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# DRUG PRICE DIFFERENTIALS CAUSED BY DE-LISTING AND PRICE CAP POLICIES

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**Abstract:** This paper analyses the behaviour of pharmaceutical companies that face the threat of having their drugs excluded from reimbursement and the markets characterised also by price caps. We conclude that price elasticity of demand and cost differentials cause the price discounts which drug firms offer to health care organisations. Additionally, we conclude that price cap regulations affect the time path of prices, resulting in higher prices for new products and lower prices for old products.

Keywords: Drugs, prices, reductions, reimbursement, de-listing, caps.
JEL codes: H42; H51; I18.

**Resum:** Aquest treball analitza el comportament dels laboratoris farmacèutics que s'enfronten a l'amenaça de veure els seus productes exclosos de les prestacions farmacèutiques i que operen en mercats en els que existeixen preus màxims. El treball conclou que l'elasticitat al preu de la demanda i les diferencies de cost fan que els laboratoris ofereixin descomptes a les organitzacions que presten els serveis sanitaris. A més, el treball conclou que la regulació de preus màxims afecta a la trajectòria dels preus al llarg del temps, en forma de majors preus pels productes nous i menors preus pels productes vells.

## 1. Introduction

There is anecdotal evidence that pharmaceutical companies offer price reductions to health care organisations (HCOs) which implement a de-listing policy. In the US drug firms offered price reductions on brand name prescription medicines only to HCOs. Retail pharmacists seek treble damages in private law suits alleging that pharmaceutical firms violated the US antitrust laws with such price discrimination policy (Scherer 1997 and related papers in the same issue).

Not only Health Maintenance Organisations (HMOs), but also National Health Services (NHSs), and generally speaking private or government controlled HCOs usually have de-listing policies. De-listing of drugs by NHSs is still an extremely rare event. De-listing had occurred twice in the UK (1985 and 1998) and in Spain (1993 and 1998). During the two rounds of de-listing negotiations, pharmaceutical companies offered the UK and Spanish governments price reductions to avoid having their brand name medicines excluded.

Secondly, companies are also subject to prices controls. While in the UK, NHS list prices are set using a sort of rate-of-return regulation, many governments, such as the Spanish and the French, control drug prices using product by product price cap regulations. In 1993, price cap regulation was even a matter of public debate in the US but was discarded in the end (see Abbott III 1995). As Danzon (1997, 311) states, 'a government purchaser negotiates on behalf of an entire country and hence has significant monopsony power.'[1]

[1] As pointed out by one referee, with decreasing average costs due to large drug R&D sunk costs, monopsony power drives drug prices down, even near constant marginal cost, but also increases the quantity of drugs consumed and pharmaceutical expenditures when risk bearing mechanisms are not introduced at the health care provider level.

Therefore, pharmaceutical companies are subject to two mechanisms which may cause price differentials across sectors and countries. HCOs determine the medicines that are included in formulary and the conditions under which the drugs may be de-listed. And both governmental and private purchasers control pharmaceutical expenditures using price setting mechanisms.

This paper tries to explain drug price differentials caused by de-listing and price cap policies. We will show how these policies may affect price trends over time. Our starting point is that markets for drugs may be viewed as monopolistically competitive. According to Danzon (1997, 303), 'aggressive competitive entry of differentiated therapeutic substitutes implies that the industry is best characterised as monopolistically competitive, with possible pockets of oligopoly early in the life of a new therapeutic class'. Thus, products within a therapeutically defined market are differentiated, and average cost of each variety can be seen as decreasing with respect to the quantity produced.

This follows if we assume that producers face an ex ante known fixed cost for developing and granting market approval of a new medicine (research, development and authorisation costs) while the production of medicines exhibits constant returns to scale. Within this setting, Nash equilibrium prices on a therapeutic market result from the inverse elasticity rule, and entry occurs until profits of new entrants are zero or negative ex ante.

Although the break-even condition is hardly compatible with patent protection, this assumption conforms to models of endogenous innovation and rent dissipation in which firms obtain zero profits in the long-run steady-state equilibrium like in Grossman and Helpman (1996 and 1994) and Helpman (1993).

Our analysis of the impact of the de-listing policy on drug prices is closely related to Zweifel and Crivelli (1996) and Zweifel and Breyer (1997, 320-325). These authors have considered the effects of the risk of a reference

price being imposed by the government on prices in a otherwise non regulated market. We analyse equilibrium prices when suppliers face the risk of having their products de-listed. Contrary to those authors, however, we assume demand for each variety to be price elastic, according to the monopolistically competitive frameworks which may be more realistic in countries such as the US and the UK. Our results are fully consistent with those obtained by Zweifel and Crivelli (1996) and Zweifel and Breyer (1997, 320-325). Equilibrium prices are lower when reference pricing or de-listing risks are introduced either in a model with price elastic demand and with perfectly price inelastic demand.

Our model supports the line of reasoning of Elzinga and Mills (1997) and Danzon (1997) that price reductions offered to major US HCOs did not violate antitrust laws. Rather, they saw an increased price elasticity of demand which they related to doctors whose prescribing habits were not approved by the HCO being penalised.

We also show how the threat of de-listing and price caps modify the development of prices over time. According to Abbott III (1995), pharmaceutical firms in a deregulated market, such as that of the US, increase prices over time. Therefore, if a price cap is imposed at the beginning of the life cycle of a new drug, firms would react by charging a higher introductory price, fearing that government will disallow future increases in excess of consumer price index. We study this type of strategic price dynamics in the case of monopolistically competitive markets with majors purchasers having a de-listing policy.

In the next section, we move on to model the decisions of patients, doctors, purchasers and pharmaceutical companies. We also introduce de-listing policy and price caps. In section 3, the paper turns to present calculations in order to predict the price reductions which would have been offered to the NHS

in the UK and the price dynamics if a price cap is set. We conclude with some remarks about price differentials observed in the markets for pharmaceuticals.

## 2. The model

We will use superscript *i* for denoting price and quantity ($q^i_j$, $p^i_j$) consumed if product *j* is included in a purchaser's formulary. On the other hand, we will use superscript *e* to denote the case where drug *j* is excluded from the formulary ($q_j^e$, $p_j^e$).

### 2.1 Demand equation in the case of exclusion from reimbursement

Let us firstly focus on the case of the demand equation when a drug is not reimbursed by the HCO. We assume that it is the patient who decides which medicine to consume and how much of it to consume. Although patients usually seek medical advice and may even have to ask for a prescription, we assume that they make the final decisions, taking into account the doctor advise and their income constraint since they will end up paying fully for the drug.

Following the symmetric monopolistically competitive models developed by Dixit and Stiglitz (1977) and Spence (1976), the utility function of the representative patient can be thought of as having two arguments. A sub-function whose value depends on the quantities of *j* consumed ($q_j^e$) for a given condition (like for instance analgesics) containing *j* differentiated product types and the *numéraire* good ($q_0^e$) that does not exhibit product differentiation. Price for numeraire is assumed to be one, $p_0$=1.

The utility sub-function of the differentiated drugs has constant elasticity of substitution (CES). The CES form requires that price elasticity of demand for each variety to be unaffected by new product entries, and hence, price-cost

margins to be positive and independent of the number of varieties in the market. However, if entry causes price elasticities of demand for existing varieties to increase and entry is costless, prices converge to marginal cost when the number of varieties in the market increases. In this latter case, varieties become increasingly closer substitutes as entry occurs. By contrast, in this paper, we will assume that price elasticity of demand for each variety in the market is constant with respect to the number of varieties in the market. So doing, we will focus our attention on the effect of de-listing policy on prices rather on the discussion about how entry impacts on the price-cost margin.

The patient's decision in the case of an excluded drug is to maximise her utility subject to the income constraint, where $I$ is income in terms of a *numéraire*.

$$\underset{q_j^{\,e}}{Max} \quad U = U\left[ q_o^e, \left( \sum_{j=1}^{N^e} q_j^{\,r^e} \right)^{\frac{1}{r^e}} \right], \tag{1}$$

$$subject \quad to \quad q_o^e + \sum_{j=1}^{N^e} p_j^e \, q_j^e \le I \, . \tag{2}$$

For concavity, the elasticity of substitution must be less than unity ($r^e$ <1), and since we want quantities consumed to be positive or zero, the elasticity of substitution must be greater than zero ($r^e$ > 0).

Optimisation accounts to a two-stage budgeting procedure in this case. In the first stage, patients decide the quantity of the *numéraire* ($q_0{}^e$), and the total quantity of differentiated pharmaceuticals ($Q^e$), depending on patient income (see eq. 3) and on the aggregate price index of pharmaceuticals ($P^e$),

$$q_0^e = I\left[1 - s_{-0}^e(P^e)\right] \qquad Q^e = I \, \frac{s_{-0}^e(P^e)}{P^e} \, , \tag{3}$$

where $P^e$ and $Q^e$ are dual price and quantity indices of the differentiated pharmaceuticals in the therapeutic category considered (see eq. 4) and $s^e_{-0}(P^e)$ is

the function which shows the percentage of income being spent in pharmaceuticals depending on the price index.

$$P^e = \left( \sum_{j=1}^{N^e} (p_j^e)^{-\frac{r^e}{1-r^e}} \right)^{-\frac{1-r^e}{r^e}} \quad , \quad Q^e = \left( \sum_{j=1}^{N^e} (q_j^e)^{r^e} \right)^{\frac{1}{r^e}} . \tag{4}$$

In the second stage, the patient decides how much she spends on each of the pharmaceuticals. The demand for a variety $j$ is given by,

$$q_j^e = Q^e (P^i)^{-h} (p_j^e)^{-h} , \tag{5}$$

with $h > 0$ denoting the absolute value of the constant common price elasticity of demand. As long as the number of differentiated drugs in a given therapeutic category is reasonably large, we may neglect the effect of each $p_j^e$ on the price index $P^e$ and on the quantity index $Q^e$. In this case, the price elasticity $h$ is,

$$h = -\frac{\partial \ln q_j^e}{\partial \ln p_j^e} = \frac{1}{1-r^e} \text{ where } h>1. \tag{6}$$

If the elasticity of substitution between product types tends to one ($r^e \rightarrow 1$), the $j$ product types are perfect substitutes. Accordingly, price elasticity of demand tends to infinity ($h \rightarrow \infty$). By contrast, if the elasticity of substitution tends to zero ($r^e \rightarrow 0$), product types are perfectly differentiated, and price elasticity of demand tends to unity ($h \rightarrow 1$). In the terminology of Chamberlain, this is the elasticity of the variety-specific *dd* curve which relates the demand for an individual variety to its own price, with all other prices held constant.

## 2.2 Demand for a reimbursed drug

Let us now turn to the case where the drug is reimbursed. In this case, we assume that doctors act as perfect agents of their patients in deciding which drug to consume and how much to consume. We also assume that doctors act as

agents of their HCOs in respecting the budget constraint in the treatment of a patient.

We also assume that patients, as it is the case in the UK, either pay a fixed prescription charge or are exempt of any copayment. Therefore, the prescription charge is not related to the price of a drug; while reducing the welfare of patients, it does not affect the price elasticity of demand.

The doctor's decision problem is to maximise patient welfare subject to budget constraint imposed by the HCO, where $B$ is the budget available per representative patient,

$$\underset{q_j^i}{Max} \quad U = U\left[ q_0^i, \left( \sum_{j=1}^{N^i} (q_j^i)^{r^i} \right)^{\frac{1}{r^i}} \right], \tag{7}$$

$$subject \quad to \quad q_0^i + \sum_{j=1}^{N} p_j^i \, q_j^i \leq B. \tag{8}$$

Following the same two-stage budgeting procedure as above, doctors first decide on behalf of their patients the quantity of *numéraire* ($q_0^i$), and the total quantity consumed in the market for differentiated medicines ($Q^i$), depending on the budget ($B$) and on the aggregate price index of the covered drugs in the therapeutic category considered ($P^i$),

$$q_0^i = B\left[1 - s_{-0}^i(P^i)\right], \qquad Q^i = B\,\frac{s_{-0}^i(P^i)}{P^i}, \tag{9}$$

where $P^i$ and $Q^i$ are dual price and quantity indices of the differentiated drugs,

$$P^i = \left( \sum_{j=1}^{N^i} (p_j^i)^{-\frac{r^i}{1-r^i}} \right)^{-\frac{1-r^i}{r^i}}, \qquad Q^i = \left( \sum_{j=1}^{N^i} (q_j^i)^{r^i} \right)^{\frac{1}{r^i}}. \tag{10}$$

In the second stage, the doctor decides how much to spend on each one of the differentiated $j$ drugs within the relevant category. Demand for a variety is given by,

$$q_j^i = Q^i (P^i)^{-h-d} (p_j^i)^{-h-d} . \quad (11)$$

Here $d$>0 denotes the increase in the price elasticity $h$ due to the fact that a variety is included in the formulary. It may be seen as reflecting the effects of increased price transparency within the HCO and of the monitoring of prescribing habits by the HCO.

As long as the number of differentiated drugs in a therapeutic category is reasonably large, we may neglect the effect of each $p_j^i$ on $P^i$ and on $Q^i$. Total price elasticity of demand then amounts to,

$$h + d = -\frac{\partial \ln q_j^i}{\partial \ln p_j^i} = \frac{1}{1 - r^i} \quad \text{where} \qquad h > 1 \text{ and } d \geq 0. \quad (12)$$

Therefore, demand for drugs included in the formulary is more price elastic than demand for varieties that excluded.

### 2.3 De-listing policy of the HCO

The way we model de-listing policy conforms to Zweifel and Crivelli (1996, 260), who model the effect of the risk faced by pharmaceutical firms of being constrained by a future reference price. We define by $a_j$ ($0 < a_j < 1$) the probability of a variety being de-listed. This depends on $p_j^i$ with a common elasticity $e$ >0, i.e. on the price charged for the variety. Moreover, $a_j$ depends on a parameter ($E$ >0) not related to price, such as the effectiveness of the drug:

$$a_j = 1 - E(p_j^i)^{-e} \qquad \text{where } e > 0. \quad (13)$$

This function is a way of expressing in a simple way a de-listing policy which would result from minimising pharmaceutical expenditure subject to the constraint of securing a given level of expected utility to the representative patient. The listing policy price sensibility ($e$) thus measures the percentage

change of the probability of retaining a drug in the formulary when price increases 1 percent:

$$e = -\frac{\partial \ln(1-\alpha_j)}{\partial \ln p_j^i} > 0 \qquad (14)$$

## 2.4 Pricing equation

In this section, we derive price discounts offered by pharmaceutical companies to HCOs. We assume that the HCO only decides whether or not she includes a drug in the formulary. When a drug is included, the price proposed by the supplier becomes the list price of the product, whereas once a drug is de-listed, its price is unconstrained.

For simplicity, let each variety be produced by a different firm. Denote $c$ for the common constant marginal cost of production of a drug. However, firms face a fixed cost of entry denoted by $F$ which depends on whether or not the product is included ($F^i$ and $F^e > 0$).

For modelling entry decisions, Mas Colell, Whinston and Green (1995) suggest a two-stage approach. First, firms decide whether or not they pay the fixed entry cost to enter into the market, engage in research and development and marketing of a drug. In the second stage, firms in the market compete for consumers, entry cost being sunk.

Using this perspective the expected profits for each product $j$ are $E(p_j)$ is given by,

$$\underset{p_j^e,\, p_j^i}{Max} \quad E(p_j) = \alpha_j (p_j^e - c) q_j^e + (1-\alpha_j)(p_j^i - c) q_j^i . \qquad (15)$$

Firms maximise expected profits obtained from having her products whether excluded or included in a HCO formulary without taking into account fixed costs. The FOC with respect to de-listing price is given by,

$$\frac{dE(p_j)}{dp_j^e} = a_j\,(p_j^e - c)\,\frac{dq_j^e}{dp_j^e} + a_j\,q_j^e = 0\,. \tag{16}$$

Simplifying, one obtains the equilibrium price, which in the case of de-listing contains the conventional mark-up over marginal cost,

$$p_j^e = \frac{h}{h-1}\,c\,. \tag{17}$$

The FOC with respect to listing prices is the following:

$$\frac{dE(p_j)}{dp_j^i} = \frac{da_j}{dp_j^i}(p_j^e - c)q_j^e - \frac{da_j}{dp_j^i}\left(p_j^i - c\right)q_j^i + (1-a_j)(p_j^i - c)\frac{dq_j^i}{dp_j^i} + (1-a_j)q_j^i = 0\,. \tag{18}$$

From (18) multiplied in both sides using (21) and using the free entry break-even expressions (19) and (20), we obtain the list price given by (22):

$$(p_j^i - c)\,q_{jt}^i = F^i\,, \tag{19}$$

$$(p_j^e - c)\,q_{jt}^e = F^e\,, \tag{20}$$

$$\frac{\partial p_j^i}{\partial a_j}\,\frac{1}{q_j^i}\,, \tag{21}$$

$$\frac{F^e}{q_j^i} - \frac{F^i}{q_j^i} + \frac{h+d}{e}(p_j^i - c) - \frac{p_j^i}{e} = 0\ . \tag{22}$$

Since we may assume that the fixed cost in the case of listing ($F^i$) is smaller than fixed cost in case of de-listing ($F^e$) we write that $F^e = f \cdot F^i$ where $f$ >1. This assumption tries to reflect that mainly marketing fixed costs are larger when a product is de-listed, while the amount of research costs are the same in case of listing and in case of de-listing.

Equilibrium list price is given by,

$$p_j^i = \frac{h+d+(f-1)e}{h+d+(f-1)e-1}\,c\,. \tag{23}$$

The SOC implies that the following restriction must be satisfied for the equilibrium being one of maximum profit, $\left( (h+d)(1+e) + \frac{e}{q_j^i} + \frac{e\,c}{q_j^i} \right) p_j^i > c(h+d)e$.

According to our assumptions, $\Delta = (d + (f-1)e) > 0$ is strictly positive and therefore the mark-up over marginal cost of list prices shown in (23) is smaller than the mark-up over marginal cost of de-listing prices shown in (17), $\frac{h}{h-1} > \frac{h+\Delta}{h+\Delta-1} = \frac{h+d+(f-1)e}{h+d+(f-1)e-1}$.

This is the case when one or both of our following assumptions are met: (1) de-listing policy is price elastic ($e > 0$) and, at the same time, fixed costs of entry are smaller in the case of reimbursement than otherwise ($f > 1$); (2) when demand in case of being included in the HCO formulary is more price elastic than demand in case of de-listing from the formulary ($d > 0$).

This result supports the evidence cited by Elzinga and Mills (1997) and Danzon (1997) that when drug firms compete monopolistically within a therapeutic category, they offer discounts to avoid having their products excluded from HCOs formularies.

## 2.5 Price cap constraint

In many countries, like France or Spain, prices of all drugs in the market are also subject to caps while in others, such as the US, there has been debate about limiting the increase of pharmaceutical prices. When prices are subject to cap constraints, firms have to set introductory prices according to expected parameters values throughout the product life.

For taking into account the cap constraints we move on to a dynamic analysis (i.e, considering the product life $t$=0,1,2,...,$T$). We discount the firm

profits flow during the product life and we include the price cap regulation constraint.

Price cap regulation allows prices to rise with the rate of inflation less a fixed percentage called the "X factor". We assume that our price cap regulation "X factor" equals the inflation rate. Introductory price become the price cap during the life of each product type. We use the Abbott III (1995) assumption that firms know parameters values with certainty. Firms maximise the profit flow under de-listing policy and price cap regulation constraint as given by,

$$\underset{p^{e}_{jt},\, p^{i}_{jt}}{Max} \quad \sum_{t=0}^{T} b^{t} \cdot E(p_{jyt}) = \sum_{t=0}^{T} b^{t} \left\{ a_{jt}(p^{e}_{jt} - c_t)q^{e}_{jt} + (1 - a_{jt})(p^{i}_{jt} - c_t)q^{i}_{jt} \right\}, \qquad (24)$$

$$subject \quad to \qquad p^{i}_{jt} \le p^{i}_{jt+1}. \qquad (25)$$

We may obtain the FOC as before. Equilibrium list price depend on the parameter values which appear in the following expression across the product type life:

$$p^{i}_{j} = \frac{\sum_{t=0}^{T} \frac{b^{t}}{e_t} \left[ h_t + d_t + (f_t - 1)\, e_t \right] c_t}{\sum_{t=0}^{T} \frac{b^{t}}{e_t} \left[ h_t + d_t + (f_t - 1)\, e_t - 1 \right]} \qquad \text{for all } t = 1, \ldots, T. \qquad (26)$$

The price cap is binding only when one of the following conditions is satisfied: (1) when de-listing policy price elasticity ($e_t$) is decreasing over time; (2) when demand price elasticity ($h_t$+$d_t$ ) is decreasing over time; (3) when marginal ($c_t$) or fixed costs ($F^{i}_{t}$) are increasing over time. Any of those conditions implies that prices not subject to a price cap regulation tend to increase over time. In all those cases, the problem is just to select a launch price ($p^{i}_{j}$=$p^{i}_{jt}$ for $t$=0,1,2,..., $T$).

By contrary, when de-listing policy price elasticity ($e_t$) or demand price elasticity ($h_t$+$d_t$ ) increase over time, or when marginal ($c_t$) or fixed costs ($F^{i}_{t}$)

are decreasing over time prices would suffer a decreasing trend and therefore the price cap constraint is not binding. Firms would propose price reductions over time according to the equations outlined in the previous section.

Therefore, price reductions to major HCOs or price differentials across countries are heavily dependent on the expected values of demand price elasticity, de-listing policy price elasticity, and cost across time within each country.

## 3. Examples

### 3.1 Example of price discounts caused by de-listing policy

We are going to show price reductions which would have been offered by drug firms to the NHS in the UK when marketing medicines within a hypothetical therapeutic market if those firms would have been subjected to a different types of de-listing policy constraints.

Equilibrium price under de-listing policy constraint may be calculated using the equation given by (23) and a set of parameter values. The parameters values have been chosen for satisfying our model restrictions and also for offering list prices equal to the median price of reimbursed medicines by the NHS and dispensed in England in 1996 which was £8.33 (See Borrell 2001).

We assume that common marginal cost equals to £6.52 ($c$=6.52). We also assume that the price elasticity of $dd$ demand curve is equal to 3 ($h$=3), that the additional price elasticity of demand elasticity due to HCO prescription controls is equal to 1 ($d$ =1), and that the price elasticity of listing policy is equal to 4 ($e$ = 4). We also assume that fixed cost in case of de-listing is 15% larger than fixed cost in case of inclusion in the formulary ($f$=1.15).

Table 1 shows three equilibria: first, de-listing equilibrium; second, equilibrium when listing policy is perfectly price inelastic ($e$ = 0); and third, equilibrium when de-listing policy is price elastic ($e$ = 4).

Table 1
Example of drug price discount

| | $e$ | Price (£) | Discount from de-list price |
|---|---|---|---|
| De-listing | - | $p^e_j$ = 9.78 | - |
| Non price depended de-listing policy | 0.00 | $p^i_j$ = 8.69 | 11.14 % |
| Price depended de-listing policy | 4.00 | $p^i_j$ = 8.33 | 14.83 % |

Source: Author's calculations using the parameters $c$=6.52, $f$=1.15, $h$=3 and $d$ =1.

When de-listing policy is perfectly price inelastic ($e$ = 0), firms would set list price equal to £8.69, that is 11.14 % below the price which would like to set firms in case of de-listing, £9.78. When listing policy is prices elastic ($e$= 4), table 1 shows that firms would be kind to offer a 14.83 % discount on de-list prices.

Table 2 shows the results from equilibrium list price calculations. Results from the outlined case ($h$+$d$= 4 and $e$= 4) are compared to those cases with a larger demand elasticity ($h$+$d$ =5) and with a smaller demand elasticity ($h$+$d$ =3). Base case results are also compared with those cases with a larger price elasticity of de-listing policy ($e$ = 3) and those cases with a smaller price elasticity of de-listing policy ($e$ = 5).

Table 2
Examples of list prices ($p^i_j$) when firms have a risk $a_j$
of having their products de-listed from the formulary (£)

| | | *Lager differentiation (smaller elasticity)* | ***Benchmark*** | *Smaller differentiation (larger elasticity)* |
|---|---|---|---|---|
| | | $h+d$ =3.00 | $h+d$ =4.00 | $h+d$ =5.00 |
| *Smaller de-listing elasticity* | $e$ =3.00 | $p^i_j$= 9.18 | $p^i_j$= 8.41 | $p^i_j$= 7.99 |
| ***Benchmark*** | $e$ =4.00 | $p^i_j$= 9.03 | $\boldsymbol{p^i_j}$**= 8.33** | $p^i_j$= 7.94 |
| *Larger de- listing elasticity* | $e$ =5.00 | $p^i_j$= 8.89 | $p^i_j$= 8.26 | $p^i_j$= 7.89 |
| *Price in case of de-listing* ($d$ =1) | | $p^e_j$= 13.04 | $p^e_j$= 9.78 | $p^e_j$= 8.69 |

Source: Author's calculations using parameter $c$=6.52 and $f$=1.15.

Table 3
Examples of list prices ($p^i_j$) when firms have a risk $a_j$
of having their products de-listed from formulary (£)

| | | *Lager differentiation (smaller elasticity)* | ***Benchmark*** | *Smaller differentiation (larger elasticity)* |
|---|---|---|---|---|
| | | $h+d$ = 3.00 | $h+d$ = 4.00 | $h+d$ = 5.00 |
| *Smaller de-listing elasticity* | $e$ = 3.00 | $p^i_j$=9.55 | $p^i_j$= 8.59 | $p^i_j$= 8.09 |
| ***Benchmark*** | $e$ = 4.00 | $p^i_j$= 9.48 | $\boldsymbol{p^i_j}$**= 8.56** | $p^i_j$= 8.07 |
| *Larger de-listing elasticity* | $e$ = 5.00 | $p^i_j$= 9.42 | $p^i_j$= 8.53 | $p^i_j$= 8.05 |
| *Price in case of de-listing* ($d$ =1) | | $p^e_j$= 13.04 | $p^e_j$= 9.78 | $p^e_j$= 8.69 |

Source: Author's calculations using parameter $c$=6.52 and $f$=1.05.

List prices are smaller when demand elasticity is larger and that list prices are smaller when the price elasticity of de-listing policy is larger. Table 3 shows the same type of examples when fixed costs in case of de-listing are only 5 percent larger than fixed costs in case of including drugs in the formulary ($f$=1.05).

When the lag between fixed costs in case of listing and de-listing is smaller, drug firms offer smaller price discounts on de-list prices. When $f$ equals 1.05 list price in our benchmark case is £8.56, that is only 12.47 % discount in front of the 14.83 % discount on de-list price offered in the benchmark case when $f$ equalled 1.15.

### 3.2 Examples of price differentials under reimbursing and cap constraints

Let us show equilibriums when drug firms are not only constraint by de-listing policy but also by a price cap set by a national price regulator or a major HCO when a drug is launched into the market. In this example, we use the following parameters: (1) following to Abbott III (1995) we have considered that the product life is 14 years (column 1, table 4); (2) common marginal cost is £6.52 across time ($c_t$=6.52 for $t$=0,1,...,13) and fixed costs in case of de-listing are 15 percent larger than in case of being included in the formulary ($f_{jt}$=1.15 for $t$=0,1,...,13); (3) common price elasticity of demand is constant across time and equals the elasticity of the outlined benchmark case ($h$=3 and $d$ =1); (4) the price elasticity of de-listing policy ($e_t$) is initially set equal to 5.47 ($e_t$ = 5.47) and decreases across time at a 5 percent rate each year as it is shown in column 2 of table 4 (the expected value of $e_t$ during the 14 year time period is equal to 4 as in the outlined benchmark case).

According to the equation given by (26) we find that firms would like to increase list prices ($p^i_j$) across time from £8.16 to £8.36 as column 4 of table 4

shows. However, list prices are always smaller than de-list prices would be ($p^e_{jt}$= 9.78 for $t$=0,1,...,13).

When drug firms are also constrained by a price cap, prices cannot be increased during the product life, and therefore assuming a 3 percent discount rate (as column 5 in table 4 shows), firms would set a higher introductory list price, that is equal to £8.34 in our example as it is shown in column 6 of table 4.

Table 4
Examples of equilibrium prices when de-listing policy elasticity is decreasing ($e_t$ *decreasing over t)* and prices are cap constrained

| | | *De-list price* | *List prices* | *List price under a cap* | |
|---|---|---|---|---|---|
| $t$ | $e_t$ | $P^e_{jt}$ | $p^i_{jt}$ | $b^t$ | $p^i_{jt}$ |
| 0 | 5.470 | 9.78 | 8.16 | 1.00 | 8.34 |
| 1 | 5.197 | 9.78 | 8.18 | 0.97 | 8.34 |
| 2 | 4.937 | 9.78 | 8.20 | 0.94 | 8.34 |
| 3 | 4.690 | 9.78 | 8.22 | 0.91 | 8.34 |
| 4 | 4.455 | 9.78 | 8.23 | 0.89 | 8.34 |
| 5 | 4.233 | 9.78 | 8.25 | 0.86 | 8.34 |
| 6 | 4.021 | 9.78 | 8.27 | 0.83 | 8.34 |
| 7 | 3.820 | 9.78 | 8.28 | 0.81 | 8.34 |
| 8 | 3.629 | 9.78 | 8.30 | 0.78 | 8.34 |
| 9 | 3.447 | 9.78 | 8.31 | 0.76 | 8.34 |
| 10 | 3.275 | 9.78 | 8.32 | 0.74 | 8.34 |
| 11 | 3.111 | 9.78 | 8.34 | 0.72 | 8.34 |
| 12 | 2.956 | 9.78 | 8.35 | 0.69 | 8.34 |
| 13 | 2.808 | 9.78 | 8.36 | 0.67 | 8.34 |

Source: Author's calculations using parameter $c$=6.52, $f$=1.15, $h$=3, $d$ = 1 and E($e_t$)=4.

When prices are sticky at the launch level, drug firms set list introductory price (£8.34) higher than the list introductory price which would be in equilibrium without price cap constraint (£8.16). However, when time goes by, list prices sticky at the launch level become smaller than those list prices which would have been set without the cap. For instance, at $t$=13 the price in

case of price cap regulation remains at £8.34 while prices would reach £8.36 otherwise.

Therefore, drug firms constrained by price cap would initially offer smaller price discounts to major HCOs for having their drugs included in the formulary. In our calculation, drug firm would offer only a 14.72 % discount (list price of £8.34 instead of de-list price of £9.78) rather than a 16.56 % discount which would have been offered without price cap constraint (list price of £8.16 instead of de-list price of £9.78).

These results are similar to that obtained by Abbott III (1995). In our model the force behind the increasing pattern of list prices when firms are not constrained by a price cap derives from the decreasing trend of the price elasticity of listing policy across time rather than from the decreasing trend on the price elasticity of demand over time as it is the case in Abbott III (1995). This author assumes that patients were less price elastic as each drug got older due to therapeutic and brand loyalty.

By contrary, we are assuming that HCOs find increasingly difficult to exclude older therapeutic categories of drugs. We model some sort of therapeutic loyalty building up across time which affect the decision of HCOs. Older therapeutic categories of drugs are priced below they would have been priced otherwise, while newer therapeutic categories of drugs are priced above they would have been priced otherwise.

## 4. Concluding remarks

We have studied why drug firms offer different prices due to reimbursing and price cap policies. Our model show that price reductions offered by pharmaceutical companies to major purchasers may have one or both of the following two causes: firstly, demand may become more price elastic once a

drug is included in the formulary; secondly, price reductions may also reflect the fact that costs are lower for products that are included in the formulary while, at the same time, the HCO de-listing policy is price-sensitive.

These results conform to the anecdotal evidence described and analysed by Elzinga and Mills (1997) and Danzon (1997) on the price discounts offered by drug firms to HCOs in the US. Drug firms offer price discounts when reimbursement implies a larger price elasticity of demand and, therefore, they do not violate antitrust laws.

Additionally, these results capture the key that the monopolistically competitive nature of medicine markets may explain price reductions. Drug firms offer price reductions when they face smaller fixed costs of prescription promotion in case of having a drug included in the formulary.

The results of this paper capture also the anecdotal evidence on price reductions offered by drug firms when the British or the Spanish governments announced that they were going to exclude medicines from the state-led HCO formulary. De-listings affected a smaller number of products than that announced due to price reductions not only in Great Britain but also in Spain. Drug firms offered price discounts on those drugs which were going to be de-listed, and like in Spain in 1998, some drug firms avoided having their products effectively de-listed.[2]

Finally, we have found the threat of de-listing and price caps modify the development of prices over time. Pharmaceutical firms would like to increase prices when the price elasticity of de-listing policy decreases over time. Drug firms would react by charging a higher launch price when the government

[2] As noted by one referee, may be political claims on how de-listing might impact on some firms profits might have also played a role on how many drugs were effectively de-listed in Spain in 1998. In our model, this producer bias might have affected the perception of the

disallow future increases of prices in excess of consumer price index. This is the case in Spain where price caps mainly affect the time path of prices, resulting in higher prices for new products but lower prices for old products.

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effective risk of de-listing faced by each company. A producer bias might reduce the price discounts offered by drug firms to the government.

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