Risk-sharing pricing models in the distribution of pharmaceuticals

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FOREWORD

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Europe Economics Staff Working Papers are intended to provide a complementary channel for making available economic analysis undertaken by individuals within the firm.

The present paper has been prepared by Andrew Lilico. Andrew is a consultant at Europe Economics. The paper sets out a formal economic framework within which to consider the merits or otherwise of risk-sharing contracts in the pricing of pharmaceuticals.

It is hoped that this work will provide a relevant technical contribution to an important area of current debate.

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Introduction

Negotiations with the NHS over the price of pharmaceuticals can sometimes be protracted and complicated. But usually, once a price is agreed, the pricing model is fairly simple. Each unit (e.g. a pill) costs a certain amount. If the NHS purchases more than a certain volume of units there may be some adjustment in the price, but pricing models are rarely much more complicated than that.

But from May 2002 the UK Department of Health (DoH) and pharmaceuticals companies supplying beta interferon and glatiramer for the treatment of multiple sclerosis (MS) agreed to a novel “risk-sharing” pricing scheme. Under this scheme payments by the NHS for these drugs is reduced on a sliding scale if patients show no improvement — that is to say, the drugs are paid for only to the extent that they work.

Although formalizing such a risk-sharing arrangement with the NHS is quite novel, such arrangements can be regarded as similar, conceptually, to money-back guarantee schemes, such as Merck’s “Get-to-goal” guarantee for patients taking Zocor (under which Merck promised to refund patients the cost of up to six months of their prescription if Zocor therapy, in addition to diet, did not help them lower their LDL cholesterol to target levels identified by their physicians).

A risk-sharing arrangement may seem at first sight simply a way for a health insurer or patient to pay less for drugs, since payment is made only some of the time. But a moment’s reflection shows that matters are not as simple as this. Less would be paid for the drug only if the price were unaffected by the change to risk-sharing — a very unlikely outcome. Perhaps, then, the price would rise so that the expected payment — taking into account the price and the probability that it would be paid — was left unchanged? As we shall see below such an outcome is plausible (under certain quite strong assumptions), but is by no means the general case. The most straightforward reason is that a risk-sharing contract, as its name would suggest, involves a re-allocation of risk between the patient (or the patient’s insurer) and the pharmaceuticals company. Under a standard pricing contract a patient bears the risk that he pays for a treatment but gains no benefit from it. Under a risk-sharing contract, in contrast, more risk is taken on by the pharmaceuticals company, which now takes on itself the risk that it supplies a treatment but is not paid for it.\(^1\)

Pharmaceuticals companies are often large multinationals that can reasonably be modelled as expected profit maximisers — that is to say, they are “risk neutral”, or at least relatively so. Patients, especially over treatment for diseases, are likely to be substantially more risk

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1 It is important to note that this is not all the risk here. Many treatments have unpleasant side-effects for the patient and, in any event, given that often treatments are exclusive (one would not take both paracetamol and aspirin for the same headache) the patient risks the lost opportunity cost of acquiring a different and more effective treatment.
averse than large companies. Thus a transfer of risk from patients to companies may represent a welfare gain. In cases where patients pay for their treatments directly, or pay a proportion of the price in a co-payment scheme (i.e. their insurance coverage is less than 100 per cent), or have some lobbying power over their health insurers (e.g. via political influence over national health systems), such a welfare gain may lead the patient to be prepared to pay a higher expected price — with the consequence of higher expected profits for pharmaceuticals companies. Section 1 sets out conditions under which this will be true, but it is worth noting a few here. Typically the gains from risk sharing will be greater:

- the more risk-averse are patients;
- the more unpleasant is the disease; and
- (under some conditions) the lower the success-rate of the treatment.²

Given that MS is an unpleasant disease and that the success-rates of beta interferon and glatiramer in treating MS are believed low, our analysis suggests that these drugs are natural candidates for there to be substantial gains from risk-sharing.

Of course, in many cases pharmaceuticals companies do not deal directly with patients or their political representatives, but instead with health insurers. Large health insurers may not have a very different attitude to risk from pharmaceuticals companies. However, in such cases there may still be gains from risk-sharing. One is that by engaging in risk-sharing pharmaceuticals companies may be able to add credibility to their claims about the effectiveness of drugs, thereby securing a higher price or even allowing the use of treatments that it would not otherwise be cost-effective to employ.³

Furthermore, in all these cases a risk-sharing contract gives incentives to pharmaceuticals companies to improve the effectiveness of their products by creating a direct link between effectiveness and return.

However, as we shall see the arguments about risk-sharing are not all one way. In order to make risk-sharing work there needs to be substantial monitoring by the pharmaceuticals company or some third-party. The costs of such monitoring will not typically be low and in many cases may outweigh the gains from risk-sharing. There are also other difficulties such as the need to limit eligibility.

We believe that under certain conditions risk-sharing schemes may be a promising way forward, both for drug companies and for patients — particularly for certain relatively new treatments. However, risk-sharing is not an arrangement likely to be desirable for all pharmaceuticals. Our aim in this paper is to identify conditions under which it might be

² Under more complicated scenarios (e.g. if there are different categories of patient by success probability) there are other conditions, as we shall see below.
³ Conditions under which this will be true are modelled below in Section 4.
desirable, issues that may lead to it not being desirable, and insights into new opportunities risk-sharing may bring.  

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4 Related schemes have also been employed recently in the US. For example, in Florida Pfizer managed to get its products on the Medicaid formulary by offering a scheme in which it promised that the use of its products will yield $33 million of saving over two years. To achieve that, Pfizer proposed a disease management program, in which 60 case-manager nurses, using Pfizer software to target chronically ill Medicaid recipients, are expected to produce $16.5 million in annual savings. These would come mostly from improving patients’ regular use of medicines, maintaining better dietary requirements and reducing their emergency room visits. Pfizer promised to reimburse Medicaid in case the savings do not meet the target. It intends to concentrate on monitoring about 12,000 high-cost patients, mainly with asthma, diabetes and heart diseases. Academics have however expressed doubts as to whether any savings can be verified in such a short period (two years) and whether the impact of the Pfizer scheme can be meaningfully separated from general decreases in prices of high-cost medicines.

Though there are conceptual similarities between the Pfizer scheme and the MS scheme in the UK, there are extra complexities in modelling Pfizer-type situations. In the analysis below we focus on cases like the UK MS scheme.
SECTION 1 — DEALING WITH A RELATIVELY RISK-VERSE PHARMACEUTICALS PURCHASER

In our first set of models we shall consider situations in which those buying pharmaceuticals are relatively more risk-averse than those selling them. There are a number of reasons why this might be so. One very straightforward case might be when those buying pharmaceuticals are individual patients (perhaps via co-payment schemes with insurance companies where coverage is less than 100 per cent), while those selling pharmaceuticals are large multi-national companies with a wide range of products. Another might be when those buying pharmaceuticals are national health systems accountable to the public, and where adverse newspaper coverage of one particular drug purchase that proved overly expensive or ineffective could result in political damage. In either case those buying drugs want this particular drug to work, and cannot afford to rely on the averages working out over a wide range of products. In contrast, a large pharmaceuticals producer with a wide range of products will be interested in his overall long-term profits, and can afford to take more (appropriate and carefully-judged) risks in the short-term.

For convenience we shall refer to the relatively risk-averse purchasers of pharmaceuticals as “patients” and model pharmaceuticals suppliers as expected profit-maximisers (with the consequence that they are risk-neutral) — though as set out above this will also apply when health insurers or national health systems play the role described here as “patients” and when pharmaceuticals companies as risk-averse, provided only that pharmaceuticals supplying companies are less risk-averse than the purchasers.

In our initial model there will be \( n \) identical sick people. Firms compete to treat the sick people and (for analytical convenience) to start with we assume they make zero profits. We shall assume that any fixed costs are sunk and have already been absorbed, so that firms maximise expected current profits, given by

\[
E(\pi) = n(p - c)
\]

where \( p \) is the average price received for treatment and \( c \) is the marginal cost of production. We shall take it that, throughout our initial discussion, \( E(\pi) = 0 \) (later we shall need expected profits to be positive). Unless otherwise specified we shall always assume that \( c \) is fixed (constant returns to scale).

Patients maximise expected utility. They start off sick, and have wealth \( W \). Their payoff from not being treated (\( U_{NT} \)) is given by

\[
U_{NT} = V(W - d)
\]

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5 The utility function specified in this section is a particular one convenient for presentational purposes. Varying the utility function, say by making health complementary with other consumption, can produce a richer variety of results. For example, when health is complementary and income depends on the health condition then risk-sharing contracts are most likely to be beneficial for expensive treatments of diseases that cause large potential differences in income connected with the state of health (e.g. the health problems of professional athletes). They are less likely to be attractive for people whose income does not increase when disease is cured (e.g. pensioners on fixed incomes). Risk-sharing schemes would still be, as found in the current model, more beneficial for more risk-averse individuals.
where $V(.)$ is the utility function for wealth and $d$ is lost earnings (or lost potential growth in earnings) from being sick (or the monetary equivalent of the unpleasantness of illness\(^6\)). Patients are risk-averse and hence $V' > 0$ and $V'' < 0$.

To save notation, we allocate being well a monetary equivalent of zero.\(^7\) Being treated leads to lost earnings (or has an unpleasantness equivalent to a monetary value, or involves an opportunity cost) of $T$. An index variable $i$ indicates whether treatments are successful ($i = 1$) or unsuccessful ($i = 0$). $q$ is the average probability that treatment is successful across the $n$ patients. $U_T$ gives the utility from being treated. $U_T$ will differ depending on the pricing scheme in place. There are two types of pricing we shall consider:

- First we consider the traditional case in which what is sold is the treatment (the drug, say)
- Then we consider the case in which what is sold is the cure.

### Selling the treatment

In this case what is sold by the manufacturer is the treatment, say at price $p^*$. The patient bears the risk that the treatment does not work, along with the risk that an unpleasant treatment is undergone to no effect. In this case the utility of treatment is given by

$$U_{T*} = V(W – p^* – T – (1-i).d)$$

and expected utility is given by

$$E(U_{T*}) = qV(W – p^* – T) + (1-q)V(W – p^* – T – d) \quad (1)$$

Hence the gain to the patient from treatment is given by

$$g^* = E(U_{T*}) - U_{NT}$$

Note that we require $q.d > T$, otherwise the treatment is so unpleasant that the patient would not undergo it even if it is free. Since the firm makes zero expected profits, and in this case the price received by the firm is guaranteed

$$\pi^* = n(p^* – c) = 0 \Rightarrow p^* = c$$

### Selling the cure

Next we consider the novel pricing policy whereby the patient pays only if he gets better. We might say that in a sense what the manufacturer sells to the patient this time is a cure for his disease, rather than a drug for its treatment. If the patient does not get better he does not pay the agreed price (which we shall this time call $p^{**}$). Thus in this case some of the risk of treatment is

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\(^6\) Alternatively, if it seems too mercenary to think of a disease in terms of its monetary value we could think of $W$ as the equivalent in units of health of our wealth.

\(^7\) This has no effect on the results. Alternatively, we can think of the value of being healthy as already incorporated into $W$. 

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transferred to the manufacturer (though the patient still bears the risk that the unpleasant treatment will be undergone to no effect). As manufacturers maximise expected profits we say they are risk-neutral,\(^8\) while patients are risk-averse, so we should expect that this sort of risk-transfer will improve overall welfare — and it does, as we shall now demonstrate.

In this case utility from treatment is given by

\[ U_t^{**} = V(W - i.p^{**} - T - (1-i).d) \]

Hence

\[ \mathbb{E}(U_t^{**}) = q.V(W - p^{**} - T) + (1-q)V(W - T - d) \] \hspace{1cm} (2)

So the patient's gain from treatment is now

\[ g^{**} = \mathbb{E}(U_t^{**}) - U_{NT} \]

As before the manufacturers make zero profits. Their average received price, \( p \), is equal to the price charged, \( p^{**} \), times the proportion of patients actually paying, \( q \). Hence

\[ p = q.p^{**} \]

\[ \pi^{**} = n(q.p^{**} - c) = 0 \Rightarrow p^{**} = c/q = p^*/q \]

**Showing that risk-sharing increases welfare**

Figure 1 illustrates what is happening here. The curved line gives the utility from different outcomes. For example, when the agent has bought the treatment (i.e. there is no risk-sharing) and it does not work, the final wealth equivalence is \( W - p^* - T - d \). In that case utility can be read off horizontally from the curve line at the left-hand \( X \). Expected utility from purchasing a treatment without risk-sharing will be at some point on the line connecting the two \( X \)'s. Exactly how far depends on \( q \). In the diagram we take \( q = 0.5 \) and mark the expected utility from the non-risk-sharing contract by "EU*".

\(^8\) We can imagine that a large drugs company has many products, diversified across many forms of treatment, and hence suffers markedly less impact from the failure of a treatment than does the patient.
Coming to the risk-sharing contract, the increase in final wealth in the case where the treatment
does not work is to raise it by \( p^* \). In the case of a successful treatment, final wealth is lower under
risk-sharing \((W - T - p*/q)\) than under a standard contract \((W - T - p^*)\) by \( p^*/q - p^* \) (because the
new risk-sharing price is higher).

Now consider expected wealth in the two cases. Call final wealth in the case of no risk sharing \( y^* \)
and final wealth in the case of risk-sharing \( y^{**} \). Then we have

\[
E(y^*) = q(W - p^* - T) + (1-q)(W - p^* - T - d) = W - p^* - T - (1-q).d
\]

\[
E(y^{**}) = q(W - T - p*/q) + (1-q)(W - T - d) = W - p^* - T - (1-q).d
\]

Thus \( E(y^{**}) = E(y^*) \). Since expected final wealth in these cases is always the same under the
risk-sharing contract as under the non-risk-sharing contract, any risk-averse patient will prefer the
scenario under which there is less spread in his possible final wealth. That is to say, such a
patient will prefer the risk-sharing pricing model, under which it is the cure which is sold.

**Implications**

Clearly, the more risk-averse are patients, the greater the gains from risk-sharing. We might
expect also that typically lower \( q \) would mean greater risk and hence greater gains from risk-
sharing. But in fact the exact effects of changing \( q \) depend on patient utility functions.\(^9\) Likewise

\(^9\) For example, if \( V''' > 0 \) always, then \( \partial G / \partial q < 0 \) regardless of other parameters, i.e. the gains increase as \( q \) falls, no matter how
unpleasant or otherwise the disease and the treatment, and regardless of the wealth of the patient.
the effect of changes in $W$ and $T$ are ambiguous, and will depend on the precise details of patient utility functions.

We can, however, prove that the returns from risk-sharing are greater for diseases which are more unpleasant (i.e. for which $d$ is higher), as follows:

Define the gain from risk-sharing over non-risk-sharing by

$$G = E(U_{t}^{**}) - E(U_{t}^{*})$$

$$= q.V(W - p^{**} - T) + (1-q)V(W - T - d) - q.V(W - p^{*} - T) - (1-q)V(W - p^{*} - T - d)$$

Now consider what happens as a disease becomes more unpleasant:

$$\partial G/\partial d = 0 - (1-q)V'(W - T - d) - 0 + (1-q)(V'(W - p^{*} - T - d))$$

$$= (1-q)(V'(W - p^{*} - T - d) - V'(W - T - d))$$

Now note that

$$W - p^{*} - T - d < W - T - d$$

for $p^{*} > 0$ (i.e. for $c > 0$)

and that

$$V^{*} < 0$$

Hence

$$V'(W - p^{*} - T - d) > V'(W - T - d)$$

$$\Rightarrow \partial G/\partial d > 0$$

Hence more unpleasant (or longer-term) diseases whose monetary equivalent value is higher offer greater opportunities from risk-sharing.

We have modelled here a case in which firms are competitive and make zero profits. In cases where firms do have some bargaining power there will be increased profits for firms as well. Thus, in the standard case of a fixed number of relatively risk-averse purchasers of pharmaceuticals, **risk-sharing offers the opportunity for increased profits for firms and increased welfare for patients, and the more unpleasant or long-term the disease, the greater the gains.**
Additional patients and lowered success probability

In our discussion so far we have assumed that the switch in pricing policy makes no difference to how many people are treated. That is to say, we have assumed that $n$ is fixed. However, there is the possibility that patients differ, and that some patients who would not purchase treatment under the old scheme will want to take advantage of the reduced risk of the risk-sharing pricing scheme.

First consider what happens if $n$ grows without any change in $q$. Note that if $p^* = p^*/q$, then by the results of the earlier section, consumers are better off under the new pricing model (given sufficient risk aversion and sufficiently high $q$). Increased production scale may also benefit manufacturers. The increased profits can either be retained by manufacturers or shared with consumers through lower prices — once again depending on the relative bargaining power of manufacturers and patients.

It seems plausible that additional patients will be those for whom the old treatment was less likely to succeed, and that will be our assumption here (this is quite a strong assumption, of course, and it could be that those who do not purchase under the original scheme differed instead in their initial wealth or the unpleasantness of treatment or the severity of the disease). There are a number of ways to motivate this. For example, consider the following story, for a case in which patients are following doctor recommendations:

The magnitude in increase in $n$ will depend on the degree to which doctors follow patients’ preferences, rather than purely the quality of medicines available and best match to particular conditions. In principle, the closer the doctors follow patient tastes, the higher is the expected increase in $n$ and thus in manufacturer profits.\[10\]

However, if the probability of success $q$ is an increasing function of the match between pharmaceutical properties and the specific type of patient conditions, then increase in the number of patients using the medicine may result in lower match between conditions and the pharmaceutical properties for the marginal patient, thus decreasing $q$.

This effect might be strengthened by patient and doctor perceptions that they do not lose anything by trying the pharmaceutical (if the therapy proves unsuccessful, they receive their money back). (Obviously this assumes that $T$ is relatively low.)

To formally analyse such a case, we assume that changing the pricing model attracts a new set of $n_2$ consumers with probability of therapeutic success equal to $q_2 < q_1$. If the original group of patients consisted of $n_1$ individuals with probability of therapeutic success equal to $q_1$, then the manufacturer’s profits under both pricing models are equal to:

$$\pi^* = n_1(p^* - c)$$

and

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\[10\] The manufacturer has no means to directly affect $n$, apart through marketing campaigns. Although, at least initially, the new sales strategy is likely to be perceived attractive (e.g. through its novelty), in the long-term, once the new sales strategy becomes popular, the effectiveness of such marketing campaigns will be limited.
Let’s assume that manufacturer does not want to decrease profits through switching to the new pricing model (i.e. $\pi^{**} \geq \pi^*$). Then:

$$\pi^{**} = p^{**}(n_1q_1 + n_2q_2) - (n_1 + n_2)c$$

$$\Rightarrow p^{**} \geq \frac{(n_1p^* + n_2c)(n_1q_1 + n_2q_2)}{(n_1q_1 + n_2q_2)}$$

and

$$q_1p^{**} \geq p^*.\frac{(n_1n_2c/p^*)(n_1 + n_2q_2/q_1)}{n_1 + n_2q_2/q_1}$$ \hspace{1cm} (3)$$

In the earlier section we have shown that the patient’s utility is enhanced by the new pricing model when $p^{**} \leq p^*/q_1$. Since $q_2 < q_1$ and $p^*/q_2 > p^*/q_1$, the increased utility of consumers in the first group also implies increased utility of the consumers in the second group. This condition can only be satisfied along with (3), if:

$$(n_1 + n_2c/p^*)(n_1 + n_2q_2/q_1) \leq 1$$

which implies that

$$q_2/q_1 \geq c/p^*$$

or

$$q_1/q_2 - 1 \leq p^*/c - 1$$ \hspace{1cm} (4)$$

Condition (4) means that the manufacturer is able to benefit from new pricing model as long as the expected percentage decrease in the probability of successful treatment among the new consumers, as compared to the initial group, is lower than the marginal profit on each unit sold. Note that for the perfectly competitive case we considered earlier, $p^* = c$, so condition (4) could not be fulfilled given that $q_1 > q_2$. Hence in such a case\(^{11}\) there can be no gain from risk-sharing if new patients who are more difficult to treat will be attracted by the new policy.

In summary, it appears that if the change of pricing strategy attracts new consumers, then:

- all consumers will be able to benefit as long as the new price is not higher than the old price multiplied by the probability of successful treatment in the initial group; and
- the manufacturer will be able to benefit as long as the profit margin on each unit sold is higher than the percentage decrease in the success probability between the original and new consumers.

\(^{11}\) e.g. perhaps out-of-patent generic drugs
From a practical perspective, this implies that the new pricing scheme appears attractive to manufacturers for pharmaceuticals for which:

- there is a big difference between marginal cost and price (e.g. high-value patented products); and
- new consumers attracted by the new pricing scheme have treatment characteristics similar to those of the existing consumers.
SECTION 2 — IMPROVING INCENTIVES

In the first section we have assumed that the success rate of a drug does not change once it is accepted on a formulary. Although this may be true under current arrangement between insurers and manufacturers, it need not hold in general.

A risk-sharing scheme gives clear incentives for companies to exploit any feasible improvements in the success-rate of treatments. Once a price is agreed, companies will make higher profits by increasing $q$ if that is possible.

It may be the case, for example, that a properly motivated manufacturer continues research aimed at increasing the success rate of a drug. This could be achieved not only through improvements in the chemical formulas used (which might require lengthy formal approval procedures) but also through improved dosage, company sponsored monitoring of patients under treatment or other innovative methods.\footnote{cf. the Pfizer scheme in Florida.}

This section argues that, unlike traditional arrangements, risk-sharing contracts create incentives for manufacturers to engage in activities improving the success rates of drugs even after they come into use.

Figure 2 illustrates the impact of a traditional fixed-price contract and risk-sharing contract on manufacturer incentives. The vertical axis depicts the revenue and the horizontal axis shows the success rate. Under traditional contracts, the firms’ revenue does not depend on the realisation of the success rate. Once a medicine is accepted on the formulary (i.e. it is assessed to have expected success rate of at least $q = q^*$), the firm is guaranteed revenue of $\pi^*$ per-unit sold, independently of the actual performance of the drug.

By comparison, admission to the formulary under the risk-sharing scheme makes revenues a function of the actual, rather than the expected, success rate of the medicine. If the success rate
is zero then the firm does not receive any money (the thick upward sloping line passes through the origin), while if the actual success rate is far above expectations the per-unit profit $\pi$ exceeds the $\pi^*$ level.

One could also imagine an intermediate solution where the risks and incentives connected with the difference between actual and expected success rate are shared between the insurer and the firm (the dotted upward sloping line). Under such a contract the firm is guaranteed some small fee per unit sold and a "bonus" per every successful treatment. The difference between thick and dotted upward sloping lines denotes the share of the insurer in risk and potential return. Such an approach appears sensible when a success of a treatment depends both on the firm and on the insurer (e.g. on the way the treatment is administered by the insurer's contracted employees).

In any case, it is straightforward to see that any upward sloping incentive-based revenue profile provides manufacturers with an incentive to increase the rate of success of the drug sold in the most cost effective manner. Any such improvement leads to higher profits for manufacturer and in extra consumer surplus for the additional patients that recover thanks to the improvements made.

**Summary**

Risk sharing contracts improve incentives faced by pharmaceutical manufacturers continuously to improve the efficiency of their medicines used by insurers. Such improvements, which may be achieved through modification of the chemical components used or through better implementation and monitoring of the treatment process, benefit the firm through higher revenues and consumers through consumer surplus accrued by additional patient recovery.
SECTION 3 — MONITORING

In the risk-sharing contracts we have been considering, manufacturers are paid only if their treatments are successful. Of course this may lead to perverse incentives for medical staff or patients to under-report success in treatment. Hence it may be necessary for the manufacturer to monitor patients to assess for itself how many actually recover. However, this may not be straightforward. Similarly, we have seen that a manufacturer offering a risk-sharing policy does not want to attract additional patients with a low probability of being treated successfully. The manufacturer may encounter difficulties in monitoring the actual number of failed treatments and whether the patients who started treatment actually qualified for it.

There are three important stages in the implementation of any risk-sharing scheme after its approval by the insurer:

- selecting patients eligible to participate in the programme (e.g. under the MS scheme only some 12.5-15 per cent of patients were eligible);
- assisting patients through the treatment; and
- verifying whether the disease has been cured.

Monitoring must be done carefully, so that the agency problem between the manufacturer (principal) and monitoring doctors (agents) is alleviated. The most obvious solutions include:

- monitoring in designated centres by well trained specialist doctors, which alleviates the agency problem through reputation effect (doctors are not willing to produce false reports to reclaim money, as decline in their reputation would be larger than any benefits they could accrue);
- monitoring by own company staff (the agency problem becomes an internal problem within the company and the motivations of employees can be aligned with those of the company through supervision or salary contracts).

Another possibility could include providing monitoring staff with financial motivation to perform their duties well, but this could result in adverse effect of underreporting failures.

Monitoring and restrictions on those eligible for risk-sharing treatment may also be beneficial for insurers. Although health insurers do not pay for unsuccessful therapies, treatment involves other uses of resources, such as doctor and nurse time and administrative costs. Hence, health insurers can benefit from monitoring of failed treatments and conditions of patients admitted (rejected) to the programme. Locating such monitoring and success verification in designated centres may well be a cost-efficient solution. By using designated centres and restricting eligibility, health insurers may also make the most of risk-sharing schemes.
Incentives for doctors

For reputational reasons, doctors participating in large-scale risk-sharing programmes might be looking for highest possible share of patients recovered. This would create two types of potential distortions:

- Doctors may overstate the number of patients recovered, or admit only patients whose chances of recovery are relatively high (the latter distortion is likely to occur even if recovery is verified by a third party).

- Doctors may be pressurised by patients or by insurers to admit patients with recovery chances below the threshold agreed by manufacturer and insurer.

Both problems could be at least partially alleviated by putting doctors on a pay scheme, which could counter the incentives to accept only best cases (or accept everyone) and align the characteristics of patients participating in the programme with those agreed by manufacturer and insurer.

An illustrative candidate pay scheme would be a rule whereby doctors receive a share of manufacturer profits (i.e. revenues from the insurer less production costs). Assuming that every treatment creates some effort cost to the doctor, the doctor is likely to accept the patient as long as the expected revenue for the treatment paid by the manufacturer to the doctor exceeds the effort cost. In that way, he faces the financial incentive to also accept patients with relatively low recovery chances, as long as such chances are higher than the manufacturer's threshold and are likely to result in additional revenues to the doctor.

When put under such schemes, doctors would face incentives to report high recovery rates, since these would increase their income. Even without incentive pay, they may have incentives to overstate the true recovery to boost their reputation of success and attract new people (or understate it if paid by the insurer depending on per-patient costs). Clearly schemes of this sort would be very radical and have wider implications. They are mentioned to illustrate issues rather than as concrete recommendations.

Verification of recovery is a particularly sensitive task. It not only determines doctor reputation and pay but also determines the payments from health insurer to the manufacturer. Since the insurer and the manufacturer have opposing financial incentives (the former wants low observed recovery rates, while the latter wants high), this task may best be performed either by a joint team or by third party experts independent of both the manufacturer and the insurer.

Putting doctors on a revenue-based incentive pay and establishing independent panels assessing patients' recovery would go some way towards alleviating the implementation and monitoring problems related to risk sharing schemes.

Monitoring in designated centres by well-trained specialist doctors would offer another partial solution, since it would alleviate the agency problem through reputation effects (doctors are less
willing to produce false reports to reclaim money, as the decline in their reputation could be larger than any benefits they accrue in the short-term).

**Monitoring costs**

The use of specially designated centres would result in relatively high per-patient costs of recovery verification, which in turn may mean that risk-sharing schemes can only be implemented successfully for expensive treatments, for which costs of recovery verification are a low fraction of total treatment costs.

There are a number of issues to note about the costs of monitoring:

- It is in the interests of health insurers to monitor patient outcomes to evaluate the effectiveness of therapies and to verify that those treated are actually sick, regardless of the pricing scheme of drugs. Since monitoring is going to occur anyway, it may be that the costs can be defrayed between the insurer and the drug company, perhaps by employing an independent verifier.

- However, it may be cheaper for a health insurer to verify that for a drug manufacturer or an independent verifier. A health insurer will probably have an existing relationship with medical staff and be able to use these relationships as part of outcome evaluation relatively cheaply. A drug company or independent verifier may need to duplicate much of the relationship-building and payments which health insurers must engage in anyway (simply to deliver treatment). The additional costs of doing this may be sufficiently high to outweigh the gains from risk-sharing.

In general, it seems likely that for standard drugs, where the disease is not very unpleasant, the probability of success is not very low, the decision-makers involved are not highly risk-averse, and the difficulties of monitoring are high, the costs of monitoring risk-sharing contracts will outweigh the gains. Risk-sharing will probably not become the dominant form of pricing in pharmaceuticals. However, this conjecture, and the precise crossover point at which monitoring costs outweigh other gains, may be subject to fruitful empirical testing.
SECTION 4 — DEALING WITH INSURERS THAT ARE NO MORE RISK-averse THAN PHARMACEUTICALS COMPANIES

The focus of most pharmaceuticals companies is to get their drugs onto the major insurers’ and national health systems’ formularies – their lists of drugs approved for use. The above analysis illustrates that there are gains to be made for manufacturers in offering to sell consumers a cure for their ailments, thereby bearing some of the risk that treatments fail. The gains are possible because pharmaceuticals companies are likely to be more able to bear risk than individual consumers. Consider two broad categories of cases:

1) Those in which the decision-makers for insurers are risk-averse.

2) Those in which the decision-makers for insurers are broadly risk-neutral.

In cases where there are co-payments by patients (so that the insurance coverage is less than 100 per cent) or where decision-makers in major insurers or national health systems are likely also to be risk-averse the above analysis would still largely apply. For example, if there were some major political downside to paying for a drug treatment which does not work an NHS decision-maker might prefer to pass that risk onto the drug companies. Similarly, a large national insurer like the NHS might be sub-divided into separate local trusts with their own decision-makers, and the financial impact of a failed treatment might be sufficiently large to induce risk-aversion. In these cases a drug company may have more success in getting its products onto insurer formularies if it offers risk-sharing.

However, let us consider also cases in which there is no co-payment by patients, and in which major health insurers are also relatively risk-neutral (or at least no more risk-averse than pharmaceuticals companies), so that the gains from risk sharing might seem at first to be less. The analysis this time focuses on asymmetric information issues.

Consider a pharmaceutical company approaching a health insurer with a new drug, hoping to get it onto the formulary. The drug company claims that it cures the ailment some percentage of the time, and can produce laboratory tests to illustrate this. But the health insurer may not be able to check independently the success-rate of the drug, and even if it can there still may be differences between the performance of the drug in practice and in trials. One way that the drug company can provide credibility to its claims about the effectiveness of a drug is to back up those claims by taking on itself the risk of failure. One way to do that is to offer a pricing model in which only successful treatments are paid for. Thus in this case risk-sharing is a way for the drug company to overcome the moral hazard problem that it may lack transparent incentives to gather accurate data on the effectiveness of its treatments.

We can set up a model to illustrate this point. Consider a principal-agent problem in which the principal is the insurer (say, a risk-neutral NHS decision-maker) and the agent is a drug company. Let us assume that the drug company wants to sell the NHS some drug, X, which has not been in

13 Note that all we require here is that the health insurer is rather more risk averse than the drug company, rather than its being markedly risk averse per se.
use before. Let us suppose that the drug might work well, in which case it treats successfully with probability $q_H$, or it might work badly, in which case it treats successfully with probability $q_L$, where $q_H$ is greater than $q_L$. Let us assume that from the NHS decision-maker’s point of view each of these is equally likely, and that he has no independent way of determining which is true. Call the expected success probability from the point of view of the NHS decision-maker $q^\wedge$, where $$q^\wedge = \frac{1}{2}q_H + \frac{1}{2}q_L$$

The company, from its own internal testing knows whether the success probability is $q_H$ or $q_L$, but has no credibility if it claims that the probability is $q_H$ because the drug is only to be used once (or it is about to be used for the first time), and if it doesn’t work that may just be bad luck.

Otherwise, notation is as before. Note that the NHS decision-maker is risk neutral, so now his expected utility is simply his subjective expectation of his final wealth equivalent.

In this situation, under a traditional pricing scheme in which the drug is sold and risk is not shared, we can work out how much is the most the NHS will be prepared to pay as follows.

$$E(U_{NT}) = W - d$$

$$E(U_*) = q^\wedge(W - p^* - T) + (1-q^\wedge)(W - p^* - T - d)$$

Hence the NHS will purchase the treatment iff

$$q^\wedge(W - p^* - T) + (1-q^\wedge)(W - p^* - T - d) - W + d \geq 0$$

$$\Rightarrow p^* \leq q^\wedge d - T$$

$$\Rightarrow \pi^* \leq n(q^\wedge d - T - c)$$

In such a situation we shall see that a firm which knows that the success probability is actually $q_H$ can increase its profits by offering a risk-sharing contract, provided that the disease is sufficiently more unpleasant than the treatment, relative to $q_L$. As we have seen previously, in a risk-sharing contract, profits are given by

$$\pi^{**} = n(q^\wedge p^{**} - c)$$

If the success probability is actually $q_L$ then that means

$$\pi^{**} = n(q_L p^{**} - c)$$

Hence at a sufficiently low price for $p^{**}$, a drug company which knows that its success probability is $q_L$ will prefer to confess this and be paid

$$p^* = q_L d - T$$
The necessary condition is that profits from confessing and accepting a traditional contract under which it is assumed that $q = q_L$ should be greater than from lying and taking a risk-sharing contract:

$$\pi^{**} < \pi^* \text{ for } q = q_L$$

$$\Rightarrow q_Lp^{**} < q_L(d - T)$$

$$\Rightarrow p^{**} < d - T/q_L \quad (5)$$

At the same time, under certain conditions the price for $p^{**}$ can be high enough that a company with success probability $q_H$ will prefer to claim this and be paid $p^{**}$.

The condition here is that profits should be higher from taking the risk-sharing contract rather than to accept a traditional contract under which the NHS has no idea what $q$ is (for if even the high-success-rate drug companies will take the traditional contract, then that contract would no longer be a screening device to separate the types of company). This means that

$$q_Hp^{**} > q^\wedge d - T \quad (6)$$

For conditions (5) and (6) to be satisfied at the same time we require

$$q_H(d - T/q_L) > q^\wedge d - T = (\frac{1}{2}q_H + \frac{1}{2}q_L)d - T$$

$$\Rightarrow d > 2T/q_L$$

Hence, when there are sufficiently unpleasant diseases, with sufficiently mild treatments and the chances of an ineffective treatment failing are not too low, it can be beneficial to a drug company to offer a risk-sharing contract as a way of providing credibility to its claims about the effectiveness of a drug.

Where there is some bargaining process between insurers and firms, so that any gains from risk-sharing are shared between them, then insurers will gain as well.
SECTION 5 — OTHER SNAGS

We have argued that there are situations in which risk-sharing pricing models can offer advantages to manufacturers, patients, and consumers. However, at least until recently, explicit risk-sharing contracts have not often been observed. One important reason, as discussed above, may be the possibly prohibitive costs of monitoring. In this section we consider other possible reasons.

Conflict between local and national objectives

Another snag is that if local health-insurance decision-makers (e.g. decision-makers in local NHS trusts) are risk-averse while the national health insurer is relatively risk-neutral, it might happen that a local decision-maker would agree to a price under a risk-sharing scheme which would make the scheme undesirable from the point of view of the national insurer. For example, consider the case where drug companies are able to gain some of the rents from risk-sharing and the national insurer is totally risk-neutral. Then the national insurer would not be prepared to pay anything extra for risk-sharing (since, as we saw in Section 1, the expected payment is the same in each case) but the local decision-maker would. If a local decision-maker is more risk-averse that can lead to risk-sharing being unprofitable for the national health insurer.

Disclosure incentives

Some drugs work better on some types of patient than others, as we have discussed above. There we considered circumstances under which offering risk-sharing attracted additional patients whom the drug company might not want as patients, and suggested that drug companies might need to use eligibility tests to restrict the number of patients. Here, instead, we consider the opposite kind of problem - situations in which a drug company may have incentives not to disclose that its drug works better on some types of patient than others.

The kind of situation we have in mind is as follows. Let us suppose there is a health insurer with $n$ sick patients. Drug A treats all sick patients successfully with probability $r$. There is another drug, B. The supplier of B knows that half of patients would be treated successfully by drug B with relatively high probability $q_H$ (where $q_H > r$) and the other half with relatively low probability $q_L$ (where $q_L < r$). The supplier of B also knows how to identify which patients will be treated successfully with high probability and which with low. However, the insurer does not know either that there are different sorts of patient or how to identify them. All he knows is that the average probability of treatment by drug B (which the supplier of B knows to be $(q_H + q_L)/2$) is $q^* > r$.

Thus on average drug B is a better drug than drug r. But what the health insurer would like ideally is for the supplier to confess that $q_L < r$ and supply B only to those treated with probability $q_H$, leaving the rest to be treated with drug A. However, it is not always in the interests of the supplier of B to do this, as we shall see now.
Ignore for the moment issues of risk-sharing, and consider a situation in which both the health insurer and the drug company are risk-neutral (which, on this occasion, is going to leave them indifferent between risk-sharing and traditional pricing). First consider supply of drug A. The insurer will buy A if the expected value of treatment exceeds the expected value of no treatment. Using the same notation as before, the expected value of no treatment is given by

\[ U_{NT} = W - d \]

The expected value of being treated with drug A is given by

\[ E_{UA} = r(W - p_A* - T) + (1-r)(W - p_A* - T - d) = W - T - p_A* - (1-r)d \]

Now consider the options facing the supplier of drug B. He can supply all \( n \) patients and conceal that he knows that half of them are better treated by drug A, or he can reveal that and supply only the half most effectively treated with B. Call these alternatives “conceal” and “reveal”. Let us assume that the supplier of B has sufficient bargaining power in either case to recover all gains from trade as positive profits.

Consider his returns from the “conceal” strategy. Then if he buys drug B the expected utility of the health insurer is

\[ E_{UB}^{\text{conceal}} = q^H(W - p_B^{\text{conceal}} - T) + (1-q^H)(W - p_B^{\text{conceal}} - T - d) = W - p_B^{\text{conceal}} - T - (1-q^H)d \]

Which means that drug B will be preferred by the health insurer provided

\[ p_B^{\text{conceal}} \leq p_A* + (q^H - r)d \]

On the other hand, for the “reveal” strategy we have

\[ E_{UB}^{\text{reveal}} = q^H r(W - \frac{1}{2}p_A* - \frac{1}{2}p_B^{\text{reveal}} - T) + q^H (1-r)(W - \frac{1}{2}p_A* - \frac{1}{2}p_B^{\text{reveal}} - T - \frac{1}{2}d) + (1-q^H) r(W - \frac{1}{2}p_A* - \frac{1}{2}p_B^{\text{reveal}} - T - \frac{1}{2}d) + (1-q^H) (1-r)(W - \frac{1}{2}p_A* - \frac{1}{2}p_B^{\text{reveal}} - T - d) \]

\[ = W - T - (p_A* + p_B^{\text{reveal}})/2 - (1 - (q^H - r)/2).d \]

In this case, drug B will be purchased provided that

\[ p_B^{\text{reveal}} \leq p_A* + (q^H - r)d \]

Profits to the supplier of B are given by

\[ \pi_B^{\text{conceal}} = n(p_B^{\text{conceal}} - c) = n.(p_A* + (q^H - r)d - c) \]

and

\[ \pi_B^{\text{reveal}} = \frac{1}{2}n(p_B^{\text{reveal}} - c) = \frac{1}{2}n.(p_A* + (q^H - r)d - c) \]

Since firms maximise expected profits, the supplier of B will choose to “reveal” iff
Suppose, for simplicity, that when the supplier of A make all the gains from trade his production is just profitable. Then

\[ p^*_A = r.d - T \]

and the supplier of B will “reveal” iff

\[ \frac{1}{2} n (r.d - T + (q_H - r)d - c) \geq n (r.d - T + ((q_H + q_L)/2 - r)d - c) \]

\[ \Rightarrow c \geq q_L.d - T \]

That is to say, he will reveal only if he wouldn’t be able profitably to sell drug B as a treatment for only that half of the population for which it is least effective, even if drug B were the only available drug on the market. So for drugs with very low marginal costs of production, there are incentives to conceal those classes of patients for which they are least effective. On the other hand, when drugs are relatively expensive to produce companies have incentives to identify for which sections of the population they are most effective.

Move on now to the case of a risk-averse insurer. Since the gains from selling drugs tend to increase with risk-sharing, since the gains from risk-sharing are affected by the probability of success of drugs, and since the gains from concealing information about the effectiveness of drugs are also related to their effectiveness, it seems conceivable that there may be situations in which it would not be advantageous to conceal information about the effectiveness of drugs under traditional pricing, but it would be under risk-sharing. Conversely, it also seems conceivable (though intuitively less likely) that there may be situations in which it would be advantageous to conceal information about the effectiveness of drugs under traditional pricing, but it would not be under risk-sharing. This is yet to be proven robustly, but since it has significant implications for regulation under risk-sharing it seems an important area for future research.

**Pharmaceuticals used repeatedly**

In earlier sections, we have assumed that consumers face the same uncertainty each time they buy a medicine (or, alternatively, that they buy the medicine only once). But consider medicines taken by consumers repeatedly. We shall assume that consumers learn in the first period whether a medicine provides a successful treatment and then decide whether to continue using it or to abandon further purchases. In addition, at any given moment, the population of consumers is dominated by individuals knowing with certainty (or near certainty) whether the medicine is successful in their conditions. In such a case, any increase in prices will be disadvantageous for those consumers and to maintain a non-decreased utility of each consumer, the manufacturer has to keep the price on the same level under both pricing models.
If $n$ denotes the number of people trying given medicine ($n$ is assumed constant under both pricing schemes) and $v$ the average number of periods over which the medicine is being taken, then the manufacturer’s profits under both pricing models are equal to:

$$\pi^* = q \cdot n \cdot v \cdot (p^* - c) + (1-q) \cdot n \cdot (p^* - c) = n \cdot p^* \cdot (q \cdot v + 1-q) - n \cdot (q \cdot v + 1-q) \cdot c$$

and

$$\pi^{**} = q \cdot n \cdot v \cdot (p^{**} - c) - (1-q) \cdot n \cdot c = n \cdot p^{**} \cdot q \cdot v - n \cdot (q \cdot v + 1-q) \cdot c$$

Hence for $\pi^* = \pi^{**}$, it must be the case that:

$$p^{**} = p^* \cdot (1 + (1-q)/(q\cdot v))$$

(5)

This would however imply a price increase, at a disadvantage to some of the existing consumers. To see how big the change would be, consider a simple example in which the probability of success is 90 per cent and the number of periods over which medicine is usually taken is equal to 10. Then the percentage price increase would be $0.1/9 = 1.11$ per cent.

Can such a price increase be avoided? The analysis of the case of increasing customers points to possible sources of compensating revenue for manufacturers. Additional profits balancing revenues decreased because of maintaining the same price could be obtained if the number of consumers increases sufficiently, or when new consumers have lower success probability, if condition (4) is broad enough to accommodate the percentage drop in revenues.

However, the general message of this model is that gains from risk-sharing may be less when medicines are used repeatedly.
SECTION 6 — CONCLUSION

We have considered a novel form of pricing policy currently under review particularly in the pharmaceutical industry, under which drugs are paid for only if treatment is successful. We have identified a number of conditions and scenarios under which such risk-sharing pricing policies may be superior to traditional selling of drugs. In particular

- **When supplying drugs to patients, or to risk-averse insurers**
  - When those paying for drugs are risk-averse, provided that not too many marginal patients are attracted for whom treatment probabilities are low, risk sharing schemes offer potential benefits.
  - The more unpleasant the disease, the greater the gains from risk-sharing.
  - A risk-sharing scheme gives clear incentives for companies to exploit any feasible improvements in the success-rate of treatments.
  - When extra harder-to-treat patients are attracted by risk-sharing, it can still be a good idea provided that marginal profits per unit are sufficiently high (e.g. consider patented drugs for which the marginal cost may be very low).

- **When supplying drugs to large, relatively risk-neutral insurers**
  - Risk-sharing pricing can be beneficial in giving credibility to a drug companies claims about the effectiveness of new drugs, provided that diseases are sufficiently unpleasant and the side-effects of treatments relatively mild.

We have also identified a number of issues to bear in mind and possible snags when considering risk-sharing:

- When offering risk-sharing, drugs companies need to monitor for themselves the success of treatments, and may need to exclude from eligibility certain categories of patient for whom successful treatment is unlikely. (Such an approach will also be in the interests of health insurers.)

- Since both drug companies and manufacturers need to do monitoring under risk-sharing, this might best be done by an independent outsider.

- Where an independent outsider cannot be used for verification, or where the additional costs of outside verification are very high, these can outweigh the gains from risk-sharing.

- When local decision-makers are more risk-averse than national decision-makers locally-agreed risk-sharing can be undesirable for national insurers. (This provides a rationale for nationally-agreed risk-sharing prices.)
When drugs are likely to be used repeatedly, so that each person quickly learns his own probability of being treated successfully, there is less to gain from risk-sharing.

Areas for further research include:

- Extending the analysis of this paper to schemes like the Pfizer scheme in Florida
- Proving robustly whether allowing firms to offer risk-sharing can create perverse (or positive) incentives to reveal the effectiveness of therapies for different classes of patient.
- Designing contracts that would lead to successful implementations of risk-sharing schemes.
- Identifying whether specific drugs meet the conditions laid out for risk-sharing schemes to offer potential net benefits.

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