Essays on the Pharmaceutical Industry

A thesis presented

by

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to

The Department d'Economia i d'Història Econòmica

in partial fulfillment of the requirements

for the degree of

Doctor of Economics

under the supervision of

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Universidad Autònoma de Barcelona

Bellaterra, September 2001

Acknowledgments

I want to thank Xavier Martínez for his continuous support and encouragement. The different parts of this Thesis have benefited from comments and suggestions of many people. In particular, I would like to mention Pedro Barros, David Pérez-Castrillo, Nicolás Porteiro and Jaume Puig, and those people involved in the Informal Workshops on Industrial Economics held in the Department d'Economia i Historia Econòmica at Universitat Autonoma de Barcelona. Also, I want to express my gratitude to those classmates that were by my side when I needed them. The articles of this thesis have also benefitted from the comments of the participants of various international conferences. My family deserves a special acknowledgment. Finally, this Thesis could not have been done without the support of Marian. Thanks for being there at all times.

Contents

Preface

The pharmaceutical industry has been for many years, and will still be for long, under observation from many economic agents. There are two reasons for this. First is the nature of the goods produced: ethical drugs. Second is the role played by Health Authorities. Furthermore, the importance that R&D plays in this industry is vital for the discovery of new drugs. One very important feature of this industry is the famous trilogy: the one who decides neither pays nor consumes, the one who pays neither decides nor consumes, and the one who consumes neither decides nor pays. Hence, many agents have an active role in this sector, but more importantly, the objectives of these usually do not coincide. Consumers want better drugs at accessible prices, Health Authorities want to reduce health expenditures on ethical drugs but at the same time they have to ensure that the drugs available are sufficient and efficient, while pharmaceutical firms need enough profits to ensure a constant flow of new, but more importantly, better drugs on the market.

The aim of this thesis is to try to give some economic analysis on pharmaceutical issues. While conducting my research, I observed that most analysis of this industry were descriptive and empirical, and found that there was a lack of economic theory to explain the data. Hence, the objective of this research is clear: using industrial economics theoretical models, I wanted to explain the functioning of this industry in order to give a formal economic explanation for some results. For this purpose, I concentrated on two aspects of the pharmaceutical industry. In the first section, which includes Chapters 1 and 2, I focused on explaining the effects of implementing a reference price (RP) system, and the response

of pharmaceutical firms to a change in the price regulation these firms face. The analysis will focus on both short (prices) and long term (R&D decisions) issues. In the second section, which includes Chapter 3, the focus is on the so-called “branded generics”. I aim to explain why branded good producers also tend to produce a generic version of their original drug once the patent for the original good expires. Throughout the whole thesis, we will consider the existence of generic drugs. During the last years, these drugs have become increasingly important in the pharmaceutical industry, as explained later. To give an example that illustrates their importance, generics’ share can be upto 50% of total market share in the US.

A reference price reimbursement system categorises products into groups with similar therapeutic effects so that the reference price is the maximum reimbursement of the third-party payer to the manufacturers for all products in that group. Manufacturers are free to set prices. If prices set are higher than the reference price, it is the consumer who pays the difference. In relation to the trilogy mentioned above, such system tries to give some responsibility to patients, increasing their consciousness about costs, and providing them incentives. The objective of this system is twofold: first, it is believed that implementing a RP system encourages price competition, and second, with this increased price competition, expenditure of Health Authorities in ethical drugs will be reduced. Hence, implicitly, what this system is trying to do is to reduce the differences in incentives of the economic agents involved, as expressed in the above trilogy. However, the view of the pharmaceutical firms is that the introduction of such system will make them worse off due to lower profits, which will reduce their incentives to carry out R&D. Note the importance

of the relation between reference prices and the existence of generic (cheaper) products. Generic goods are those goods that enter the market when the patent on the active ingredient of the original, branded, ethical drug has expired. Their main characteristic is that they are sold without a brand, and as a result are usually cheaper than the already established, branded, medicine. In all but few cases, these generics are certified by the respective Health Authorities to be perfect substitutes to the branded good since their active ingredient is identical. Furthermore, they are bioequivalent in the sense of being statistically indistinguishable from the established product in key aspects of therapeutic use. However, they could vary in characteristics such as shape, colour, packaging and labelling. Taking into account the fact that not all consumers switch immediately to generics gives support to the idea of both goods not being perfect substitutes. A necessary condition for an efficient implementation of a reference price system is a well-developed generic market. The reason for this is that the reference price is usually set around the price of the cheapest goods available. Should a generic good exist, it would normally have the lowest prices. However, the existence of such market is not a sufficient condition for an efficient implementation of such system, as more detailed described in Mestre-Ferrándiz (1999a). Broadly speaking, reference prices are aiming to reduce prices, so such system should be implemented in markets where the high pharmaceutical public expenditure was due to high average prices rather than due to high consumption levels. Moreover, the price difference between the drugs grouped should be significant; otherwise, the potential cost-savings of implementing a reference price system will be minimal.

RPs have been implemented in many developed countries, the first one being Germany in 1989. From then on, many other countries followed Germany, and recently, Spain has also introduced it. Notice that the way RP have been implemented in each country has not been universal, so we will analyse two different possibilities of introducing such system. I believe that the analysis conducted in this thesis regarding the effects of reference prices is important due to the lack of theoretical research about this important topic. Chapters 1 and 2 give some formal economic analysis on these issues.

The effects of implementing a reference price system will be analysed in two steps. The reason for this is to try to take into account the nature of the pharmaceutical industry, and the importance of R&D. Hence, and broadly speaking, we can say that Chapter 1 will focus on short-run decisions (prices, quantities), while Chapter 2 will focus on long-term variables (R&D). More specifically, in Chapter 1, we concentrate on what will be the effects price-wise of implementing a reference price system, compared to the situation with copayments. We will have a duopoly setting, with a branded and a generic good. We will consider two possible scenarios. In each scenario, we compare the outcomes between two forms of demand structures. Broadly speaking, the aim is to examine the differences between a situation where consumers pay a fixed proportion of the price (copayments) with a situation where RP exist. The difference between the two scenarios is that in the first scenario, under copayments, the consumer pays the full price i.e. the copayment is equal to one. Under reference prices, consumers will have to pay the difference between the price of the good and this reference price. This model implies that the reference price set is below the price of both the branded and the generic good. The second scenario

analysed will compare the case where, under copayments, consumers pay a percentage of the price (i.e. do not have to pay the full price anymore) with reference prices. In this setting, reference prices will be modelled as the way they have been introduced in Spain. This case implies that the reference price is set higher than the price of the generic good but lower than the price of the branded. Hence, if the consumer buys the branded good, the net price paid by the consumer will be equal to the difference between the price of the branded good and the reference price, plus the same copayment as before associated this time to the reference price. If the consumer decides to buy the generic good, then (s)he would have to pay the same copayment as before the implementation of reference prices. Furthermore, we analyse how firms' profits and expenditure of Health Authorities vary accordingly. As mentioned before, how the reference price has been set has not been universal. Finding the optimal reference price is beyond the scope of this thesis, although future research will be focusing in this issue. For this purpose, we have constructed two scenarios to take into account two possibilities that we observe in countries with such systems: setting the reference price below or above the price of the price of the generic drug (but never above the price of the branded good).

The main result of the first case analysed is that prices are higher under reference prices, as well as total costs of the system, although reference prices are welfare enhancing. The net price paid by consumers is reduced under such system. The intuition is that we have compared a situation where consumers initially pay the full price with a situation where Health Authorities finance upto the reference price. Moreover, the reference price

set in this way acts as a subsidy for the producers. Summarising, what we obtain is that consumers buy more, but at a cheaper price.

When reference prices are implemented in the Spanish way, and we allow that under copayments, Health Authorities finance a proportion of the price of both goods, we show that prices and pharmaceutical costs are reduced under reference prices 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.

Chapter 2 complements Chapter 1, since it provides insights on firms' long-run decision (R&D). The aim of this chapter is to analyse how pharmaceutical firms' decision to innovate are affected by such RP system. We compare a situation with copayments with the situation where reference prices are introduced in the Spanish way (i.e. we adapt the demand function of case 2 of Chapter 1). The importance of this chapter arises due to the type of competition we are observing in this industry. Firms also compete through product innovation, as well as in prices. This is due to the regulatory measures that many developed countries have in order to control for the prices of ethical drugs. The idea of this chapter is to model explicitly the decision of the firms undertaking R&D (the branded good producers), and see how this decision is affected by the introduction of reference prices instead of copayments. The model will incorporate the two type of goods that can arise after investing resources in R&D: breakthrough or me-too drugs. The former refers to very innovative drugs, and usually imply spending sufficiently high level of resources. The latter, however, involves less resources, although they are considered to be improvements of existing drugs.

What we observe is that breakthrough drugs create a new market, while me-too drugs will have to compete with existing branded drugs and generics, if they exist. We will have a mature market, where the initial situation involves both a branded and a generic good. We examine the incentives that the incumbent has to become multiproduct i.e. we want to analyse whether and when will the incumbent have higher incentives to produce a breakthrough drug, a me-too drug, or substitute the old drug by the new one under reference prices or copayments. The idea is that the higher the resources spent on R&D, the more differentiated the new product will be with respect to the existing ones.

Results show that the decision of what type of new drug to produce is affected by changing a copayment system to a reference price system. When the incumbent firm produces a breakthrough drug, profits for the incumbent might be reduced if the latter system is introduced. This is because implementing a reference price system can achieve price reductions, but also demand reduction for the branded goods; hence, profits are reduced and the branded good producer is left worse off under reference prices than under copayments. The story is similar when the incumbent firm produces a me-too drug. Substitution of the old drug by the new one can also occur whenever the potential demand for the new drug is sufficiently high. If this is not the case, the incumbent firm will prefer to have both goods in the market, sharing revenues, rather than concentrating sales on one drug (the new one). Finally, results show that there is no clear-cut relationship between profits earned by the incumbent firm when producing either the breakthrough or the me-too drug, irrespectively of the price regulation system. However, we can say that it seems that production of

a breakthrough drug is more probable the lower the R&D cost of this drug with respect to the me-too, and the lower the degree of market power that the incumbent firm has.

These two chapters are important because they offer a formal explanation of various empirical results. Pavcnik (2000) shows the effects of implementing reference prices in Germany, and demonstrates that pharmaceutical firms respond to them. She shows that producers significantly reduce prices after the reference price system was implemented, and moreover, branded producers that face more generic competition reduce prices more. As Pavcnik mentions, this shows that "the relevant competition in the pharmaceutical market occurs between generics and the brand name version of the same active ingredient rather than across products that are therapeutic substitutes" (Pavcnik (2000), page 20). She also shows that branded and generic producers respond differently quantitative and qualitatively. Results of Chapters 2 and 3 of this thesis give the theoretical conditions under which this decrease in prices can be achieved. As with respect to the different incentives for R&D, Chapter 3 is the first paper that analyses explicitly the R&D decision given that either copayments or reference prices are enforced. As Pavcnik mentions in her paper, future research has to identify this trade off between lower prices and R&D investment; this is a first step to analyse formally this trade off.

Section 2, which includes Chapter 3 (published in Health Economics-Mestre-Ferrandiz (1999b)), gives an economic intuition to a process we have been observing during the last years in the pharmaceutical industry. Branded good producers, once the patent for the active ingredient has expired, also enter the generic market producing their own generic alternative. It is hence like a process of cannibalising their own consumers by producing a

drug that can potentially be competing directly with the original good. The idea behind this observation is that the incumbent firm can take advantage of the so called first-mover advantages that exist in the generic market. Hence, since the original firm knows that generics will enter the market, it is in his own interest to be the first one in that market, and produce the so-called “branded-generics”. This paper gives fuel to the Roche-Bolar case, since we find that if the branded good producer produces its generic alternative, rather than another firm specialised in the production of generics, prices can be higher, and consumer surplus can be reduced. The idea underlying the Roche-Bolar case is allowing generic producers to carry out research about the (branded) ethical drug before the patent expires, so that the time lag between the patent expiration and the introduction of these independent generic producers is minimised.

In this chapter, we will have the market segmented. On the one hand, we will have the so-called “loyal” customers, whose demand for the branded good is unaffected by the existence of generics. On the other, the “sensitive” consumers may buy the generic good. These consumers see both the branded and the generic good as (imperfect) substitutes. We find that the firm producing the branded good has incentives to produce its own generic alternative, owing to this market segmentation effect. This induces an increase in the price of the branded good, which in turn, results in a welfare reduction. Hence, it is as if the incumbent firm is price discriminating between consumers. The branded-good seller prefers to increase the price in the loyal segment and produce its own generic version for the price-sensitive customers rather than reducing the price of the branded good to these sensitive consumers.

We believe that it is worth mentioning in this preface the kind of model that will be used throughout the entire thesis to differentiate between the branded and the generic good. We will assume that there exists a degree of horizontal differentiation between both goods. We mentioned before that from the Health Authorities point of view, both kinds of goods are perfect substitutes, although from the consumers' point of view, it has been shown that this is not the case. Hence, we need to differentiate the two goods. Generic goods have gone through safety tests to enter the market, so we believe that quality issues here are not important. The idea with these drugs is that since they have the same active ingredient as the branded good, the differences between the two goods are the excipients and side effects although statistically they behave similarly. With these kind of horizontal differentiated models, we could obtain that out of equilibrium, the price of the generic could be higher than the price of the branded good. Not only we observe circumstances where the price of the former is higher (although rare), but also we could argue that the side effects, or excipients, of the generic good may be preferred by some consumers, so that there would exist a demand for such good eventhough the price was higher. Hence, we can treat the measure of differentiation between both goods as the difference in side effects and/or excipients. If both goods are very differentiated (similar), it would imply that the side effects or the excipients are very different (alike). However, the actual process of curing the sickness is identical.

It is also important to mention that we will assume that there exists a perfect agency relationship between the physician and the patient. Hence, the demand functions that we obtain for the analysis that follows result from the problem of the physician maximising the

utility of the patient, which are identical as the ones that would be obtain if the consumer decides.

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Chapter 1

The Effects of Implementing a Reference Price System in the Pharmaceutical Industry

1.1 Introduction.

Prescription drugs and the pharmaceutical industry play a very important role in health economics. Drug therapies have usually supplemented medical care, nutrition and sanitation as methods for preserving health. However, during the last decades, both budgetary problems and rising health care expenditures have led countries to implement cost containment policies in the health sector. As an example, health care represented, in 1997, 6.7% of GDP for the U.K., 8.5% for Netherlands, 10.4% in Germany and 14% in the U.S. (PhRMA 1999). For the case of Spain, it represented 6.2% in 1995 (Murillo 1998). For pharmaceuticals its share represents the 0.9% of GDP in Netherlands, 1.1% in the U.S., 1.2% in the U.K. and 1.3% in Germany (PhRMA 1999). In Spain, cost of pharmaceuticals represent 18% of total health costs (Murillo 1998), which corresponds to 1.1% of GDP. Drugs are widely used to treat many diseases and conditions, and usually either represent alternatives to more invasive surgical procedures, or are used in conjunction with these treatments. Despite these successes, the pharmaceutical industry has come under intensive medic and legislative scrutiny. Furthermore, most industrialised countries are targeting the pharmaceutical sector as a preferred area for cost-containment. One of the reasons is the fact that for example, in the US, pharmaceutical firms are among the largest and most profitable.

As shown in Table 26.1 pp. 585 in Folland et al. (2001), two pharmaceutical companies ranked in the top 10 firms in 1999, and another seven appeared in the top 50, where firms are ranked by market value. One component which is seen as specially attractive is the cost of ethical drugs. Furthermore, the appropriate use of pharmaceuticals is a critical component of any health system. Hence, what governments are aiming for is to reduce costs of pharmaceuticals maintaining broad access and ensuring high quality drugs. To achieve this goal governments have imposed a variety of controls and regulations.

These regulations can be directed at either the supply of medicines (manufacturers) or at its demand (wholesalers, retailers, doctors and patients). Broadly speaking, they fall into four general categories:

1. Price controls (e.g. reference prices, generic substitution).
2. Volume controls (e.g. positive/negative lists, formularies).
3. Spending controls (e.g. profit controls, physician health care budgets).
4. Controls on barriers to entry (e.g. patents, approval procedures).

This article is devoted to the analysis of price-controls affecting both the supply and the demand side. Specifically, I want to analyse the impact of implementing a reference price system coupled with the existence of generic drugs. It is important to consider the two regulatory schemes together, since a reference price system usually comes together with the promotion of generic drugs.

Before going into the analysis of the relationship between these two price controls, one should try to understand the functioning of the health care market, and more precisely, the market for ethical drugs. This market is subject to the famous trilogy: the one who

decides neither pays nor consumes, the one who consumes neither pays nor decides, and the one who pays neither consumes nor decides. Information plays a very important role. Physicians should be properly informed, since they transmit information to their patients. Hellerstein (1998) shows the importance of the physician in prescription patterns.

A reference price reimbursement system categorises products into groups with similar therapeutic effects[1] so that the reference price system is the maximum reimbursement of the third-party payer to the manufacturers for all products in that group. Notice that manufacturers are free to set prices. If the prices they set are actually higher than the reference price, it is the consumer who pays the difference. In relation to the trilogy mentioned in the previous paragraph, a system of reference prices could be understood as a mechanism that tries to give some responsibility to patients, augmenting their consciousness about costs, providing them an economic incentive (Mestre Ferrándiz 1999b).

A generic drug is one that is sold under a generic denomination, once the branded good has lost its patent over the active ingredient. Usually, the branded good is sold with a fantasy name, which in itself does not mean anything, although it identifies the product that is sold by the firm. The main characteristic of generic drugs is that they can cost up to a 50% less than the branded good, so their promotion arises mainly due to a public health cost-containment concern. Moreover, these drugs are certified by the respective health authorities to be perfect substitutes to the branded good in that their active ingredient is identical. Furthermore, they are bioequivalent in the sense of being statistically indistinguishable from the established product in key aspects of therapeutic use. However,

[1] There can be three different ways to categorise drugs: same active ingredient, comparable active ingredients and comparable therapeutic effect.

consumers do not switch immediately to generics when they appear, which gives support to the idea of both goods not being perfect substitutes from the consumer's point of view. Not only this, but empirical results (see Mestre Ferrándiz (1999a) for references) show that rather than observing convergent prices for branded and generic drugs, we are observing the gap widening with the introduction of the latter. Briefly, Frank and Salkever (1997) conducted a study for 32 drugs whose patent had expired and generic alternatives were already in the market. They showed that branded prices had increased after generic entry. Furthermore, Grabowsky and Vernon (1992) obtain a similar result when analysing 18 high-sales volume pharmaceutical products that were subject to generic competition. This result was expressed by Scherer (1993) as the Generic Competition Paradox.

It has been argued that the main impediments for generic penetration seem to come from the demand side, rather than the supply side. Very briefly, these arise, firstly, due to the accumulated goodwill of branded producers. Secondly, the role of pharmacists in dispensing a generic or an original brand is also very important. This is related to the laws governing the possibility of substituting drugs once the physician has prescribed the drug and a generic is available. Supply side entry barriers are considerable lower for generic drugs than for new product developments. The interested reader will find a more detailed explanation of these barriers to entry in Mestre Ferrándiz (1999a).

What is then the link of a reference price system with the introduction of generic drugs? One of the requisites of an efficient implementation of a reference price system is a developed generic market. When the maximum reimbursement price is set (i.e. the reference price), this price usually coincides with the lowest price of the equivalent products

in the group. Hence, when generic drugs exist, these usually have the lowest prices, so that the natural reference price to set would be around this price.

This relation is important and should be analysed in order to see what are the likely effects of implementing such a system. A reference price system has been implemented in 12 countries up to date. The system has been used in Germany since 1989, in Holland from 1991 and in Sweden, Denmark and Norway since 1993. Furthermore, it was introduced in Australia and New Zealand in 1998. In Spain, it will be introduced for 50 drugs around December 2000. To illustrate the importance of the relation between reference prices and generics, notice that in Australia and New Zealand the price set corresponds to the lowest price for each group. In Denmark, the reference price is set as the mean of the two cheapest products, and in Sweden, the price is set 10% above the cheapest good. It should be noted that most of these countries have in common that the market for generics is highly developed[2]. What are then the main objectives of such a system? Countries implementing this system aim to increase price competition and ultimately, reduce health costs. Theoretically, the first effect could be achieved by giving economic incentives to consumers, which would result in pressuring the prescriber in his/her therapeutic decision towards a more efficient outcome, both socially and individually. Hence, one could expect, in principle, pharmaceutical companies' prices approaching the reference price to maintain their market share. With respect to the contention of costs, these could be achieved thanks to lower unitary costs. However, casual empiricism suggests that in those countries where such a system has been implemented, prices of those drugs included in the system have been reduced, al-

[2] Note that in 1996/1997, the share of the sales of generic medicines by value in Germany was 39%, in Denmark 38%, in Holland 13% and in Sweden it was 4%. For more figures, see N.E.R.A. (1999).

though this system by itself has not been able to reduce public costs in pharmaceuticals. For a more detailed explanation, see Mestre Ferrándiz (1999b).

It must be said that most of the reference price literature is mainly descriptive (Lopez-Casanovas and Puig-Junoy (1999)). Few papers have tried to model theoretically the impact of implementing such a system. 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.

The aim of this paper is to model the effect of implementing a reference price system, once a generic drug already exists in the market, and see what will be the response of pharmaceutical firms to this change. Furthermore, we are interested in analysing whether such system actually reduces prices, and ultimately, whether or not public costs in pharmaceuticals are reduced.

We will analyse the effect of implementing reference prices in two ways. The supply side of the market will be the same for both cases: we will have a branded good producer, and a generic one, with a degree of differentiation between both goods. More details about the market structure considered here are found below. The first way will be to study how the introduction of a subsidy equivalent to the reference price affects firms' decisions. The idea here is to exclude any other form of public intervention, and concentrate purely on the effects of such regulatory procedure. It is as if in the initial situation, Health Authorities do not finance any part of the price paid by consumers, and then they finance upto the reference price. Moreover, it is implicitly assumed that the reference price will be set below the price of the branded and the generic good. The results obtained in this scenario show that when reference prices are set in this way, total costs of the system are increased, although the situation with reference prices is welfare enhancing. The idea behind this result is that we are comparing a situation where consumers pay the full price with the situation where Health Authorities finance upto the reference price. Hence, we have that consumers will end up buying more, but at a cheaper price.

The second case will include in the two possible subcases the possibility of Health Authorities financing part of the price. The difference between the two possible cases that we want to compare is that in the initial situation, there exists a partial public subsidy of the price of the ethical drug (in this case, we will have that Health Authorities finance a fixed percentage (copayment) of the price). The implementation of a reference price system alters the copayment paid by the consumer in the following manner: if the consumer decides to buy the branded good, then (s)he pays the sum of two elements; on the one

hand, pays the same copayments as before, but this time associated to the reference price, and on the other, the difference between the price set by the firm producing this good and the reference price. If however, the consumer decides to buy the generic version, then (s)he pays the same copayments as before. Hence, another difference between the two cases is that in this situation, the (exogenous) reference price implemented will be higher than the generic price, but lower than the branded's one. Notice that the implementation of reference prices in the various countries mentioned above has not been universal; for exposition purposes, we have used the way that they have been implemented in Spain.

Summarising, and in order to clarify the main difference between the two cases we will analyse here, we have that in the first case, the copayment that consumers pay in the first situation is one i.e. they pay the full price. The implementation of a reference price system in this scenario implies now that the copayment that consumers have to pay is the difference between the price of either of the drugs and the reference price. In the second case, we have that in the original situation, consumers pay a proportion of the price, irrespectively of which good they buy i.e. the copayment is between 0 and 1. In the new situation, with reference prices, the consumer who buys the branded good pays the same copayment as before, but this time associated to the reference price plus the difference between the price of the branded good and the generic. The consumers who purchase the generic good pay the same proportion, or copayment of the price set by the generic producer. Table 1 summarises the differences between the net price paid by the consumer in both cases.

Table 1. Differences in net price paid by consumers.

$Net\ price\ paid$	CASE 1	CASE 1	CASE 2	CASE 2
	$COPAYS$	RP	$COPAYS$	RP
Branded	p_{1B}^C	$p_{1B}^{RP} - r_1$	γp_{2B}^C	$\gamma r_2 + p_{2B}^{RP} - r_2$
Generic	p_{1G}^C	$p_{1G}^{RP} - r_1$	γp_{2G}^C	γp_{2G}^{RP}

where p_{ti}^C, $t = 1, 2$, $i = B, G$, stands for the price set by the branded and generic good producer respectively, when no reference prices are implemented, p_{ti}^{RP}, $t = 1, 2$, $i = B, G$, stands for the price set by the branded and generic good producer when reference prices are implemented, and $t = 1$ and 2 refer to the first case and second case analysed respectively. Furthermore, $\gamma \in (0, 1]$ is the copayment, r_1 is the exogenous reference price set by Health Authorities in case 1 and r_2 is the reference price set by Health Authorities in case 2. Note that the implicit assumptions in the model are that p_{1B}^C and p_{1G}^C are higher than r_1, $p_{2B}^{RP} > r_2$ and $p_{2G}^{RP} < r_2$.

1.2 The Model.

We will have in both cases a duopoly setting where firms act non-cooperatively. Firms will choose prices simultaneously. The demand side is a simplified version of Singh and Vives (1984), but taking into account that in every situation in both cases the net price paid by the consumer for each good is different. There is a continuum of consumers of the same type. The representative consumer maximises

$$U(q_i, q_j) - \sum_{i}^{B,G} \hat{p}_i, \tag{1}$$

where $i, j = B, G$, $i \neq j$, q_i is the amount of good i and $\hat{p}_i$ is the net price paid by the consumer for this good. Recall Table 1 to see the exact definition of $\hat{p}_i$. $U(q_i, q_j)$ is

assumed to be quadratic and strictly concave as

$$U(q_i, q_j) = a_B q_B + a_G q_G - \frac{b}{2}\left(q_B^2 + q_G^2 + 2\theta q_B q_G\right). \tag{2}$$

The parameter $\theta \in (0, 1)$ represents the degree of differentiation between the branded and generic good. 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). Moreover, $a_B, a_G, b > 0,$ This utility function gives rise to the following inverse linear demand systems:

$$\hat{p}_i = a_i - bq_i - b\theta q_j.$$

Since firms choose prices, we have to inverse the inverse demand functions to obtain the demand system:

$$q_i = \frac{a_i - \theta a_j}{b(1-\theta^2)} - \frac{\hat{p}_i}{b(1-\theta^2)} + \theta\frac{\hat{p}_j}{b(1-\theta^2)}.$$

Assuming linear cost functions, and that there are no fixed costs, we have that following profit functions for both firms:

$$\begin{aligned} \pi_B &= (p_B - c_B)\, q_B, \\ \pi_G &= (p_G - c_G)\, q_G. \end{aligned}$$

We need to impose some restrictions on the parameters to have a well defined system of non-negative equilibrium values, and to incorporate the characteristics of the pharmaceutical industry.

Assumption 1. $a_i \geq c_i$. This ensures non-negative profits.

Assumption 2. $a_B \geq a_G$. In words, we have that the market size for the branded good is greater than the market size of the generic drug.

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, in order to reflect what we observe in practice.

This will be the common setting for both cases. As mentioned before, firms will choose prices simultaneously. Let us consider now each case.

1.3 Case 1.

When consumers have to pay the full price, the demand functions faced by the branded and generic good producer, are, respectively:

$$q_{BNR} = \frac{(a_B - \theta a_G)}{b(1-\theta^2)} - \frac{1}{b(1-\theta^2)} p_{BNR} + \frac{\theta}{b(1-\theta^2)} p_{GNR}, \tag{1.3}$$

$$q_{GNR} = \frac{(a_G - \theta a_B)}{b(1-\theta^2)} - \frac{1}{b(1-\theta^2)} p_{GNR} + \frac{\theta}{b(1-\theta^2)} p_{BNR}, \tag{1.4}$$

where the subscripts B, G represent the branded and the generic producer respectively, NR stands for the case where there is no reference price system, and $\theta \in [0, 1)$ represents the degree of differentiation between both goods[3].

When we impose a reference price system, the demand functions are as follows:

[3] Notice that demand functions are not defined when $\theta = 1$.

$$q_{BR} = \frac{(a_B - \theta a_G)}{b(1-\theta^2)} - \frac{1}{b(1-\theta^2)}(p_{BR} - r) + \frac{\theta}{b(1-\theta^2)}(p_{GR} - r), \quad (1.5)$$

$$q_{GR} = \frac{(a_G - \theta a_B)}{b(1-\theta^2)} - \frac{1}{b(1-\theta^2)}(p_{GR} - r) + \frac{\theta}{b(1-\theta^2)}(p_{BR} - r), \quad (1.6)$$

where $r > 0$ is the reference price, and the subscript R stands for the scenario with reference prices. We will have that both firms move simultaneously. Before solving the model, we make the following assumptions.

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

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

These assumptions are sufficient conditions to ensure non-negative equilibrium values.

The Nash equilibrium prices of this game are

$$p^*_{BNR} = \frac{\left(2-\theta^2\right)a_B - \theta a_G + (2c_B + \theta c_G)}{\left(4-\theta^2\right)}, \quad (1.7)$$

$$p^*_{GNR} = \frac{\left(2-\theta^2\right)a_G - \theta a_B + (2c_G + \theta c_B)}{\left(4-\theta^2\right)}. \quad (1.8)$$

Under reference prices, we obtain:

$$p^*_{BR} = \frac{\left(2-\theta^2\right)a_B - \theta a_G + (2c_B + \theta c_G) + r(2-\theta-\theta^2)}{\left(4-\theta^2\right)}, \quad (1.9)$$

$$p^*_{GR} = \frac{\left(2-\theta^2\right)a_G - \theta a_B + (2c_G + \theta c_B) + r(2-\theta-\theta^2)}{\left(4-\theta^2\right)}. \quad (1.10)$$

Notice that from (1.9) and (1.10), we obtain that $\frac{\partial p^*_{iR}}{\partial r} > 0, \forall\, i = B, G$. Hence, the higher is r, the higher will be the prices set by both firms. Furthermore, we have that the

effect of changing r has the same effect on both the price of the branded and the generic good, due to the simultaneity of the game considered here.

We want to compare equilibrium values within and between scenarios. With the assumptions made previously about the size of both markets and the difference between marginal costs, we obtain the results shown in lemma1.

Lemma 1 *If $a_B \geq a_G$ and $c_B \geq c_G$, then $p^*_{BNR} \geq p^*_{GNR}$ and $p^*_{BR} \geq p^*_{GR}$ (with a strict inequality if $a_B > a_G$ and/or $c_B > c_G$).*

Proof. We have that $p^*_{BNR} - p^*_{GNR} = p^*_{BR} - p^*_{GR} = \dfrac{(1+\theta)(a_B - a_G) + (c_B - c_G)}{(2+\theta)}$. With the above assumptions, since the denominator is always positive, the numerator will always be greater or equal than zero. ■

This result tells us that generic goods will be cheaper than branded goods, which is consistent with what we observe in reality. Hence, an explanation for this result follows from the fact that the difference in price between these two goods arises because of the difference in market size and marginal cost.

Now, we are interested in the comparison between the cases with and without reference prices i.e. comparisons between scenarios. We want to see what will be the response price-wise of firms when the reference price system is implemented. Lemma 2 shows the result.

Lemma 2 *For any strictly positive reference price r, we find that $p^*_{BR} > p^*_{BNR}$ and $p^*_{GR} > p^*_{GNR}$.*

Proof. We get that $p^*_{BR} - p^*_{BNR} = p^*_{GR} - p^*_{GNR} = \frac{(1-\theta)}{(2-\theta)}r > 0, \forall r > 0$. Since $\theta \in [0, 1)$, it implies that the numerator and the denominator are always positive, hence the result follows. ■

Hence, for whatever reference price the government chooses, prices for both goods will be higher when the reference price system is implemented compared to the situation where firms face no such system. The intuition behind this result is that in this setting, the reference price plays a similar role to the introduction of a subsidy equivalent to this price.

The next step involves evaluating equilibrium quantities. Substituting equilibrium prices into the demand functions ((1.3) to (1.6)), we obtain the associated equilibrium quantities with no reference prices:

$$q^*_{BNR} = \frac{(2-\theta^2)(a_B - c_B) - \theta\,(a_G - c_G)}{b\left(\theta^2 - 4\right)\left(\theta^2 - 1\right)}, \tag{1.11}$$

$$q^*_{GNR} = \frac{(2-\theta^2)(a_G - c_G) - \theta\,(a_B - c_B)}{b\left(\theta^2 - 4\right)\left(\theta^2 - 1\right)}. \tag{1.12}$$

Of course, we have to impose the non-negativity of equilibrium quantities. Sufficient conditions for quantities to be non-negative are given by Assumptions 4 and 5. Note that Assumption 5 ensures that q^*_{GNR} is non-negative, and that combining this assumption with Assumption 4 ensures that q^*_{BNR} is also non-negative. For the case under reference prices, we obtain the following equilibrium quantities for the branded and generic good respectively:

$$q^*_{BR} = \frac{(2-\theta^2)(a_B - c_B) - \theta\,(a_G - c_G) + r(2-\theta-\theta^2)}{b\left(\theta^2-4\right)\left(\theta^2-1\right)}, \tag{1.13}$$

$$q^*_{GR} = \frac{2a_G + \theta a_B + b\left[\theta c_B - (2-\theta^2)c_G + r(2-\theta-\theta^2)\right]}{b\left(\theta^2-4\right)\left(\theta^2-1\right)}. \tag{1.14}$$

Note that Assumptions 4 and 5 imply that these two quantities will be positive too. This is because for both equations (1.13) and (1.14), there is an extra positive term in the square brackets ($r(2-\theta-\theta^2)$), so that if q^*_{BNR} and q^*_{GNR} are non-negative, it follows that q^*_{BR} and q^*_{GR} will be non-negative too. Before comparing equilibrium quantities between scenarios, we want to compare them in each scenario for the branded and the generic good respectively. We obtain that under no reference prices and with reference prices, demand for the branded good is higher than for the generic. This result is shown in the next lemma.

Lemma 3 *Under Assumption 4, we have that* $q^*_{BNR} \geq q^*_{GNR}$ *and* $q^*_{BR} \geq q^*_{GR}$.

Proof. We have that $q^*_{BNR} - q^*_{GNR} = q^*_{BR} - q^*_{GR} = \dfrac{(a_B - c_B) - (a_G - c_G)}{b(2+\theta)(1-\theta)}$. Then, since $\theta \in [0,1)$, and $b \geq 0$, the denominator is positive. By Assumption 4, we have that the numerator is positive, hence the result follows. ■

Comparing equilibrium quantities between both cases gives rise to the next lemma.

Lemma 4 *For any strictly positive reference price* r, *we find that* $q^*_{BNR} < q^*_{BR}$ *and* $q^*_{GNR} < q^*_{GR}$.

Proof. We get that $q^*_{BR} - q^*_{BNR} = q^*_{GR} - q^*_{GNR} = \dfrac{r}{b\,(2-\theta)\,(1+\theta)} > 0, \forall r > 0.$ ■

In words, demand for both goods increases under the reference price system. It seems strange that demand for both goods has increased eventhough we have seen that implement-

ing this system has caused an increase in the price set by both firms. However, the following proposition provides the economic intuition to the previous one, and will be very useful for later analysis.

Proposition 5 *In equilibrium, we have that* $p^*_{BNR} > p^*_{BR} - r$, *and* $p^*_{GNR} > p^*_{GR} - r, \forall r > 0$.

Proof. We obtain that $p^*_{BNR} - p^*_{BR} + r = p^*_{GNR} - p^*_{GR} + r = \frac{r}{2-\theta}$. This will always be strictly positive for $r > 0$. Hence, the result follows through. ■

This proposition gives one of the most important results of the paper, whereby independently of the magnitude of r, the net price paid by the consumer for both goods under the reference price system ($(p^*_{BR} - r)$ and $(p^*_{GR} - r)$ for the branded and generic good respectively), is lower than the price paid when there are no reference prices (p^*_{BNR} and p^*_{GNR}). In the analysis that follows, this result will be crucial to explain some of the results presented here. Note that what this result is saying is that even though the gross price received by the producer is higher under reference prices, as shown in lemma 2, what consumers have to pay for the good is less than when there is no such system implemented.

Next is to compare *total costs* of the system under price and no-price regulation, where total cost is calculated as $\sum_i p^*_i q^*_i$, $i = B, G$. Total costs when consumers pay the full price and when there exists reference prices will be denoted as TC^*_{NR} and TC^*_R respectively. Note that when the reference system is implemented, this cost is spread among consumers and health authorities, while in the former case, the consumer pays for all this cost. Hence, in a situation with reference prices, total costs of the system, TC^*_R, is equal

to the sum of two parts, $\sum_i (p_i^* - r)q_i^*$, $i = B, G$, which is the cost borne by the consumer, and $\sum_i r q_i^*$, $i = B, G$, which is borne by the health authorities. This obviously reduces to $\sum_i p_i^* q_i^*$.

We obtain that

$$TC_R^* - TC_{NR}^* = \frac{2(a_B + a_G)(1-\theta) + \theta(c_B + c_G) + 2(1-\theta)r}{b\left(-2+\theta\right)^2(1+\theta)} r. \tag{15}$$

This difference will always be positive, for any $r > 0$, and $\theta \in [0, 1)$, since both the numerator and the denominator will always be positive. We can summarise this result in the following proposition.

Proposition 6 *For any positive reference price, r, imposed by the health authorities, total costs for the simultaneous game described above are greater when the reference price system is implemented.*

This result follows since we have seen that the optimal reaction by firms when such system is implemented is to increase prices, and furthermore, this causes an increase in the quantities demanded of both firms.

Following with comparisons between scenarios, an obvious continuation is to compare total *consumer surplus* for both cases. If we denote CS_{NR}^* and CS_R^* total consumer surplus with subscripts indicating in which situation we are, we obtain that:

$$CS_R^* - CS_{NR}^* = \frac{(1-\theta)[(a_B - c_B) + (a_G - c_G) + r]}{b(\theta-2)^2(1+\theta)} r. \tag{16}$$

From Assumption 2, we know $(a_B - c_B)$ and $(a_G - c_G)$ are greater or equal than cero. Hence, consumer surplus is, for any $r > 0$, greater when the reference price system is implemented. This result can be summarised with the next proposition.

Proposition 7 *For any $r > 0$, total consumer surplus is higher if the reference price system is implemented.*

This result follows from combining Lemma 4 and Proposition 5. We saw that the implementation of a reference price system causes an increase in the price of both goods. However, with such a system, the government pays for part of the good, and r will determine the net price paid by consumers. It has been shown in Proposition 5 that any $r > 0$ covers for the increase in price caused by the introduction of the reference price. Lemma 4 shows that quantity demanded for both goods increases when the reference price system has been implemented. These two effects lead to higher consumer welfare. Notice that given that total costs of the system are always higher under reference prices, a sensible criterion to endogenise this reference price is to choose the one yielding the highest consumer surplus[4].

An obvious thing to do now is to compare producer surplus under both scenarios. Let $\pi^*_{NR} = \pi^*_{BNR} + \pi^*_{GNR}$ denote total profits for both firms with no reference prices, and let $\pi^*_R = \pi^*_{BR} + \pi^*_{GR}$ denote total profits under the reference price system. We have that

[4] Actually if we let the planner choose the optimal r that minimises the costs of having such a system, it will naturally be $r = 0$. Hence we are faced to a second-best solution.

$$\pi^*_R - \pi^*_{NR} = \frac{2(1-\theta)[(a_B - c_B) + (a_G - c_G) + r]}{b(\theta-2)^2(1+\theta)} r. \tag{17}$$

Notice that the expression in equation (1.17) is similar to expression (1.16), which represented the difference in consumer surplus between both scenarios. Hence, we know that by Proposition 6, this difference will be positive for any $r > 0$; hence we can summarise what happens to producer surplus when we implement a reference price system with Proposition 8.

Proposition 8 *For any $r > 0$, total producer surplus is higher if the reference price system is implemented.*

Summarising then, we have that for the game described in this section, implementing a reference price system increases total costs, although it is welfare increasing.

We have also considered the case where firms decide prices sequentially. This setting implies that the branded good producer chooses first, in order to give this producer some first-mover advantage. The main conclusions obtained are similar qualitatively as with the simultaneous game just described.

1.4 Case 2.

Recall that in this setting, we have that Health Authorities are present in both subcases considered. The difference between these is the amount that Authorities finance. The aim of this section is to compare a situation with a fixed copayment irrespective of the drug

purchased, with a situation where reference prices are implemented. The modelling of such system will be the one used in Spain.

As discussed above, the first scenario we will consider here 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 are, respectively:

$$q_{B\gamma} = \frac{(a_B - \theta a_G)}{b(1-\theta^2)} - \frac{1}{b(1-\theta^2)}\gamma p_{B\gamma} + \frac{\theta}{b(1-\theta^2)}\gamma p_{G\gamma}, \quad (1.18)$$

$$q_{G\gamma} = \frac{(a_G - \theta a_B)}{b(1-\theta^2)} - \frac{1}{b(1-\theta^2)}\gamma p_{G\gamma} + \frac{\theta}{b(1-\theta^2)}\gamma p_{B\gamma}, \quad (1.19)$$

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.

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

$$q_{Br} = \frac{(a_B - \theta a_G)}{b(1-\theta^2)} - \frac{1}{b(1-\theta^2)}\left(\gamma r + p_{Br} - r\right) + \frac{\theta}{b(1-\theta^2)}\gamma p_{Gr}, \quad (1.20)$$

$$q_{Gr} = \frac{(a_G - \theta a_B)}{b(1-\theta^2)} - \frac{1}{b(1-\theta^2)}\gamma p_{Gr} + \frac{\theta}{b(1-\theta^2)}\left(\gamma r + p_{Br} - r\right), \quad (1.21)$$

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 (1.18) and (1.19)). 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.

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:

$$\pi_{Bi} = (p_{Bi} - c_B)\, q_{Bi}, \tag{1.22}$$

$$\pi_{Gi} = (p_{Gi} - c_G)\, q_{Gi}, \tag{1.23}$$

where $i = \gamma, r$ (the situation with copayment only and copayment and reference prices together respectively). Recall that we are assuming that $c_B \geq c_G$.

Before solving the model, we introduce the following assumptions to ensure the non-negativity of the equilibrium values.

Assumption 6. $(a_B - c_B) \geq (a_G - \gamma c_G) \Rightarrow (a_B - a_G) \geq (c_B - \gamma c_G) \geq (c_B - c_G) \geq \gamma (c_B - c_G)$ since $\gamma \in [0, 1]$.

Assumption 7. $(2 - \theta^2)(a_G - \gamma c_G) \geq \theta(a_B - \gamma c_B) [\geq \theta (a_B - c_B)$ since $\gamma \in (0, 1]]$.

In the next subsection, we will solve the model when copayments are enforced, while subsection 4.2 shows the results when there exists reference prices.

1.4.1 Copayments.

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

$$\pi_{i\gamma} = (p_{i\gamma} - c_i) \left(\frac{(a_i - \theta a_j)}{b(1 - \theta^2)} - \frac{1}{b(1 - \theta^2)} \gamma p_{i\gamma} + \frac{\theta}{b(1 - \theta^2)} \gamma p_{j\gamma} \right). \tag{24}$$

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

$$\frac{\partial \pi_{i\gamma}}{\partial p_{i\gamma}} = \frac{a_i - \theta a_j - 2\gamma p_{i\gamma} + \theta \gamma p_{j\gamma} + \gamma c_i}{b(1 - \theta^2)} = 0, \tag{25}$$

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

Hence, from equation (1.25), and using the implicit function theorem, we can obtain (as expected) a positive relationship between the two prices:

$$\frac{dp_{i,\gamma}}{dp_{j,\gamma}} = \frac{\theta}{2} > 0. \tag{26}$$

From (1.25), we derive the best response functions for the two firms, yielding the Nash Equilibrium in prices[5]. These are given by,

$$p^*_{i\gamma} = \frac{\left(2-\theta^2\right) a_i - \theta a_j + \gamma(2c_i + c_j)}{\gamma(4-\theta^2)}, \tag{27}$$

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

We can say that an increase in the copayment γ will decrease the equilibrium price for the branded good under Assumption 2. With regards to the response of the generic producer, it will depend on the relative magnitude of market sizes. More precisely,

$$\frac{\partial p^*_{B,\gamma}}{\partial \gamma} = -\frac{\left(2-\theta^2\right) a_B - \theta a_G}{(4-\theta^2)\gamma^2} < 0, \tag{1.28}$$

$$\frac{\partial p^*_{G,\gamma}}{\partial \gamma} = -\frac{\left(2-\theta^2\right) a_G - \theta a_B}{(4-\theta^2)\gamma^2} < 0 \Leftrightarrow \frac{\theta}{\left(2-\theta^2\right)} < \frac{a_G}{a_B} \leq 1. \tag{1.29}$$

Comparing equilibrium prices, we obtain the following lemma:

Lemma 9 *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 $p^*_{B,\gamma} - p^*_{G,\gamma} = \frac{(a_B - a_G) + \gamma\,(c_B - c_G)}{\gamma(2+\theta)}$. 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,

$$q^*_{i\gamma} = \frac{(2-\theta^2)(a_i - \gamma c_i) - \theta\,(a_j - \gamma c_j)}{b(4-\theta^2)(1-\theta^2)}, \tag{30}$$

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

[5] Second order conditions are satisfied.

Note that Assumptions 6 and 7 imply that these quantities are non-negative. We can check how demand varies with γ:

$$\frac{\partial q^*_{B,\gamma}}{\partial \gamma} = \frac{\theta c_G - c_B(2-\theta^2)}{b(4-\theta^2)(1-\theta^2)} < 0 \Leftrightarrow \tag{1.31}$$

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

$$\frac{\partial q^*_{G,\gamma}}{\partial \gamma} = \frac{\theta c_B - c_G(2-\theta^2)}{b(4-\theta^2)(1-\theta^2)} < 0 \Leftrightarrow \tag{1.32}$$

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

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 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 9, 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.

1.4.2 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:

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

The FOCs are as follows:

$$\frac{\partial \pi_{Br}}{\partial p_{Br}} = \frac{a_B - \theta a_G - 2p_{Br} + \theta\gamma p_{Gr} + c_B + (1-\gamma)r}{b(1-\theta^2)} = 0, \tag{1.33}$$

$$\frac{\partial \pi_{Gr}}{\partial p_{Gr}} = \frac{a_G - \theta a_B - 2\gamma p_{Gr} + \theta p_{Br} + \gamma c_G - \theta(1-\gamma)r}{b(1-\theta^2)} = 0. \tag{1.34}$$

From equations (1.33) and (1.34), 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,

$$\frac{dp_{B,r}}{dp_{G,r}} = \frac{\theta\gamma}{2} > 0, \tag{1.35}$$

$$\frac{dp_{G,r}}{dp_{B,r}} = \frac{\theta}{2\gamma} > 0, \tag{1.36}$$

$$\frac{dp_{B,r}}{dr} = \frac{(1-\gamma)}{2} > 0, \tag{1.37}$$

$$\frac{dp_{G,r}}{dr} = -\frac{(1-\gamma)\theta}{2\gamma} < 0. \tag{1.38}$$

Equations (1.35) and (1.36) 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 (1.37) 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 (1.38) 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,

$$p^*_{Br} = \frac{(2-\theta^2)a_B - \theta a_G + 2c_B + \theta\gamma c_G + (1-\gamma)(2-\theta^2)r}{4-\theta^2}, \quad (1.39)$$

$$p^*_{Gr} = \frac{(2-\theta^2)a_G - \theta a_B + \theta c_B + 2\gamma c_G - (1-\gamma)r}{\gamma\left(4-\theta^2\right)}. \quad (1.40)$$

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

$$\frac{\partial p^*_{Br}}{\partial\gamma} = \frac{\theta c_G - (2-\theta^2)r}{4-\theta^2}, \quad (1.41)$$

$$\frac{\partial p^*_{Gr}}{\partial\gamma} = -\frac{(2-\theta^2)a_G - \theta a_B + \theta c_B - r}{\gamma^2\left(4-\theta^2\right)}. \quad (1.42)$$

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:

$$\frac{\partial p^*_{Br}}{\partial\gamma} < 0 \Leftrightarrow r > \frac{\theta c_G}{\left(2-\theta^2\right)}, \text{ and} \quad (1.43)$$

$$\frac{\partial p^*_{Gr}}{\partial\gamma} < 0 \Leftrightarrow r < \left(2-\theta^2\right)a_G - \theta a_B + \theta c_B. \quad (1.44)$$

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,

$$q^*_{Br} = \frac{(2-\theta^2)(a_B - c_B) - \theta\,(a_G - \gamma c_G) + (1-\gamma)(2-\theta^2)r}{b\left(4-\theta^2\right)\left(1-\theta^2\right)}, \tag{45}$$

$$q^*_{Gr} = \frac{(2-\theta^2)\,(a_G - \gamma c_G) - \theta\,(a_B - c_B) - \theta(1-\gamma)r}{b\left(4-\theta^2\right)\left(1-\theta^2\right)}. \tag{46}$$

Assumption 6 is a sufficient condition for q^*_{Br} to be non-negative. Assumption 7 is a necessary condition for the non-negativity of q^*_{Gr}. With these equilibrium quantities, we obtain,

$$sign\left(\frac{\partial q^*_{Br}}{\partial r}\right) > 0, \tag{1.47}$$

$$sign\left(\frac{\partial q^*_{Gr}}{\partial r}\right) < 0. \tag{1.48}$$

The intuition for equation (1.47) 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[6]. 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

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

good. For the generic good, the intuition under equation (1.48) is somewhat different but related to equation (1.47). 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.

1.4.3 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 $\frac{dp_{B,\gamma}}{dp_{G,\gamma}} = \frac{dp_{G,\gamma}}{dp_{B,\gamma}} = \frac{\theta}{2}$. However, with reference prices, we obtained that $\frac{\theta\gamma}{2} = \frac{dp_{B,r}}{dp_{G,r}} \leq \frac{dp_{G,r}}{dp_{B,r}} = \frac{\theta}{2\gamma}$. Comparing the responses under copayments and reference prices yields the following inequalities:

$$\frac{dp_{B,r}}{dp_{G,r}} \leq \frac{dp_{B,\gamma}}{dp_{G,\gamma}} = \frac{dp_{G,\gamma}}{dp_{B,\gamma}} \leq \frac{dp_{G,r}}{dp_{B,r}}. \tag{49}$$

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 10 *For* $r \lessgtr \bar{r}$, *we get that* $p^*_{B,\gamma} \gtrless p^*_{B,r}$,

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 11 *If* $r \gtrless c_B$, *we get that* $p^*_{G\gamma} \gtrless p^*_{Gr}$.

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. ■

The combination of lemmas 10 and 11 gives rise to the following proposition:

Proposition 12 *If* $r < c_B$, *then* $\begin{cases} p^*_{B,\gamma} > p^*_{B,r} \\ p^*_{G,\gamma} < p^*_{G,r} \end{cases}$.

$$\begin{aligned}
\textit{If } r = c_B \textit{, then} &\begin{cases} p^*_{B,\gamma} > p^*_{B,r} \\ p^*_{G,\gamma} = p^*_{G,r} \end{cases} . \\
\textit{If } c_B < r < \bar{r} \textit{, then} &\begin{cases} p^*_{B,\gamma} > p^*_{B,r} \\ p^*_{G,\gamma} > p^*_{G,r} \end{cases} . \\
\textit{If } r = \bar{r} \textit{, then} &\begin{cases} p^*_{B,\gamma} = p^*_{B,r} \\ p^*_{G,\gamma} > p^*_{G,r} \end{cases} . \\
\textit{If } r > \bar{r} \textit{, then} &\begin{cases} p^*_{B,\gamma} < p^*_{B,r} \\ p^*_{G,\gamma} > p^*_{G,r} \end{cases} ,
\end{aligned}$$

where $\bar{r}$ is defined in lemma 10.

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 6 guarantees that this difference is positive, hence the interval is well defined.

The second part of the proof follows from combining lemmas 10 and 11. ■

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 (1.28), (1.37) and (1.38). As shown by (1.28), we know that the price set by the original firm depends negatively on the copayment in the first situation. However, from equation (1.37), 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 (1.38). 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 13 *If* $r < c_B$, *then* $\begin{cases} q^*_{B,\gamma} > q^*_{B,r} \\ q^*_{G,\gamma} < q^*_{G,r} \end{cases}$.

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

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. ■

The intuition behind this result can be obtained using equations (1.31), (1.32), (1.47) and (1.48). The analysis is similar in spirit to Proposition 12. 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 (1.48) 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:

$$\gamma p^*_{B\gamma} - (p^*_{Br} - r(1-\gamma)) = 2\frac{(r-c_B)(1-\gamma)}{(4-\theta^2)}. \tag{50}$$

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:

$$\gamma p^*_{G\gamma} - \gamma p^*_{Gr} = \theta \frac{(r - c_B)(1-\gamma)}{(4-\theta^2)}. \tag{51}$$

The following proposition summarises equations (1.50) and (1.51).

Proposition 14 *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 (1.50) and (1.51). ■

Propositions 12 to 14 can be illustrated in Table 2.

Table 2. Summary of Propositions 12-14.

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

$$\left[\gamma p^*_{B\gamma} - (p^*_{Br} - r(1-\gamma))\right] - \left[\gamma p^*_{G\gamma} - \gamma p^*_{Gr}\right] = \frac{(r - c_B)(1-\gamma)}{2+\theta} \tag{52}$$

What equation (1.52) 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 3.

Table 3. 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 3 are obtained using the following procedure. For $r < c_B$, we know from Table 2 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 12, 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 $(1-\gamma)\left(rq_{Br}^{*}\right)$ ($\equiv TC_{Br}^{govt}$). Table 4 summarises these findings.

Table 4. 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 2 and 3.

1.5 Conclusions.

Using a simple model, we have tried to analyse the impact of implementing a reference price system. Our objective has been to see what is the reaction price-wise of firms to this system, and ultimately, to check whether this system increases total welfare and reduces total costs in pharmaceuticals. For this purpose, we have constructed a horizontally differentiated model, where the supply side of the economy is composed of a producer of a

branded good, who has lost its patent over its active ingredient, and a generic good producer. Since the way reference prices have been implemented in various countries has not been unique, we have analysed two possible scenarios.

In the first set up, we compare the situation where consumers pay the full price of the ethical drug with the situation where Health Authorities finance a part of the price of these drugs. Hence, the new situation is as if the Authorities pay a subsidy which is equal to the reference price. This setting implies that the reference price is set below the price of both the branded and generic good's price. Before comparing between scenarios, we construct the model such that we obtain that in equilibrium, the price of the branded good is higher than the price of the generic. In order to obtain this result with our model, we assume that the size of the market is larger for the branded good, as well as its marginal cost of production, assumptions which are consistent with what we observe in reality. The result obtained is that when reference prices are introduced, the optimal response for firms is to increase prices relative to the situation with no reference prices. However, rather than this effect leading to a decrease in quantity demanded, what we have is an increase in demand for both goods. This can be explained by the fact that since the government now pays for part of the good, this part (which is up to the reference price r) covers for the increase in price caused by the introduction of this system, so that what we have is actually that the net price paid by the consumer under reference prices is less than when there is no reference price. This result lead us to conclude that when reference prices are implemented in this way, they are welfare increasing (increase both consumer and producer surplus) but increase total costs in pharmaceuticals.

The second case refers to the way reference prices have been implemented in Spain. For this purpose, using again 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 (s)he still has to pay the copayment γ. But, if (s)he decides to buy the branded good, (s)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.

Overall, then, we can say that under this second scenario, Health Authorities can achieve the desired goals of reducing prices and reducing pharmaceutical costs if the reference price is set not too low nor too high. However, this result may be achieved at the expense of reducing profits for the duopolists. 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.

An obvious extension of the paper could be to analyse what will be the effects of having a reference price system for pharmaceutical R&D. Some economists have argued that implementing a reference price system reduces the incentives for R&D, although others argue the opposite. Hence, there exists a controversy in which direction the effect could go. Furthermore, we could estimate empirically this effect, and compare some measure of R&D, not only between countries with and without such a system, but also analyse if this measure of R&D has suffered any changes (if any), for each particular country, before and after the system has been implemented. Until now, I have not seen any answers to these questions; nevertheless, I hope that my future work enables me to shed some light to this unresolved questions.

Finally, the optimal choice of r has been left undetermined. One of the reasons for doing so is that the way that reference prices have been introduced in different countries

has not been unique. Every country has followed a different alternative on how to define r. Hence, the aim of this paper has been to try to understand, on general terms, how such system can affect the price decision by pharmaceutical firms. In order to see what results we would obtain for every country, we would have to give some structure to r. Of course, in the model we have here, one possibility could be to define r in terms of the price of the generic good i.e. set $r = f(p_G)$. The question that follows with this setting would be on the functional form of $f(\cdot)$, something that is not only beyond the scope of this paper, but also something that there is no consensus on.

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