Reimbursement of Medicine Outlays

An Optimal Insurance Approach

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Abstract

In this paper, the reimbursement of spending on medicin is considered as a problem of insurance, where the loss due to illness of the insured is covered totally or partially by an insurance company (which may be the government). The presence of moral hazard (in the form of the individual patient's own effort to reduce cost by avoiding unnecessary medicination and choosing the cheapest drugs) implies that an optimal insurance will have less than total coverage of the patient outlays.

The insurance approach to drug subsidization indicates that reimbursement should vary with the type of medicin rather than with accumulated patient outlays. Also, secondary investment covering the remaining part of the patient's outlays, a feature of the reimbursement system in some countries, is suboptimal.

1. Introduction

In recent years, the rules for subsidization of drug consumption has been a field of concern, which has mainly originated in the steady growth of the burden on the public finances caused by this subsidization. Attempts at reducing the growing public outlays for drug subsidization have taken the form of price regulation, agreements with industry, and recently also a restructuring of the set of rules for drug subsidization. As a result of this reform, the subsidization will no longer be on a flat rate of 50% or 75% depending on the degree of urgency of the prescribed drug, but rather a subsidization which for the individual depends on the accumulated consumption in each given period.

In the discussion of the technicalities of rule formation, the basic purpose of drug subsidization has tended to slip out of the field of interest;

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the concern about public finances has outweighed other concerns.

In official reports[2] it is stated that the purpose of drug subsidization is to guarantee that patients will not be excluded from relevant treatment by drugs for economic reasons, a statement which in the sequel is elaborated into a list of demands of a rational system of drug subsidization[3]. It follows from this that special concern should be given to patients with a particularly great need of treatment, and that the system should support a "professionally and economically appropriate pattern of drug prescriptions". Furthermore it should enhance competition in the drug market as far as possible, but it should also be easy to use from the point of view of administration and transparent for all persons and institutions involved.

As it can be seen, there are rather many different objectives of the system, and any particular proposal is bound to perform weakly in at least some of these. Anyhow, as was perhaps to be expected, there is very little mention of these objectives in the new proposal for a law on subsidization of the drug consumption[4].

In the present paper, we consider this problem of designing an optimal drug subsidization scheme. In doing so, it is rather natural to take as a point of departure the literature on optimal taxes and subsidies. However, the present field is special from at least one point of view: Drug consumption is consumption under uncertainty, consumption of contingent commodities, namely drugs in the case of illness. Therefore, it is a field where insurance comes in a natural way: The government subsidizing drug consumption is essentially providing the public with an insurance. The fact that individuals pay no premium alters little or nothing in this picture. This being so, the theory of insurance seems to be the obvious tool for analyzing optimal subsidization, and once we are there, the problems of adverse selection and (in particular) moral hazard must be faced. It turns out that presence of moral hazard may explain some of the actual patterns in drug subsidization, but on the other hand, if moral hazard is a problem of some importance, then the rules (the actual as well as the proposed new ones) do not cope with it in the proper way.

The paper is organized as follows: In Section 2, we consider the basic insurance-theoretic approach to drug subsidization. Then, in Section 3, we discuss some of the more obvious deviations from the rules for optimal insurance which can be observed in practice. In Section 4, the model is extended to the situation of several risks rather than a single one. We conclude in Section 5 with some comments on the applicability of this

[2] Here taken from: Udfordringer på lægemiddelområdet [1998], p.139

[3] Ibid., p.140.

[4] Forslag til Lov om ndring af lov om offentlig sygesikring og om lov om social service, L 128, december 1998.

approach.

2. The drug reimbursement system as an insurance contract under moral hazard

As well-known, (cf. e.g. Borch [1990], Arrow [1963]) the optimal contract between a risk neutral insurance company and a risk averse customer is that where the company repays the full amount of the loss suffered by the insured except possibly for a constant, which does not depend on the size of the loss suffered. The insurance contracts of real life are however not often of this type, but contain elements of coinsurance and risk-sharing between company and insured. In many or even most cases, this is due to the presence of *asymmetric information* in one or more of its several versions. When information is not evenly distributed between insurer and insured, one of the parties, and in this context usually the insured, knows more about individual risk and effort to avoid or reduce losses than does the company. This type of market failure induced by the differences in information of the parties involved gives rise to contracts which depart from the simple principles governing insurance in an informationally perfect world.

In our discussion here we focus on a particular version of asymmetric information, namely *moral hazard,* where the probability of loss – and in our context this means the probability of having outlays for medicine – can be influenced by the insured, although at the cost of an individual effort. The exposition below follows Shavell [1979], see also Winter [1992].

In the following we consider a simplified situation, where the insured (the patient) has an initial wealth W and is subjected to the risk of a loss of L (interpreted as the payment for medicine which is a consequence of an illness). The probability of the loss is $p(e)$, where e is the individual effort of the insured to reduce her own risk. This effort is (in our present very simple model) treated as an outlay for the insured, so that effort costs r \$ per unit.

Assume that an insurance is offered at the premium π, which provides a reimbursement Q of the loss L. We may think of this insurance as provided by the public sector or by a private company, or it may alternatively be an insurance scheme administered collectively by a group of insured. As it appears from the formalism introduced so far, we assume that all insured are identical in the sense that L, Q, $p(e)$, and r are the same for all.

If each of the insured are endowed with a (von Neumann-Morgenstern) utility function U defined on the possible levels of final wealth, we get that the optimal insurance scheme – constructed in such a way that the insured are as well off as possible – will be found by choosing π, Q and e such that expected utility

$$p(e)U(W-\pi-re-L+Q)+(1-p(e))U(W-\pi-re)$$

is maximized under the constraints

$$\begin{aligned} p(e)U(W_L(e))+(1-p(e))U(W_N(e)) \\ \geq p(e')U(W_L(e'))+(1-p(e'))U(W_N(e')),\ \text{all } e', \\ \pi \geq p(e)Q, \end{aligned} \tag{1}$$

where we have used the notation $W_L(e)=W-\pi-re-L+Q$ for wealth in the case of loss at the effort level e, and correspondingly $W_N(e)=W-\pi-re$ for wealth without loss at effort level e (the dependence on e is explicit in our notation, but W_L and W_N depend of course also on the other parameters of the model, in particular π).

The first constraint is the so-called incentive compatibility property: The level of effort chosen by the insured in order to keep down her risk of loss is the one which is the most advantageous for the insured (if not she would have chosen another level, since this is what cannot be observed by the company). The second constraint is a break-even condition, stating that the scheme must not give rise to budget losses for the company, so that the premium must be large enough to cover average losses.

Rewriting the incentive compatibility condition, which states that e maximizes expected utility given π and Q, using Kuhn-Tucker conditions for constrained optimization, we get that either

$$\begin{aligned} \frac{1}{r}p'(e)[U(W_L(e))-U(W_N(e))] \\ =(1-p(e))U'(W_N(e))+p(e)U'(W_L(e)) \text{ and } e>0, \end{aligned} \tag{2}$$

or

$$\begin{aligned} \frac{1}{r}p'(0)[U(W_L(0))-U(W_N(0))] \\ <(1-p(0))U'(W_N(0))+p(0)U'(W_L(0)) \text{ and } e=0. \end{aligned} \tag{3}$$

The incentive compatibility constraint may be used to define optimal e as a function $e(Q)$ of Q, which together with $\pi=p(e)Q$ may be inserted in the expression for expected utility, so that the latter depends only on Q. First order condition for maximum is then

$$\begin{aligned} \frac{\partial EU}{\partial Q} = & -e'p'Q[(1-p)U'(W_N)+pU'(W_L)] \\ & -p[(1-p)U'(W_N)+pU'(W_L)]+pU'(W_L)=0, \end{aligned} \tag{4}$$

where the three members of the expression on the right hand side have an interpretation as expected utility gain from an increase in the coverage by one \$ from either (i) change in premium resulting from a changed reimbursement level per \$ premium, (ii) change in premium caused by higher coverage, or (iii) change of coverage.

How large then is the optimal coverage? That of course depends on the parameters; when the cost r of reducing risk is very high, it will never, that isfor all levels of coverage, pay to choose an effort level differing from 0. But if cost r is reasonably low, the optimal coverage may well be below L. Clearly it is in particular this kind of optimal solutions which are of interest for our discussion; if full coverage is optimal, then the discussion of moral hazard and of inducing risk-reducing behavior among the insured is obviously of minor interest, since anyway it would not be rational for society to have the insured choosing effort levels different from 0. In the sequel, we assume therefore that the optimal scheme provides for non-zero effort levels of the individuals.

3. Second-best optimum for the insurance problem with moral hazard

In the previous section we have described the basic insurance problem of medicine cost reimbursement and its socially optimal solution. As always, this is the scheme which would be chosen in an idealized situation where a benevolent planner makes the right insurance – specified by the optimal π and Q – available for the citizens.

In real life there are however further constraints caused by the actual institutions in society, and it may well happen that the insurance scheme which is chosen differs from the socially optimal one. In our present case we may think of at least two reasons for such a discrepancy:

(a) Budget constraints in the insurance company: As already mentioned, the health care financing authorities are usually not an insurance company in the usual sense of this word, since the premium is not collected directly from the individuals but are obtained indirectly through the tax payments of the citizens. As a consequence, the cost covering constraint, which we used in the previous section, and which gave us the simple relationship between premium and coverage, from which the company was free to choose any combination, lacks realism; rather than having a free choice (with due consideration of the individuals' choices) the company will be constrained by a budget given from above, meaning that average cost of reimbursement of losses should not exceed some given fixed amount. With this reformulation, we get a constraint of the form

$$p(e)Q \leq \pi \leq \bar{\pi}$$

in a second-best optimization problem, where $\bar{\pi}$ is the exogenously given budget constraint.

In this new situation it may of course happen that the new constraint is not binding, so that the socially optimal coverage Q^* with associated effort level e^* already satisfies $p(e^*)Q^* \leq \bar{\pi}$. However, the interesting case is of course the one where $p(e^*)Q^* > \bar{\pi}$, corresponding to a wish of higher coverage with the individuals than what they can actually get, since this would demand too large outlays by the company. In the solution of the second-best optimization problem an effort level e^0 and a coverage Q^0 are determined as solution of

$$\begin{aligned}&\frac{1}{r}p'(e)[U(\bar{W}_L(e)) - U(\bar{W}_N(e))]\\&\qquad = (1-p(e))U'(\bar{W}_N(e)) + p(e)U'(\bar{W}_L(e)) \text{ and } e > 0,\end{aligned} \tag{5}$$

or

$$\begin{aligned}&\frac{1}{r}p'(0)[U(\bar{W}_L(0)) - U(\bar{W}_N(0))]\\&\qquad < (1-p(0))U'(\bar{W}_N(0)) + p(0)U'(\bar{W}_L(0)) \text{ and } e = 0,\end{aligned} \tag{6}$$

where $\bar{W}_L(e) = W - \bar{\pi} - re - L + Q$,and $W_N(e) = W - \bar{\pi} - re$, together with the condition

$$p(e)Q = \bar{\pi}$$

Since our solution differs from the socially optimal one in having a smaller coverage ($Q^0 < Q^*$ according to our assumption), it is to be expected that the associated effort levels e^* and e^0 satisfy the relation $e^* > e^0$ (since it is impossible to get as much coverage as wanted, the individuals substitute from insurance to risk-reducing effort). In our model, it is possible to check our intuition by looking at a small reduction in the premium from the socially optimal level and keeping track of the coverage, which at premium π will be given as $\pi/p(e)$. Considering the function

$$\begin{aligned}f(e,\pi) = &\frac{1}{r}p'(e)[U(W_L(e,\pi)) - U(W_N(e,\pi)]\\&\qquad - (1-p(e))U'(W_L(e,\pi) - p(e)U'(W_L(e,\pi))\end{aligned}$$

we have that $f(e,\pi) = 0$ when e satisfies the incentive compatibility constraint at premium π and coverage $\pi/p(e)$. The partial derivative of f w.r.t. π is

$$\begin{aligned}\frac{\partial f}{\partial \pi} = -\frac{1}{r}\frac{p'(e)}{p(e)}&[(1-p(e)U'(W_L) + p(e)U'(W_N)]\\&\qquad + (1-p(e))[U''(W_N) - U''(W_L)]\end{aligned}$$

which is positive as each of its two members is greater than 0, the first one since $p'(e) < 0$ and the second one since $U'' < 0$ (U is assumed to be concave) and $|U''|$ is decreasing as a function of W.

By the same kind of reasoning we find the partial derivative w.r.t. e as

$$\frac{\partial f}{\partial e} = \frac{1}{r}p''[U_L - U_N] + \frac{1}{r}p'\left[U_L'(-r - \pi\frac{p'}{p^2}) - U_N'(-r)\right]$$
$$- p'(U_L' - U_N') - p'U_L' - (1-p)U_N''(-r) - pU_L''(-r - \pi\frac{p'}{p^2})$$

where each of the members on the right hand side is < 0 (here we use that U and p are concave functions, so that the partial derivatives are negative. Using the Implicit Function Theorem we get that in a neighborhood of e^*, e may we written as a decreasing function of π (given that coverage is determined residually as $\pi/p(e)$).

We may now, as contended, conclude that the optimal effort level e^0 in the budget constrained solution is greater than the effort level associated with the socially optimal solution e^*. In our application, where effort is directed towards preventing illness with its consequences in the form of costly medicine consumption (or perhaps rather towards reducing cost of the medicine consumption once the illness has actually occurred – we have here a distinction between *ex ante* and *ex post* moral hazard, which have the same consequences in our crude model but might be given a separate treatment in a more detailed model), the higher effort might be interpreted as a better prevention of illness resulting in an overall higher level of health, so that there is an unexpected benefit of the budget constraint. Unfortunately, if health has a value *per se,* then there would be a high effort level even in the socially optimal solution, and the general conclusion, that the individuals put up more effort (waste more resources in prevention of illness) than what is socially efficient, will still hold true. Also, it should not be forgotten that the individual effort may well take the form of using other parts of the health care system (than consumption of medicine), so that a greater level of effort may result in greater outlays in other parts of the public system.

(b) Several insurance companies: The problem treated as far has been a rather typical second-best problem, which in principle would arise in all situations where an optimal solution has to be implemented by a suitable mechanism, but there is an additional complication in our present context of insurance under moral hazard, connected with the possible presence of additional possibilities of insuring against outlays related to medicine. As a matter of fact, such additional insurance is available in Denmark, provided by the non-profit organization "Sygeforsikringen Danmark".

Assume that in the situation previously considered, where the individual is offered an insurance scheme with coverage Q and premium π, there is an additional company offering insurance against the residual loss $L - Q$ at a premium π', which is such that average cost is covered, that is satisfying

$$\pi' \geq p(e')q',$$

where e' is the effort level chosen by the individual who is insured *both* by the original scheme and by the new supplementary one.

First of all we should check whether the individual does actually want this insurance, that is whether she is better off with the two schemes than with only one. This can be done with the tools already developed, by checking whether the utility U of the individual increases if the coverage q in the supplementary insurance gets larger than 0, and the latter question can be answered by the same arguments as those leading to (4), so that we get

$$\frac{\partial EU}{\partial q}\Big|_{q=0} = -p[(1-p)U'(W_N) + pU'(W_L)] + pU'(W_L).$$

If we assume that $\partial EU/\partial Q \geq 0$ (so that the first insurance is either optimal or has a coverage which is smaller than the socially optimal), then it is seen by comparison of the above expression with (4) that the difference is the first member on the right hand side in (4), which is negative. In other words, we man conclude that $\partial EU/\partial q > 0$, at least for small values of the supplementary coverage.

A consequence of this is that the final combined choice of insurance in society becomes suboptimal – even if the first scheme were chosen in an optimal way, it would be individually rational to substitute from risk reduction to insurance. We have here a problem of over-insurance, which reduces the incentive for individual effort to reduce risk. If the supplementary insurance is designed to provide full coverage of residual loss, the associated optimal effort level will be 0.

4. The Ramsey pricing problem of differentiated subsidies

In the previous sections we have assumed throughout that there was a well-defined money loss L connected with medicine consumption caused by illness, but that the risk of suffering this loss could be partially controlled by the individual using the effort variable e. Among the many ways in which this rather primitive model can be refined is allowing for the possibility of several different losses (presumably connected with different kinds of illness and accordingly with different prescriptions of medicine). Thus, we assume that there are several uncertain events, each with its associated money loss L_i and independent effort-determined risks $p_i(e_i)$, $i = 1, \ldots, n$. Assuming for simplicity that the risks are so small that the case of two different events occurring simultaneously may be disregarded, the expected utility obtained in n different insurance schemes, each providing insurance against a particular of the n uncertain events, with premium π_i and coverage Q_i, and with effort towards reducing the risk of the ith event being e_i, $i = 1, \ldots, n$, is given by

$$\sum_{i=1}^{n} p_i(e_i)U(W - \pi - re - L_i + Q_i) + \left(1 - \sum_{i=1}^{n} p_i(e_i)\right) U(W_N(e)), \tag{7}$$

where we have put $\pi = \pi_1 + \cdots + \pi_n$, $e = e_1 + \cdots + e_n$.

As previously, in the search for a social optimum attention should be paid to incentive compatibility for the individual on the one side and balance of premium and expected losses for the company on the other side. The incentive compatibility condition states that the effort levels $(e_1, \ldots, e_n)$ at given π_i and Q_i will be chosen in such a way that individual expected utility is maximal.

The first order conditions for this maximum are now

$$\begin{aligned} \frac{1}{r} p_i'(e_i)[U(W_{L_i}(e)) - U(W_N(e))] \\ = \left(1 - \sum_{i=1}^{n} p_i(e_i)\right) U'(W_N(e)) \\ + \sum_{i=1}^{n} p_i(e_i) U'(W_{L_i}(e)) \text{ and } e_i > 0, \end{aligned} \tag{8}$$

or

$$\begin{aligned} \frac{1}{r} p_i'(e_i)[U(W_{L_i}(e)) - U(W_N(e))] \\ < \left(1 - \sum_{i=1}^{n} p_i(e_i)\right) U'(W_N(e)) \\ + \sum_{i=1}^{n} p_i(e_i) U'(W_{L_i}(e)) \text{ and } e_i = 0, \end{aligned} \tag{9}$$

which are the counterparts of (2) and (3) above. Once again the solution of the incentive constraints gives us the effort levels $(e_1, \ldots, e_n)$ as a function of $Q_1, \ldots, Q_n$, and the optimal coverage will be that which maximizes EU with respect to $Q_1, \ldots, Q_n$, when the effort levels are regulated by incentive compatibility and the premia are such that

$$\sum_{i=1}^{n} p_i(e_i) Q_i \tag{10}$$

(only the sum of the premia matter – we assume here that all risks are insured of by the same company).

We remark that the optimal effort against loss caused by the ith event depends on Q_j for $j \neq i$ in a very indirect way (through a change in the level of average utility), so that optimal effort e_i may be considered as a function of only Q_i,

$$e_i = e_i(Q_i). \tag{11}$$

This means that we can derive a first order condition for optimality corresponding to (4) by differentiating (7) (with (10) and (11) inserted, whereby we (using (8)) get

$$\begin{aligned}\frac{\partial EU}{\partial Q_i} &= -e_i' p_i' Q_i \left[\sum_{j=1}^{n} p_j(e_j) U'(W_{L_j}) + \left(1 - \sum_{j=1}^{n} p_j(e_j)\right) U'(W_N)\right] \\ &\quad - p_i \left[\sum_{j=1}^{n} p_j(e_j) U'(W_{L_j}) + \left(1 - \sum_{j=1}^{n} p_j(e_j)\right) U'(W_N)\right] \\ &\quad + p_i(e_i) U'(W_{L_i}) = 0\end{aligned}$$

The three members of this expression have interpretations corresponding to those of (4). When there are several different losses, there is now an additional condition, stating that marginal utility of decreasing risk should be the same for all the different losses. In our context of insurance against outlays caused by illness this means that the optimal coverages should be determined in such a way that individual effort towards reduction of loss balances with insurance cost in each of the schemes, or, otherwise put, the subsidies of each type of medicine should be determined in accordance with the possibilities of individual risk reduction related to the kind of illness at which this medicine is prescribed.

The latter conclusion remains also when a budget constrained insurance company is considered. In a second-best optimum under a constraint of the form

$$\sum_{i=1}^{n} p_i(e_i) Q_i \leq \bar{\pi}$$

expected utility is maximized w.r.t. $Q_1, \ldots, Q_n$ after insertion of the incentive compatibility conditions. It is easily seen that the expression for the partial derivative of EU w.r.t. Q_i becomes quite simple, namely

$$\frac{\partial EU}{\partial Q_i} = p_i(e_i) U'(W_{L_i}), \tag{12}$$

which is the expected utility gain from having 1 $ additional coverage of loss in case of event i. In (second-best) optimum the marginal utilities w.r.t. Q_i must be identical.

This rule bears some resemblance to the well-known Ramsey rule for public pricing using inverse elasticities (cf. e.g. Bös [1989]). What matters is average utility, and it is conceivable that even large losses are only reimbursed to a small degree, namely if they either occur with very small probability or if the individual may avoid them with only minor effort.

5. Concluding comments

As it has been said repeatedly, the analysis of the previous sections has been quite primitive, treating individual illness as an uncertain event with a definite probability and giving rise to a well-determined money loss. On the other hand, this very crude approach to the problem of medicine outlays and reimbursement of these outlays has the advantage of being tractable in the sense that it is possible to derive conclusions which provide some orientation for practical policy, and which may be compared to the actual policy in the field of medicine subsidies.

The Danish debate on subsidization of the medicine consumption of the population has tended to revolve around a few basic principles, which seem not to have been contested or even debated through the years – the system should be simple, meaning that flat-rate subsidies are preferable to elaborate systems of subsidization, and it should enhance the price consciousness of the consumers through a larger individual co-payment. As it can be seen, these basic principles are not supported by the model in the previous sections: If subsidies are to be designed in such a way that it conforms as well as possible with the demand for insurance of the individual against unexpected medical cost, with due consideration to the incentive structure and the need for individual effort to prevent illness and reduce its cost, then a differentiated system is superior to a flat-rate system, since it can be tailored to the specific conditions of the different cases of illness with associated medicine outlays.

The budget constrained illness insurance company seems to be an unfortunate construction from the point of view of optimal allocation, since the budget considerations of the company distorts this allocation in the direction of too much effort being directed to individual risk reduction or cost containment. Since budget constraints seem to be unavoidable in public administration, the Danish institutional arrangement, where reimbursement of medicine outlays is taken care of by regional government, must probably be considered as less satisfactory; an independent organization, financed after other principles than lump-sum budgeting, would be preferable.

Before jumping to conclusion it might of course be worth the while to develop the model somewhat further, freeing it from some of its more unfortunate restrictions, among which are the concentration upon risk reduction rather than ex post cost reduction (in the sense of e.g. Ehrlich and Becker [1973]). This will be the theme of further research in the field.

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