad [15]$$

where $i, j = B, G; i \neq j$.

Once the model is solved, he following assumptions are introduced to ensure the non-negativity of the equilibrium values.

ASSUMPTION 4. $(a_B - c_B) \geq (a_G - \gamma c_G)$

$\Rightarrow (a_B - a_G) \geq (c_B - \gamma c_G) \geq (c_B - c_G) \geq \gamma\,(c_B - c_G)$ since $\gamma \in [0, 1]$.

ASSUMPTION 5. $(2-\theta^2)(a_G - \gamma c_G) \geq \theta(a_B - \gamma c_B)$

$[\geq \theta\,(a_B - c_B)$ since $\gamma \in (0, 1]]$.

Note, Assumptions 4 and 5 imply the quantities expressed in [15] are non-negative. To check how demand varies with γ:

$$\begin{aligned} \frac{\partial q^*_{B,\gamma}}{\partial \gamma} &= \frac{\theta c_G - c_B(2-\theta^2)}{b(4-\theta^2)(1-\theta^2)} < 0 \Leftrightarrow \qquad [16] \\ (2-\theta^2)c_B &> \theta c_G. \\ \frac{\partial q^*_{G,\gamma}}{\partial \gamma} &= \frac{\theta c_B - c_G(2-\theta^2)}{b(4-\theta^2)(1-\theta^2)} < 0 \Leftrightarrow \qquad [17] \\ \frac{(2-\theta^2)}{\theta} &> \frac{c_B}{c_G} \geq 1. \end{aligned}$$

For the case of the branded good, Assumption 3 guarantees that increasing the copayment γ decreases quantity demanded for this product (i.e. there exists a negative relationship between copayments and the quantity demanded); for the case of the generic good, this sign depends on the relative magnitude of marginal costs. More precisely, if the marginal cost of production of the branded good is not too high compared to the marginal cost of the generic, then this negative relationship still

[5] We escape the simple proofs of the three lemmas of the paper.

holds. This, as illustrated with Lemma 1, is because the higher the difference between marginal costs, the higher the price of the branded good compared to the generic's price; hence if c_B is very high, the difference between $p^*_{B,\gamma}$ and $p^*_{G,\gamma}$ is too high so that actually increasing the copayment makes people switch from the branded to the generic good. Hence, whenever c_B is sufficiently high, there exists a positive relationship between the copayment (and hence net price paid) and the quantity demanded for the generic alternative.

3.2. Reference prices

Next the equilibrium prices (interior solution) are characterised once the reference price system is implemented. Following a similar approach as before, the following FOCs are obtained

$$\frac{\partial \pi_{Br}}{\partial p_{Br}} = \frac{a_B - \theta a_G - 2p_{Br} + \theta\gamma p_{Gr} + c_B + (1-\gamma)r}{b(1-\theta^2)} = 0, \quad [18]$$

$$\frac{\partial \pi_{Gr}}{\partial p_{Gr}} = \frac{a_G - \theta a_B - 2\gamma p_{Gr} + \theta p_{Br} + \gamma c_G - \theta(1-\gamma)r}{b(1-\theta^2)} = 0. \quad [19]$$

From equations [18] and [19], and using the implicit function theorem, some useful comparative statics can be derived, providing some insights into how firms react when parameters of the model change, and giving some intuition on further results. More precisely,

$$\frac{dp_{B,r}}{dp_{G,r}} = \frac{\theta\gamma}{2} > 0, \quad [20]$$

$$\frac{dp_{G,r}}{dp_{B,r}} = \frac{\theta}{2\gamma} > 0, \quad [21]$$

$$\frac{dp_{B,r}}{dr} = \frac{(1-\gamma)}{2} > 0, \quad [22]$$

$$\frac{dp_{G,r}}{dr} = -\frac{(1-\gamma)\theta}{2\gamma} < 0. \quad [23]$$

Equations [20] and [21] show the usual strategic substitutability of prices. Note that $\frac{dp_{G,r}}{dp_{B,r}} \geq \frac{dp_{B,r}}{dp_{G,r}}$. Hence, the increase in price of the generic product is higher when its rival increases its price, compared to the increase in price of the branded good when the generic producer increases its price. The generic producer's response is larger with the introduction of a reference price system. Equation [22] implies that the optimal response of the branded good producer is to increase (decrease) price when the reference price, r, increases (decreases). The intuition behind this result is that the reference price acts as a kind of subsidy for this producer. However, equation [23] means that the optimal response of the generic producer is to decrease (increase) its price when the reference price increases (decreases). Notice that the price response of both producers to a change in the reference price is different. Algebraically,

$$\left|\frac{dp_{G,r}}{dr}\right| > \left|\frac{dp_{B,r}}{dr}\right| \Leftrightarrow \theta > \gamma.$$

Recall that both the copayment γ and the degree of substitutability θ are in the interval $(0,1)$. The difference of the absolute values of the price changes when the reference price changes depends on the degree of product differentiation and the level of copayments paid by the consumer. Using the case of Spain for illustrative examples, where $\gamma = 0{,}4$ on average, then if goods are not highly differentiated i.e. θ is sufficiently large and goods are closer substitutes, then the generic producer's price response is higher when r changes. In this case, the generic reacts more aggressively because the branded good producer has lost one of its advantages over the generic producer.

Solving for equilibrium prices yields

$$p^*_{Br} = \frac{(2-\theta^2)a_B - \theta a_G + 2c_B + \theta\gamma c_G + (1-\gamma)(2-\theta^2)r}{4-\theta^2}, \quad [24]$$

$$p^*_{Gr} = \frac{(2-\theta^2)a_G - \theta a_B + \theta c_B + 2\gamma c_G - (1-\gamma)r}{\gamma\left(4-\theta^2\right)}. \quad [25]$$

Now analysing how these prices vary with the copayment, in order to see if responses differ by introducing reference prices, the following is obtained

$$\frac{\partial p^*_{Br}}{\partial\gamma} = \frac{\theta c_G - (2-\theta^2)r}{4-\theta^2}, \quad [26]$$

$$\frac{\partial p^*_{Gr}}{\partial\gamma} = -\frac{(2-\theta^2)a_G - \theta a_B + \theta c_B - r}{\gamma^2\left(4-\theta^2\right)}. \quad [27]$$

From the above equations, it can be seen that the signs of these derivatives depend upon the value of the reference price r. Notice that:

$$\frac{\partial p^*_{Br}}{\partial \gamma} < 0 \Leftrightarrow r > \frac{\theta c_G}{\left(2-\theta^2\right)}, \text{ and} \quad [28]$$

$$\frac{\partial p^*_{Gr}}{\partial \gamma} < 0 \Leftrightarrow r < \left(2-\theta^2\right) a_G - \theta a_B + \theta c_B. \quad [29]$$

The intuition behind the effect of the copayment level and the price set by the branded good producer can be obtained by decomposing the net price paid by the consumer in two parts: γr and $p^*_{Br} - r$. If r is sufficiently high, then as the copayment increases, one of the two parts, γr, increases. Then, as a strategic response, in order to maintain a sufficient level of demand, the pioneer firm reduces the price for its good, so that the second element the consumer has to pay, $p^*_{Br} - r$, is not too high. The relationship between the copayment and the (gross) price of the generic alternative also depends on the value of r. For low values of r, the generic producer reduces its price as the copayment increases in order to keep attracting consumers, so the net price paid by the consumer for this good is not too high.

The associated equilibrium quantities are

$$q^*_{Br} = \frac{(2-\theta^2)(a_B - c_B) - \theta\left(a_G - \gamma c_G\right) + (1-\gamma)(2-\theta^2)r}{b\left(4-\theta^2\right)\left(1-\theta^2\right)}, \quad [30]$$

$$q^*_{Gr} = \frac{(2-\theta^2)\left(a_G - \gamma c_G\right) - \theta\left(a_B - c_B\right) - \theta(1-\gamma)r}{b\left(4-\theta^2\right)\left(1-\theta^2\right)} \quad [31]$$

Assumption 4 is a sufficient condition for q^*_{Br} to be non-negative. Assumption 5 is a necessary condition for the non-negativity of q^*_{Gr}. Using equilibrium quantities,

$$sign\left(\frac{\partial q^*_{Br}}{\partial r}\right) > 0, \quad [32]$$

$$sign\left(\frac{\partial q^*_{Gr}}{\partial r}\right) < 0. \quad [33]$$

The intuition for equation [32] is as follows: as r increases, two opposing effects are observed in relation to what happens to the net price paid by the consumer for the branded good. On the one hand, as r increases, the element γr increases; on the other, the element $(p^*_{Br} - r)$

is reduced, ceteris paribus. Nevertheless, it can be seen that overall, as r increases, the net price paid for the branded good decreases, given p^*_{Br}[6]. Hence, for any given p_{Br}, a higher reference price implies a lower net price, all other things being equal. This leads to higher quantity demanded for the branded good. For the generic good, the intuition under equation [33] is somewhat different but related to equation [32]. The higher r is, the higher the demand for the branded good, as people switch from the generic to the branded, hence demand for the generic good is reduced.

4. Comparing scenarios

4.1. Prices and quantities

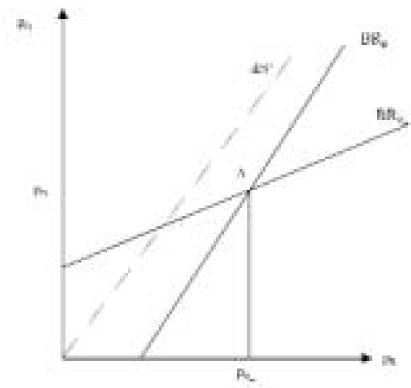
Before going into detail, it is worthwhile analysing the reaction functions of both firms under copayments and reference prices in order to show graphically the effect of the latter system. Figures 1 and 2 show the reaction functions under both scenarios. Figure 1 represents the equilibrium outcome under copayments, while Figure 2 illustrates the resulting equilibrium under reference prices for different values of r.

Point A is the resulting equilibrium under copayments. Notice that due to the assumptions, the equilibrium point is underneath the 45º line. Moreover, both reaction functions have the same slope. Introducing reference prices affects the reaction functions in two ways: both the intercepts and the slopes change. For the generic producer, the intercept (i.e. when $p_{Br} = 0$) is always lower under reference prices and the slope of the reaction function increases. For the branded good producer, the slope also increases, although the intercept of the new reaction function will be higher or lower depending on the value of the reference price: the higher the reference price, the higher the intercept. Notice, however, that changing r does not change the slope of the reaction function. Compared to the initial situation with copayments, the slopes of the reaction functions cease to be the same. The following inequality compares these responses:

$$\frac{dp_{B,r}}{dp_{G,r}} \leq \frac{dp_{B,\gamma}}{dp_{G,\gamma}} = \frac{dp_{G,\gamma}}{dp_{B,\gamma}} \leq \frac{dp_{G,r}}{dp_{B,r}} \qquad [34]$$

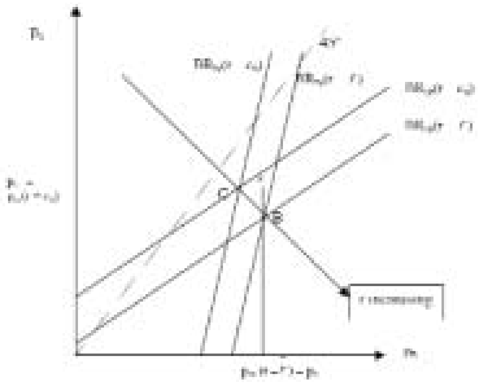
[6] This is because, for a given p_{Br}, $\dfrac{\partial\left[\tau r + (p_{Br} - r)\right]}{\partial r} = -1 + \tau \leq 0$, where as mentioned before, $[\tau r + (p_{Br} - r)]$ is the net price paid for the branded product.

FIGURE 1
Best Responses: Copayments



$BR_{i\gamma}$ = best response for firm i under copayments, $i = B,G$.
BR_{ir} $(r = \bar{r})$ = best response for firm i under RP when $r = \bar{r}$
BR_{ir} $(r = c_B)$ = best response for firm i under RP when $r = c_B$

FIGURE 2
Best Responses: RP



$BR_{i\gamma}$ = best response for firm i under copayments, $i = B,G$.
BR_{ir} $(r = \bar{r})$ = best response for firm i under RP when $r = \bar{r}$
BR_{ir} $(r = c_B)$ = best response for firm i under RP when $r = c_B$

Now, with the introduction of reference prices, the price response of each firm to a change in price of its competitor is different. Moreover, it is the generic producer who competes more aggressively. Hence, with this model, generic prices are more responsive than before, something that is implicitly wanted when such a system is introduced. This is because one of the objectives of a reference price system is to promote the use of generics and to increase price competition.

Figure 2 shows that increasing r shifts the equilibrium point under reference prices to the right i.e. higher price for the branded good and lower for the generic. This proves to be crucial explaining some of the results presented later. Two other points shown in the figure, points B and C are of great importance for the rest of the analysis, as will be explained later.

When analysing how firms respond to the introduction of a reference price system, the following lemma compares the equilibrium price for the branded good under reference prices to the equilibrium price under the copayment system.

LEMMA 2. *When the reference price is set sufficiently high, the price of the branded drug under reference prices will be higher than under a copayment regime.*

Algebraically, when $r \gtreqless \overline{r}, p^*_{B,r} \gtreqless p^*_{B,\gamma}$,

where $r \equiv \frac{(2-\theta^2)a_B - \theta a_G + \theta\gamma c_G}{\gamma(2-\theta^2)} (< 0)$.

This lemma shows that under a reference price system, the branded good producer has incentives to decrease its price if the reference price is not too high. However, if the reference price is set too high (higher than the upper bound $\bar{r}$), this producer will increase the price above the price set under copayments. This critical bound depends positively on a_B and c_G, but negatively on a_G and γ.

The following lemma compares equilibrium prices for the generic good, before and after the introduction of reference prices.

LEMMA 3. *If the reference price is set higher than the marginal cost of producing the branded good, the price of the generic alternative will be higher under copayments.*

That is, if $r \gtreqless c_B, p^*_{G\gamma} \gtreqless p^*_{Gr}$.

Proposition 1 summarises lemmas 2 and 3:

PROPOSITION 1. *When the reference price is set in a certain interval, the price of both the branded drug and its generic alternative are lower under reference prices as compared to a copayment regime.*

Algebraically,

If $r \leq c_B$, *then* $p^*_{B,\gamma} > p^*_{B,r}$ *and* $p^*_{G,\gamma} \leq p^*_{G,r}$.

If $c_B < r < \overline{r}$, *then* $p^*_{B,\gamma} > p^*_{B,r}$ and $p^*_{G,\gamma} > p^*_{G,r}$.

When $r \geq \overline{r}$, *then* $p^*_{B,r} \leq p^*_{B,\gamma}$ and $p^*_{G,\gamma} > p^*_{G,r}$,

where $\overline{r}$ *is as defined in lemma 2.*

Proof. The first step is to prove that the interval $(c_B, \overline{r})$ is well defined.

The difference $r - c_B = \frac{(2-\theta^2)a_B - \theta a_G + \theta\gamma c_G}{\gamma(2-\theta^2)} - c_B$, is positive whenever $(2-\theta^2)(a_B - \gamma c_B) - \theta(a_G - \gamma c_G) > 0$. Assumption 4 guarantees that this difference is positive, hence the interval is well defined.

The second part of the proof follows from combining lemmas 2 and 3.■

The resulting equilibrium when $r = \bar{r}$ is illustrated by point B in Figure 1B. Point C shows the outcome when $r = c_B$. As shown in the previous proposition, when $r = \bar{r}$, $p^*_{B,\gamma} = p^*_{B,r}$ and $p^*_{G,\gamma} > p^*_{G,r}$, hence point B. Point C can be obtained similarly. Hence, in order for the reference price system to achieve the objective of decreasing prices of both goods, the reference price must be set in the interval $(c_B, \bar{r})$ i.e. a reference price level that will give rise to an equilibrium point that is in between points B and C in Figure 2.

Since one of the objectives of the paper was to find under what conditions a reference price system achieves lower prices, the rest of the paper focuses on comparisons in this interval. For a full set of results, see Appendix A1. (Tables A1, A2, A3).

The intuition behind this result is given by equations [13], [22] and [23]. As shown by [13], the price set by the incumbent firm depends negatively on the copayment in the first situation. However, from equation [22], the optimal response for the branded good producer is to increase its price as r increases. Nevertheless, recall that for sufficiently high levels of r, the relationship between copayments and $p^*_{B,r}$ was negative. Then, the increase in price due to a higher r is sufficiently high to increase the price over the one under copayments only when r is sufficiently high. That is, only above the upper bound $\bar{r}$, is this effect stronger than the negative effect that γ has on the equilibrium price.

For the generic producer, this effect is reversed, as shown by equation [23]. For low values of r, $\dfrac{\partial p^*_{G,r}}{\partial \gamma} < 0$. For these values, however, the negative effect that r has on $p^*_{G,r}$ is not strong enough. Hence the price of the generic version is lower under copayments. However, as the reference price starts increasing, this negative effect starts to dominate. This implies that for values of r greater than c_B, the generic's price is lower under the reference price system.

Summarising, for low levels of r, the branded good firm has incentives to decrease its price when the reference price system is introduced. However, the generic producer has incentives to decrease its price under reference prices only for high values of r. Hence, only for the interval $(c_B, \bar{r})$ will both prices be reduced.

Graphically, it can be seen that as r increases, the equilibrium point shifts towards the right. This is because the reaction function for the branded good producer shifts to the right, while the reaction function for the generic producer shifts downwards.

The next step is to compare equilibrium quantities between both scenarios. The next proposition summarises the results:

PROPOSITION 2. *In the interval where the reference price achieves lower prices, under such system the demand for the branded drug will be higher while the demand for the generic alternative will be lower compared to a copayment regime.*

Algebraically, if $r \leq c_B$, *then* $\begin{cases} q^*_{B,\gamma} \geq q^*_{B,r} \\ q^*_{G,\gamma} \leq q^*_{G,r} \end{cases}$.

if $r > c_B$, *then* $\begin{cases} q^*_{B,\gamma} < q^*_{B,r} \\ q^*_{G,\gamma} > q^*_{G,r} \end{cases}$.

PROOF. We obtain that $q^*_{B,\gamma} - q^*_{B,r} = -\frac{(2-\theta^2)(1-\gamma)(r-c_B)}{b(4-\theta^2)(1-\theta^2)}$,

and $q^*_{G,\gamma} - q^*_{G,r} = \theta\frac{(1-\gamma)(r-c_B)}{b(4-\theta^2)(1-\theta^2)}$. The result follows through.■

The intuition behind this result can be obtained using equations [16], [17], [32] and [33]. The analysis is similar in spirit to Proposition 1. The sign of the difference between the demand for both products also depends on r. For low values of r, the positive effect that r has on the demand for the branded good under a reference price system is not strong enough to dominate the negative effect that γ has under a copayment system. Hence, demand is higher under a copayment system. However, when r is set high enough, the effect is reversed, which causes an increase in demand for the branded good with a reference price system.

For the generic good, the intuition is reversed; for low values of r, demand is higher when the reference price system is implemented; for higher values of r, the negative effect illustrated by equation [33] is stronger and dominates. Hence, demand for the generic good is higher under the copayment system only when r is sufficiently high.

Now to analyse the effect of introducing a reference price system on the net price paid by the consumer, net prices paid under both scenarios for both goods are compared. For the branded good, the consumer pays a net price of $\gamma p^*_{B\gamma}$ under a copayment system, and $(p^*_{Br} - r(1-\gamma))$ under both systems. The difference between these two prices is equal to:

$$\gamma p^*_{B\gamma} - (p^*_{Br} - r(1-\gamma)) = 2\frac{(r-c_B)(1-\gamma)}{(4-\theta^2)}. \quad [35]$$

For the generic good, the consumer pays the proportion γ for both scenarios. The difference between $\gamma p^*_{G\gamma}$ and γp^*_{Gr} is

$$\gamma p^*_{G\gamma} - \gamma p^*_{Gr} = \theta\frac{(r-c_B)(1-\gamma)}{(4-\theta^2)}. \quad [36]$$

The following proposition summarises equations [35] and [36]. ■

PROPOSITION 3. *In the interval where the reference price achieves lower prices, the consumer pays a lower net price for both products under reference prices.*

PROOF. The proof follows by combining equations [35] and [36].

Propositions 1 to 3 can be illustrated in Table 1.

TABLE 1
Summary of propositions 1-3

	$r = c_B$	$r \in (c_B, \bar{r})$	$r = \bar{r}$
$p^*_{B,\gamma} - p^*_{B,r}$	+	+	0
$p^*_{G,\gamma} - p^*_{G,r}$	0	+	+
$q^*_{B,\gamma} - q^*_{B,r}$	0	−	−
$q^*_{G,\gamma} - q^*_{G,r}$	0	+	+
$\gamma p^*_{B,\gamma} - \left(p^*_{B,r} - (1-\gamma)r\right)$	0	+	+
$\gamma\left(q^*_{G,\gamma} - q^*_{G,r}\right)$	0	+	+

Comparing the changes in net prices paid by consumers for branded and generic goods, when the reimbursement system is altered, the following is obtained:

$$\left[\gamma p^*_{B\gamma} - (p^*_{Br} - r(1-\gamma))\right] - \left[\gamma p^*_{G\gamma} - \gamma p^*_{Gr}\right] = \frac{(r - c_B)(1-\gamma)}{2+\theta} \quad [37]$$

Equation [37] analyses how the consumer's decision on which product to buy is affected by changing the reimbursement system. For reference prices higher than c_B, the change in price for the branded good is higher. Hence, it can be concluded that the price of the branded and generic good respond differently, both qualitative and quantitatively.

4.2. Profits

The equilibrium profits for both producers are now compared and a summary of the results shown in Table 2. For a full set of results, refer to Appendix 1.

TABLE 2
Comparison between profits for both firms

	$r = c_B$	$r \in (c_B, \bar{r})$	$r = \bar{r}$
$\pi^*_{B,\gamma} - \pi^*_{B,r}$	$+$	$+/-$	$-$
$\pi^*_{G,\gamma} - \pi^*_{G,r}$	0	$+$	$+$

Focusing again on the interval $r \in (c_B, \bar{r})$, the price for the branded product is lower under reference prices, but demand is higher. Hence, the sign of $\left(\pi^*_{B,\gamma} - \pi^*_{B,r}\right)$ is ambiguous. However, the higher the value of the reference price, the higher the probability that profits for this producer will be higher under reference prices. This means that there exists a critical value for r in this region such that profits under both regimes will be equal.

In the region $r \in (c_B, \bar{r})$, the generic producer is unambiguously left worse off under reference prices. This is because both the price and demand for its product are lower under reference prices for this interval of r.

Overall, then, as seen in Proposition 1, if Health Authorities set a reference price in the region $(c_B, \bar{r})$ so that prices of both goods are decreased, profits for the generic producer will be lower. However, for profits of the branded good producer not to be decreased, r should be set close enough to $\bar{r}$.

4.3. Pharmaceutical costs

As mentioned before, the ultimate objective of a reference price system is to reduce the public pharmaceutical bill. Such expenditure varies when the reimbursement system is altered. Before analysing further, it is necessary to define what the costs are for the Health Authorities. In case 1, under the copayment system, Health Authorities pay a proportion $(1-\gamma)$ of the price of both goods; hence the costs for the Authorities of financing the purchase of the generic and branded good are, respectively $(1-\gamma)\left(p^*_{G\gamma}q^*_{G\gamma}\right)$ (defined as $TC^{govt}_{G\gamma}$) and $(1-\gamma)\left(p^*_{B\gamma}q^*_{B\gamma}\right)$ $(\equiv TC^{govt}_{B\gamma})$. When the reference price system is implemented, the proportion is left unchanged for the generic good (but this time is defined as TC^{govt}_{Gr}); however, the amount that Health Authorities pay now for the branded good is $(1-\gamma)\left(rq^*_{Br}\right)$ $(\equiv TC^{govt}_{Br})$. Table 3 summarises these findings.

TABLE 3
Comparing total costs for health authorities

	$r = c_B$	$r \in (c_B, \bar{r})$	$r = \bar{r}$
$TC^{govt}_{G\gamma} - TC^{govt}_{Gr}$	0	+	+
$TC^{govt}_{B\gamma} - TC^{govt}_{Br}$	+	+/−	−

Therefore, Health Authorities are better off financing generics under a reference price system, within the interval where reference prices increase price competition ($r \in (c_B, \bar{r})$). In this interval, total costs for the authorities of financing the branded drug are higher or lower depending on the value of the reference price. The greater the value of r, the higher the probability that these costs are higher under reference prices.

These results are due to the different effects that implementing a reference price system has on prices and quantities for both goods, as illustrated in Tables 1 and 2.

Having analysed consumers, firms and authorities it is clear that determining the overall welfare effect of implementing reference prices is not simple. In the interval where prices are lower under a reference pricing scheme rather than a copayment regime, introducing reference prices can actually reduce (gross) prices set by firms compared to a copayment system. Moreover, the consumer faces lower net prices for both goods. This lower net price implies higher demand for the branded drug, but not for the generic alternative, so the effect on total demand needs to be checked, hence

$$sign\left[\left(q_{Br}^{*}+q_{Gr}^{*}\right)-\left(q_{B\gamma}^{*}+q_{G\gamma}^{*}\right)\right]=sign\left(r-c_{B}\right). \qquad [38]$$

Equation [38] shows that in the relevant region, total demand is higher under reference prices i.e. when $r > c_B$, $\left[\left(q_{Br}^{*}+q_{Gr}^{*}\right)-\left(q_{B\gamma}^{*}+q_{G\gamma}^{*}\right)\right] > 0$. It seems that total consumer surplus will be higher under reference prices in the interval $r \in (c_B, \bar{r})$.

Health Authorities then face a trade off when deciding whether or not to implement a reference price system. On the one hand, there is a certain interval for the reference price where the two objectives can be achieved: reduced prices and pharmaceutical expenditure. Moreover, total demand for drugs is increased. However, profits for the duopolists can actually decrease.

5. Conclusion and future research

The aim of this paper is to analyse theoretically the response of pharmaceutical firms to the implementation of a reference price system, based upon a study of the mechanism being used in Spain. Using a differentiated duopoly model, the reference price system is compared with a copayment regime. Under copayments, the consumer pays a copayment (γ) irrespective of what drug he/she buys, generic or branded. However, the situation differs when the reference price r is introduced. If the consumer decides to buy the generic good, then he/she still has to pay the copayment γ. But, if he/she decides to buy the branded good, he/she has to pay the proportion γ of the reference price r, plus the difference between the price of the branded good and r.

Reference prices have two main objectives: reduce prices and public pharmaceutical expenditure. This paper shows that a reference price system can in fact achieve such objectives, but only if the reference price is set in a certain interval. In this interval, both gross and net prices are lower for both products. Even though demand is higher for the branded product and lower for its generic alternative in this interval, total demand is higher under reference prices. However, profits for both firms can be reduced. In fact, profits for the generic producer will be unambiguously reduced if the reference price is set anywhere in this interval; the branded producer will prefer, should the Authorities decide to implement a reference price system and set the reference price in this interval, that the reference price is set closely to the upper bound of the interval, since the probability that profits under such system will be higher than under copayments is higher.

One of the objectives of implementing a reference price system is to reduce the pharmaceutical bill. Results show the greater the value of r, the more costly it would be to finance branded goods, but the cheaper to finance generics. Again, this is due to the opposite effects that implementing r has on both producers' behaviour.

The main result that can be derived from this analysis is that Health Authorities have to be cautious in how to define r. Whether Health Authorities achieve their desired goal of increasing price competition and reduced health costs depends on the magnitude of r. There seems to be a trade off between achieving reduced prices and pharmaceutical costs at the expense of reduced profits for the firms. Considering the importance of R&D to the pharmaceutical industry, Health Authorities should take into consideration the loss of profits and the resulting impact this might have on development of new drugs. One limitation of this paper is that a static model is used to analyse a policy that has dynamic implications.

Another issue not discussed here is the possibility of the branded good producer becoming multi-product and producing its own generic version. This has been studied in Mestre-Ferrándiz (1999b).

There are a number of ways to extend the work undertaken in this paper. Firstly, to obtain empirical estimates of the critical bounds of the interval. However, obtaining these critical bounds might be problematic if they depend on parameters that are not easily observable. Secondly, to introduce a regulator which has to choose the optimal reference price. This will involve establishing an objective function, which raises timing issues. It would entail introducing an initial stage in the game, whereby the regulator maximises social welfare by choosing an optimal level of the reference price. Given this choice, firms will then choose prices subject to the reference price chosen by the regulator.

Lastly, further investigation is required to understand what the likely effects of implementing a reference price system on R&D and innovation will be, particularly for the pharmaceutical industry.

Annex A1

TABLE A1
Summary of propositions 1-3

	$r < c_B$	$r = c_B$	$r \in (c_B, \bar{r})$	$r = \bar{r}$	$r > \bar{r}$
$p^*_{B,\gamma} - p^*_{B,r}$	$+$	$+$	$+$	0	$-$
$p^*_{G,\gamma} - p^*_{G,r}$	$-$	0	$+$	$+$	$+$
$q^*_{B,\gamma} - q^*_{B,r}$	$+$	0	$-$	$-$	$-$
$q^*_{G,\gamma} - q^*_{G,r}$	$-$	0	$+$	$+$	$+$
$\gamma p^*_{B,\gamma} - \left(p^*_{B,r} - (1-\gamma)r\right)$	$-$	0	$+$	$+$	$+$
$\gamma \left(q^*_{G,\gamma} - q^*_{G,r}\right)$	$-$	0	$+$	$+$	$+$

TABLE A2
Comparison between profits for both firms

	$r < c_B$	$r = c_B$	$r \in (c_B, \bar{r})$	$r = \bar{r}$	$r > \bar{r}$
$\pi^*_{B,\gamma} - \pi^*_{B,r}$	$+$	$+$	$+/-$	$-$	$-$
$\pi^*_{G,\gamma} - \pi^*_{G,r}$	$-$	0	$+$	$+$	$+$

TABLE A3
Comparing total costs for health authorities

	$r < c_B$	$r = c_B$	$r \in (c_B, \bar{r})$	$r = \bar{r}$	$r > \bar{r}$
$TC^{govt}_{G\gamma} - TC^{govt}_{Gr}$	$-$	0	$+$	$+$	$+$
$TC^{govt}_{B\gamma} - TC^{govt}_{Br}$	$+$	$+$	$+/-$	$-$	$-$

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Resumen

El objetivo de este artículo es analizar los efectos de las políticas recién instauradas en el mercado farmacéutico español: la promoción de medicamentos genéricos y la introducción de precios de referencia. Los principales objetivos de estas reformas son aumentar la competencia en precios y reducir el gasto público farmacéutico. El método español para implementar precios de referencia alcanza estos objetivos, en comparación a un sistema de copago, si el precio de referencia se sitúa en un cierto intervalo. Además, los beneficios de las empresas productoras de medicamentos de marca y genéricos pueden reducirse.

Palabras clave: Precios de referencia, copagos, genéricos, industria farmacéutica.

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