DRUG PRICING AND RISK SHARING AGREEMENTS

by
Stefano Capri
Rosella Levaggi

Discussion Paper n. 0810
Drug pricing and risk sharing agreements

Stefano Capri and Rosella Levaggi

June 9, 2008

Abstract

In the recent past some forms of risk sharing agreements have been used in some countries in drug pricing. In this note we present a specific risk sharing agreement on effectiveness and show how such mechanism is going to affect the market in the long run. In particular, we will show how the regulator may create a trade off between expected efficacy and the number of patients to be treated using the pricing formula.

Keywords: Efficacy, Effectiveness, Drug pricing, risk sharing, listing

J.E.L. I18, I11, D45

1 Introduction

In Europe national authorities have continued to implement a series of measures, both controls (e.g. budget impact limitations for a single drug) and incentives (e.g. prescription limitations to be followed by physicians) to influence supply of and demand for pharmaceuticals. Although the form of the price regulation may vary, one of the essential elements of the process is that the outcome of the listing process for a drug is uncertain and depends on the efficacy \(D\), the price \(p\) and the market of the new drug \(x\). In other words, the profit an industry is expected to obtain from the commercialisation of a new drug can be written as:

\[
\max_{D,x} \pi(D; px) (p - c) x
\]

where \(\pi(D; px)\) is the probability of the new drug of being listed which depends on the efficacy of the drug and on the budget that it will require to be offered to the patients that will benefit from the drug \(px\). The probability of being listed is increasing and concave in \(D\) \(\left(\frac{\partial^2 \pi(D; px)}{\partial D^2} < 0\right)\) and decreasing in \(px\) \(\left(\frac{\partial^2 \pi(D; px)}{\partial px} > 0, \frac{\partial^2 \pi(D; px)}{\partial px^2} \geq 0\right)\).

Most systems do not foresee penalties if the drug effectiveness falls short of the declared efficacy and/or the volume is greater than what agreed. Only recently some forms of risk sharing agreements have been used in some countries (e.g. UK and Italy), where for some drugs the manufacturer has to rebate the full or the 50% of the treatment in case of failure. A new strand of the literature, starting with the contribution by Zaric and O’Brien (2005) incorporates in the
pricing mechanism a specific penalty if the quantity sold exceeds the negotiated one. In this note we present a specific risk sharing agreement on effectiveness and show how the risk sharing formula affects the definition of the price of the drug itself. In particular, we will show how the regulator may use the pricing formula and the parameters of the probability of being listed to influence the market for each drug.

2 The model

We assume that while the expected efficacy of the drug can be verified by both parties through the results of the randomised clinical trials the industry has to produce to the regulator, its effectiveness is not known when the price is set. Such uncertainty depends on several elements such as the role of compliance, the interactions with other drugs when patients have several pathologies, the appropriateness of physicians’ prescription behaviour. The industry has more precise information on the likely effectiveness of the drug because it has access to more information than the minimum required by the regulatory process and it can, to some extent, control the effectiveness of the drug through detailing. However, the regulatory systems often used in western countries do not give enough incentives to the industry to promote an appropriate targeting of the new drugs. In this note we assume that the price of the drug is set according to the efficacy as declared by the industry, but it might be reduced ex post if the effectiveness is lower than expected. The industry is trying to maximise its expected profit while the regulator wants to avoid overpaying for drugs having a limited effectiveness. The industry knows better than the regulator the probability distribution of the effectiveness owing to its information advantage on the way the efficacy results have been obtained. On the contrary, the regulator has more contractual power because it can set the rules of the game as concerns the parameters of the pricing reimbursement formula.

A new drug is about to be commercialised. Its level of cost effectiveness lies within a range of values $(0,A)$, with a known probability distribution $g(E)$ with $G(0) = 0; G(A) = 1$. To simplify the exposition, we assume that the distribution of this function is uniform, i.e. $g(e) = 1/A$. The price for any new drug is defined by the following formula:

$$p = \alpha D - z\alpha \int_0^A (D - E) \frac{1}{A} dE + k E$$

where:

$F$ = fixed costs (mainly research and marketing) the industry has borne and/or is going to incur to commercialise the product. We assume it to be a determined outside the model.

$D$ = is the cost efficacy that is declared by the industry for reimbursement purposes and that it will have to lie in the range $(0,A)$

$E$ = is the ex post effectiveness that can be observed by both parties, later in time.

$\alpha$ and $z$ are the parameters of the incentive formula.
The formula is asymmetric since the industry pays a penalty if the ex post effectiveness falls short the declared efficacy, but it will not be rewarded if it happens that the drug is more effective than declared. The reason for this asymmetry mainly depends on the consideration that the industry may have better information than the regulator on the likely effects of the drug hence it has a strong advantage in setting this parameter.

The industry applies for the drug to be reimbursed by the regulator. The latter may decide or not grant reimbursement; such decision depends on the effectiveness of the drug and on the budget \(B = px\) that is necessary to take care of the possible benefiter \((x)\) of the new drug. Both variables are measured in relation to the market in which the new drug is introduced. In particular we assume that the probability of being reimbursed can be defined \(\pi(D, B)\) where \(D^o\) and \(B^o\) is the efficacy of the drug and the budget spent for the old active principle. The function is assumed to be separable and additive in \(D\) and \(B\), i.e. \(\pi = \pi^{1} D + \pi^{2} B\).

This function is common knowledge to the actors in the decision process, i.e. the industry knows the parameters of this function before setting \(D\). Given that during the negotiation process both parties do not know the true effectiveness, the budget that the regulator uses in the decision to list the drug is the expected cost \(p^e = c + \alpha D\).

3 The decision by the pharmaceutical firm

The industry wants to maximise its expected profit and to do so it has to choose which level of efficacy that maximises the following function:

\[
\text{Max}_{D,x} \quad E\Pi = \left(\pi^{1} \left(\frac{D}{D^o}\right) - \pi^{2} \left(\frac{\alpha D x + kF}{p^o x^o}\right)\right) \left(\alpha D - z\int_{0}^{D} \left(D - E\right) \frac{1}{A} dE\right) x - (1 - k)F
\]

The F.O.C can be written as:

\[
\frac{1}{2}\alpha x \frac{4D\pi^{1} p^{o} x^{o} A - 3\pi^{1} p^{o} x^{o} z D^{2} - 4D\pi^{2}\alpha x D^{o} A + 3\pi^{2}\alpha x D^{o} z D^{2} - 2\pi^{2} D^{2} k FA + 2\pi^{2} D^{o} k F z D}{D^{o} p^{o} x^{o} A} = 0
\]

\[
-\frac{1}{2}\alpha D \left(-2A + zD\right) \frac{2\pi^{2} D^{o} \alpha D x - \pi^{1} D p^{o} x^{o} + \pi^{2} D^{o} k F}{D^{o} p^{o} x^{o} A} = 0
\]

The first order conditions can be interpreted as follows: for \(D\), the firm chooses the point where the marginal increase in the profit due to a change in the marginal probability of being listed is equal to the expected penalty the firm will have to pay if \(D < E\). For \(x\) the firm chooses the point where the marginal
increase in profit is equal to the marginal expected unitary profit. These conditions depend on the form of the probability function, on the distribution of the effectiveness parameter and on the reimbursement parameters $\alpha$ and $z$.

In particular, it is interesting to note that if the probability of being listed did not depend on efficacy and the penalty function was symmetric, the industry would have an incentive to play strategically only if $z \neq 1$.

If instead the probability of being listed depends on $D$, the firm may have an incentive in reporting $D$ strategically and the penalty $z$ can be used to reduce the incentive to misreport $D$. The choice is not so straightforward since the firm has to take account of the effect $D$ has on the budget and in taking this decision the firm can control $x$ as well. In this context $z$ can be used to reduce the incentive to the industry to bee too optimistic on the likely effectiveness of the drug. The optimal solution for $D$ and $x$ can be written as:

$$D^* = \frac{4A}{3} + \frac{kF}{3} \frac{\pi^2}{\pi^1} \frac{\Delta^\circ}{\Delta^\circ}$$

$$x^* = x^\circ \frac{2\pi^1 B^\circ A - z\pi^2 D^\circ kF}{\alpha (4\pi^1 B^\circ A + z\pi^2 D^\circ kF)} \frac{\rho^\circ}{\Delta^\circ} D^\circ = \frac{(2\pi^1 B^\circ A - z\pi^2 D^\circ kF)}{3\alpha z\pi^2 D^\circ D^*}$$

The efficacy declared does not depend on the rate at which it is reimbursed $(\alpha)$, but on other parameters such as the form of the probability of being reimbursed and on the proportion of fixed costs that the regulator is going to reimburse. The quantity for which the industry applies for listing is negatively related with the fine as one could expect. From a policy point of view it is interesting to note that the quantity is also negatively related with the declared efficacy. The equation presented above aslo show the relationship between price setting of different products. $z$ has a clear depressing effect on the profit since it decreases the price and quantity sold. As for $\alpha$, there effect is not so clearcut since it affects the price, the quantity and the probability of being reimbursed. To show how risk sharing affects the industry’s decision, let assume that the price is set by taking into account only the efficacy of the drug. In a long run equilibrium we may think that the price of any drug is set according to its efficacy. This implies that the price for the old drug is equal to $\alpha D^\circ$. The optimal level for $D$ and $x$ can be written as:

$$D^* = \frac{4A}{3} \frac{1}{z}$$

$$x^* = x^\circ \frac{1}{2\alpha} \frac{\rho^\circ}{D^\circ} \frac{\pi^1}{\pi^1} = x^\circ \frac{1}{2\pi^2}$$

This model shows how the efficacy $(D^*)$ and the number of potential patients $(x^*)$ will normally result in this regulated market. $D^*$ will be probably quite

\footnote{In this case in fact the derivative of $D$ with respect to profit is equal to $\alpha(1-zE)^*x$}

\footnote{For a discussion of such system see Capri and Levaggi (2002;2006)}
high (which is in line with the new innovative technologies) unless penalty \((z)\) is very high (which is quite improbable). The number of patients treated may be controlled by the regulator through the listing process. For example, if the latter wants the same number of patients treated with the old and the new drug, it will have to give a double importance to the efficacy compared to the budget. To some extent this may not be a perverse effect of regulation given that the new drugs are more effective, but also more targeted on restricted number of patients (Pirmohamed and Lewis 2004).

4 Conclusion

In this note we have presented a possible risk sharing mechanism based on the efficacy and effectiveness of the new drug. Such formula seems to limit the number of people that will be treated instead of increasing it as the risk sharing mechanism proposes by (NICE 2007; Barros 2007). In our analysis we have assumed that the number of patients to be treated is set before the negotiation and any patient in excess of \(x^*\) will not be reimbursed. Given the importance played by \(x\) in this model, the mechanism proposed by Zaric and O’Brien (2005) to control patients becomes even more important and the two instruments should be used together.

In actual fact such a system may be difficult to be used because drugs may have different cost of production and such a system would penalize those that have an higher cost. However we think that this simple relationship may shed some lights on the way regulation rules should be set. Finally, a pricing scheme has to be clearly specified and stable in the short an long term, otherwise it could damage rather than improve a reimbursement system (Claxton et al. 2008).

5 References

References


\(^3\)If \(\pi^1\) (the marginal probability to be listed directly correlated with the efficacy) is twice \(\pi^2\) (the probability to be listed inversely correlated with the budget),


Discussion Papers recentemente pubblicati

Anno 2006
0601 – Francesco MENONCIN “The role of longevity bonds in optimal portfolios” (gennaio)
0603 – Roberto CASARIN, Carmine TRECROCI “Business Cycle and Stock Market Volatility: A Particle Filter Approach” (febbraio)
0604 – Chiara DALLE NOGARE, Matilde VASSALLI “A Pressure-Augmented Taylor Rule for Italy” (marzo)
0605 – Alessandro BUCCIOL, Raffaele MINIACI “Optimal Asset Allocation Based on Utility Maximization in the Presence of Market Frictions” (marzo)
0606 – Paolo M. PANTEGHINI “The Capital Structure of Multinational Companies under Tax Competition” (marzo)
0607 – Enrico MINELLI, Salvatore MODICA “Credit Market Failures and Policy” (gennaio)
0609 – Françoise FORGES, Enrico MINELLI “Afriat’s Theorem for General Budget Sets” (marzo)
0610 – Aviad HEIFETZ, Enrico MINELLI “Aspiration Traps” (marzo)
0611 – Michele MORETTO, Paolo M. PANTEGHINI, Carlo SCARPA “Profit Sharing and Investment by Regulated Utilities: a Welfare Analysis” (aprile)
0612 – Giulio PALERMO “Il potere come relazione sociale. Il caso dell’università baronale italiana” (giugno)
0613 – Sergio VERGALLI “Dynamics in Immigration Community” (luglio)
0614 – Franco SPINELLI, Carmine TRECROCI “Maastricht: New and Old Rules” (luglio)
0615 – Giulio PALERMO “La valutazione dei titoli scientifici dei docenti del Dipartimento di Scienze Economiche dell’Università di Brescia” (settembre)
0616 – Rosella LEVAGGI “Tax evasion and the cost of public sector activities” (settembre)
0617 – Federico BOFFA, Carlo SCARPA “Exporting Collusion under Capacity Constraints: an Anti-Competitive Effect of Market Integration” (ottobre)
0618 – Monica BILLIO, Roberto CASARIN “Stochastic Optimisation for Allocation Problems with Shortfall Risk Constraints” (ottobre)

Anno 2007
0701 – Sergio VERGALLI “Entry and Exit Strategies in Migration Dynamics” (gennaio)
0702 – Rosella LEVAGGI, Francesco MENONCIN “A note on optimal tax evasion in the presence of merit goods” (marzo)
0703 – Roberto CASARIN, Jean-Michel MARIN “Online data processing: comparison of Bayesian regularized particle filters” (aprile)
0704 – Gianni AMISANO, Oreste TRISTANI “Euro area inflation persistence in an estimated nonlinear DSGE model” (maggio)
0705 – John GEWEKE, Gianni AMISANO “Hierarchical Markov Normal Mixture Models with Applications to Financial Asset Returns” (luglio)
0706 – Gianni AMISANO, Roberto SAVONA “Imperfect Predictability and Mutual Fund Dynamics: How Managers Use Predictors in Changing Systematic Risk” (settembre)
0707 – Laura LEVAGGI, Rosella LEVAGGI “Regulation strategies for public service provision” (ottobre)
Anno 2008
0801 – Amedeo FOSSATI, Rosella LEVAGGI “Delay is not the answer: waiting time in health care & income redistribution” (gennaio)
0802 - Mauro GHINAMO, Paolo PANTEGHINI, Federico REVELLI “FDI determination and corporate tax competition in a volatile world” (aprile)
0803 – Vesa KANNIAINEN, Paolo PANTEGHINI “Tax neutrality: Illusion or reality? The case of Entrepreneurship” (maggio)
0804 – Paolo PANTEGHINI “Corporate Debt, Hybrid Securities and the Effective Tax Rate” (luglio)
0805 – Michele MORETTO, Sergio VERGALLI “Managing Migration Through Quotas: an Option-Theory perspective” (luglio)
0806 – Francesco MENONCIN, Paolo PANTEGHINI “The Johansson-Samuelson Theorem in General Equilibrium: A Rebuttal” (luglio)
0807 – Raffaele MINIACI – Sergio PASTORELLO “Mean-variance econometric analysis of household portfolios” (luglio)
0808 – Alessandro BUCCIOL – Raffaele MINIACI “Household portfolios and implicit risk aversion” (luglio)
0809 – Laura PODDI, Sergio VERGALLI “Does corporate social responsibility affect firms performance?” (luglio)