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Asymmetric Information and the Demand for Health Care – the Case of Double Moral Hazard

Udo Schneider

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Adresse:
Udo Schneider
University of Bayreuth
Department of Law and Economics
Economics and Public Finance
D-95440 Bayreuth
Germany
Phone: +49-921-552929
Fax: +49-921-555821
e-mail: Udo.Schneider@uni-bayreuth.de

Abstract

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The production of health does not only depend on the medical services supplied by the physician but is also influenced by the patient's compliance. A model of medical treatment is presented in which both the actions of physician and patient are modeled as a productive input. The analysis distinguishes between three cases of strategic interaction. The consequences of asymmetric information between physician and patient are lower activity levels, only in the case of strategic substitutes the result might change. Furthermore, the effects of the implementation of a demand-side coinsurance are discussed.

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1 Introduction

The key relationship in a health care system is the relation between patient and physician. In many economic studies dealing with the health care sector the physician has an informational advantage in supplying medical services.[1] A theoretical model applied to the physician-patient relationship is the principal-agent theory that deals with situations of asymmetric information and the delegation of tasks if comparative advantages exist.[2] Compared to practice, the theoretical results for the organization of health care systems differ in a multitude of issues (cf. Holmström, 1979 and Zweifel et al., 2001). Furthermore, the application of a standard principal-agent model to the health care system is somewhat problematic (cf. Schneider, 1998). Actually, one major difference between theory and practice is that in the health care sector several “complementary agents” (Zweifel, 1994) affect the physician-patient relationship. Among these agents especially the insurance company plays an important role. There exist contractual arrangements that incorporate both key participants of the health care sector, physicians and patients (cf. Kortendieck, 1993, Gaynor, 1994, Börsch-Supan, 1998 or Cutler / Zeckhauser, 2000). It follows that the insurance company plays the role of a mediator with the result that individual actions like the demand for medical care, the consumption of health care goods and its financing fall apart (cf. Wille / Ulrich, 1991).

A lot of models deal with the physician-patient relationship that incorporate an insurance company, e. g. Selden, 1990, Blomqvist, 1991, Ellis / McGuire, 1990 or Ma / McGuire, 1997. All these models do not face the problem of mutual asymmetric information between the actions of physician and patient. In detail, this means that the latter cannot evaluate the effects of the physician’s services and the physician does not possess exact information about the treatment-accompanying behavior of the patient.[3] This behavior is called *compliance*, the health-related effort of the patient that is chosen in addition to the medical services (cf. Wille / Ulrich, 1991, p. 27). It is possible to characterize the relation between medical services and compliance by the concepts of *strategic substitutes*, *strategic complements* or *strategic independence* (cf. Bulow et al., 1985). In the first case, an increase in the activity of one agent leads to a decrease in the marginal productivity of the other agent’s activity. In contrast to

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[1] For literature concerning the physician’s behaviour see Dionne / Contandriopoulos, 1985 or Pauly, 1980.

[2] Another point of view is that market failure due to asymmetric information is no reason for public intervention. Instead the failure should be interpreted as scarcity and handled by a market process (cf. Shmanske, 1996, p: 197 ff.).

[3] The patient plays a role as consumer and production factor and the treatment result is a “joint product” of medical services and individual utilisation (cf. Wille / Ulrich, 1991, p. 27).

this, actions are strategic complements if the marginal productivity increases due to an increase in the level of the other's action. In the case of strategic independence there is no effect on the marginal productivity of the other action.

The paper is organized as follows: the next section describes the theoretical basis and the model structure with the main focus on the equilibrium of cooperative and non-cooperative solutions. The third section deals with the relation between the patient's compliance and the medical services and takes a look at the implications of a demand-side coinsurance.

2 A model of treatment decisions

2.1 Basic structures

The following model neglects the patient's decision about the consultation of a physician. Instead, the analysis concentrates on the treatment stage. After the patient's decision to choose medical treatment the physician and the patient pick their actions simultaneously.[4] The patient's expected utility depends on his net income. This corresponds to his gross income y minus the insurance premium σ and his co-payment βm, with the coinsurance parameter $0 < \beta < 1$. The gross income is positively related to the state of health G after medical treatment.[5] As a consequence, the patient is able to obtain a high income level in a good state of health whereas a bad state of health reduces his productivity and his income will decrease.[6] The insurance premium has to be paid in all states of the world but the co-payment only in situations when the patient decides to visit the physician in order to receive treatment.

As a simplification we consider two conditions for the patient's post-treatment health status: either the patient is healthy after treatment or he is still sick. In the first case the variable G takes a high value G_1 and in the second case a low value G_0, with $G_1 > G_0$. A good state of health is realized with probability $p \in (0, 1)$, a bad one with probability $(1-p)$. That is why recovery is not a deterministic but a stochastic process. The probability of a good state of health can be written as $p(a, m)$, given the patient's compliance (a) and the medical services supplied by the physician m. For that reason, $p(\cdot)$ can be interpreted as a health care produc-

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[4] The model presented here is based on a paper by Cooper / Ross, 1985 about product warranties and the care of buyers and sellers. If we look instead on the problem of sequential actions, this will result in a Stackelberg-equilibrium.

[5] It is assumed that the gross income is sufficiently large so that the net income is always positive.

[6] An example to think of is the payment of sickness benefits. If the patient cannot work because of an illness he will receive a transfer payment from the insurance company that is lower than his initial income. If one considers a self-employed person, his income will be mainly determined by his productivity.

tion function. With regard to the two inputs (a, m) it is assumed that both reveal a positive but diminishing marginal productivity, i. e. through an increase of one input the probability of a good state of health rises too, but at a decreasing rate. The important result of this formulation of the health care production function is that with higher inputs bad states of health become less likely but cannot be ruled out (cf. Schneider, 1998).

The patient's expected-utility function is additive-separable in utility resulting from net income $U(\cdot)$ and disutility of 'providing' the compliance $D(a)$, i. e. the more a patient supports the treatment the higher is the resulting disutility.[7] The patient is risk-avers in his net income and the corresponding utility-function is concave. The disutility is assumed to be a convex function of the compliance. The expected utility can be written as:

$$EU = p\,(a,m)\,U\left(y\left[G_1\right] - \sigma - \beta\, m\right) + \left(1 - p\,(a,m)\right)\,U\left(y\left[G_0\right] - \sigma - \beta\, m\right) - D\,(a)\,. \qquad (2.1)$$

Subsequently, U_1 is defined as the utility resulting from a good state of health (G_1) and U_0 as the utility from a bad state of health (G_0):

$$U_0 = U\left(y\left[G_0\right] - \sigma - \beta\, m\right),$$
$$U_1 = U\left(y\left[G_1\right] - \sigma - \beta\, m\right).$$

The physician's utility is additive-separable in income, professional ethics and medical effort. He is risk-neutral in income because he is able to spread the risk over all patients. He receives remuneration for the supplied medical services that consist of a flat rate payment ($\omega > 0$) and a cost reimbursement component per unit of medical treatment (δ). The physician faces a supply-side cost sharing if only a fraction of the medical costs is reimbursed (cf. Ellis / McGuire, 1990 and Ellis / McGuire, 1993). On the other hand, he gets a markup on the marginal costs of medical care. All in all, the physician gets a fee per unit of medical care minus his costs.[8] Furthermore, it is assumed that the physician truthfully reports the medical services supplied. The provision of medical services produces disutility $C(m)$ despite the medical costs with $C' > 0$ and $C'' > 0$. We assume for the professional ethics that the expected state of the patient's health enters positively in the following expected utility function:

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[7] An additive-separable utility function states that the degree of risk aversion of the income-dependent utility ($U(\cdot)$) does not vary with the effort-level a (cf. Macho Stadler / Perez Castrillo, 1997, p. 19).

[8] Under the assumption of constant marginal costs for medical care equal to one it follows that the total remuneration is $\omega + (\delta + 1)m - m = \omega + \delta m$ (see equation (2.2)).

$$EV = [\omega + \delta\, m] + \varepsilon \left[p\, G_1 + [1 - p]\, G_0\right] - C\,[m]. \tag{2.2}$$

The parameter $\varepsilon \in [0, 1]$ describes the intensity of the professional ethics. If the physician exhibits no ethics the parameter will take a value $\varepsilon = 0$. On the other hand if $\varepsilon = 1$ he acts as a perfect agent to the patient. In general, the higher the value of ε the higher the physician weights the expected health status.

The insurance company finances the health care expenditures against a premium σ. The insurance company pays for all treatment costs except the co-payment βm. The insurance is supplied at actuarial fair premiums on a competitive insurance market where E is the expectation of getting sick:[9]

$$\sigma = E\,\left(\omega + [\delta - \beta]\; m\right). \tag{2.3}$$

Moreover, the following assumptions concerning the information structure are made: First, the physician and the patient have knowledge about the realized state of health but the insurer has not. This implies that it is not possible to write contracts contingent on the state of health. The production function, the relation between the input factors and the probability of a good state of health, is well-known ex ante but the physician and the patient cannot draw conclusions about the other's action from the realized state of health.

2.2 Cooperative solution

As shown in the previous section, the health care sector is characterized by a situation of mutual asymmetric information between physician and patient. The medical services provided as well as the patient's effort (compliance) have an influence on the value of the treatment for both actors. This situation is known as double moral hazard (cf. e. g. Bhattacharyya / Lafontaine, 1995, Cooper / Ross, 1985, Demski / Sappington, 1991 as well as Kim / Wang, 1998). To analyze the effects of the double moral hazard we first consider the situation of complete information.

Both players choose their actions cooperatively to maximize the sum of expected utilities. The resulting first-best solution is specified by the following problem:

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[9] The possibility for the patient to influence this probability is neglected (no ex ante moral hazard). Furthermore, we only consider linear contracts for the patient and the physician.

$$\max_{a,m} \quad S = p(a,m)\left[U_1 + \varepsilon G_1\right] + \left(1 - p(a,m)\right)\left[U_0 + \varepsilon G_0\right] + (\omega + \delta m) - D(a) - C(m) . \tag{2.4}$$

The first-order conditions are given by:

$$\frac{\partial S}{\partial a}: \quad p_a \left[U_1 - U_0 + \varepsilon\left(G_1 - G_0\right)\right] = D' , \tag{2.5}$$

$$\frac{\partial S}{\partial m}: \quad p_m \left[U_1 - U_0 + \varepsilon\left(G_1 - G_0\right)\right] + \delta = C' + \beta\left[p\, U_1' + (1-p)\, U_0'\right] . \tag{2.6}$$

Equation (2.5) describes the patient's choice of effort. It states that the joint marginal expected utility of physician and patient on the left hand side equals the marginal disutility of a higher level of compliance on the right hand side. Equivalently, for equation (2.6) it follows that the joint marginal expected utility on the left hand side equals the marginal expected costs of medical treatment on the right hand side. The latter consists of the marginal disutility of the medical services and the marginal costs of the patient's co-payment. The first-order conditions depend on the compliance and the medical services. The solution to this problem is denoted (a^*, m^*) and is first-best given the corresponding reaction-functions.

2.3 Non-cooperative solution

In the presence of double moral hazard the physician and the patient are unable to observe the other side's action. Both maximize their own expected utility without taking interactions into account. The patient cannot draw conclusions about the quality of the medical services from the realized state of health whereas the physician cannot infer the level of compliance from the realized state of health. Following the described approach the objective function of the patient's maximization problem is given by

$$\max_{a} \quad p(a,m)\, U_1 + \left(1 - p(a,m)\right) U_0 - D(a) . \tag{2.7}$$

The resulting first-order condition after rearranging the terms is:

$$p_a(a, m)\left(U_1 - U_0\right) = D' . \tag{2.8}$$

Equation (2.8) shows that the patient chooses his health-related effort by equating the marginal expected utility of compliance and the marginal disutility. Concerning the insurance parameters it is of major interest how an increase in the coinsurance parameter affects the patient's compliance. By applying the implicit function rule one obtains from equation (2.8)

$$\frac{da}{d\beta} = \frac{p_a \left(U_1' - U_0'\right)\left(m + \frac{\partial \sigma}{\partial \beta}\right)}{p_{aa}\left(U_1 - U_0\right) - D''} > 0 \,. \tag{2.9}$$

The denominator is the sufficient condition for a utility maximum and therefore negative. The nominator is also negative because first the difference of the marginal utility of income ($U_1' - U_0'$) is negative due to the concavity of the utility function. Second, the sum of medical services (m) and derivation of the premium with respect to the coinsurance parameter ($\partial\sigma/\partial\beta$) is positive, even though the premium effect is negative.[10] The overall effect is that an increase in the coinsurance parameter leads to a higher effort level given the amount of medical services. This will lead to a substitution of medical services by health-related effort because patient's compliance is relatively cheaper. Empirical studies show a price elasticity of demand for medical services of –0.2, i. e. the demand decreases as the price that the patient has to pay increases (cf. Cutler / Zeckhauser, 2000, p. 584 ff.).

The physician maximizes his expected utility with respect to medical services. The problem and the first-order condition are

$$\max_m \quad [\omega + \delta m] + \varepsilon\left(p(a,m)\, G_1 + \left(1 - p(a,m)\right) G_0\right) - C(m) \tag{2.10}$$

and

$$\delta + p_m(a,m)\, \varepsilon\left(G_1 - G_0\right) = C' \,. \tag{2.11}$$

From the physician's point of view, the optimal amount of medical services is the level where the marginal utility consisting of the marginal utility of income and the marginal utility of a better state of health equals the marginal disutility.

In analogy to the patient one can ask how changes in the remuneration system affect the amount of medical services supplied. The physician is risk-neutral in income. Therefore, his

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[10] Partial differentiation of the premium with respect to the coinsurance parameter yields to $\left|\partial\sigma/\partial\beta\right| = E(\beta m) = \beta E(m) < m$, as $\beta < 1$.

decision does not depend on the flat rate payment but only on the reimbursement parameter (δ). This leads to the following expression:

$$\frac{dm}{d\delta} = - \frac{1}{\varepsilon p_{mm} \left(G_1 - G_0 \right) - C''} > 0 \,. \qquad (2.12)$$

The denominator is the sufficient condition for a maximum and is negative, so the overall effect is positive. Higher reimbursement of costs results in an incentive to expand the amount of medical services given the level of compliance.

For further analysis equations (2.8) and (2.11) are at the centre of interest. They specify the actions of a player as a function of the behavior of the other player. This means that the patient chooses his effort as a reaction to the medical services and vice versa. These reaction functions specify a Nash-equilibrium, the non-cooperative solution (a^N, m^N).

2.4 Comparison of both solutions

A conjecture about the effects of asymmetric information can be drawn from a comparison of the full information solution and the double moral hazard situation. Under the assumption of higher marginal disutility the patient's compliance is higher in the full information case than in the case of asymmetric information. Using equations (2.5) and (2.8) one can show that $a^*(m) > a^N(m)$ if $D'(a^*)>D'(a^N)$. For this to be true it follows that the left hand side of equation (2.5) exceeds the left hand side of equation (2.8):

$$a^* \left(m\right) > a^N \left(m\right) \Leftrightarrow p_{a^*}\left[U_1 - U_0 + \varepsilon \left(G_1 - G_0\right)\right] > p_{a^N}\left[U_1 - U_0\right]. \qquad (2.13)$$

This condition is fulfilled if the marginal expected utility of the compliance in the case of cooperation is higher than the marginal expected utility in the case of non-cooperation. Then the first-best level of compliance is higher than the non-cooperative level. In this case the patient realizes that the physician benefits from a higher state of health. As long as the physician reveals some professional ethics, the patient has a higher effort level in the full information case than under asymmetric information, given the level of medical services. Therefore, for the reaction function it follows that the first-best function runs above the reaction function in the non-cooperative case.

For the physician one can draw the following conclusions: Suppose that the level of medical services under full information is higher than in the case of asymmetric information

($m^*(a) > m^N(a)$). This results in a higher marginal disutility because of the convexity of the disutility function. In this case, the left hand side of equation (2.6) minus the marginal co-payment has to exceed the left hand side of equation (2.11):

$$
\begin{aligned}
& m^*(a) > m^N(a) \Leftrightarrow \\
& p_{m^*}\left[U_1 - U_0 + \varepsilon\left(G_1 - G_0\right)\right] + \delta - \beta\left[p\,U_1' + (1-p)\,U_0'\right] \\
& > \delta + p_{m^N}\varepsilon\left(G_1 - G_0\right).
\end{aligned} \tag{2.14}
$$

The first part of the inequality condition denotes the expected marginal utilities of medical services (m^*) for physician and patient minus the expected marginal co-payment in the case of cooperation (cf. equation (2.6)). The second part is the expected marginal utility of medical services (m^N) for a non-cooperative solution (cf. equation (2.11)). The amount of medical services is higher in the case of cooperation if the inequality (2.14) strictly holds, i. e. $m^* > m^N$. In this situation the reaction function of the physician runs above the non-cooperative one. For $\varepsilon = 0$, i. e. no professional ethics, the left-hand side of the inequality (equation (2.14)) simplifies to the condition specifying the optimal amount of medical services demanded by the patient.[11]

3 The relation between patient's compliance and medical services

3.1 Substitutes vs. complements

The outcome of the health production process is influenced by the choice of medical services and the patient's effort which both affect the probability of a good state of health. The input levels are determined by the reaction functions. For the following analysis it is assumed that the reaction functions form a unique and stable Nash-equilibrium. Up to now, the difference between the reaction functions of full and asymmetric information has been considered. At this point it is necessary to analyze the effects of the reaction functions' slope on the level of medical services and compliance. Especially the connection of the two input variables and their interdependences deserve further discussion. Therefore, the relation of the actions of both players under asymmetric information lies in the centre of interest.

In the subsequent analysis it is assumed that the action of one player is strictly positive (a, $m > 0$) even if the other party is providing no input at all. Otherwise no equilibrium in positive

[11] The resulting level can be thought of as rationing the physician because under full information he would not expand the level of medical services above that one desired by the patient.

actions exists (cf. Cooper / Ross, 1985, p. 106). In termini of the model this means that $a(m=0) > 0$ and $m(a=0) > 0$. To derive the slope of the reaction functions it is necessary to transform the first-order conditions of patient and physician (equations (2.8) and (2.11)) by applying the implicit function rule. For the patient it follows that the relation between compliance and medical services can be expressed as

$$\frac{da}{dm} = \frac{\beta p_a \left(U_1' - U_0'\right) - p_{am} \left(U_1 - U_0\right)}{p_{aa} \left(U_1 - U_0\right) - D''} . \tag{3.1}$$

The denominator is the sufficient condition of the patient's utility maximum and therefore negative. The sign of the nominator depends on two factors: The first term is only different from zero if the coinsurance rate (β) is positive (*coinsurance component*). The second term is the *strategic component* and it depends on the sign of the cross derivation of the probability of a good state of health (p_{am}). This derivation shows how the marginal productivity of the compliance changes due to an increase in the medical services.[12] The expressions *strategic complements* and *strategic substitutes* will be used for this behavior (cf. Bulow et al., 1985, p. 494). The difference to the concept of complements and substitutes, as they are known from microeconomic theory, is that the latter describes a direct relation between the variables whereas the former only illustrates the effect of one variable on the marginal product of the other. In the case of interest this means that additional medical services raise the marginal productivity of the health-related effort and thus the probability of a good state of health increases (strategic complements). In the reverse case, a higher level of compliance lowers the marginal productivity of the medical services (strategic substitutes). An example for the former effect is the obeying of a therapeutic advice. Strategic substitutes are present if the patient does not visit his physical therapist but practices the exercises on his own.

From equation (2.11) one obtains for the slope of the physician's reaction function

$$\frac{dm}{da} = - \frac{\varepsilon p_{am} \left(G_1 - G_0\right)}{\varepsilon p_{mm} \left(G_1 - G_0\right) - C''} . \tag{3.2}$$

Here the denominator also corresponds with the sufficient condition for the physician's utility maximum and is therefore negative. A closer look at the nominator shows that the slope of the

[12] It is worth mentioning that an increase in one of the input factors increases the probability of a good state of health and so the term marginal productivity is not correct in a strict sense.

reaction function only depends on the existence of strategic complements or strategic substitutes. The absence of both strategies is called strategic independence. For a physician with no professional ethics ($\varepsilon = 0$) the slope is always zero.

3.2 Results without coinsurance

Without considering the effects of a co-payment for the patient the slopes of the reaction functions only depend on the three strategic effects, i. e. whether the inputs are strategic substitutes, complements or independent. Equation (3.1) for the patient can then be reduced to

$$\frac{d\,a}{d\,m} = -\frac{p_{am}\left(U_1 - U_0\right)}{p_{aa}\left(U_1 - U_0\right) - D''}, \tag{3.3}$$

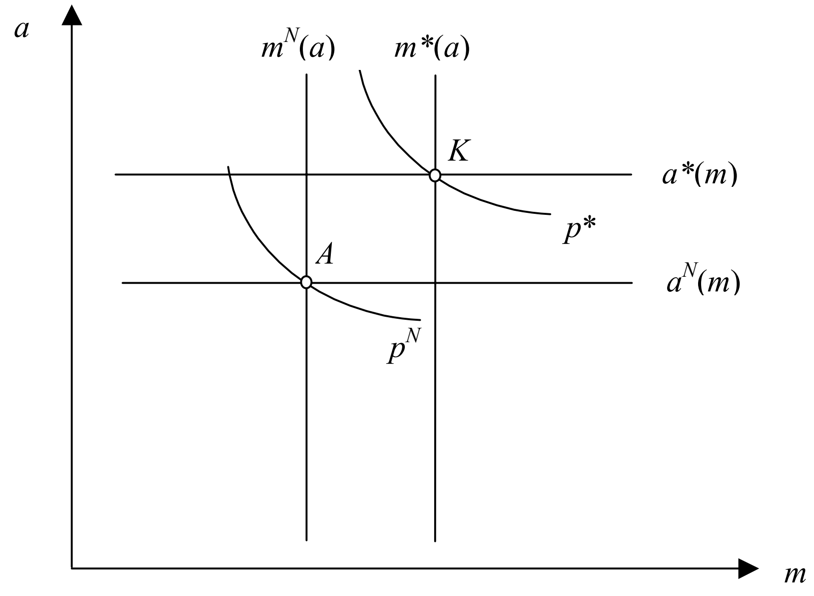
whereas equation (3.2) for the physician remains unchanged:

$$\frac{d\,m}{d\,a} = -\frac{\varepsilon\, p_{am}\left(G_1 - G_0\right)}{\varepsilon\, p_{mm}\left(G_1 - G_0\right) - C''}. \tag{3.4}$$

The denominator of both equations is negative. If the marginal productivity is independent of the level of the other input ($p_{am}= 0$) both reaction functions are inelastic to changes in the other input. Figure 1 illustrates this case.

The axes show the level of medical services (*m*) and the patient's effort level (*a*). The reaction functions a^* and m^* indicate the first-best solution under full information. Compared to the solution in the case of asymmetric information (a^N and m^N) one recognizes that for a given amount of *a* or *m* respectively, the chosen action of the other input is on a higher level. Point *K* indicates the first-best solution that lies in the point of intersection of the corresponding reaction functions. Compared to the non-cooperative equilibrium (point *A*) the level of medical services as well as the compliance is higher for cooperation. The iso-probability-curve p^* denotes the probability of a good state of health under full information and p^N signifies this probability in the case of asymmetric information. The negative slope results from total differentiating $p(a, m)$. Curves further off the origin show higher probabilities for a good state of health and therefore, at least the level of one input increases (cf. Lanoie, 1991).

Figure 1: Independence of compliance and medical services



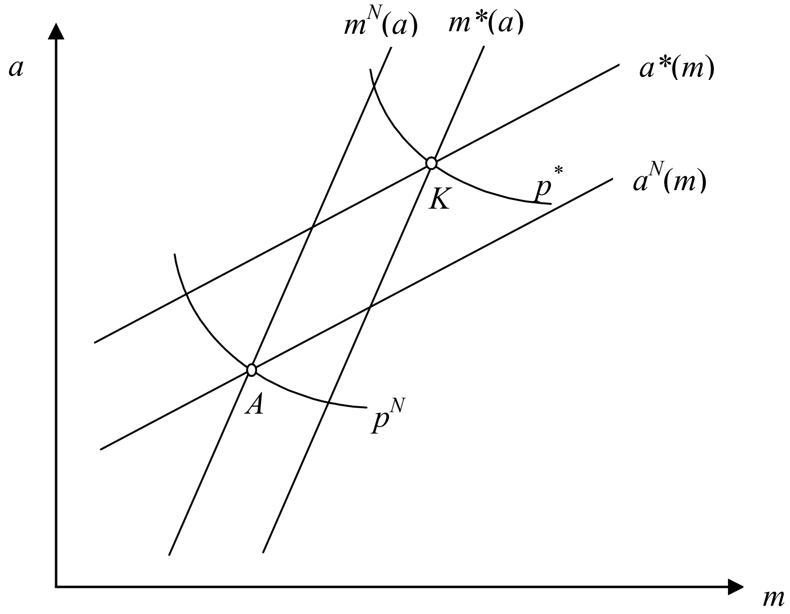
Source: Following Cooper / Ross, 1985.

If an increase in the medical services raises the marginal productivity of the patient's compliance or if higher health-related effort leads to a higher marginal productivity of medical services we face the situation of *strategic complements* ($p_{am} > 0$). Here, the nominator of equations (3.3) and (3.4) is negative and the overall effect and the slopes of the reaction functions are positive: $da/dm > 0$ or $dm/da > 0$ (see figure 2).[13]

The lines a^* and m^* represent the full information reaction functions. The resulting first-best equilibrium is again denoted by point *K*. In comparison to the non-cooperative solution, given in point *A*, it is obvious that in the situation of double moral hazard both the amount of medical services and the patient's compliance are at a lower level. This result can be regarded as an incentive problem because of the lack of knowledge about the consequences of the individual actions.

[13] As a simplification, in the following presentation the reaction functions are assumed to be linear in the other input. Actually, this depends on the utility function as well as on the density function. Furthermore, first-best and non-cooperative reaction functions are assumed to run parallel.

Figure 2: Compliance and medical services in the case of strategic complements

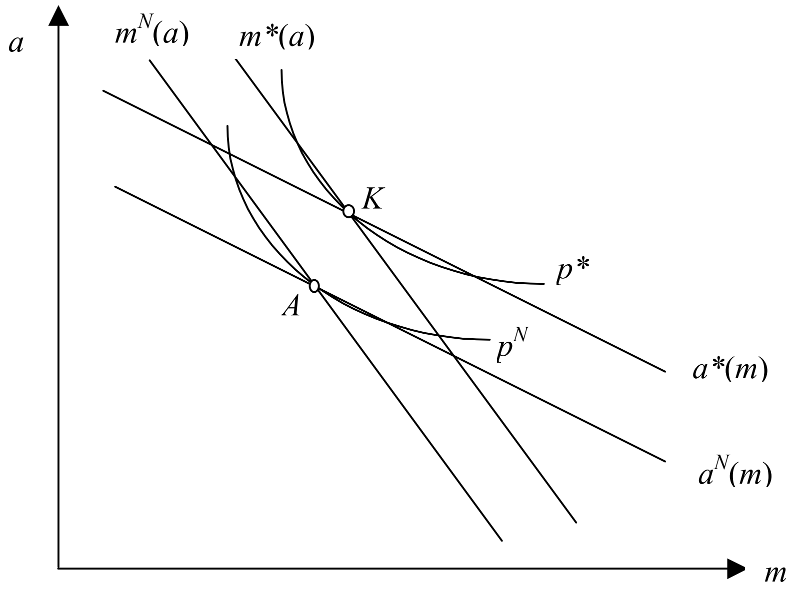


Source: Following Cooper / Ross, 1985.

In the case of *strategic substitutes* the marginal productivity of the compliance falls due to an increase in the medical services and vice versa. An example for the latter case is a slower recovery through exaggerated exercises. The slope of the reaction functions is negative ($da/dm < 0$ and $dm/da < 0$) because the nominator in equations (3.3) and (3.4) is positive. The medical services provided by the physician and the patient's compliance turn out to be substitutes now. Whilst the results in the case of strategic independence and complements are unambiguous, a more sophisticated analysis is necessary when strategic substitutes exist (see figures 3 and 4).

In the first case (figure 3) the non-cooperative reaction functions are below the one in the full information case. The asymmetric information results in a lower level of both inputs. The iso-probability curve p^N is beneath p^* which means that the probability to recover from an illness is lower if double moral hazard is present. These results correspond to the results in the case of strategic complements.

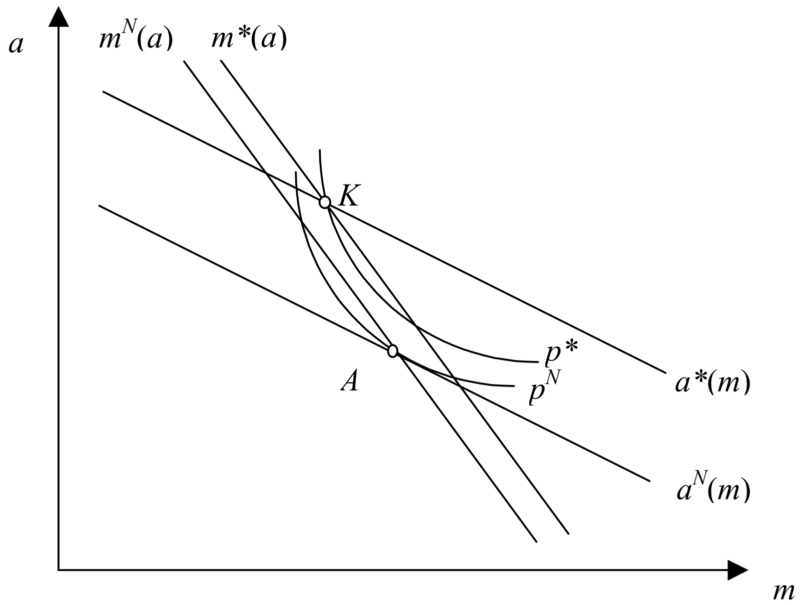
Figure 3: Comparable effects in the case of strategic substitutes



Source: Following Cooper / Ross, 1985.

A different result is shown in figure 4. In this case, the reaction functions under asymmetric information again run below the first-best reaction functions. However, on the one side the level of the compliance is lower and one obtains on the other side an increase in the medical services (cf. points *K* and *A*). The explanation is quite intuitive (cf. Cooper / Ross, 1985, p. 108 f. and Yavaş 1995, p. 253 f.): Starting from the cooperative solution one first observes decreasing levels of both inputs as an effect of the mutual asymmetric information. This corresponds to the shift in the reaction functions. A second effect occurs because the reduction of the patient's compliance results in a higher marginal productivity of medical services for a good state of health. Therefore, the physician will increase his treatment services. The same is true for the reversed case in which a reduction of the medical services leads to a higher marginal productivity of the compliance. It is possible that the second effect of a higher marginal productivity outweighs the effect of the asymmetric information for either the patient or the physician. This is true just for one actor, i. e. it is only possible that for one actor, physician or patient, the first-best level is exceeded.

Figure 4: Different effects in the case of strategic substitutes



Source: Following Cooper / Ross, 1985.

3.3 Introduction of a coinsurance

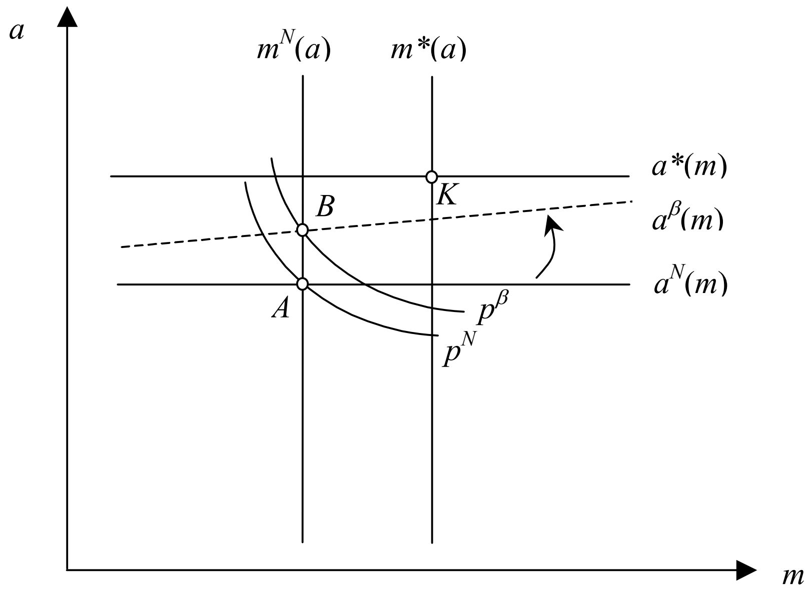
The resulting Nash-equilibrium is affected by the introduction of a coinsurance for the patient. First of all, the coinsurance component in equation (3.1) now differs from zero. Moreover, the utility and the marginal utility of the patient are influenced by his medical expenditures on basis of the coinsurance parameter. Equation (3.1) indicates that the slope of the patient's reaction function depends on the characteristics of the *coinsurance component* as well as the *strategic component*.

In addition, the introduction of a coinsurance leads to a variation in net income, whereby the utility as well as the marginal utility are influenced. Therefore, for the subsequent analysis we assume as a simplification that the net income remains unchanged after the introduction.[14] Through this assumption a direct comparison with the results of the preceding section becomes possible. Generally, using equation (2.9) one obtains the effect that c. p. a higher coinsurance rate leads to an increase in the health-related effort. Therefore, in a non-cooperative equilibrium the patient's new reaction function lies above the reaction function without coinsurance for all levels of medical services supplied.

[14] An introduction of a coinsurance rate leads to a lower insurance premium so that the patient's net income is not reduced by the full amount of the co-payment. Though, one has to keep in mind that the coinsurance goes along with incentives on the demand for medical services and that the assumption above neglects these incentives.

The introduction of a coinsurance leads to a positive slope of the patient's reaction function in the case of *independence* of compliance and medical services ($p_{am} = 0$) (dotted line a^{β} in figure 5). Hence, from the patient's point of view there exists a complementary relation between the physician's medical services and his own compliance (see figure 5).

Figure 5: Independence and coinsurance

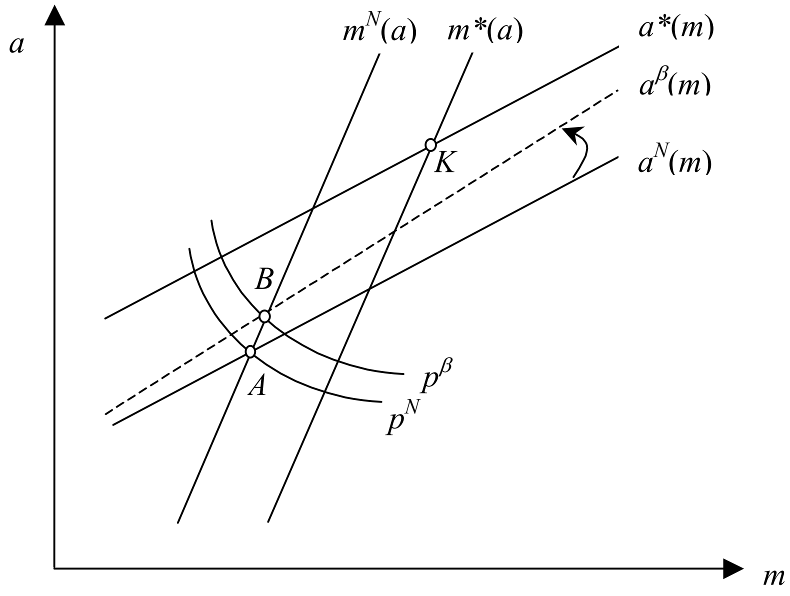


In contrast to the situation without coinsurance, an increase in the amount of medical services raises the compliance. This leads to a new equilibrium (point *B*) on a higher iso-probability curve (p^{β}). For each level of the physician's services the patient will raise his health-related effort because his own effort is now relatively cheaper in comparison to the medical services. In addition, this higher level results in an increase in the patient's expected utility of income. The overall expected utility rises if the above mentioned effect exceeds the increase in disutility (see equation (2.1)).

Given *strategic complements* ($p_{am} > 0$), a coinsurance leads to an amplification of the results without coinsurance. The patient's reaction function runs above the one in the case of non-cooperation. It follows that the patient will further increase his compliance compared to the situation without a coinsurance for a given level of medical services. This effect is presented as the new reaction function in figure 6 by the dotted line (a^{β}).[15]

[15] The real slope of the reaction function a^{β} is irrelevant for the qualitative result. The presented change of the reaction function in the following figures exemplifies the effect of the coinsurance.

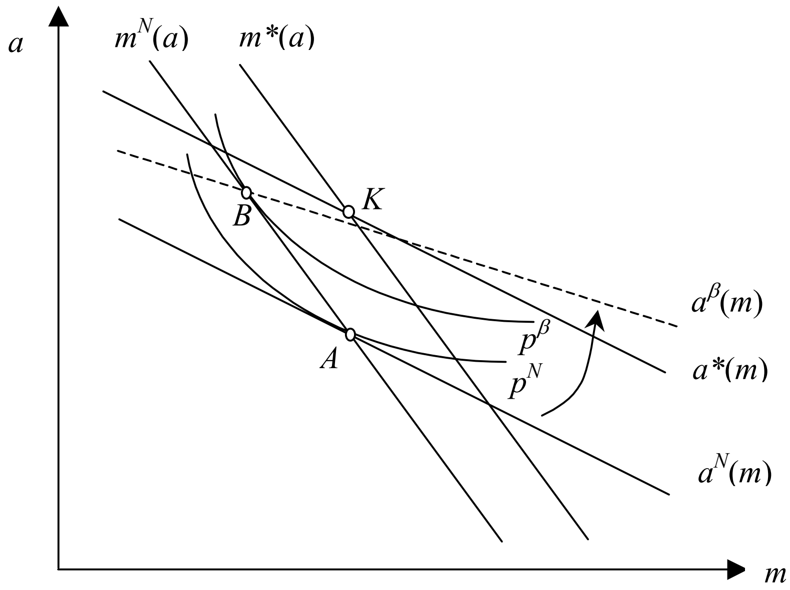
Figure 6: Strategic complements and coinsurance



The line a^{β} specifies the new reaction function for the patient whereas the physician's one remains unchanged. It is obvious that in the intersection with the reaction function m^N (point *B*) the level of medical services as well as the level of compliance are higher than in the case without coinsurance. Thereby the probability of a recovery (p^{β}) increases compared to that one in the Nash-equilibrium without coinsurance (p^N). The expected utility of the patient rises if the net utility gain is positive, i. e. that the expected utility of income increases more than the disutility of the compliance. Moreover, the magnitude of these effects depends on the slope of the reaction functions.

One obtains different results for the case of *strategic substitutes* ($p_{am} < 0$). Here, the implementation of a coinsurance possibly reduces the slope (in absolute terms) of the patient's reaction function (see figure 7). Given the physician's treatment decision the patient's compliance is c. p. at a higher level. In principle, it is possible that the influence of the coinsurance component prevails against the strategic component and the slope of the reaction function is positive.

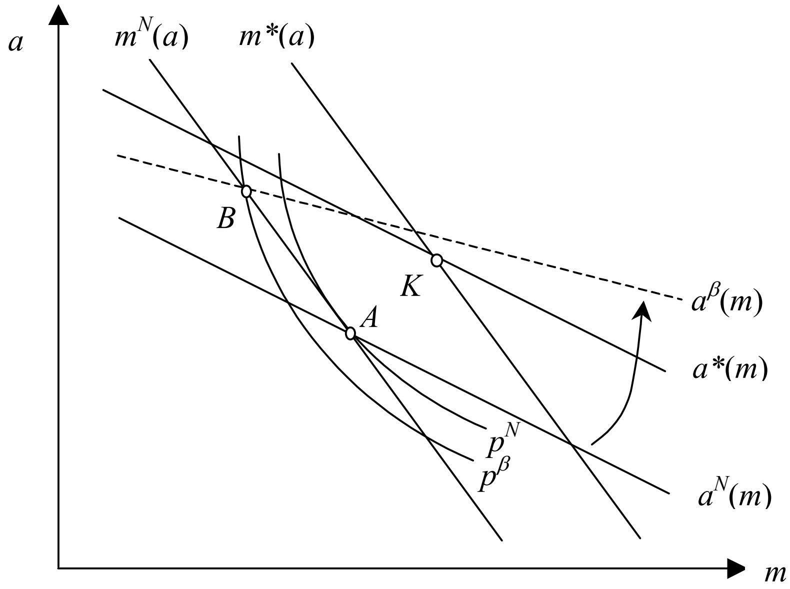
Figure 7: Strategic substitutes and increasing probability of recovery



It is obvious that because of the new reaction function (a^β) the amount of medical services decreases whereas the amount of compliance increases (point *B*). It is also possible that the patient's effort is above the first-best level. Thus, the medical services are substituted by the compliance. The welfare effect depends on the higher probability of a recovery. Again, the patient's expected utility increases if the change in the expected utility of income exceeds the change in the disutility.

The slope of the iso-probability curve given by the marginal rate of substitution between compliance and medical services depends on the marginal productivity of both inputs. For the case of a steeper iso-probability curve it is possible that the probability of a good state of health decreases (see figure 8). The higher level of compliance and the associated increase in the probability cannot compensate the decreasing probability of a good state of health due to the decreasing medical services. Thus the possibility that the patient faces a decrease in his expected utility cannot be ruled out.

Figure 8: Strategic substitutes and decreasing probability of recovery



In summary, one can state that for all forms of the strategic interaction the compliance increases due to an introduction of a coinsurance. The explanation is that the health-related effort and the medical services are productive inputs. Without coinsurance the marginal costs of the consumption of medical services are zero. After the implementation the patient faces positive treatment costs. Compliance becomes relatively cheaper in comparison to medical services. The change in the patient's expected utility depends besides the levels of compliance and medical services on the probability of recovery.

4 Conclusion

The paper at hand analyzes how the relationship between the medical services provided by the physician and the patient's compliance influences the resulting equilibrium at the point of treatment. The utilization of medical services and the level of health-related effort strongly depend on their productivity characteristics, i. e. if the inputs are strategic complements, substitutes or independent factors. In contrast to the other solutions, the non-cooperative equilibrium in the case of strategic substitutes does not necessarily lead to lower medical services and compliance compared to the first-best solution. It is possible that the level of one input of the health production process is above the first-best level while the other one is below. The introduction of a coinsurance for the patient alters these findings. The patient's reaction function is shifted towards the cooperative one. This implies that the patient always chooses a higher level of compliance for a given level of medical services. While in the case of independence the amount of medical services remains unchanged, in the case of strategic substitutes the latter is reduced. If we consider strategic complements both the effort and the medical services increase.

The assumptions concerning the knowledge of physician and patient are problematic in different ways. It is not clear if physician and patient really possess the relevant information about the strategic interactions or if they realize the consequences of their individual actions. If the patient has no information about the effects of a higher compliance on the health production process this will lead to wrong decisions ex post. Therefore, it can be considered that the physician provides the patient with the necessary information about the strategic interaction of medical services and compliance.

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