Physician Reimbursement and Technology Adoption

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Abstract

This study analyses the incentives of health care providers to adopt new technologies in a world with ex-post moral hazard. It is shown that even in a second best efficient world with respect to insurance coverage, there does generally not exist a simple remuneration scheme which implements the adoption of second best efficient technologies. The second part of the analysis assumes a standard coinsurance contract. Here, a shift from cost reimbursement to capitation as in the German in-patient sector or in some managed care plans in the US is likely to drive monetary costs down. But this effect may be outweighed by undesirable incentives with respect to non-monetary costs to the patient and the technically feasible level of healing.

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1 Introduction

The importance of technological change in the health sector has been a widely discussed topic in the economic literature[1]. Especially the discussion of the reasons for expenditure increases and cost explosion has recognized the key role of technical advances. The existing theoretical literature in the field has so far focused on welfare implications of new technologies under various insurance schemes. Yet one important player in the health care market has so far been neglected in the discussion: the provider of health care services. After all, it is the physician (or the hospital) who decides whether a technical innovation is adopted and offered to the patient or not. The technology choice and treatment recommendation depend on the financial incentives associated. A better understanding of the incentives implied by different reimbursement schemes is crucial for the state to induce welfare improving behaviour by providers. This study builds on the existing literature and analyses the incentives of health care providers to adopt new technologies.

A technology is described by a quadruple of parameters: monetary costs of treatment, non-monetary costs of treatment to the patient, non-monetary costs of applying the technology to the physician, and the level of healing which is possible using this specific technology. First, the results of the existing literature are replicated when asking which types of technological advances are welfare improving in a world without and with ex-post moral hazard. In the first best case both the provider's technology choice and the units of health restored for the patient are contractible. In this situation, decreases in monetary and non-monetary costs are welfare improving, whereas an increase in the technologically feasible boundary of healing is socially desirable. In the second best case technology still can be contracted upon, but the amount of health restored is chosen by the patient and cannot be determined by the state any longer. Welfare effects in this setting of ex-post moral hazard remain the same except for the technological boundary. If this boundary helps to limit overcon-

[1] See for example Fuchs (1996) and Weisbrod (1991).

sumption then an increase would induce even more overconsumption and in this case an increase would reduce social welfare. These results have already been derived by Baumgardner (1991). Building on them, the providers' incentives for adopting new technologies are investigated for various reimbursement schemes. Cost sharing, cost reimbursement, and cost subsidy are analysed. The welfare implications of these schemes in a world which is second best efficient with respect to insurance coverage are summarized in Proposition 1. It turns out that only in very special cases can the adoption of second-best efficient technologies be achieved by a simple remuneration scheme. This is the case if the physician receives a subsidy and the patient has to bear a positive copayment. Furthermore, the demand for health restored has to be elastic with respect to costs. In this setting, the physician has an incentive to reduce monetary and non-monetary costs to the patient. Finally, an increase in the feasible boundary of healing has to be desirable, which is most likely for extremely severe illnesses. In general, though, social welfare will be lower than in the second best case.

An important contribution of the analysis concerns the ongoing shift towards capitation systems for reasons of cost savings. In order to study the welfare effects of these changes, one first has to analyse the effects of technology parameter changes in a world with a given standard coinsurance contract which is not second best efficient. Effects of changes in the technological boundary and in non-monetary costs to the physician stay the same as in the second best case. But increases in costs to the patient may now be welfare improving if the patient's demand for health responds to such increases in a very elastic way. Then, the subsequent reduction in premiums offsets the negative effects of increased costs. Proposition 2 summarizes the corresponding welfare implications of the above mentioned reimbursement schemes in this situation. One can conclude that monetary costs are indeed in general driven down when changing from cost reimbursement to capitation. But incentives with respect to non-monetary costs and to the technological boundary of treatment may well offset these positive welfare effects. This holds true especially for the case of extremely severe diseases. A reduction in monetary costs may thus go hand in hand with welfare losses which more than outweigh the effects of cost savings. As a first attempt to reduce welfare losses, it might be useful to classify technologies in subgroups which are reimbursed differently.

In the empirical economic literature, there are a few studies which present direct evidence for the impact of technological change on cost growth. Some studies show at an accounting level that static supply and demand factors can only explain less than half of the growth of medical spending. They attribute the residual to technological change. Newhouse (1992) analyses health care expenditure growth per capita in the US from 1929 to 1990. He finds that aging, increased insurance, increased income, supplier-induced demand, and factor productivity changes account for less than 50% of the increase in expenditure. Growth rates of health care expenditure between 4 and 12.2% exceeded by far the growth rates of real GNP per capita in that period. Newhouse believes that the bulk of the residual increase which cannot be explained by the above factors is attributable to technological change. This kind of analysis cannot provide an explanation, though, for what actually drives technological change. It merely states its important role as one of the determinants of cost increases in the health sector.

One of the few studies which addresses this issue more closely is the study by Cutler and McClellan (1996). The authors examine the sources of expenditure growth in heart attack treatment. They first show that essentially all of the cost growth is a result of the diffusion of particular intensive technologies. Then they distinguish six factors that may influence technology diffusion: organizational factors within hospitals, the insurance environment in which technology is reimbursed, public policy regulating new technology, malpractice concerns, competitive or cooperative interactions among providers, and demographic composition. The authors conclude that insurance variables, technology regulation, and provider interactions have the largest quantitative effect on technological diffusion[2]. These factors affect both technology acquisition and the frequency of technology use. The study thus shows that in a micro-level analysis the impact of technological change on cost increases is probably even larger than suggested by the studies based on residual analysis.

The existing theoretical literature in the field does not explain the diffusion of new technologies nor look at the impact of regulation and the role of providers of health care. There are only a few studies which try to model technical advances in the health sector. They focus on the role of insurance coverage for welfare effects of technological change. Goddeeris (1984a, 1984b) derives conditions under which a costly technological change that increases capabilities increases or decreases welfare. Each technology is defined by a "healing function" which depends on health care expenditures. A technical advance changes this functional form such that a higher level of healing is possible using the same financial resources. This special structure does not allow differentiation between various types of technological advances. One could for instance imagine a new technology which uses the same financial resources for producing the same healing level as the old standard technology but which causes less suffering to the patient during the treatment. Certainly, we would want to capture this as a real "advance" from a welfare point of view. Baumgardner (1991) addresses this issue by describing a technology by three parameters: monetary costs of treatment, non-monetary costs, and the technical boundary up to which healing is possible using this technology. He analyses welfare effects of technological change under different insurance systems, but the type of technical advance can now be specified more clearly. Each parameter change can be analysed separately, which allows a better qualitative and quantitative measuring of technological change.

Differentiating between these separate effects is an important contribution of Baumgardner's study. We learn which types of technological advances are welfare improv-

[2]This is in line with an early study by Coleman et al. (1957) who looked at the role of physician networks for technology diffusion.

ing under full insurance, under co-insurance, and in a special HMO system[3]. Nevertheless, neither of these studies has yet explained which types of new technologies will actually be used in the health care market. We still cannot tell whether welfare improving or welfare decreasing technologies will be adopted. In my opinion, one should not neglect the role of an important player in the health care market: the role of the provider of health services, i. e. the physician or the hospital. It is the providers who actually are in the position to adopt a new technology and to offer the corresponding treatment to the patient. In fact, even if the state was able to classify new technologies according to Baumgardner's suggestions it would still have to consider the physicians' incentives to adopt these technologies. Therefore, if we want to answer the question of which innovations will experience a wider diffusion in the health care market, and how we can implement the diffusion of welfare improving technologies, we have to consider the incentives of physicians and hospitals to adopt these technologies. Analysing providers' incentives is the first respect in which I have extended Baumgardner's analysis. Secondly, I not only look at a world with second best efficient insurance contracts but also analyse the welfare implications of technology parameter changes in a situation which seems to fit the real world more closely. In the second part of the paper I study welfare effects assuming a standard coinsurance contract which is in general not second best efficient but accounts for truthful reporting requirements[4]. Although the results become more ambiguous the more descriptive approach appears be a necessary step for deriving policy implications.

I follow in my analysis the lines of the literature on the interaction of physician, patient, and insurer (see, for instance, Ellis and McGuire (1990, 1993) or Ma and McGuire (1997)). This literature combines the phenomenon of ex-post moral haz-

[3]Note that Baumgardner's approach in modelling HMOs differs from mine. He assumes that HMOs both use a capitation reimbursement scheme and limit the amount of health care provided by the physician. In my setting, the managed care system is only characterised by capitation. This implies different welfare effects from Baumgardner's analysis.

[4]See Ma and McGuire (1997).

ard with strategic actions of the physician. Although information is complete, the provider's action is not contractible and induces a demand response by the patient[5]. In my setting, the physician chooses a technology and offers this technology to the patient. The patient then chooses the units of health restored which maximize his utility given the technology offered[6]. Taking these actions into account, the insurer (or social planner) designs a remuneration scheme for the physician and an insurance contract for the patient. He cannot contract upon technology choice and amount of health restored. Although it seems reasonable that the state can indeed prohibit technologies which are obviously welfare decreasing, it will still leave some choice to the physician because the physician may be better informed about innovations entering the market or about the patient's needs. The assumption that the patient can choose the amount of care he consumes may seem stronger. It is in line, though, with the literature on ex-post moral hazard[7] and it seems to be a reasonable assumption for the analysis of certain institutions and certain types of treatment. As patients are increasingly better informed about health care products and treatments this demand response may even be strengthened in the future. The current setup fits any situation where the patient has some influence on the amount of treatment he receives. As an example one could think of routine checkups or preventive examinations. The costs and inconvenience they cause certainly influences the patient's decision on the frequency of use. Still, as also pointed out in section 5, there is space for future research relaxing this assumption.

I analyse a five stage game. In the first stage, the insurer offers contracts to the physician and to the patient. The insurance contract specifies a premium and a co-

[5]See McGuire (2000) for a survey on this literature.

[6]Note that the patient does not exactly choose the amount of health care consumed but the units of health restored through treatment. This follows Baumgardner's (1991) setup which allows a simple modelling of the technical boundary of healing limiting the patient's choice. Nevertheless, concerning the cost parameters, an interpretation of the results in terms of amount of health care chosen can be made.

[7]See Ma and McGuire (1997) for a discussion of "demand response".

payment rate, the remuneration contract for the physician specifies a fixed payment and the share in total costs of treatment which has to be born by the physician and which is deducted from the fixed payment. Both the patient's copayment rate and the physician's share can be positive (cost sharing) or negative (subsidy). In the second stage the patient and the physician decide whether to accept the contracts. Then nature decides whether the patient falls ill or not. In case of illness, the physician chooses the treatment technology in the fourth stage. A technology is specified by a quadruple of parameters, namely monetary costs per unit of health restored, non-monetary costs per unit of health restored to the patient, non-monetary costs of applying the technology to the physician, and the technical boundary of treatment. This boundary is defined as the maximal amount of health which can be restored and chosen by the patient and it captures the point up to which healing is possible using this special technology. In the example of preventive examinations the boundary can be interpreted as physical or capacity constraints on treatment use. Finally in the fifth stage the patient chooses the amount of health restored which is of course less than or equal to the technical boundary.

The rest of the paper is structured as follows: In section 2, the basic model in the first best situation is set up and the optimal contracts for the patient and for the physician are derived. Then, the welfare effects of changes in technology parameters are analysed. In section 3, ex-post moral hazard is modelled by assuming that the amount of health restored is chosen by the patient. Second best efficient contracts are derived and welfare effects of parameter changes through new technologies are established. Then, the incentives of providers for adopting new technologies are studied and analysed with respect to their welfare implications. Section 4 repeats the analysis for a standard coinsurance contract. As two examples, the German case of reimbursement in the in-patient sector and the US system of managed care are discussed. Section 5 concludes and considers topics for further research.

2 Model Setup in a First Best World

In this section, the first best insurance contract for the patient and the first best remuneration scheme for the physician are derived, taking the technology as given. Then it is shown how variations of the technology parameters affect social welfare. From this we can conclude which types of new technologies the social planner would like to implement.

The social planner maximises the patient's expected utility subject to the zero-profit conditions for the insurer and for the physician[8]. The optimal amount of health restored may be constrained by the technologically feasible boundary B. This is a convenient way to capture the idea that healing is only possible up to a certain level. The planner's problem therefore is given by

$$\begin{aligned} &\max_{m,P,a,R,s} (1-\pi)U(Y-P) + \pi U(Y-P-a\cdot c\cdot m-\epsilon+G(m)-n\cdot m) \\ &s.t. \\ &P-\pi(1-s-a)c\cdot m-\pi R \geq 0 \qquad \text{(zero-profit condition insurer)} \\ &R-(s\cdot c\cdot m+k) \geq 0 \qquad \text{(zero-profit condition physician)} \\ &m \leq B \qquad \text{(technology constraint)} \end{aligned} \tag{1}$$

with $G'(\cdot) > 0, G''(\cdot) < 0, \lim_{m\to 0} G'(\cdot) \to +\infty, U'(\cdot) > 0, U''(\cdot) < 0$

The patient has a strictly concave utility function. With probability $(1-\pi)$, he is in the good state of the world where no illness shock occurs. In that case, only the premium P is deducted from his initial endowment Y. The illness state occurs with probability π. In this case, the patient incurs an illness shock with a monetary equivalent of ϵ. In order to cure the illness shock the patient receives a certain amount of restored health m. Via the strictly concave production function G the chosen level of m is transformed into the monetary equivalent of restored health. Despite the fixed premium P the patient also has to bear part of the monetary costs $c\cdot m$ of

[8]This approach implies the assumptions of either competitive markets for both physicians and insurers or a state insurer who does not want to make profits and who extracts the physicians' rents.

treatment, with c representing constant marginal monetary costs of treatment. The share a he has to incur is determined by his insurance contract which specifies the fixed premium P and the copayment rate[9] a. Finally, the patient has to suffer from constant marginal non-monetary costs of treatment $n \cdot m$ where n are the marginal non-monetary costs.

If the patient falls ill, he receives treatment from the physician. This holds true if the physician's profit from signing the contract and treating the patient is at least as big as his outside option, here normalized to zero. The physician receives a fixed payment R and incurs part of the monetary costs from treating the patient. The share s of total costs which he has to bear can be positive (cost sharing) or negative. In this latter case, the physician receives a subsidy for every unit of treatment which he offers. Also the physician incurs non-monetary costs from treating the patient. These costs k are costs of applying the technology, e.g. costs of informing the patient on the procedure or the time needed to carry out an operation[10].

The insurer receives the premium P in both states of the world. In the illness case, he has to bear the share $(1 - s - a)$ of total monetary costs which is not born by either patient or physician. Furthermore, he has to pay the fixed payment R to the physician.

The technology in this setting is determined by marginal monetary costs of treatment c, by marginal non-monetary costs n to the patient, by the technological boundary B, and by costs k of applying the technology to the physician.

From the First Order Conditions with respect to the relevant variables m, P, a, R, s

[9]Note that a could also be negative, which would imply a subsidy to the patient for every unit of treatment.

[10]The non-monetary costs k of applying the technology have been modelled as fixed costs in order to focus on the parameters which have an impact the patient's demand response. The costs k do not influence this decision and are therefore less important for the main results of this study. As will become clear later, they nevertheless complete the model in the case of cost reimbursement as the physician is indifferent to changes of other technology parameters but still wants to reduce his non-monetary costs.

we obtain the well-known result that marginal utility is equalized over states, i.e. $U'(S) = U'(H)$ where S is income in the sickness state and H is income in the health state. The premium P thus includes all expected monetary and non-monetary costs incurred by the patient, i.e. $P = \pi(c \cdot m + \epsilon - G(m) + n \cdot m + k)$, whereas the physician is reimbursed for all his expenses: $R = s \cdot c \cdot m + k$. The patient's share in monetary costs a can be positive or negative because the patient is compensated for non-monetary costs of treatment and for the difference in utility between illness shock and healing. If, for instance, the maximal healing level is lower than the illness shock then the patient receives a monetary compensation for the residual of the illness shock which is left after the consumption of health care. For the characterisation of the first best amount of care, we have to distinguish two cases:
If $m^* < B$, then the first best amount of care is characterised by the condition $G'(m^*) = n + c$, i.e. marginal utility equals the sum of marginal non-monetary and monetary marginal costs. m^* decreases if n or c increase, and is unaffected by marginal variations of B and k.
If $m^* = B$, the condition $\pi U'(S)(G'(m^*) - n - c) - \mu = 0$ holds where μ is the Lagrange multiplier with respect to the technology constraint. m^* then increases with a marginal increase in B and remains constant when monetary costs c or non-monetary costs n or k are varied.
Now the effects of changes of technology parameters on social welfare can be analysed.

Lemma 1 *In the first best situation, social welfare decreases in monetary costs c and in non-monetary costs n and k. Marginal changes in monetary costs c and non-monetary costs to the patient n are perfect substitutes in their effect on welfare. When the technological boundary B increases*
i) welfare remains constant if the first best amount of care is an interior solution
ii) welfare increases if the first best is a corner solution.

Proof Using the Envelope Theorem, one can show that the effects of changes in technology parameters on social welfare are unambiguous. When denoting $V(c, n, k, B)$ as the value function the following results are derived:
$\frac{\partial V}{\partial c} = -\pi \cdot m \cdot U'(S) < 0$
$\frac{\partial V}{\partial n} = -\pi \cdot m \cdot U'(S) < 0$
$\frac{\partial V}{\partial k} = -\pi \cdot U'(S) < 0$
$\frac{\partial V}{\partial B} = \mu \geq 0$
where S indicates the income in the illness state. This replicates the results derived by Baumgardner (1991). **QED**

3 Provider Incentives and Welfare in a World of Ex-Post Moral Hazard

In the following, welfare implications of new technologies in a situation where patients exert ex-post moral hazard are studied. As a starting point, technology is still contractible but the level of restored health chosen by the patient is not. Throughout the paper it is assumed, though, that total costs of treatment are verifiable ex post. This allows us to abstract from an otherwise necessary reporting subgame[11]. Having replicated the results derived by Baumgardner (1991, p.41ff.) for the case of conventional coinsurance, incentives of providers for adopting new technologies and the corresponding welfare implications are analysed.
The social planner has to take into account the patient's response to a given insurance contract and technology. In case of illness the patient maximizes his utility over m. This is equivalent to maximizing his income in the illness state:

$$m_{SB} = \quad \text{argmax} \;\; Y - P - a \cdot c \cdot m - \epsilon + G(m) - n \cdot m \tag{2}$$

[11] Ma and McGuire (1997) consider such a subgame and therefore restrict their analysis to a positive copayment rate for the patient and to copayment rate and physician's share in total costs to less than or equal 1, an arrangement which induces truthful reporting to the insurer of the amount of care consumed.

s.t. $m \leq B$. The First Order Condition defines m_{SB} as an implicit function of a and the technology parameters. In the case of an interior solution, the condition $G'(m_{SB}) = n + a \cdot c$ holds. That means that the patient chooses m such that marginal utility equals marginal costs faced by him. m_{SB} decreases in the coinsurance rate a and in the non-monetary costs n, and is unaffected by variations of k and B. Variations in monetary costs c have an ambiguous effect on m_{SB} because this depends on a: If the patient is subsidized for each unit of health restored, i.e. if $a < 0$, then an increase in monetary costs in fact reduces total marginal costs faced by the patient and induces him to consume more, $\frac{\partial m_{SB}}{\partial c} \geq 0$. If the patient bears a positive copayment rate, $a \geq 0$, then he suffers from increases in monetary costs and consequently reduces the chosen amount, thus $\frac{\partial m_{SB}}{\partial c} \leq 0$. If there is a corner solution, m_{SB} increases in B, but is unaffected by marginal changes of other parameters.

The social planner takes the patient's response into account when designing the optimal insurance contract and remuneration scheme for the physician. He maximizes

$$\begin{aligned}
&\max_{P,a,R,s} (1-\pi)U(Y-P) + \pi U(Y - P - a \cdot c \cdot m - \epsilon + G(m) - n \cdot m) \\
&s.t. \\
&P - \pi(1-s-a)c \cdot m - \pi R \geq 0 \qquad \text{(zero-profit condition insurer)} \\
&R - (s \cdot c \cdot m + k) \geq 0 \qquad \text{(zero-profit condition physician)} \\
&m = m_{SB}(a, c, n, B) \qquad \text{(patient's reaction function)}
\end{aligned} \tag{3}$$

This yields the First Order Condition

$$-[(1-\pi)U'(H) + \pi U'(S)] \cdot [(1-a)\tfrac{\partial m}{\partial a} - m] = m \cdot U'(S) \tag{4}$$

which replicates Baumgardner's results for the coinsurance case[12]. a_{SB} is set such that the marginal expected gain from a marginal increase in a, which would lead to a reduction in P in both states of the world, is equalized to the marginal expected loss from a higher copayment in the illness state. a_{SB} can be derived from this

[12] See Baumgardner (1991), p.41, equ. (6)

condition. It still can be positive or negative. This allows us to calculate m_{SB} and P_{SB}. R and s can be chosen as one likes but such that the physician's participation constraint is binding.

Note that only if $a = 1$ is the first best amount of restored health chosen by the patient. But it may come as a surprise that ex-post moral hazard here may go in either direction. m_{SB} may be smaller, equal, or larger than m_{FB}. It is smaller if $a_{FB} \geq 1$ because then $a_{SB} > 1$ holds[13].

Now the effects of changes in technology parameters can again be analysed.

Lemma 2 *In the second best situation, social welfare decreases in monetary costs c and in non-monetary costs n and k. Marginal changes in monetary costs c and non-monetary costs to the patient n are no longer perfect substitutes in their effect on welfare*[14].

The effect of variations in B is now ambiguous. If $m_{SB} \geq m_{FB}$, B may put an upper limit on overconsumption. Then increases in B reduce welfare.

Proof Using the Envelope Theorem, one can derive the effects of changes in technology parameters on social welfare. When denoting $V(c, n, k, B)$ as the value function the following results are obtained:

$\frac{\partial V}{\partial c} = [(1-\pi)U'(H) + \pi U'(S)] \cdot \pi \cdot [a(1-a)\frac{\partial m}{\partial a} - m] < 0$

$\frac{\partial V}{\partial n} = [(1-\pi)U'(H) + \pi U'(S)] \cdot \pi \cdot [(1-a)\frac{\partial m}{\partial a} - m] < 0$

$\frac{\partial V}{\partial k} = -\pi \cdot [(1-\pi)U'(H) + \pi U'(S)] < 0$

If B is not a binding constraint, then $\frac{\partial V}{\partial B} = 0$

If B is a binding constraint, then $\frac{\partial V}{\partial B} = [(1-\pi)U'(H) + \pi U'(S)][-\pi(1-a)c] + \pi \cdot$

[13]This may happen in a situation where the patient is made better off by a small or even negative premium but has to bear more than the full costs of treatment in case of illness. For such a situation to be optimal the illness shock has to be very small compared to the first best amount of treatment. That is, the patient is "overtreated" in case of illness. Baumgardner (1991) excludes this possibility by restricting m such that medical treatment cannot raise health above its no-illness level.

[14]According to Baumgardner (1991) they are perfect substitutes; but he allows a_{SB} to be adjusted whereas here calculations present marginal effects using the Envelope Theorem.

$U'(S)[-ac + G'(B) - n]$

The latter expression is ambiguous in its sign. The first term is negative and represents the expected marginal disutility caused by a higher premium payment when B is marginally increased. This effect might offset the second positive term which stands for expected marginal utility from marginally increased treatment. This again replicates the results derived by Baumgardner (1991). **QED**

Let us now go one step further: Within this setting of ex-post moral hazard the physician can now choose the technology which he offers to the patient. Assume that there is a standard technology in the market which the physician uses. Now, an innovation takes place and a new technology is available. Which types of innovations the physician will adopt depends on his remuneration. From the second best analysis, it has become clear that the social planner would want him to adopt technologies which reduce costs, but the desired activity with respect to the boundary B is unclear.

In the last stage of the game the patient adjusts his preferred amount of restored health, m_{SB}, to changes in the technology parameters induced by the physician. The physician takes these adjustments into account when taking his decision. The physician maximizes his profit

$$\max_{n,c,B,k} \Pi = R - s \cdot c \cdot m_{SB}(a, c, n, B) - k \tag{5}$$

over n, c, B, k where $m_{SB}(\cdot)$ is the patient's response function. The First Order Conditions are

$$\frac{\partial \Pi}{\partial n} = -s \cdot c \frac{\partial m_{SB}}{\partial n} \qquad \text{with } \frac{\partial m_{SB}}{\partial n} \leq 0$$

$$\frac{\partial \Pi}{\partial c} = -s \cdot c \frac{\partial m_{SB}}{\partial c} - s \cdot m_{SB} \quad \text{with } \frac{\partial m_{SB}}{\partial c} \leq 0 \text{ if } a \geq 0 \text{ and with } \frac{\partial m_{SB}}{\partial c} \geq 0 \text{ if } a < 0$$

$$\frac{\partial \Pi}{\partial B} = -s \cdot c \frac{\partial m_{SB}}{\partial B} \qquad \text{with } \frac{\partial m_{SB}}{\partial B} \geq 0$$

$$\frac{\partial \Pi}{\partial k} = -1 \tag{6}$$

Obviously, the adoption of a new technology by the physician depends on s and on the patient's adjustment of m_{SB}. Only with respect to non-monetary costs k of applying the technology has the physician always the right incentives. He will - taken the other parameters as given - always choose the technology which causes the lowest non-monetary costs to him. The incentives and corresponding welfare implications regarding variations in the technology parameters are summarized in the following proposition:

Proposition 1 *(Second Best)*

- *Irrespective of his reimbursement, the physician always has the welfare increasing incentive to adopt technologies which lower his non-monetary costs k of applying the technology.*

- *Suppose $s = 0$ (cost reimbursement): The physician is indifferent between adopting a new technology or not, regarding variations in costs to the patient n, c and in the technical constraint B.*

- *Suppose $s > 0$ (cost sharing): The physician adopts technologies with higher non-monetary costs n; this is a welfare loss.*
  Technologies with a lower boundary B are adopted; this is socially desirable

only if B limits overconsumption.

The physician adopts technologies with lower (higher) monetary costs if $\frac{\partial m_{SB}}{\partial c} \cdot \frac{c}{m_{SB}} \geq -1$ (< -1)*; that is incentives are correct if the demand for health is rather inelastic with respect to cost.*

- *Suppose $s < 0$ (subsidy): The physician adopts technologies with lower non-monetary costs n; this is a welfare improvement.*

  Technologies with a higher boundary B are adopted; this is socially desirable only if B does not limit overconsumption.

  The physician adopts technologies with lower (higher) monetary costs if $\frac{\partial m_{SB}}{\partial c} \cdot \frac{c}{m_{SB}} \leq -1$ (> -1)*; that is incentives are correct if the demand for health is rather elastic with respect to cost.*

¿From this one can conclude that the state has to weigh potential welfare losses and gains against each other when designing a remuneration scheme for the physician. Only in very special cases may there exist a simple linear remuneration scheme, namely a cost subsidy, which induces correct incentives with respect to all possible parameter changes. This result is summarized in the following:

Corollary 1: *Second best efficiency can only be achieved in the following situation: The state implements a subsidy which induces the correct incentives with respect to non-monetary costs n. A higher B has to be socially desirable, this is the case if the illness shock is sufficiently severe or if the current technical boundary is very low. The copayment for the patient needs to be positive, and the cost elasticity of demand for health has to be elastic.*

In all other cases we are not able to achieve second best efficiency with a simple remuneration scheme. Expected utility of the patient will be lower than in the second best case.

4 Provider Incentives and Welfare Under "Standard Coinsurance"

The analysis in the previous section relied on the assumption that the state implements second best efficient insurance contracts. This is of course not what we observe in the real world. We observe insurance contracts which do neither differentiate between various diseases in terms of copayment rates nor adjust copayment rates as a response to technical changes in treatment. For our approach to provide policy implications it seems reasonable to analyse technology parameter changes for such a given real world coinsurance contract.

Let us assume in the following that the state sets a copayment rate $\bar{a}$, with $0 \leq \bar{a} < 1$[15]. The state then sets $\bar{s}$, $\bar{P}$, and $\bar{R}$ such that the participation constraints of the physician and of the insurer are just binding. This insurance contract will in the following be referred to as "standard coinsurance" contract. Notice that for the welfare analysis the size of $\bar{s}$ is not important as it always cancels out. The patient's utility under this given contract is

$$\bar{V} = (1-\pi)U(Y - \pi[(1-\bar{a})c \cdot m_{SB}(\cdot) + k]) + \pi \cdot U(Y - \pi[(1-\bar{a})c \cdot m_{SB}(\cdot) + k] \\ -\bar{a} \cdot c \cdot m_{SB}(\cdot) - \epsilon + G(m_{SB}(\cdot)) - n \cdot m_{SB}(\cdot)) \tag{7}$$

where $m_{SB}(\bar{a}, c, n, B)$ is the patient's reaction function to parameter changes and is equivalent to the second best case.

Now the effects of changes in technology parameters can be analysed for this standard coinsurance contract[16].

Lemma 3 *For a standard coinsurance contract with parameters $0 \leq \bar{a} < 1$, $\bar{P}$, changes in technology parameters have ambiguous effects on welfare. The more elastic the patient's response is to increases in monetary and non-monetary costs,*

[15] This may be seen as a tribute to the requirement of truthful reporting.

[16] It is assumed that P is always adjusted such that the zero-profit conditions for the insurer and for the physician are fulfilled.

the more likely is such an increase a welfare improvement because a high reduction in premiums is induced.
An increase in B allows on the one hand more treatment but this may be offset on the other hand by higher premiums to be charged.

Proof Differentiation of $\bar{V}$ with respect to the technology parameters gives[17]
$\frac{\partial \bar{V}}{\partial c} = -[(1-\pi)U'(H) + \pi U'(S)] \cdot \pi(1-\bar{a})m \cdot (1 + \frac{\partial m}{\partial c} \cdot \frac{c}{m}) - \pi \cdot \bar{a} \cdot m \cdot U'(S)$
$\frac{\partial \bar{V}}{\partial n} = -[(1-\pi)U'(H) + \pi U'(S)] \cdot \pi(1-\bar{a})\frac{m \cdot c}{n}(\frac{\partial m}{\partial n} \cdot \frac{n}{m}) - \pi \cdot m \cdot U'(S)$
$\frac{\partial V}{\partial k} = -\pi \cdot [(1-\pi)U'(H) + \pi U'(S)] < 0$
If B is not a binding constraint, then $\frac{\partial V}{\partial B} = 0$
If B is a binding constraint, then $\frac{\partial V}{\partial B} = -[(1-\pi)U'(H) + \pi U'(S)][\pi(1-\bar{a})c] + \pi \cdot U'(S)[-\bar{a} \cdot c + G'(B) - n]$
Variations in B and k have the same effects as in the second best case. Concerning changes in c and n, the first term represents the marginal utility which stems from a lower premium P when costs increase and consequently the amount of care goes down. The second term represents the marginal disutility caused by higher treatment costs. **QED**

The physician's maximisation problem is the same as in the second best case. So the following proposition can be established concerning incentives and welfare effects of technology parameter changes for a standard coinsurance contract:

Proposition 2 *(Standard Coinsurance)*

- *Irrespective of his reimbursement, the physician always has the welfare increasing incentive to adopt technologies which lower his non-monetary costs k of applying the technology.*

- *Suppose $s = 0$ (cost reimbursement): The physician is indifferent between*

[17]Here, for c and n only the results for inner solutions are reported.

adopting a new technology or not, regarding variations in costs to the patient n, c and in the technical constraint B.

- *Suppose $s > 0$ (cost sharing): The physician adopts technologies with higher non-monetary costs n; this is a welfare improvement if the demand for health is rather elastic with respect to non-monetary costs.*
  Technologies with a lower boundary B are adopted; this is socially desirable only if gains from additional treatment are low.
  The physician adopts technologies with lower (higher) monetary costs if $\frac{\partial m_{SB}}{\partial c} \cdot \frac{c}{m_{SB}} \geq -1$ (< -1); this is in line with welfare improvements requiring the demand for health to be inelastic (elastic) with respect to monetary costs.

- *Suppose $s < 0$ (subsidy): The physician adopts technologies with lower non-monetary costs n; this is a welfare improvement if the demand for health is very inelastic with respect to non-monetary costs.*
  Technologies with a higher boundary B are adopted; this is socially desirable only if gains from additional treatment are high.
  The physician adopts technologies with lower (higher) monetary costs if $\frac{\partial m_{SB}}{\partial c} \cdot \frac{c}{m_{SB}} \leq -1$ (> -1); this contradicts welfare improvements requiring the demand for health to be inelastic (elastic) with respect to monetary costs.

In reality, most technological advances will imply simultaneous changes of various technology parameters. The results from Proposition 2 can be used to illustrate such a situation. In Figure 1, simultaneous changes of non-monetary costs to the patient n and monetary costs c are considered, taking the other parameters as given. Four areas depending on the demand elasticities for health with respect to costs can be established. In the lower left corner of the graph, for example, the demand for health restored with respect to both monetary costs ($\eta_{m/c}$) as well as non-monetary costs ($\eta_{m/n}$) is inelastic. Indifference curves for the patient and isoprofit functions for the physician can be drawn[18]. In the lower left corner, a reduction in both monetary

[18] Figure 1 is a merely qualitative illustration. The slopes of the functions have been calculated

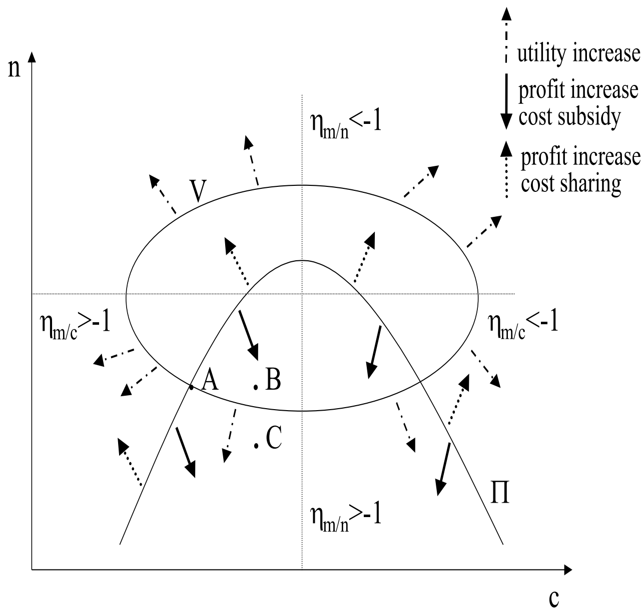

Figure 1: Simultaneous changes of non-monetary costs n and monetary costs c

and non-monetary costs is a welfare improvement for the patient. The physician's incentives depend on the reimbursement scheme. According to Proposition 2, he tends to adopt technologies which reduce monetary costs and increase non-monetary costs under cost sharing in this lower left corner of the graph. Unter a cost subsidy, his incentives are changed. Take the example of technology A. If an alternative technology B is offered which increases monetary costs the physician will adopt it under a cost subsidy, and this is a clear welfare reduction for the patient. If instead of technology B technology C is offered which not only increases monetary costs but also reduces non-monetary costs this shift may well be a welfare improvement.

In many countries, there is a tendency to shift from cost reimbursement to capitation systems. In **Germany**, for example, patients are in general publicly insured with a copayment rate of approximately $\bar{a} = 0$. Physicians in the out-patient sec-

by applying the Implicit Function Theorem to the physician's profit function (equation (5)) and the patient's expected utility (equation (7)).

tor receive cost reimbursement ($s = 0$). This implies that the only incentive they face with respect to new technologies is to choose technologies with a lower k, i.e. a lower non-monetary cost to them. Consequently, technical advances should not account for a large share in cost increases in the German out-patient sector. We should only observe the adoption of new technologies which reduce the physician's non-monetary costs and at the same time may increase or decrease the other technology parameters.

The more interesting case is the German in-patient sector: Since 1996, elements of prospective payment systems have been introduced for certain treatments, but today they still account for less than 25% of all cases[19]. Currently, the introduction of the system of Diagnosis Related Groups (DRGs) for a wider range of treatments is on the way. DRGs classify patients according to the diagnosis they have received into a certain category which implies a fixed payment to the hospital. That means that hospital reimbursement changes for an increasing number of treatment categories from cost reimbursement to cost sharing ($s = 1$). Consequently, the incentives for physicians change: They still choose technologies with a lower k. But they are no longer indifferent with respect to changes in the technology parameters c, n, and B. According to Proposition 2, incentives with respect to c are indeed welfare improving in this setting, as with $\bar{a} = 0$ the cost elasticity of demand for health is equal to 0. This is good news for the health care budget as we should observe in the near future a decline in health care cost increases caused by the adoption of new technologies. Nevertheless, cost savings come along with incentives to adopt technologies with higher non-monetary costs to the patient and with a lower technical boundary. These effects may or may not be socially desirable. For the case of severe illness shocks a tendency to lower B is in most cases not welfare improving. It is also very likely that for severe illnesses patients have a relatively inelastic demand for treatment with respect to non-monetary costs of treatment. At the same time, severe illness shocks are usually treated in a cost-intensive way and may induce

[19] See European Observatory (2000).

cost-cutting innovations.

In the last decades, managed care systems have found widespread utilization in the **United States** health care system[20]. These plans are so diverse that it is impossible to categorize them into one single scheme. Most plans require small copayments from their patients (and sometimes larger ones for treatment outside the network). But they use a wide range of methods to pay physicians and hospitals, including salaries, fee-for-service, and capitation. The largest HMO, Kaiser Permanente, for example currently demands small deductibles from patients for out-patient visits and a copayment of 30% (maximal $500) for in-patient procedures. The physicians are organized in regional groups and reimbursed according to group capitation and individual salaries. In my setting, this is represented by partial cost sharing. Still, my approach cannot capture the whole variety of managed care plans. Baumgardner (1991), for example, suggests that in an HMO system the organisation constrains the amount of care consumed by the patient. He then derives different welfare effects for the changes in technology parameters from those derived in our second best case. In a more detailed analysis these additional policy variables would have to be taken into account. The variety of reimbursement schemes could be used, though, for an empirical analysis of technology adoption. Depending on the payment scheme, certain technologies should experience a faster and wider diffusion under some managed care plans as compared to others. Case studies which analyse certain diseases and try to focus more explicitly on the type of technological progress which is introduced by a new technology seem to be a field for fruitful further research.

Overall, one should also observe more innovations with respect to those technologies which are adopted by physicians. This may provide another useful approach for empirical investigations.

[20]See Glied (2000) for an overview.

5 Conclusion

Provider incentives and welfare implications for adopting new technologies under various reimbursement schemes have been analysed. It has been shown that in a second best world of ex-post moral hazard, only in very special cases does there exist a simple remuneration scheme which implements the adoption of second best efficient technologies. Furthermore, the analysis of the current tendency to shift from cost reimbursement to capitation in countries like Germany has proved that the incentives for cost savings in a capitation system may be outweighed by negative welfare effects with respect to non-monetary costs of treatment or the technical boundary of treatment. The state should consider the different welfare effects of parameter changes when designing a remuneration scheme. It might then classify diseases or treatments in subgroups which may be reimbursed differently in order to achieve the desired welfare effects in each subgroup. Especially for the case of extremely severe illness shocks a return to cost reimbursement or even a subsidy may be socially desirable. It is these very severe diseases where the capitation system not only seems to induce negative welfare effects with respect to non-monetary costs but also with respect to the technologically feasible boundary of treatment. Bearing further cost increases in this sector of the health care market would probably be socially desirable.

Future research on provider incentives can be directed in many ways. The US system of managed care plans seems to provide due to its diversity of reimbursement schemes an ideal base for empirical research in this field. But also further theoretical investigations are due. Ongoing research is dedicated to the analysis of incentives in a setup of supplier-induced demand. This would relax our assumption that the patient chooses the amount of care he consumes and might fit certain institutional settings and treatment categories in a more adequate way. It would in particular take informational asymmetries between physician and patient more explicitly into account.

What has also been neglected in the analysis so far is the role of fixed costs. Especially when reimbursement systems change or new technologies come to the market physicians might experience a lock-in effect if they have adopted an expensive technology. The incentives for adopting technologies in the first place will certainly change in this setting. But physicians could also use the investment decision as a signalling device for patients in order to reduce informational asymmetries.
Finally, a closer look at strategic interactions of providers might be worthwhile. As pointed out in the empirical literature, competition as well as networks between providers seem to have a strong influence on the adoption of new technologies.

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