Reference Prices: The Spanish Way

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Abstract

The aim of this paper is to analyse the effects of recent regulatory reforms that Spanish Health Authorities have implemented in the pharmaceutical market: the introduction of a reference price system together with the promotion of generic drugs. The main objectives of these two reforms are to increase price competition and, ultimately, reduce pharmaceutical costs. Before the introduction of reference prices, consumers had to pay a fixed copayment of the price of whatever drug purchased. With the introduction of such system, the situation differs in the following way: if (s)he buys the more expensive branded drug, then (s)he pays a sum of two elements: the copayment associated to the reference price plus the difference between the price of this good and the reference price. However, if the consumer decides to buy the generic alternative, with price lower than the reference price, then (s)he has to pay the same copayment as before. We show that the introduction of a reference price system together with the promotion of generic drugs increase price competition and lower pharmaceutical costs only if the reference price is set in a certain interval. Also profits for the duopolists might be reduced. These results are due to the opposing effects that reference prices have on branded and generic producers respectively.

1 Introduction.

The aim of this work is to give some insights on the possible effects that recent regulatory reforms introduced by the Spanish Health Authorities might have in the pharmaceutical market. These have been the promotion of generic drugs coupled with the introduction of a reference price system. A generic drug may be sold under generic denomination, once the patent of the branded (pioneer) good for the active ingredient has expired. A reference price system is a reimbursement system by which drugs are categorised into groups with similar active 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 have been implemented in various developed countries, such as Germany, Sweden, Denmark and Holland. Furthermore, in each country, this system has been implemented in different ways. For example, in Germany, if the price set by pharmaceutical firms exceeds the reference price, the consumer pays the difference, while the patient does not need to copay otherwise (Pavcnik 2000). In Spain, the following mechanism has been enforced: if the physician has prescribed a drug with a price higher than the reference price, then the consumer has two options: either (s)he buys a generic or a branded (more expensive) version. In the former case, the consumer pays the same copayment that was paid before. In the latter, the total payment results from the sum of the difference in price between the branded good and the reference price and the copayment associated to the *reference price* (El Pais, 21 July 2000). The difference between this system with the previously enforced is that the patient used to pay only a (fixed) copayment of the price. Hence, we want to compare a situation with copayments only with a situation with copayments and reference prices whereby if the price of the drug prescribed and purchased by the consumer is higher than the reference price, then the consumer will not only have to pay the previous copayment, but also an extra cost.

The idea is to see how will firms respond to these changes. Few papers have tried to modelise this situation theoretically, and most literature is mainly descriptive (Lopez-Casanovas and Puig-Junoy (1999)). Danzon and Liu (1997) used a kinked demand model in order to predict price responses to a reference price system. They do this in the context of a model of physician decision making under the assumption of imperfect agency between the physician and the patient. Zweifel and Crivelly (1997) use a duopoly model to analyse market reactions by pharmaceutical firms, by having a probability

of such system being implemented. Finally, 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) makes a very interesting empirical analysis in Germany, comparing the situation before and after the implementation of the reference price system. Her results show that in that country, producers have responded by reducing prices after the introduction of such system, and that the existence of generic competition is a very important factor. When the competition faced by branded good producers is tougher, the reduction in price is higher.

Mestre-Ferrándiz (2000) uses a similar approach as in this paper to analyse the introduction of reference prices, although the analysis of this paper is different in spirit to this one. In the previous paper, we assume that the reference price is set below the price of both branded and generic goods. In this paper, and to take into consideration how Spanish Authorities have implemented such system, the reference price will be higher than the price of the generic alternative but lower than the price of the branded good. This is an important difference, as we will see later. Nevertheless, and for clarifying purposes, it is worth mentioning that the results differ due to the different response by generic and pioneer firms. Furthermore, copayments will be introduced here.

The supply side will be a duopoly, with one branded and one generic good with each firm producing one good respectively. The results we obtain show that for the reference price system to reduce prices and pharmaceutical costs, this reference price must be set in a certain interval. However, profits for both firms might be reduced. Before introducing reference prices, consumers only had to pay a (fixed) copayment. In this case, results show that under certain conditions, both firms will have incentives to decrease price the higher is the copayment. However, if the reference price system is implemented, the branded good producer and the generic producer respond differently to the implementation of such system. On the one hand, branded good producers have incentives to increase their price as the reference price increases, but on the other, producers of the generic alternative have an incentive to reduce it. Only in the interval previously mentioned we will obtain that prices for both firms will decrease.

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 extensions.

2 The model.

We will have a differentiated duopoly market, 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 θ. This is because a generic product may not be a perfect substitute for the original brand due to both subjective and objective factors, and are these factors that allow the original brand to keep selling despite the presence of low-price generic competition (Hudson 2000). Assumptions on underlying preferences are assumed such that partial equilibrium analysis can be undertaken.

As discussed above, the first scenario we will consider involves analysing the pharmaceutical market just with the existence of a (fixed) copayment, $\gamma \epsilon [0, 1]$. The demand functions faced by the branded and generic good producer[1] are, respectively:

$$q_{B\gamma} = \frac{(a_B - \theta a_G)}{b(1-\theta^2)} - \frac{1}{b(1-\theta^2)}\gamma p_{B\gamma} + \frac{\theta}{b(1-\theta^2)}\gamma p_{G\gamma}, \qquad (1)$$

$$q_{G\gamma} = \frac{(a_G - \theta a_B)}{b(1-\theta^2)} - \frac{1}{b(1-\theta^2)}\gamma p_{G\gamma} + \frac{\theta}{b(1-\theta^2)}\gamma p_{B\gamma}, \qquad (2)$$

where the subscripts B, G represent the branded and the generic producer respectively, γ stands for the case where a copayment system is implemented, and $\theta \in [0, 1)$ represents the degree of differentiation between both goods. This demand system is derived from the inverse demand functions of the following kind:

$$\gamma p_i = a_i - bq_i - b\theta q_j; \; i = B, G, i \neq j. \qquad (3)$$

where γp_i is the net price paid for good i by the consumer,

Once the reference price system is implemented, the demand functions faced by both producers are, for the branded and generic good respectively,

$$q_{Br} = \frac{(a_B - \theta a_G)}{b(1-\theta^2)} - \frac{1}{b(1-\theta^2)}(\gamma r + p_{Br} - r) + \frac{\theta}{b(1-\theta^2)}\gamma p_{Gr}, \quad (4)$$

$$q_{Gr} = \frac{(a_G - \theta a_B)}{b(1-\theta^2)} - \frac{1}{b(1-\theta^2)}\gamma p_{Gr} + \frac{\theta}{b(1-\theta^2)}(\gamma r + p_{Br} - r), \quad (5)$$

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[1]See Singh and Vives (1984).

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where the subscript r denotes the situation under copayments and reference prices together, and r is the (fixed) reference price set by the Health Authorities. 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. Recall that since we are analysing the Spanish reference price system, the reference price will be less than the price of the original good but higher than the generic alternative. In other words, what we are implicitly assuming with this setting is that there has been a previous time period where firms chose their prices where consumers only had to pay the copayment γ (prices denoted $p_{B\gamma}$ and $p_{G\gamma}$ for the branded and generic good respectively in demand functions (1) and (2)). What has happened now is that the Spanish Health Authorities have decided to implement a reference price system such that this price is set in between the (more expensive) branded good and the (cheaper) generic alternative. Then, what we want to see is whether and when will firms reduce prices with such system compared to the previous situation, and under what circumstances (if any) will pharmaceutical costs for Health Authorities be reduced.

Before going on, we should introduce 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, we make the following assumptions.

Assumption 1. $a_B \geq a_G$. In words, this assumption is telling us that the size of the market is greater for the branded good, since this implies that $a_B - \theta a_G \geq a_G - \theta a_B$.

Assumption 2. $a_i \geq c_i$, $i = B, G$. This assumption ensures non-negative profits for all non-negative prices.

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), we can construct the profit functions for both firms, which are:

$$\pi_{Bi} = (p_{Bi} - c_B)\, q_{Bi}, \tag{6}$$
$$\pi_{Gi} = (p_{Gi} - c_G)\, q_{Gi}, \tag{7}$$

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

Assumption 3. $c_B \geq c_G$. The marginal cost of production for the branded producer is greater or equal than the marginal cost for the generic producer, according to casual observation.

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3   Equilibrium.

Assume firms decide prices simultaneously. We will look for a Nash Equilibrium of the game. Before solving the model, we introduce the following assumptions 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. $(2-\theta^2)(a_G-\gamma c_G) \geq \theta(a_B-\gamma c_B) \left[\geq \theta (a_B - c_B) \text{ since } \gamma \in (0, 1]\right]$.

In the next subsection, we will solve the model when copayments are enforced, while subsection 3.2 shows the results when there exists reference prices.

3.1   Copayments.

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

$$\pi_{i\gamma} = (p_{i\gamma} - c_i) \left(\frac{(a_i - \theta a_j)}{b(1 - \theta^2)} - \frac{1}{b(1 - \theta^2)}\gamma p_{i\gamma} + \frac{\theta}{b(1 - \theta^2)}\gamma p_{j\gamma} \right) \qquad (8)$$

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

$$\frac{\partial \pi_{i\gamma}}{\partial p_{i\gamma}} = \frac{a_i - \theta a_j - 2\gamma p_{i\gamma} + \theta\gamma p_{j\gamma} + \gamma c_i}{b(1 - \theta^2)} = 0 \qquad (9)$$

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

Hence, from equation (9), and using the implicit function theorem, we can obtain (as expected) a positive relationship between the two prices:

$$\frac{dp_{i,\gamma}}{dp_{j,\gamma}} = \frac{\theta}{2} > 0. \qquad (10)$$

From (9), we derive the best response functions for the two firms, yielding the Nash Equilibrium in prices[2]. These are given by,

$$p_{i\gamma}^* = \frac{\left(2 - \theta^2\right) a_i - \theta a_j + \gamma(2c_i + c_j)}{\gamma(4 - \theta^2)}, \qquad (11)$$

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

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[2]Second order conditions are satisfied.

We can say 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,

$$\frac{\partial p_{B,\gamma}^*}{\partial \gamma} = -\frac{\left(2 - \theta^2\right) a_B - \theta a_G}{(4 - \theta^2)\gamma^2} < 0, \tag{12}$$

$$\frac{\partial p_{G,\gamma}^*}{\partial \gamma} = -\frac{\left(2 - \theta^2\right) a_G - \theta a_B}{(4 - \theta^2)\gamma^2} < 0 \Leftrightarrow \frac{\theta}{\left(2 - \theta^2\right)} < \frac{a_G}{a_B} \leq 1. \tag{13}$$

Comparing equilibrium prices, we obtain the following lemma:

Lemma 1 *If Assumptions 1 to 3 hold, then $p_{B,\gamma}^* \geq p_{G,\gamma}^*$ (with strict inequality if $a_B > a_G$ and/or $c_B > c_G$).*

Proof. We have that $p_{B,\gamma}^* - p_{G,\gamma}^* = \dfrac{(a_B - a_G) + \gamma (c_B - c_G)}{\gamma(2 + \theta)}$. With the assumptions above, and since the denominator is always non-negative, the numerator will always be greater or equal than zero. ∎

The associated equilibrium quantities for the copayment system are,

$$q_{i\gamma}^* = \frac{(2 - \theta^2)(a_i - \gamma c_i) - \theta \left(a_j - \gamma c_j\right)}{b(4 - \theta^2)(1 - \theta^2)}, \tag{14}$$

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

Note that Assumptions 4 and 5 imply that these quantities are non-negative. We can check how demand varies with γ:

$$\frac{\partial q_{B,\gamma}^*}{\partial \gamma} = \frac{\theta c_G - c_B \left(2 - \theta^2\right)}{b(4 - \theta^2)(1 - \theta^2)} < 0 \Leftrightarrow \tag{15}$$

$$(2 - \theta^2)c_B > \theta c_G.$$

$$\frac{\partial q_{G,\gamma}^*}{\partial \gamma} = \frac{\theta c_B - c_G \left(2 - \theta^2\right)}{b(4 - \theta^2)(1 - \theta^2)} < 0 \Leftrightarrow \tag{16}$$

$$\frac{\left(2 - \theta^2\right)}{\theta} > \frac{c_B}{c_G} \geq 1.$$

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

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magnitude of marginal costs. More precisely, we obtain that 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 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 will exist a positive relationship between the copayment (and hence net price paid) and the quantity demanded for the generic alternative.

3.2   Reference Prices.

Next we characterise the equilibrium prices (interior solution) once the reference price system is implemented. Profit functions for the branded and generic good producers are, respectively:

$$
\pi_{Br} = (p_{Br} - c_B)\left(\frac{(a_B - \theta a_G)}{b(1 - \theta^2)} - \frac{1}{b(1 - \theta^2)}(\gamma r + p_{Br} - r) + \frac{\theta}{b(1 - \theta^2)}\gamma p_{Gr}\right),
$$

$$
\pi_{Gr} = (p_{Gr} - c_G)\left(\frac{(a_G - \theta a_B)}{b(1 - \theta^2)} - \frac{1}{b(1 - \theta^2)}\gamma p_{Gr} + \frac{\theta}{b(1 - \theta^2)}(\gamma r + p_{Br} - r)\right).
$$

The FOCs are as follows:

$$
\frac{\partial \pi_{Br}}{\partial p_{Br}} = \frac{a_B - \theta a_G - 2p_{Br} + \theta\gamma p_{Gr} + c_B + (1 - \gamma)r}{b(1 - \theta^2)} = 0, \qquad (17)
$$

$$
\frac{\partial \pi_{Gr}}{\partial p_{Gr}} = \frac{a_G - \theta a_B - 2\gamma p_{Gr} + \theta p_{Br} + \gamma c_G - \theta(1 - \gamma)r}{b(1 - \theta^2)} = 0. \qquad (18)
$$

From equations (17) and (18), and using the implicit function theorem, we can derive some useful comparative statics. This will provide some insights on how firms will react when parameters of the model change, and will be helpful to give us some intuition on further results. More precisely, we obtain that,

$$\frac{dp_{B,r}}{dp_{G,r}} = \frac{\theta\gamma}{2} > 0, \qquad (19)$$

$$\frac{dp_{G,r}}{dp_{B,r}} = \frac{\theta}{2\gamma} > 0, \qquad (20)$$

$$\frac{dp_{B,r}}{dr} = \frac{(1-\gamma)}{2} > 0, \qquad (21)$$

$$\frac{dp_{G,r}}{dr} = -\frac{(1-\gamma)\theta}{2\gamma} < 0. \qquad (22)$$

Equations (19) and (20) 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 will be 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 (21) tells us 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 (22) implies that the optimal response of generic producers 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 will be different. We have that

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

Recall that both the copayment γ and the degree of substitutability θ are in the interval $(0,1)$. Hence, if the copayment is higher than the degree of substitutability, then the absolute value of the change of the price of the branded good will be higher. Hence, if both goods are close substitutes (so that $\theta \approx 1$), then it is probable that the change in prices will be greater for the generic alternative, specially if we consider that on average, the copayment in Spain is equal to 0.4. One would expect that as goods become closer substitutes, it is as if the branded good producer has lost one of the sources of its advantage over the generic alternative. Hence, the generic producer in this case can behave more aggressively and fears less the strategic behaviour of the pioneer firm. These results will provide useful insights on the results presented below.

When solving for equilibrium prices, we get,

$$p_{Br}^* = \frac{(2-\theta^2)a_B - \theta a_G + 2c_B + \theta\gamma c_G + (1-\gamma)(2-\theta^2)r}{4-\theta^2} \quad (23)$$

$$p_{Gr}^* = \frac{(2-\theta^2)a_G - \theta a_B + \theta c_B + 2\gamma c_G - (1-\gamma)r}{\gamma\left(4-\theta^2\right)} \quad (24)$$

It would be interesting to analyse how these prices vary with the copayment in order to see if their response varies if we introduce reference prices. We obtain that

$$\frac{\partial p_{Br}^*}{\partial \gamma} = \frac{\theta c_G - (2-\theta^2)r}{4-\theta^2} \quad (25)$$

$$\frac{\partial p_{Gr}^*}{\partial \gamma} = -\frac{(2-\theta^2)a_G - \theta a_B + \theta c_B - r}{\gamma^2\left(4-\theta^2\right)} \quad (26)$$

From the above equations, we can see that the signs of these derivatives will depend upon the value of the reference price r. Notice that:

$$\frac{\partial p_{Br}^*}{\partial \gamma} < 0 \Leftrightarrow r > \frac{\theta c_G}{\left(2-\theta^2\right)}, \text{ and} \quad (27)$$

$$\frac{\partial p_{Gr}^*}{\partial \gamma} < 0 \Leftrightarrow r < \left(2-\theta^2\right)a_G - \theta a_B + \theta c_B. \quad (28)$$

Hence, we can say that if r is sufficiently high, then as the copayment increases, one element of the net price paid by the consumer for the branded good, 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 other element that the consumer has to pay, $p_{Br}^* - r$, is not too high. With respect to the relationship between the copayment and the (gross) price of the generic alternative, we see that for low values of r, generic producers have to reduce prices as the copayment increases in order to keep attracting consumers, so that the net price paid by the consumer for this good is not too high.

The associated equilibrium quantities are,

$$q_{Br}^* = \frac{(2-\theta^2)(a_B - c_B) - \theta\left(a_G - \gamma c_G\right) + (1-\gamma)(2-\theta^2)r}{b\left(4-\theta^2\right)\left(1-\theta^2\right)}, \quad (29)$$

$$q_{Gr}^* = \frac{\left(2 - \theta^2\right)\left(a_G - \gamma c_G\right) - \theta\left(a_B - c_B\right) - \theta(1 - \gamma)r}{b\left(4 - \theta^2\right)\left(1 - \theta^2\right)} \tag{30}$$

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}^*. With these equilibrium quantities, we obtain,

$$sign\left(\frac{\partial q_{Br}^*}{\partial r}\right) > 0, \tag{31}$$

$$sign\left(\frac{\partial q_{Gr}^*}{\partial r}\right) < 0. \tag{32}$$

The intuition for equation (31) is as follows: as r increases, we observe two opposing effects 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 τr increases; on the other, the element $(p_{Br}^* - r)$ is reduced. Nevertheless, we see that overall, as r increases, the net price paid for the branded good decreases[3]. Hence, for any given p_{Br}, a higher reference price implies a lower net price, ceteris paribus. This leads to higher quantity demanded for the branded good. For the generic good, the intuition under equation (32) is somewhat different but related to equation (31). The higher is r, the higher is 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.

It is worth mentioning that the introduction of a reference price system makes both firms react differently when the rival changes its prices. As we saw before, under copayments, we had that $\dfrac{dp_{B,\gamma}}{dp_{G,\gamma}} = \dfrac{dp_{G,\gamma}}{dp_{B,\gamma}} = \dfrac{\theta}{2}$. However, with reference prices, we obtained that $\dfrac{\theta\gamma}{2} = \dfrac{dp_{B,r}}{dp_{G,r}} \leq \dfrac{dp_{G,r}}{dp_{B,r}} = \dfrac{\theta}{2\gamma}$. Comparing the responses under copayments and reference prices yields the following inequalities:

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[3]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.

$$\frac{dp_{B,r}}{dp_{G,r}} \leq \frac{dp_{B,\gamma}}{dp_{G,\gamma}} = \frac{dp_{G,\gamma}}{dp_{B,\gamma}} \leq \frac{dp_{G,r}}{dp_{B,r}} \tag{33}$$

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 modelisation, what we obtain is that generic prices are more responsive than before, something that is implicitly wanted when such 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.

The second thing we want to analyse is how firms respond to the introduction of a reference price system. The following lemma compares equilibrium prices for the branded good,

Lemma 2 *For* $r \lesseqgtr \bar{r}$, *we get that* $p_{B,\gamma}^* \gtreqless p_{B,r}^*$,

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

Proof. We obtain that $p_{B,\gamma}^* - p_{B,r}^* = \dfrac{(1 - \gamma)\left[(2 - \theta^2)a_B - \theta a_G + \theta\gamma c_G - \gamma(2 - \theta^2)r\right]}{\gamma(4 - \theta^2)}$.

Since the denominator is always positive, and $(1 - \gamma) > 0$, we get that $p_{B,\gamma}^* > p_{B,r}^* \Longleftrightarrow \left[(2 - \theta^2)a_B - \theta a_G + \theta\gamma c_G - \gamma(2 - \theta^2)r\right] > 0 \Longleftrightarrow$

$r < \dfrac{(2 - \theta^2)a_B - \theta a_G + \theta\gamma c_G}{\gamma(2 - \theta^2)} \equiv \bar{r}$. Furthermore, since $a_B \geq a_G$, we know that $\bar{r} > 0$. ∎

This lemma tells us that when there exists a reference price system, branded good producers will have 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 $\bar{r}$), branded good producers will find it more profitable to increase the price. This critical bound depends positively on a_B and c_G, but negatively on a_G and γ.

We now proceed to compare equilibrium prices for generic goods, before and after the introduction of reference prices. The following lemma summarises the result obtained.

Lemma 3 *If* $r \gtreqless c_B$, *we get that* $p_{G\gamma}^* \gtreqless p_{Gr}^*$.

Proof. The result follows using the following equation, $p_{G\gamma}^* - p_{Gr}^* = \theta\dfrac{(1 - \gamma)(r - c_B)}{b(4 - \theta^2)}$, and taking into account that the denominator is always positive, and $(1 - \gamma)\theta \geq 0$, the result follows through. ∎

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The combination of lemmas 1 and 2 gives rise to the following proposition:

Proposition 1 *If $r < c_B$, then* $\begin{cases} p_{B,\gamma}^* > p_{B,r}^* \\ p_{G,\gamma}^* < p_{G,r}^* \end{cases}$.

If $r = c_B$, then $\begin{cases} p_{B,\gamma}^* > p_{B,r}^* \\ p_{G,\gamma}^* = p_{G,r}^* \end{cases}$.

If $c_B < r < \bar{r}$, then $\begin{cases} p_{B,\gamma}^* > p_{B,r}^* \\ p_{G,\gamma}^* > p_{G,r}^* \end{cases}$.

If $r = \bar{r}$, then $\begin{cases} p_{B,\gamma}^* = p_{B,r}^* \\ p_{G,\gamma}^* > p_{G,r}^* \end{cases}$.

If $r > \bar{r}$, then $\begin{cases} p_{B,\gamma}^* < p_{B,r}^* \\ p_{G,\gamma}^* > p_{G,r}^* \end{cases}$,

where $\bar{r}$ is defined in lemma 2.

Proof. The first step is to prove that the interval $(c_B , \bar{r})$ is well defined. We get that $\bar{r} - c_B = \dfrac{(2 - \theta^2)a_B - \theta a_G + \theta\gamma c_G}{\gamma(2 - \theta^2)} - c_B$. This difference 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. ∎

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 $(c_B, \bar{r})$. For a reference price above $\bar{r}$, the price of the generic good is reduced, while the price of the branded good increases with respect to the situation where only a copayment system exists. On the other hand, we see that if r is too low (lower than c_B), then it is in the generic producer interest to increase price with respect to the situation with copayments only. Branded good producer's interest is to set a price lower with both systems than with just a copayment system.

The intuition behind this result is given by equations (12), (21) and (22). As shown by (12), we know that the price set by the original firm depends negatively on the copayment in the first situation. However, from equation (21), 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, we see that the increase in price due to higher r is sufficiently high to increase the price over the price under a copayment only when r is sufficiently high. That is, only above this upper bound $\bar{r}$, this effect is stronger than the negative effect that γ has on the equilibrium price.

For the case of the generic producer, this effect is reversed, as shown by equation (22). We have seen that for low values of r, $\dfrac{\partial p^*_{G,r}}{\partial \gamma} < 0$. However, the negative effect that r has on $p^*_{G,r}$ is not strong enough. Hence we obtain that 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 will the original firm have incentives to decrease prices when the reference price system is introduced. However, only for high enough values of r will the generic producer have incentives to decrease his price when the reference price system is implemented. Hence, only for the interval $(c_B, \bar{r})$ will both prices be reduced.

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

Proposition 2 *If $r < c_B$, then* $\begin{cases} q^*_{B,\gamma} > q^*_{B,r} \\ q^*_{G,\gamma} < q^*_{G,r} \end{cases}$.

$\qquad\qquad$ *If $r = c_B$, then* $\begin{cases} q^*_{B,\gamma} = q^*_{B,r} \\ q^*_{G,\gamma} = q^*_{G,r} \end{cases}$.

$\qquad\qquad$ *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 $q^*_{B,\gamma} - q^*_{B,r} = -\dfrac{(2 - \theta^2)(1 - \gamma)(r - c_B)}{b(4 - \theta^2)(1 - \theta^2)}$,

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

The intuition behind this result can be obtained using equations (15), (16), (31) and (32). The analysis is similar in spirit to Proposition 1. For low values of r, the positive effect that r has on the demand for the branded good under a copayment and 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, causing an increase in demand for the branded good with both systems implemented.

For the generic good, the story works in the opposite direction; 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 (32) is stronger and dominates. Hence, we obtain that demand for the generic good is higher under the copayment system only when r is sufficiently high.

We are interested in analysing how the net price paid by the consumer is affected when introducing a reference price system. For this purpose, we want to compare net prices paid under both scenarios for both goods. For the branded good, we know that 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:

$$\gamma p_{B\gamma}^* - (p_{Br}^* - r(1-\gamma)) = 2\frac{(r-c_B)(1-\gamma)}{(4-\theta^2)}. \tag{34}$$

For the generic good, the consumer pays the proportion γ for both scenarios, so we are interested in the difference between $\gamma p_{G\gamma}^*$ and γp_{Gr}^*. This difference is found to be:

$$\gamma p_{G\gamma}^* - \gamma p_{Gr}^* = \theta\frac{(r-c_B)(1-\gamma)}{(4-\theta^2)}. \tag{35}$$

The following proposition summarises equations (34) and (35).

Proposition 3 *For $r < (>)c_B$, we get that the consumer pays a higher (lower) net price for the branded and generic good when the reference price system is implemented.*

Proof. The proof follows by combining equations (34) and (35). ∎

Propositions 1 to 3 can be illustrated in Table 1.

Table 1. 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	+	+	+

It is worth comparing the changes in net prices paid by consumers for branded and generic goods when the reimbursement system is altered. We obtain that

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$$\left[\gamma p^*_{B\gamma} - (p^*_{Br} - r(1-\gamma))\right] - \left[\gamma p^*_{G\gamma} - \gamma p^*_{Gr}\right] = \frac{(r - c_B)(1-\gamma)}{2+\theta} \qquad (36)$$

What equation (36) tries to analyse is how at the end of the day consumers are affected in their decision to decide to buy the branded or generic version. From previous analysis, we know that the net price paid by consumers for either good is lower under copayments for low levels of r. Furthermore, we obtain that for these low values of r ($< c_B$), the change in price for the branded good is lower than the change in price of the generic. However, for reference prices higher than c_B, the reverse occurs so that the change in price for the branded good is higher. Hence, we can say that not only brands' and generics' prices respond qualitatively different, but also quantitatively.

The next step is to compare equilibrium profits for both producers. Results are shown in Table 2.

Table 2. 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	+	+	+

Results shown in Table 2 are obtained using the following procedure. For $r < c_B$, we know from Table 1 that both quantity demanded and price for the branded good are higher under the copayment system. Hence, profits are greater for this producer when the copayment system is implemented. As r is increased, we have seen that eventhough (gross) prices are increased, demand for this good has also increased. Hence, as r starts to increase, these two positive effects reinforce each other, which leads to higher profits for the branded good producer. Note that when $r \in (c_B, \bar{r})$, the sign of $\left(\pi^*_{B,\gamma} - \pi^*_{B,r}\right)$ is ambiguous. This is because we have that the price of the branded good in this region is lower under a reference price system, although quantity demanded is higher. This means that there exists a critical value for r such that both profits are the same.

When $r < c_B$, both the price of the generic good and its quantity demanded are higher when the reference price system is implemented, so that profits for this producer are higher under such system. However, when r is sufficiently high, the generic producer is left worse off. The motivation is as follows. As r starts increasing, the price of the generic version is decreased. However, as exposed before, this producer suffers a reduction in its quantity demanded, so that it has two negative effects moving in the same direction.

Hence, for sufficiently high levels of r, the negative effect of the reference price on prices and quantity is too high, reducing profits and thereby causing the difference in profits between copayments and reference prices for the generic producer to be positive.

Overall, then, as we saw 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 $\bar{r}$. This is so that the increase in demand caused by the reduction in net price that consumers have to pay for this good is large enough to offset the negative effect of the copayment in case 1 on price and quantity demanded for the branded good.

Given that one objective of the implementation of a reference price system is to lower the cost of the health sector, next we check this effect in our model. Before going into the analysis, we have to be precise in defining what the costs would be for the Health Authorities. In case 1, under the copayment system, we have that Health Authorities pay a proportion $(1 - \gamma)$ of the price of both goods; hence we have that the costs of the Authorities in financing the purchase of generic and branded good, respectively, will be $(1 - \gamma)\left(p_{G\gamma}^* q_{G\gamma}^*\right)$ (defined as $TC_{G\gamma}^{govt}$) and $(1 - \gamma)\left(p_{B\gamma}^* q_{B\gamma}^*\right)$ $(\equiv TC_{B\gamma}^{govt})$. When the reference price system is implemented, this proportion is left unchanged for the generic good (but this time is defined as TC_{Gr}^{govt}); however, the amount that health authorities will finance now for the branded good will be equal to $(1 - \gamma)\left(r q_{Br}^*\right)$ $(\equiv TC_{Br}^{govt})$. Table 3 summarises these findings.

Table 3 Comparing Total Costs for Health Authorities.

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

Health Authorities will be better off in financing generics under a reference price system in the interval where reference prices increases price competition $(r \in (c_B, \bar{r}))$. However, we get an ambiguous sign for the branded good. Hence, when r is sufficiently high $(r > c_B)$, we see that two opposing effects arise. On the one hand, total costs for the generic good will be higher under the copayment system, although costs for the branded good will be higher under the reference price system. This is 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.

5 Conclusion & Future Research.

The aim of this paper has been to analyse theoretically the response of pharmaceutical firms to the implementation of a reference price system. We have studied the mechanism that is being used in Spain. For this purpose, using a differentiated duopoly model, we have compared the following situations; in the first case, we have that consumers pay a fixed copayment (γ) irrespectively of what drug they buy, 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 still has to pay the copayment γ. But, if he decides to buy the branded good, he has to pay the proportion γ of the reference price r, plus the difference between the price of the branded good and r.

We have seen that the introduction of such reference price system will effectively reduce prices if it is set neither too high nor too low. This is because the reference price affects the generic and branded good producer differently. It makes the latter increase its price, while the opposite effect appears for the former. If r is set too low, then the price of the generic good will be higher with the introduction of such r, while if it is set too high, then the price of the branded good will be set too high. This has some implications regarding the net price paid by consumers. We have seen that for both goods, introducing a reference price system allows them to pay less for them. This effect is important for the branded good producer, since we obtain that demand for the branded good is higher under such system. However, the opposite occurs for the generic producer, since now it faces a lower demand (recall that we are considering r sufficiently high). Differences in profits between both cases move in opposite directions for both producers. The branded good producer benefits for a reference price high enough, although the generic producer suffers and sees her profits being reduced.

We know that one of the objectives of implementing a reference price system is to reduce the pharmaceutical bill. Results show that the higher is 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.

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.

A natural extension would be to try to obtain empirical estimates of the critical bounds of the interval. However, obtaining these critical bounds might be problematic empirically if they depend on parameters that are not

easily observable. Moreover, a further question should be addressed, and this implies going one step ahead: what are the effects on R&D when reference prices are implemented? Until now, I have not seen any answers; nevertheless, I hope that my future work enables me to shed some light to this unresolved question.

References

[1] Danzon, P. and Liu, H. (1997), "Reference Pricing and Physician Drug Budgets: The German Experience in Controlling Pharmaceutical Expenditures", Working Paper, Philadelphia: The Wharton School.

[2] Johnston, M. and Zeckhauser, R. (1991), "The Australian Pharmaceutical Subsidy Gambit: Transmuting Deadweight Loss and Oligopoly Rents to Consumer Surplus", Working Paper No. 3783, NBER.

[3] Hudson, J. (2000), "Generic take-up in the Pharmaceutical market Following Patent Expiry. A Multi Country Study", International Review of Law and Economics, 20, pp. 205-221.

[4] Lopez-Casanovas, G. and Puig-Junoy, J. (1999), "Review of the Literature on Reference Pricing", Research Center for Health and Economics.

[5] Mestre-Ferrándiz, J. (1999a), "Relación entre un Sistema de Precios de Referencia y Medicamentos Genéricos", Hacienda Pública Española, 150, pp. 173-79.

[6] Mestre Ferrándiz, J. (1999b), "The Impact of Generic Goods in the Pharmaceutical Industry", Health Economics, 8, pp. 599-612.

[7] Mestre Ferrándiz, J. (2000), "The Effect of Implementing a Reference Price System in the Pharmaceutical Industry", mimeo UAB.

[8] Singh, A. and Vives, X. (1984), "Price and Quantity Competition in a Differentiated Duopoly", RAND Journal of Economics, 15(4), pp. 546-54.

[9] Woodfield, A., Fountain, J. and Borren, P. (1997), "Money and Medicines. An Economic Analysis of Reference Pricing and Related Public-Sector Cost-Containment Systems for Pharmaceuticals with Special Reference to New Zealand", Merck Sharp & Dome, New Zealand.

[10] Zweifel, P. and Crivelly, L. (1996), "Price Regulation of Drugs: Lessons from Germany", Journal of Regulatory Economics, 10, pp. 257-73.