Lukas, Daniel

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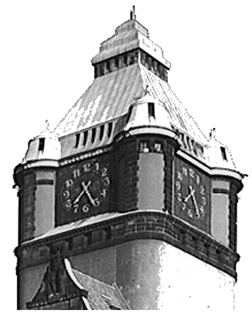

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DANIEL LUKAS

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Address of the author(s):

Daniel Lukas
Technische Universität Dresden
Department of Business and Economics
Chair of Economic Policy and Economic Research
01062 Dresden
Germany

e-mail : daniel.lukas@tu-dresden.de

Editors:

Faculty of Business and Economics, Department of Economics

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Working paper coordinator:

Andreas Buehn
e-mail: wpeconomics@mailbox.tu-dresden.de

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Patient autonomy and education in specific medical knowledge

Daniel Lukas
Technische Universität Dresden
Department of Business and Economics
01062 Dresden
daniel.lukas@tu-dresden.de

Abstract:

The asymmetry between the patient as a layman and the physician as an expert is a key element in health economics. However, a change to a higher degree of patient autonomy has taken place. Furthermore, there is a consensus in a positive correlation between general education and productivity of medical care. This paper focuses on the individual investments of laymen in specific medical education as a decision problem in which the ex-post strategies of the individual are consultation and self-care as imperfect substitutes. It is assumed that specific knowledge increases the self-diagnosis competence (self-protection) and the self-care productivity (self-insurance) as dimensions of autonomy. The analysis is divided into two forms of ex-post decision making according to individual rationality: 1. ambiguity 2. uncertainty. An elaboration of necessary conditions for investments in education is undertaken.

JEL-Classification: D01, D80, I12 , I20

Keywords: patient autonomy, education, self-care, ambiguity, uncertainty

1 Introduction

In economical literature a lot of research has been done concerning the impact of uncertainty with regards to the factual health stage and the effectiveness of medical care in which Grossman's (1972) health production function is often used as a basis.[1] The demand underlies a trade-off between different objectives including different kind of investments in health. In this context, education is mostly discussed as a general and not specified input to decrease the rate of depreciation of health, to increase productivity of care and to reduce uncertainty leading to an increase of allocative efficiency of demand. Empirical evidence about a positive relation between health and general education is also given as presented by Cutler and Lleras Muney (2006) as a survey.

Taking this positive relationship as granted and acknowledging the increase of importance of patient autonomy in health related sciences this paper discusses investments in, not general, but specific education as an individual decision problem. Very specific education has attracted less interest in economical literature. Specifically, education is related to a decision in a situation of an acute indisposition ex-post, in which consultation and self-care are alternative strategies. Then, self-diagnosis competence and the self-care productivity are specific dimensions of patient autonomy.

There is an extensive discussion in the medical and ethical literature in the field of informed and educated individuals/patients driven by a change of the classical paternalistic framework of a patient-physician relationship (PPR) to a more patient centered conception (Taylor (2009)). The focus is on shared decision making, either with general information to enforce self-help for patients who encounter a specific clinical situation or with very specific information in the form of decision aids which alleviates choice between treatments (Llewellyn-Thomas (1995)). Generally, a transition to consumer behaviour with a higher degree of patient autonomy and personal responsibility based on patient empowerment is in focus. From an ethical point of view this empowerment means a strengthening of self-awareness, knowledge and skills to improve the individual decision competence which, for instance, can be of special importance for chronic illnesses (Anderson and Funnell (2005)). Haug and Levin (1981) already described self-care and effort in education as crucial elements for an increase of patient autonomy. Parker (2006) identifies health literacy as essential for the individual to participate within a health care system to have access, to navigate and also to manage self-care. To empower the individual to become a more autonomously acting, informed or reflexive individual it is necessary to use different sources of information such as the Internet or more traditional sources (Henwood et al. (2003)). There is also some empirical evidence that information influences medical demand, as from Wagner et al. (2001), who analyzes investments in sources such as

[1] See amongst others Muurinen (1982), Wagstaff (1986), van Doorslaer (1987), Dardanoni and Wagstaff (1989), Selden (1992), Chang (1996), Liljas (1997), Picone et al. (1997).

books and the Internet and finds a potential to decrease medical demand. Kenkel (1990) analyzes symptoms as imperfect information as a basis for demanding a physician or not. He finds that the more severe a health status, the higher the value of acquiring further information. An increase of available information is also able to increase medical demand. A more specific contribution regarding patient education is delivered by Price and Simon (2009). They show that specific proposals, according to the choice of appropriate treatments produced by medical research, have a positive impact on the individual medical behaviour. However, this relates more to the level of the individual general education. This can be regarded as an indicator for the positive relation between the converting of specific information into a concrete behaviour and the necessity of a capacity to afford such a conversion, maybe as education in more specific medical knowledge.[2]

The PPR is characterized as asymmetric due to an information gradient between an expert and a laymen. This is a simple translation of a paternalistic relation described in the medical literature. Arrow (1963) already defined the information competence of medical specialist as costly due to investments in a professional education in which the complexity of information and its value increase with the severity of the illness. A perfect medical education for every individual is inefficient, therefore, work sharing in health care makes more sense. Despite Arrows point of inefficiency he already thought about differentiation of quality in which different trained suppliers could also offer differentiated medical supply (see also Smith (2005)). Vuori (1980) discusses the optimal but not maximal supply of medical care in which the general choice between alternative forms of medical care is directed to an optimization of care.

Related to this are the preferences of the patient as it has already been discussed by Feldstein (1968). The resource allocation within the health-care system should be directed to the individuals' preferences to maximize welfare. Feldstein did not intend to implement self-care as a further alternative. However, during the last decades, both objects, preferences and patient autonomy, have developed a complementary relation to each other. Hence, self-care as an alternative use of resources turns into a legitimate subject. In this context the bounded rationality of an individual is of importance. Culyer (1971) discusses the rationality of a patients' ability to decide according to preferences and the problem of behaving in this way. Amongst others, there is uncertainty about the assessment of the actual illness and the knowledge about an adequate treatment, or a rational choice of it respectively. Specific medical education should be directed to an improvement of these responsibilities. Lee (1995) delivers an interesting idea of a threshold determined by illness severity and socio-economic variables for choosing a consultation. His idea is that the patient only generates demand due to a lack of information. Otherwise, the

[2]However, Price and Simon also give alternative explanations that because more highly educated people choose more sophisticated physicians. Furthermore, education is a proxy for income and access to the physicians. Hence, education and the ability to convert information is a possible but not necessary channel.

patient could take care of himself. However, self-care is not discussed. The patient is able to identify the diagnosis but cannot produce adequate treatment. Lee focuses on the uncertainty the patient has according to the physician's supply. However, my approach has the individual and the self-care strategy in focus in which the physician within the consultation strategy represents a perfect agent.

Derived from the discussion above I am going to discuss consultation and self-care as a polarized differentiation of medical supply. Given an increase of the individual productivity of medical care in *general* education I am going to discuss individual investments in *specific medical* education as an individual decision problem. A general level of education and the simple act of collecting information are not sufficient for an increase in autonomy. More specific knowledge with corresponding investments are necessary to handle specific information. Investments imply a loss of money and time in order to purchase professional teaching in medical subjects for laymen. While the kind of investments in education, presented with the empirical literature above, is often directed to the individual behaviour within a PPR; I want to discuss a more extreme position of the individual, namely to (partially) replace physician contact with self-care. If the main fields of a physician's competence are diagnosis and therapy, education must increase "self-diagnosis competence" and "productivity of self-care". Self-diagnosis competence can be interpreted as self-protection in the sense of a reduction of the risk of a false diagnosis affiliated with a loss of utility through the wrong choice of consultation or self-care. Productivity of self-care can be interpreted as self-insurance, which means a reduction of utility loss through an illness. However, a total replacement of a physician seems to be unrealistic for which reason self-care must be interpreted as an imperfect substitute. Imperfect means that self-care is not appropriate for each kind of illness. A differentiation between illnesses is necessary according to the real effectiveness of education.

To put it in a nutshell, education is directed on as extension of treatment alternatives through self-care and an improvement of liability through self-diagnosis competence leading to a more efficient allocation of resources in medical care.

The decision problem is modeled in a framework of expected utility and is based on a decision-tree framework.[3] There are two decisions: a) choice of self-care or consultation ex-post, b) investments in education ex-ante. The discussion in this paper is divided into different decision structures, 1.) ambiguity ex-post, 2.) uncertainty ex-post. The separation is motivated by a fundamental distinction of decision behaviour. The difference is the use of probabilities for the decision between self-care and consultation. While under

[3]In this context Pauker and Kassirer (1980) discuss a framework of decision threshold in health care. Eeckhoudt et al. (1984) and Eeckhoudt (2002) also analyze the decision behaviour under uncertainty also focused on diagnostic tests and conditional decisions under imperfect information. More general studies and useful research of the basical techniques of information values under imperfect information are delivered by La Valle (1968) and Hirshleifer and Riley (1979).

ambiguity these are not implemented and the decision is based on the fixing of a self-diagnosed illness and the application of a decision rule, under uncertainty probabilities are directly used to derive a decision.

The results can be summarized as follows. An individual welfare gain is possible, however, as long as self-care is an alternative to consultation and self-diagnosis competence is imperfect, the first best solution cannot be achieved. Basically, the incentive to invest in education must be separated into the effectiveness of self-insurance and self-protection to increase self-care productivity and to improve self-diagnosis competence. A utility loss through a false self-diagnosis stimulates education. The illness severity and risk aversion are ambiguous in their influence. Furthermore, education is inhibited if consultation realizes different forms of dominance either based on a subjective pessimism and error probabilities or on an objective factual superior utility. Education can eliminate dominance but induce a potential loss in the case of a false self-diagnosis. Then, education is not beneficial necessarily and can also be understood as a measure to reduce the level of patent autonomy. If a decision takes place under uncertainty, the decision is conditionalized on the use of information about the quality of self-diagnosis. An information value is generated by the use of the symptoms as an imperfect indicator which is influenced by education. Finally, a threshold value of an objective illness probability for an individual welfare gain through education can be calculated, which is extended if imperfect information is used.

The outline of this paper follows. Chapter two discusses the basic elements of the model. Chapter three analyzes education under ambiguity and chapter four under uncertainty. Chapter five summarizes the results.

2 The theoretical framework

I only consider the patient as an active decider. The physician is a perfect agent. The decision is made with a preference to avoid a consultation if it is unnecessary.

Uncertainty and ex-post strategies

There are two health states: 1.) severe sickness H_1, 2.) banal sickness H_2, with $\bar{H} > H_2 > H_1$ and $\bar{H}$ as health state, which excludes any form of sickness. H_1 occurs with an a-priori objective probability π and H_2 with $1-\pi$. Hence, the occurrence of an illness is certain, however, not its severity. The individual is at least crudely informed, specifically about the own health history and is therefore able to deviate π ex-ante.

Self-diagnosis

In the ex-post case of an acute indisposition, the patient has to assess the current health status and decide, whether it is H_1 or H_2.[4] Let H substantiate into H_1, e. g. a heart attack, typically connected with pain in the left arm. This symptom is seen as information, however, as it is assumed in this framework, a perfect one for a physician and an imperfect for the individual. The latter could also derive a pulled muscle or something similar. The imperfection arises through the bounded competence to draw a correct conclusion. Then, beside π, subjective error probabilities $1 - \pi_i$ regarding the self-diagnosis exist. In medical language, the decision can be correct or false positive or negative (tab. 1). π_i depends on x with $\pi_i(x_1, ..., x_m)$ in which x represents individual characteristics,

Illness	**Self diagnosis (sd)**	π_i	**type of diagnosis**
H_1	H_1	π_1	correct positive (negative) sd H_1 (H_2)
H_1	H_2	$1 - \pi_1$	false positive (negative) sd H_2 (H_1)
H_2	H_2	π_2	correct positive (negative) sd H_2 (H_1)
H_2	H_1	$1 - \pi_2$	false positive (negative) sd H_1 (H_2)

Table 1: Types of self-diagnosis

e.g. age, general education etc. which influence the capability of a correct self-diagnosis without any specific medical education. There is a stochastically dependence between H_i and π_i. The probability of a correct self-diagnosis depends on the factual health status. In principle, $\pi_1 = \pi_2$ is possible. However, this means a loss of information. Different probabilities represent a different illness perception. A factual situation H_1 can be underrated because symptoms typically seem to be very simple and suggest H_2. Otherwise, H_2 often has symptoms with a higher degree of an acute indisposition like qualm, headache or fever. Furthermore, medical education for laymen can differ in its potential to increase self diagnosis competence. A layman diagnosis of H_1 should be more difficult than of H_2 and depends on the learning capacity. For further discussion, $\pi_1 < \pi_2$ is assumed. The chance of a correct self-diagnosis in the case of H_2 is higher than for H_1.[5]

Ex-post utility

The utility states are defined in tab 2. They depend on the type of illness and type of care with $u'(y) > 0$ and $u''(y) < 0$ and y as net-income. Y is the gross-income with $Y' > 0, Y'' < 0$. Health is an input for Y and produced by $H + q$ with q as medical input either through consultation or self-care. α and γ are the marginal costs separated in c and sc. N and M are fixed costs which can be interpreted very differently. M could be waiting time given a specific medical provider and N could represent costs of searching for

[4] In this context a self-diagnosis H_1 does not primarily mean a real diagnosis, but an exclusion of H_2 due to the high degree of difficulty for laymen to give a correct diagnosis in the case of a critical illness.

[5] A dependence $\pi_1'(\pi) > 0$ in which $\pi_2'(\pi) < 0$ is conceivable. An increase in π can increase the sensitivity of the individual if H_1 is the factual illness, e.g. through a specific exposition and disposition to be sick. However, there is also an increase of sensitivity for a false positive diagnosis of H_1 in the case H_2. Otherwise, the opposite can be the case of π is low. Then, a false self-diagnosis according to H_1 can be supported. This is not equal to a stochastically dependence of the probabilities.

	consultation (c)	self-care (sc)
H_1	$u_c^{H_1} = u(Y_c(H_1 + q_1) - \gamma q_1 - M)$	$u_{sc}^{H_1} = u(Y_{sc}(\lambda H_1 + q_{1\lambda}) - \alpha q_{sc} - \gamma q_{1\lambda} - N - M - S)$
H_2	$u_c^{H_2} = u(Y_c(H_2 + q_2) - \gamma q_2 - M)$	$u_{sc}^{H_2} = u(Y_{sc}(H_2 + \delta q_{sc}) - \alpha q_{sc} - N)$

Table 2: Specification of utility for consultation and self-care

adequate *sc*. Furthermore, N can cover costs connected with a certificate of incapacity to work, which cannot be issued in the case of *sc*. In addition, costs can be connected to a kind of inconvenience which arises through the habit of c in the case of illness. The latter point can be very different between individuals. Maybe elderly search for contact to a physician, sometimes only for a social contact. Other individuals are very sensitive when they fall ill, accompanied with an urgent personal requirement to be attended to by a physician.[6]

The physician's competence of diagnosis is perfect and ones productivity is assumed to be one. δ represents the *sc*-productivity for H_2. The *sc*-productivity for H_1 is assumed as zero (see below). The patient is able to assess the productivity, which reflects a crude idea about the own competencies in self-care. δ can take any value also above one. Someone could argue that $\delta < 1$ is necessary because the physician would at least give the same advise the patient would realize with *sc*. But it can also be argued that especially in the case of banal illnesses, the patient knows more about his physiological and psychological conditions and also about appropriate provisions, e. g. through experiences and a better assessment of the individual requirements. This is a very fundamental aspect, also in the ethical discussion about patient autonomy, in which, at first, the patient has to perceive himself before contacting an external person for care.

The optimal demand ex-post with y as the state dependent net-income is given by:

$$Y_c^{H_i\prime} = \gamma \;\rightarrow\; q_1^* > q_2^* \tag{1}$$

$$Y_{sc}^{H_2\prime} = \alpha/\delta \;\rightarrow\; q_{sc}^* \tag{2}$$

$$Y_{sc}^{\lambda H_1\prime} = \gamma \;\rightarrow\; q_{1\lambda}^* > q_1^* \tag{3}$$

The marginal productivity of the health status must equalize the marginal costs. (1) is the condition for demand of consultation. Given the diagnosis of the physician the demand can be differed in dependence of the diagnosis. To simplify matters, $H_c^i + q_c^i = \bar{H}$. The physician is always able to recover perfect health.

The demand of *sc* is more specific. If *sc* is chosen the individual is still not informed about the factual illness. However, due to a productivity of zero in a case of H_1, the

[6] Cauley (1987) identifies a time price as an equivalent to loss of income during demand of medical care. See also Wagner et al. (2001) who delivers some evidence for M.

individual only demands for H_2 if sc is chosen with (2) as condition. The marginal costs are adjusted up- or downwards by $\delta \neq 1$. Beside any fixed costs, as long as $\gamma < (\alpha/\delta)$ the net-income for $sc(H_2)$ is smaller than for $c(H_2)$ with $u_{sc}^{H_2} < u_c^{H_2}$. For $\gamma > (\alpha/\delta)$, $u_{sc}^{H_2} > u_c^{H_2}$ must be valid. The latter means an equalization of gross-incomes $Y_c(\bar{H}) = Y_{sc}(\bar{H})$. However, as long as $\delta < 1$, this equalization is only based on a cost-advantage with $\alpha < \gamma$. If $\delta > 1$, it is also based on a reduced demand with $q_2^* > q_{sc}^*$. Both cases generate a reduction of variable costs if self-care is chosen. Finally, $u_{sc}^{H_1}$ is composited as follows. Due to the reason of work-sharing and knowledge about u, $u_c^{H_1} > u_{sc}^{H_1}$ is necessary. It follows, if H_1 is the factual illness but sc is chosen, the choice can only be based on a false positive self-diagnosis H_2. The demand is based on (2). Hence, q_{sc} in $u_{sc}^{H_1}$ is conditional on the false self-diagnosis. The productivity of q_{sc} is zero leading to costs αq_{sc} and N without a health increasing effect. As a result a depreciation of H_1 with $\lambda < 1$ with a following choice of c is assumed with an optimal demand (3). Additionally, $S \geq 0$ are fixed costs through a further inconvenience. Then, the optimal gross-income is $Y(H_1 + q_1) = Y(\lambda H_1 + q_{1\lambda})$ but $u_c^{H_1} > u_{sc}^{H_1}$.

Summarized, self-care is an imperfect substitute for consultation with $u_c^{H_1} > u_{sc}^{H_1}$ and $u_c^{H_2} \gtreqless u_{sc}^{H_2}$. The background is a remaining division of work, which does not allow a substitution of c for each kind of illness.

As discussed in this paper, there is certainty about the utility within each health stage and therefore about the effectiveness of medical care. Uncertainty arises through the risk of a false self-diagnosis and consequently an inadequate or not utility maximizing demand.

Patient autonomy and information ex-post

How is the ex-post decision and information structured? From an ex-ante point of view the individual can assess both π and π_i. However, this knowledge can be different ex-post. Different to an ex-ante situation of perfect health the individual is in a situation of an acute indisposition ex-post.

In chapter three the decision takes place under ambiguity. A kind of decoupling of ex-ante information and ex-post behaviour takes place. The patient is not aware of any probabilities. However, the individual is always aware of the given symptom and forced to generate a self-diagnosis. After deriving a self-diagnosis the individual is also aware about the strategies one can choose and also about the corresponding utility values within each strategy. However, at this point the decision takes place under a reduced form of rationality. The individual is not aware about the amount of risk of having H_i and the risk of a false self-diagnosis. The individual must choose a strategy with awareness of all possible cases under use of a decision rule under ambiguity. It follows, that the stochastical dependence π_i and H_i has no technical consequences.

The discussion is extended in chapter four. The decision takes place under uncertainty. π and π_i as imperfect information are known ex-post as a higher degree of rationality. A corresponding application of a conditional decision is necessary.

Finally, an important discussion regarding the concept of paternalism and autonomy must be conducted. Paternalism means that a decision competence does not exist within a PPR. The patient is in a situation of "unconsciousness", which brings the physician in a situation of a personal guardian. At first glance, there is no conscious decision for or against c. However, the construction of utility presents a simple set of strategies - c or sc. In the case of pure paternalism, c can be seen as dominant (tab. 3). If

	c	dominance	non-dominance	sc
H_1	$u_c^{H_1}$	$>$	$>$	$u_{sc}^{H_1}$
H_2	$u_c^{H_2}$	$>$	$<$	$u_{sc}^{H_2}$

Table 3: Dominance and non-dominance of consultation

$u_c^{H_2} > u_{sc}^{H_2}$ the patient knows that c is superior to sc. The physician is always the best alternative from a rational point of view described as paternalism in this context. Hence, dominance arises if $u_c^{H_2} > u_{sc}^{H_2}$ or $Y_c(H_2 + q_2) - Y_{sc}(H_2 + \delta q_{sc}) > \gamma q_2 - \alpha q_{sc} + M - N$.[7] Generally, I define two different kinds of realizing a dominance of c. 1.) Given a decision under ambiguity, the patient always chooses c if a concrete health status is identified and the column of dominance in tab. 3 is valid. Another source of dominance could be the application of any kind of decision rule e.g. a subjective weighting of each utility value with a corresponding expected utility. In both cases, the parameters within u are in such a constellation that sc is inferior in general (e.g., low δ, high N, high α). 2.) Under uncertainty ex-post dominance of c can also arise through $EU_c > EU_{sc}$ due to the implementation of probabilities.

In this framework, paternalism does not mean a full loss of decision competence, but a loss of alternative strategies for the patient. As a result, the aid of autonomy means an abolishment of dominance in c. Then, autonomy can be interpreted as a gradual value increasing in the number of alternatives. However, to simplify matters, only two strategies are discussed. Autonomy is a categorical variable in the sense that someone decides autonomically (c is non-dominant) or does not (c is dominant).

[7]Please note, if $N < M$ then $Y_c(H_2+q_2)-Y_{sc}(H_2+\delta q_{sc}) < \gamma q_2 - \alpha q_{sc}$ and non-dominance is possible. Someone could argue justifiably that in such a case, similar to $sc(H_1)$, a depreciation of health capital takes place because self-care is not able to achieve $\bar{H}$. As a consequence, self-care decreases in its utility and c turns to dominance and an elimination of $N < M$ as a possible case of non-dominance. However, as can be seen in the further discussion an incentive to invest in education could still remain. A specific implementation of this case does not influence the results significantly, however, it adds an additional proposition.

The pure extension of strategies does not mean to be impeccable. A second dimension of autonomy, self-diagnosis competence, is of importance in which it is reasonable that a perfect competence with $\pi_i = 1$ cannot be achieved. The absence of this ability is sometimes a reason for paternalism and a shift from the decision competence from the patient to the physician, for instance through a higher health care authority. Therefore, the pure extension of alternatives is not a guarantor of utility maximizing decisions.[8]

Given the defined dimensions of patient autonomy, specific education E has two essential effects: 1.) Increase of π_i with $\pi_i'(E) \geq 0$ and $\pi_i''(E) \leq 0$, $\pi_2'(E) \lesseqgtr \pi_1'(E)$; 2.) Increase of productivity in self-care with $\delta'(E) \geq 0$ and $\delta''(E) \leq 0$. The first effect can be defined as self-protection, similar to the definition of Ehrlich and Becker (1972), who defines self-protection as a decrease of the objective illness risk π. However, the improvement of competence of self-diagnosis also reduces a risk, although only the risk of a suboptimal strategy choice. The second effect decreases the effective marginal costs for self-care, which can be defined as self-insurance, similar to Ehrlich and Becker. This stands for a reduction of the risky amount, specifically medical expenditures in the case of self-care. The effect on the implicit productivity of self-care for illness H_1 cannot be influenced by education. In addition, $N'(E) \geq 0$, $N''(E) \leq 0$ and $M'(E) = 0$. Education does not have any preventive impact ($\pi'(E) = 0$).

3 Education and ex-post decision under ambiguity

The decision structure from an ex-ante point of view is given by fig. 1:

- Figure 1 -

From an ex-ante point of view, the first best case without education is:

$$EU_{fb} = \pi u_c^{H_1} + (1 - \pi) max\{u_c^{H_2}; u_{sc}^{H_2}\} \tag{4}$$

The individual should choose the utility maximizing strategy for each health stage. To realize (4), a perfect self-diagnosis competence is necessary.

At this point of discussion the ex-post decision takes place under ambiguity. The decision has a sequential structure. If H_i is realized the individual is forced to generate a self-diagnosis. Given the self-diagnosis, a decision rule is necessary to realize a decision between the strategies ex-post. In other words, the knowledge about the possibility of a false self-diagnosis squeezes the individual to attend each of the possible health stages in the calculus. The rule used in this context is the Hurwicz decision rule (Hurwicz

[8]Please note, due to the static consideration of investments in education an intertemporal choice under attention of a discounting of a future value of health is not implemented as another determinant of autonomy. Please see for this subject inter alia Reach (2009).

(1951)) which includes the maximin and maximax rule as extreme cases. The individual is characterized by an intrinsic parameter of optimism θ with $0 \leq \theta \leq 1$ which is used to weight the utility values for each strategy:

$$EU_k(\theta) = \theta u_k^{H_1} + (1-\theta) u_k^{H_2} \ with \ k = c, sc \tag{5}$$

For $\theta = 1$, (5) is $EU_k(\theta) = u_k^{H_1}$ with a corresponding choice of c due to $u_c^{H_1} > u_{sc}^{H_1}$. For $\theta = 0$, (5) is $EU_k(\theta) = \max\{u_c^{H_2}; u_{sc}^{H_2}\}$ with a corresponding choice c or sc. The first case can be translated into the maximin rule with the maximum pessimism with avoidance of the worst case $u_{sc}^{H_1}$. The latter case can be translated into the maximax rule with the maximum optimism due the best case $u_{sc}^{H_2}$ if $u_{sc}^{H_2} > u_c^{H_2}$. From this definition dominance arises either through $u_c^{H_i} > u_{sc}^{H_i}$ or through the concrete value of θ. A threshold level according to θ and a choice of sc can be calculated with $u_c^{H_1} - u_{sc}^{H_1} = a$ and $u_{sc}^{H_2} - u_c^{H_2} = b$ (see also Eeckhoudt (1984)):

$$\theta^* < b/(a+b) \tag{6}$$

Through risk aversion, a choice of sc is more difficult to realize due to $u_{sc}^{H_1} < u_c^{H_1} < u_c^{H_2} < u_{sc}^{H_2}$ or $u_{sc}^{H_1\prime} > u_s^{H_1\prime} > u_c^{H_2\prime} > u_{sc}^{H_2\prime}$. It is reasonable to assume that $y_c^{H_1} - y_{sc}^{H_1} >> y_{sc}^{H_2} - y_c^{H_2}$ and therefore $\theta^* << 0,5$.

θ is assumed to be state dependent. Given H_1 (H_2) as self-diagnosis, θ_1 (θ_2) is realized. c (sc) is chosen generally if $\theta^* < (>) \theta_i$. For the further discussion the following relations are assumed: $\theta^* < \theta_1$, $\theta^* \gtreqless \theta_2$. Given a self-diagnosis H_i the weight is shifted to $u_k^{H_i}$. This assumption can be seen as the individual's belief into the own competence of self-diagnosis. Then, θ_1 is comparably high and θ_2 comparable low.

Given (4) as maximum ex-ante utility and θ_2 as exogenous and characteristic for the individual the first best solution can also be calculated as (7):

$$EU_{fb}(\theta_2) = \pi u_c^{H_1} + (1-\pi) u_k^{H_2}(\theta_2) \tag{7}$$

(7) = (4) if $u_c^{H_2} > u_{sc}^{H_2}$ or $u_c^{H_2} < u_{sc}^{H_2}$ and $\theta_2 < \theta^*$, otherwise, (7) < (4).

Finally, under an imperfect competence of self-diagnosis fig. 1 can be translated into the following ex-ante condition:

$$EU(\pi_i, \theta_i) = \pi \left[\pi_1 u_c^{H_1} + (1-\pi_1) u_k^{H_1}(\theta_2)\right] + (1-\pi)\left[\pi_2 u_k^{H_2}(\theta_2) + (1-\pi_2) u_c^{H_2}\right] \tag{8}$$

If $\theta_2 < \theta^* < \theta_1$, (8) changes to:

$$EU(\pi_i, \theta_i) = \pi \left[\pi_1 u_c^{H_1} + (1-\pi_1) u_{sc}^{H_1}\right] + (1-\pi)\left[\pi_2 u_{sc}^{H_2} + (1-\pi_2) u_c^{H_2}\right] \tag{9}$$

For dominance, (8) can be simplified for $\theta_2 \geq \theta^*$ or $u_c^{H_2} > u_{sc}^{H_2}$:

$$EU(\pi_i, \theta_i) = \pi u_c^{H_1} + (1-\pi) u_c^{H_2} \tag{10}$$

(7) = (9) if $\pi_i = 1$, otherwise, (7) > (9). (10) = (7) if $u_c^{H_2} > u_{sc}^{H_2}$ or $\theta_2 \geq \theta^*$. Hence, if any kind of dominance exists the first best solution is achieved if θ is given as characteristical parameter of the individual.

If θ can be influenced, (4) is the benchmark. (9) and (10) are not able to achieve this maximum if self-care is utility maximizing for H_2 and $\pi_i < 1$. Then, a second-best solution arises independently of θ_2. Hence, the first best solution is able to be achieved only if $u_c^{H_2} > u_{sc}^{H_2}$ in which (6) and therefore (9) are not possible to be fulfilled. Then, (4) = (10). Furthermore, (4) = (9) if $\pi_i = 1$, $u_c^{H_2} < u_{sc}^{H_2}$ and $\theta_2 < \theta^*$.

Only self-insurance

Firstly, only self-insurance is implemented with $\delta'(E) > 0$ and $\pi_i'(E) = 0$. Then, the necessary condition for education $EU'(E) > 0$ under use of (8) is:

$$\pi EU'_{H_1} + (1-\pi) EU'_{H_2} < 0 \tag{11}$$

with

$$EU'_{H_1} = -(\pi_1 u_c^{H_1\prime} + (1-\pi_1) u_k^{H_1\prime}(\theta_2)) \tag{12}$$

$$EU'_{H_2} = -(\pi_2 u_k^{H_2\prime}(\theta_2) + (1-\pi_2) u_c^{H_2\prime}) \tag{13}$$

with $k = c, sc$ and $u_k^{H_i\prime}$ as derivatives of utility with subject to E.[9] (11) represents the expected marginal income loss or gain if education is implemented. Thereby, (12) and (13) quotes the expected value for H_1 and H_2. As long as c is dominant (11) changes to:

$$\pi u_c^{H_1\prime} + (1-\pi) u_c^{H_2\prime} > 0 \tag{14}$$

There is no positive effect on productivity for c. Hence, $u_c^{H_i\prime}$ is negative. Only expenditures arise and (14) cannot be fulfilled. Education is left undone.

However, if c is non-dominant with $u_{sc}^{H_2} > u_c^{H_2}$ and $\theta_2 < \theta^*$, (13) is positive if $\pi_2 u_{sc}^{H_2\prime}(\theta_2) > -(1-\pi_2) u_c^{H_2\prime}$ with $u_c^{H_2\prime} < 0$. If $\delta' > 0$, $u_{sc}^{H_2\prime}(\theta_2)$ is positive if:

$$u_{sc}^{H_2\prime}(\theta_2) = u_{sc}^{2\prime}(y) \cdot (Y'_{sc}(\delta' q_{sc} + \delta q'_{sc} \delta') - \alpha q'_{sc} \delta' - N' - 1) > 0 \; if \; \gamma < \frac{\alpha}{\delta} \tag{15}$$

[9]Please note, within this paper the notation $u_k^{H_i\prime}(\theta_2)$ means not a derivative with subject to θ_2 but only the dependence of k from the value θ_2. Furthermore, for the further discussion, $u_{sc}^{H_i\prime}(\theta_2)$ and $u_{sc}^{H_i}(\theta_2)$ also mean the dependence from θ_2 in which θ_2 takes on a value which realizes sc.

$$u_{sc}^{H_2\prime}(\theta_2) = -u_{sc}^{H_2\prime}(y) \cdot (\alpha q'_{sc}\delta' + N' + 1) > 0 \ if \ \gamma > \frac{\alpha}{\delta} \tag{16}$$

with $u_{sc}^{H_2\prime}(y)$ as derivative of utility with subject to y. In (15), $q'_{sc} > 0$ and the income effect can be positive if δ' and $|N'|$ are sufficiently high. This case is of relevance if $M - N > 0$ is sufficiently high to achieve a situation of non-dominance despite $\gamma < \frac{\alpha}{\delta}$. In (16), $q'_{sc} < 0$ and δ' and N' must be sufficiently in their absolute value to generate a positive income effect for self-care. In both cases a compensation of E through an increase of gross-income or a decrease of variable and fixed costs can take place. Then, it depends also on π_2 whether (13) is positive.

How is the situation for a (severe illness) (condition 12)? If non-dominance arises $u_{sc}^{H_1}(E) > u_{sc}^{H_1}$ as long as $\delta' > 0$ with $u_{sc}^{H_1\prime}(\theta_2) = -u_{sc}^{H_1\prime}(y) \cdot (\alpha q'_{sc}\delta' + N' + 1) > 0$ and $q'_{sc} < 0$. Again, $u_c^{H_1\prime}$ is negative. Of course, $u_{sc}^{H_1}(E) < u_c^{H_1}(E)$ remains. However, a positive income effect with $-\pi_1 u_c^{H_1\prime} < (1-\pi_1)u_{sc}^{H_1\prime}(\theta_2)$ is possible which depends on π_1 and on the absolute difference of the net-incomes between both strategies. Otherwise, if $q'_{sc} > 0$ due to $\gamma < \alpha/\delta$ the income effect for $sc(H_1)$ is negative due to an increase of variable costs $\alpha q'_{sc}$. It follows that (12) is positive.[10]

(11) is fulfilled with E^*_{imp} if there is non-dominance and the expected increase of net-income for both health states in sc is sufficiently high to compensate a decrease of net-income in strategy c.

Finally, if the competence of self-diagnosis is perfect with $\pi_i = 1$, (11) can be simplified:

$$\pi u_c^{H_1\prime} + (1-\pi)u_{sc}^{H_2\prime}(\theta_2) > 0 \tag{17}$$

E^*_{perf} as optimal investment in education increases in $1-\pi$. $E^*_{imp} > E^*_{perf}$ as long as $u_{sc}^{H_1\prime}(\theta_2) > 0$ and $|u_c^{H_2\prime}|$ is not too high, otherwise, $E^*_{imp} \leq E^*_{perf}$. In both cases $EU(E^*_{perf}) > EU(E^*_{imp})$. In the first case $EU(E^*_{imp})$ exceeds the level of education under a first best solution based on $\pi_i < 1$. In the latter case, even if identity between both levels of education exists, $\pi_i < 1$ reduces the expected utility below the first best solution.

How does risk aversion (RA) influence investments in education. For that, a linear transformation of utility (fig. 2) can be done. There is a linearity for a risk neutral individual (RN) with $(acef)$ and a concavity $(abdf)$ for RA. For the worst $sc(H_1)$ and best $sc(H_2)$ case the utilities are identical.[11] However, for $c(H_1)$ $(c(H_2))$ the utility for a

[10] Furthermore, please note that in a case of a dominant c without education and a non-dominance with education, for which an increase of net-income for $sc(H_2)$ above $c(H_2)$ and $\theta_2 < \theta^*$ are necessary, the income effect changes from a negative for $c(H_2)$ to a positive for $sc(H_2)$. Then, the first term in (13) changes in its relevant marginal utility from $u_c^{H_2\prime}$ to $u_{sc}^{H_2\prime}$ in which a positive income effect becomes significant. In (12) the situation is similar with a possible change of decision from $c(H_2)$ to a positive for $sc(H_2)$ with the consequence of $sc(H_1)$ and an increase of the negative income effect.

[11] This kind of illustration is taken from Eeckhoudt (2002). The position of $acef$ can be changed, e.g. as a linear function through the point of origin with any kind of slope also with any intersection between

RA-individual exceeds the utility of a RN-individual with $b - c$ $(d - e)$.

- Figure 2 -

(11) can be written as a threshold π^* for which investments in education are beneficial:

$$\pi^* < \frac{\pi_2 u_{sc}^{H_2\prime}(\theta_2) + (1-\pi_2)u_c^{H_2\prime}}{\pi_2 u_{sc}^{H_2\prime}(\theta_2) + (1-\pi_2)u_c^{H_2\prime} - \pi_1 u_c^{H_1\prime} - (1-\pi_1)u_{sc}^{H_1\prime}(\theta_2)} \tag{18}$$

The impact of RA depends on the marginal utilities for the different utility states. Comparing point a and f, the following relations are valid: $u_{sc}^{H_1RN\prime}(\theta_2) < u_{sc}^{H_1RA\prime}(\theta_2)$ and $u_{sc}^{H_2RN\prime}(\theta_2) > u_{sc}^{H_2RA\prime}(\theta_2)$. Hence, a loss through education in the worst (best) case reduces the incentive to invest in education more strongly under RA (RN) compared to RN (RA). The opposite is the case for a gain through education. For strategy c the relations between the marginal utilities depends on the absolute amount of net-income. As long as the $y < \widehat{y}$ $(y > \widehat{y})$, RA delivers a higher (lower) marginal utility than RN. At this point, $y_c^{H_1} < \widehat{y}$ and $y_c^{H_2} > \widehat{y}$. Given these relations of marginal utilities between RA and RN, RA has an ambiguous impact.

The arrows in fig. 2 illustrate the direction of income growth if education is implemented. According to self-care, the increase of net-income was calculated as equal for H_1 and H_2. Hence, under RA the incentive for education increases due to a higher marginal gain compared to RN if π_1 is low.[12] The threshold in (22) increases. However, if π_1 is high the incentive can decrease under RA. Contrary to that, for c (with the same decrease of net-income, E), RA decreases (increases) π^* for $c(H_1)$ $(c(H_2))$. This is due to a lower impact of loss for the latter under RA. The question is, whether $\Delta(d - e) < |\Delta(b - c)|$. Similar to strategy sc, this relation must be fulfilled between a linear and a concave utility function. Hence, for c, RA decreases the incentive to invest in education if π_1 and π_2 are high. Summarized, in the case of self-insurance, RA increases the incentive of education for sc and decreases it for c. The final answer depends on the distribution of error probabilities as well as on the absolute amounts of the changes of the differences between the utility values under RA and RN distinguished between c and sc.

Connected to RA the influence of illness severity is ambiguous for both health states. The more severe the illness the higher is the incentive for education if the weight is on the positive marginal income effect for sc. Otherwise, for c a low severity is more beneficial.

In addition, RA influences θ^* through $u_{sc}^{H_1\prime} > u_{sc}^{H_2\prime}$. The lower the value in the worst case the more probable the dominance through a low θ^*.

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the RN- and RA-function. However, the qualitative conclusion regarding the impact of risk aversion is independent from such kind of transformation.

[12]Please note, the relation $y_{sc}^{H_1} < y_c^{H_1}$ is assumed also after education.

Only self-protection

Now, only self-protection is implemented with $\pi_i'(E) > 0$ and $\delta'(E) = 0$. Then, the necessary condition for education with $EU'(E) > 0$ under use of (8) is:

$$\pi EU'_{H_1} + (1-\pi)EU'_{H_2} <$$

$$\underbrace{\pi \frac{d\pi_1}{dE}\left(u_c^{H_1}(E) - u_k^{H_1}(\theta_2, E)\right)}_{g} + \underbrace{(1-\pi)\frac{d\pi_2}{dE}\left(u_k^{H_2}(\theta_2, E) - u_c^{H_2}(E)\right)}_{h} \tag{19}$$

with

$$EU'_{H_1} = -(\pi_1 u_c^{H_1\prime} + (1-\pi_1)u_k^{H_1\prime}(\theta_2)) \tag{20}$$

$$EU'_{H_2} = -(\pi_2 u_k^{H_2\prime}(\theta_2) + (1-\pi_2)u_c^{H_2\prime}) \tag{21}$$

The left-hand side represents the income effect. Under a pure self-protection (20) and (21) are positive due to a negative income effect. The right hand-side is the marginal gain as a decrease of a potential utility loss through a false self-diagnosis (within the brackets), depending on the effectiveness of education separated into $\frac{d\pi_1}{dE}$ and $\frac{d\pi_2}{dE}$. For a high value of π, education becomes more reasonable due to the higher weight on the probably higher potential loss in case H_1. The impact of illness severity is equal for both health states. An increasing severity increases the incentive for education.[13] If c is dominant (14) is valid again and education is left undone. Furthermore, as long as $\delta'(E) = 0$ the first best solution (4) without education is the maximum value of the ex-ante expected utility. Even if the effectiveness of E is high and $\pi_i = 1$ can be achieved, (4) cannot be achieved due to a minimum of necessary expenditures $E > 0$. Despite a negative income-effect education remains beneficial if the shift to the correct positive or negative diagnosis increases the expected utility and compensates the expected income loss.

Self-insurance and self-protection

Now, let us combine self-insurance and self-protection with $\delta'(E) > 0$ and $\pi_i'(E) > 0$. Then, (19) is fulfilled as long as the income effect is positive or a negative one is compensated by a decrease of a potential loss. In addition, on the right-hand side of (19) the utility values after education are presented. Then, the more effective education according to δ the higher the potential loss in the case H_2 but the lower in case H_1 due to decreasing marginal costs $\alpha q_{sc}'$. Due to $u_{sc}^{H_2\prime} < u_{sc}^{H_1\prime}$ and $u_c^{H_2\prime} < u_c^{H_1\prime}$ the decrease of loss for H_1 compensates the increase of loss for H_2. Hence, if e. g. $\frac{d\pi_1}{dE} = \frac{d\pi_2}{dE}$, self-insurance reduces the

[13]Education is less attractive if one illness is most likely to occur with $\pi = 1$ and $\pi_1(\pi_1 = 1) = 1$ as a perfect correlation between the objective and the error probability.

effect of self-protection. Then, self-insurance partially substitutes self-protection, specifically for H_1. Otherwise, a partially complementary relation exists for H_2 in which the effectiveness of self-protection increases in the effectiveness of self-insurance. Furthermore, as long as c is dominant, (19) is not fulfilled due to a right-hand side of zero and a positive left-hand side. Hence, a utility maximizing strategy sc for H_2 and $\theta_2 < \theta^*$ is necessary for education.[14]

$E^*_{imp} \gtreqless E^*_{perf}$ is possible again if c is non-dominant. However, only in a case in which $E^*_{imp} = E^*_{perf} > 0$ and $\pi_i = 1$ after education the first-best solution after education can be achieved. Otherwise, E^*_{imp} can only implement a second-best solution specifically based on the reasonable assumption of $E \to \infty$ for $\pi_i \to 1$.

Finally, how is the impact of risk-aversion if self-protection is implemented? A threshold can be calculated again:

$$\pi^* < \frac{h + \pi_2 u_{sc}^{H_2\prime}(\theta_2) + (1-\pi_2)u_c^{H_2\prime}}{h - g + \pi_2 u_{sc}^{H_2\prime}(\theta_2) + (1-\pi_2)u_c^{H_2\prime} - \pi_1 u_c^{H_1\prime} - (1-\pi_1)u_{sc}^{H_1\prime}(\theta_2)} \tag{22}$$

The impact of self-insurance was already discussed. The impact of self-protection is focused on the difference of the absolute utility values. As can be easily seen in fig. 2 given each net-income after education the difference of utility and therefore the potential loss for H_1 is larger for RA than for RN due to a higher marginal utility in the case of RA if $y < \widehat{y}$. Otherwise, for H_2 the potential loss is higher for RN than for RA. Hence, also for self-protection the impact of RA is ambiguous. The potential loss in a case of a severe (banal) sickness is of a greater importance for the individual under RA (RN).

Again non-dominance can be induced under RN due to an increase of θ^*. Then, (19) is relevant, however, connected to the specific incentive structure under RN.

To discuss (19) in more detail the second order condition for a maximum as a sufficient condition with $EU''(E) < 0$ can be derived as (if c is non-dominant and $\gamma > \alpha/\delta$):

$$EU'' = \pi \left[\underbrace{\pi_1 u_c^{H_1\prime\prime}}_{1.-} \underbrace{+(1-\pi_1)u_{sc}^{H_1\prime\prime}}_{2.-} \underbrace{+2\pi_1'(u_c^{H_1\prime} - u_{sc}^{H_1\prime})}_{3.-} \underbrace{+\pi_1''(u_c^{H_1}(E) - u_{sc}^{H_1}(E))}_{4.-/0} \right]$$

$$+(1-\pi) \left[\underbrace{(1-\pi_2)u_c^{H_2\prime\prime}}_{5.-} \underbrace{+\pi_2 u_{sc}^{H_2\prime\prime}}_{6.-} \underbrace{+2\pi_2'(u_{sc}^{H_2\prime} - u_c^{H_2\prime})}_{7.+} \underbrace{+\pi_2''(u_{sc}^{H_2}(E) - u_c^{H_2}(E))}_{8.-/0} \right] \tag{23}$$

with

$$u_c^{H_i\prime} < 0 \; ; \; u_c^{H_i\prime\prime} < 0 \tag{24}$$

[14]Please note, c can remain also dominant if the gross-incomes are equalized and the variable costs for self-care are below the costs for consultation but the fixed costs for self-care are sufficiently high.

$$u_{sc}^{H_i\prime} = -u_{sc}^{H_i\prime}(y) \cdot (\alpha q_{sc}'\delta' + N' + 1) \tag{25}$$

$$u_{sc}^{H_i\prime\prime} = u_{sc}^{H_i\prime\prime}(y) \cdot (\alpha q_{sc}'\delta' + N' + 1)^2 - u_{sc}^{i\prime}\alpha(q_{sc}''\delta'^2 + q_{sc}'\delta'' + N'') < 0 \tag{26}$$

For a detailed analysis of (23) the FOC (19) is implemented into the SOC through a substitution of term four (see app. dev. 1). Then, $EU'' < 0$ is more likely to be fulfilled if there are decreasing returns of education according to marginal utility ($u_i'' < 0$).[15] Otherwise, u_i' and π_i' are ambiguous in their impact, given that (25) is positive.

Firstly, $|u_c^{H_2\prime}|$ and $u_{sc}^{H_2\prime}$ should be low to achieve a maximum. Term seven shows that an increase in the competence of self-diagnosis ($\pi_2' > 0$) decreases the relevance of a decreasing net-income for $c(H_2)$ but increases the weight of the positive income effect for $sc(H_2)$. This implies on the one hand the named positive expenditure effect and on the other hand the decrease of a potential risk of a utility loss through a false self-diagnosis. Then, high values $|u_c^{H_2\prime}|$ and $u_{sc}^{H_2\prime}$ increase the value of maximum expected utility.

Secondly, a high value $|u_c^{H_1\prime}|$ supports the fulfillment of the SOC as the opposite to the former effect as a shift of the decision to $c(H_1)$ connected with a negative income effect (term three).

Thirdly, $u_{sc}^{H_2\prime}$ is ambiguous on its own. It should be high if $\frac{2\pi}{(1-\pi_1)} > -\frac{\pi_1''}{\pi_1'^2}$ is fulfilled (see app.). As can be seen in term three, a shift of the decision from the positive to the negative income effect is supported by a strong effectiveness π_1'. Hence, $u_{sc}^{H_1\prime}$ should be high. It should be low, however, if there is a strong decrease of marginal returns according to self-diagnosis ($\pi_i'' < 0$) due a dilution of the former effect.

Fourthly, according to the potential loss (term eight), a large loss supports (23) if $|\frac{\pi_2''}{\pi_2'}| > |\frac{\pi_1''}{\pi_1'}|$ (see app.). Hence, a strong decrease of marginal returns according to π_2 reduces the effectiveness in terms of a decrease of a potential loss through education. Again, π_1' should be high. Term four presents a high degree of diminishing returns with respect to π_1 as supporting for a fulfillment of (23). However, $|\frac{\pi_2''}{\pi_2'}| > |\frac{\pi_1''}{\pi_1'}|$ postulates the opposite. The reason is the substitution of term four through the FOC. A high value $|\pi_2''|$ for H_2 should compensate a positive risk decreasing effect for H_1 to support (23). The opposite can be postulated if term eight would be substituted by the FOC.

Summarized, to realize a maximum of expected utility a shift from a positive to a negative income effect with a corresponding self-diagnosis competence and a diminishing effect of risk reduction are relevant. If constant returns with $u_i'' = 0$ are assumed these effects are necessary and sufficient for a maximum. In addition, $\pi_i'' < 0$ is also not necessary for $EU'' < 0$ (see app.).

[15] Please note, (26) must be negative (with $N'' > 0$) with $q_{sc}''\delta'^2 > 0$, $q_{sc}'\delta'' > 0$ and $q_{sc}'' > 0$, $\delta'' \leq 0$. Due to a maximum $\bar{Y}_{sc}$ in the case of non-dominance of c an increase of δ decreases q_{sc}, however, the decrease diminishes through $H_2 + \delta q_{sc} = \bar{Y}$, which delivers $q_{sc}'\delta'' > 0$.

In the case of pure self-protection with $\delta' = 0$, (25) is negative. Term three turns to a positive sign with $|u_c^{H_1\prime}| < |u_{sc}^{H_1\prime}|$. Then, an increase of π_1 shifts the choice to c attenuating the negative income effect. Term seven with $|u_{sc}^{H_2\prime}| < |u_c^{H_2\prime}|$ does not change its sign, but decreases compared to the case with self-insurance because of the decreasing but still existing advantage of shifting the choice to self-care.

In the case of pure self-insurance with $\pi_2' = 0$, (23) simplifies to the sum of the terms one, two, five and six. Then, a decreasing marginal utility is necessary and sufficient for $EU'' < 0$. This is clear due to the simple opposing effect of an increase of utility for self-care and a decrease for consultation both based on an increase of education expenditures.

Dominance vs. non-dominance

Connected to the shift from dominance to non-dominance the following has to be highlighted. Self-insurance increases $u_{sc}^{H_2}$ above $u_c^{H_2}$. Self-protection can only be beneficial if c is non-dominant. Connected to the former, a false negative decision against H_1 is stimulated by education despite a possible increase of π_i. As long as $u_c^{H_2} > u_{sc}^{H_2}$, the first best solution EU_{fb} or $EU_{fb}(\theta)$ is generated. However, if $u_c^{H_2} < u_{sc}^{H_2}$ and $u_{sc}^{H_i}(E) - u_{cE}^{H_i}(E)$ is sufficient for $\theta_2 < \theta^*$, (9) becomes relevant, but EU_{fb} or $EU_{fb}(\theta)$ are not necessarily exceeded. If $\theta_2 < \theta^*$ and $\pi_i = 1$, an induced non-dominance is unproblematic and $EU_{fb}(E) > EU_{fb}$ or $EU_{fb}(\theta, E) > EU_{fb}(\theta)$ are achieved as long as E is sufficiently low. However, due to $\pi_i < 1$ as the risk of a false self-diagnosis, (9) is not only below $EU_{fb}(E)$ or $EU_{fb}(\theta, E)$ but can also be below EU_{fb} or $EU_{fb}(\theta)$ with a dominant structure. *sc* becomes more attractive in a case in which the individual decides in aid of H_2 with a remaining error probability $1 - \pi_{1E} > 0$. However, c remains the better alternative for H_1 and a full dominance of c could be the better alternative. This could be interpreted as a false self-confidence or overassessment of the own abilities. Then, from an ex-ante point of view, education is only beneficial if the gain of expected utility for H_2 compensates the loss for H_1 with $\pi\Delta EU_{H_1} + (1-\pi)\Delta EU_{H_2} > 0$:

$$\pi\left[(\pi_{1E}u_c^{H_1}(E) + (1-\pi_{1E})u_{sc}^{H_1}(E)) - u_c^{H_1}\right] +$$

$$(1-\pi)\left[(\pi_{2E}u_{sc}^{H_2}(E) + (1-\pi_{2E})u_c^{H_2}(E)) - u_c^{H_2}\right] > 0 \tag{27}$$

The first term in (27) must be negative and the second can be positive. Hence, whether the total effect of $u_{sc}^{H_2}(E) - u_c^{H_2} > 0$ is positive depends on $\pi_{iE} - \pi_i > 0$ and the increase/decrease of the utility values in which risk aversion makes it more difficult to fulfill (27).

The former can also be interpreted as follows. From an ex-ante point of view a value $\pi < \pi^*$ exists for which non-dominance should be preferred. As long as $\pi < \pi^*$, $\theta_2 < \theta^*$ is necessary to realize non-dominance as optimal solution.[16] However, if $\theta_2 < \theta^*$ and $\pi^* < \pi$, dominance of c should remain, however, education is carried out. Therefore, a possible decrease of expected utility due to an extension of alternatives is based on a bias between the factual a-priori risk of a severe illness and the subjective parameter of pessimism.

If θ_2 cannot be influenced and non-dominance is the situation before education, expenditures E can decrease θ^*. c can become dominant due to the implementation of E if the income effect is negative for self-care (see (6)). Then, $u_c^{H_2}(E) < u_{sc}^{H_2}(E)$ still remains, however, through risk aversion the differences between the utilities within each health state increase. Self-care is reduced in its attractiveness, which is in fact desirable if the expected utility under dominance after education exceeds the utility under non-dominance before education.[17] If θ^* cannot be influenced sufficiently to induce dominance, the focus must be on a fulfillment of (19) with a corresponding inducement of education.

If a situation of non-dominance generates a higher expected utility than dominance and if (19) is fulfilled, a decrease of θ^* could be possible anyway, inducing dominance and making (19) no longer fulfillable. Then, education should also be left undone.[18]

As a conclusion, dominance can be a second best solution without education if the expected utility of c from an ex-ante point of view exceeds the expected utility of sc and the competence of self-diagnosis is sufficiently low. Due to the assumed decision structure under ambiguity this solution cannot be generated as long as non-dominance exists. Then, non-dominance is a third-best solution, however, a change to dominance is possible if θ^* decreases sufficiently due to education expenditures.

As an interim conclusion, if self-care is dominated by consultation through higher utility values for each health state the first best solution is realized. An extension of strategies through self-care only produces a first best solution if the optimal choices for each kind of illness factually take place. However, this can only be realized if a perfect self-diagnosis exists and the characteristic optimistic or pessimistic appreciation ex-post does not produce a general decision of consultation. Otherwise, it could be beneficial to turn education, connected with an increase of productivity, down or reduce the attractiveness of self-care generally if an extension of strategies reduces the ex-ante utility. However, if an alternative strategy already exists self-insurance and specifically self-protection could be used to close the gap between the first and second best solution. Generally, education can be interpreted either as a measure to strengthen patient autonomy or to weaken it in that sense that the alternative of self-care is dominated.

[16] Please note, $\pi^* \neq \theta^*$ due to π^* also pays attention to the income effect based on expenditures E.

[17] However, an increase through dominance is only possible if the necessary expenditures E are sufficiently low.

[18] Another situation must also be attended. Non-dominance could be preferred to dominance, however, $\theta^* < \theta_2$. Then, education can also increase θ^* if education improves the situation of sc relatively to c. Then, non-dominance could be induced, which is in fact beneficial as long as the expenditures for education are sufficiently low.

4 Ex-post decision under uncertainty

In the following the ex-post decision is discussed as a decision under uncertainty distinguished into two cases: 1. ex-post knowledge about a-priori probabilities π, 2. ex-post knowledge about π and π_i. The parameter θ is now excluded from the discussion and replaced by the knowledge of probabilities. The first best solution remains (4).

4.1 Ex-post knowledge about a-priori probabilities

Some knowledge exists in an acute indisposition about the disposition to fall ill according to H_i. Hence, π is taken into account to decide between c and sc, however, the symptoms are not assessed in this moment. The ex-ante expected utility is:

$$EU(\pi) = \pi max\{EU_c; EU_{sc}\} + (1-\pi)max\{EU_c; EU_{sc}\} = max\{EU_c; EU_{sc}\} \tag{28}$$

with

$$EU_k = \pi u_k^{H_1} + (1-\pi)u_k^{H_2}, \; k = c, sc \tag{29}$$

The process of choice is equal to the decision under ambiguity, except a replacement of θ by π. The threshold π^* is given by (6). The choice is illustrated in fig. 3 (bold lines).

- Figure 3 -

π^* decreases (increases) in a potential loss of H_1 (H_2). (6) cannot be fulfilled if c is dominant with $u_c^{H_2} > u_{sc}^{H_2}$. Furthermore, similar to the decision under ambiguity, π^* increases if the individual is risk neutral.

The decision is only based on the expected utilities calculated by the objective probabilities for which reason only self-insurance is an outcome of education. According to π^* the impact of education is:

$$\pi^{*\prime}(E) = (a+b)^{-1}(b' - \underbrace{b(a+b)^{-1}}_{\leq 1}(a'+b')) > 0 \tag{30}$$

As can be easily seen π^* increases if $u_{sc}^{H_i}$ is increased and $u_c^{H_i}$ decreased by education. This is illustrated in fig. 3 in which the threshold increases from π_0^* to π_1^* due to the simple reason of a more beneficial sc and a less c.[19]

$\pi^{*\prime}(E)$ does not inform about a welfare gain but only about the relation between the expected utilities before and after education. $0 < \pi < \pi_E^*$ represents the area of an individual welfare gain. If education increases $u_{sc}^{H_i}$, $\pi_E^* > \pi_0^*$ follows necessarily. Then, a

[19]Please note, if non-dominance exists only due to $N < M$, $a' > 0$ due to an increase of q_{sc} (if N' is small). This case is not discussed due to simplification.

welfare gain is produced as long as $EU_{sc}(E) > EU_c$ with:

$$\pi_E^* < \frac{u_{sc}^{H_2}(E) - u_c^{H_2}(E)}{u_{sc}^{H_2}(E) - u_c^{H_2} - u_{sc}^{H_1}(E) + u_c^{H_1}} \tag{31}$$

Again, the expected utility must rise through education. Specifically $\pi_0^* < \pi < \pi_E^*$ represents the range for which sc turns to dominance after education. Hence, education can increase dominance of sc. Education is inhibited for values of π for which the expected value of c is dominant.

4.2 Education under conditional decision ex-post

So far, the competence of self-diagnosis is not in focus, which is, however, an important dimension of patient autonomy. Hence, beside π the individual is also informed ex-post about π and π_i. Hence, the quality of a signal I_i in case H_i is known. I_i represents the self-diagnosis H_i. Quality means π_i as the competence of a correct interpretation of a symptom to derive I_i. The diagnosis and the choice between c or sc is conditional on H_i and depends stochastically on it. This can be typically described by a-posteriori probabilities with use of the theorem of BAYES and calculated under use of fig. 1:

$$p(H_1, I_1) = \frac{\pi\pi_1}{p(I_1)} = p_{11} \ ; \ p(H_1, I_2) = \frac{\pi(1-\pi^1)}{p(I_2)} = p_{12} \tag{32}$$

$$p(H_2, I_2) = \frac{(1-\pi)\pi_2}{p(I_2)} = p_{22} \ ; \ p(H_2, I_1) = \frac{(1-\pi)(1-\pi_2)}{p(I_1)} = p_{21} \tag{33}$$

with

$$p(I_1) = \pi\pi_1 + (1-\pi)(1-\pi_2) \ ; p(I_2) = \pi(1-\pi_1) + (1-\pi)\pi_2 \tag{34}$$

and the derivatives with subject to education

$$p_{11}' = p_{22}' > 0 \ ; \ p_{12}' = p_{21}' < 0 \ ; \ p(I_1)' \gtreqless 0 \ ; \ p(I_2)' \gtreqless 0 \tag{35}$$

(34) represents the probabilities that signal I_i (self-diagnosis H_i) occurs. (32) [33] represents the probabilities that H_1 [H_2] occurs conditional to the symptom is interpreted as I_1 or I_2. The lower the quality of interpretation the lower $p(H_1, I_1)$ and $p(H_2, I_2)$. Education increases the quality of the indicator (condition (35)) through an improvement of the competence of self-diagnosis. The maximum value is achieved for $\pi_i = 1$ with $p(H_1, I_1) = p(H_2, I_2) = 1$. The competence of self-diagnosis becomes perfect and the expected value from and ex-ante point of view is equal to (4), which must be higher than (28) as long as c is non-dominant (with $u_c(y)_{H_2} < u_{sc}(y)_{H_2}$).[20] If $\pi_i < 1$, the conditional

[20]Please note, the same result is produced by $\pi_i = 0$ with $p(H_1, I_1) = p(H_2, I_2) = 0$. A total incompetence results in a turn to a full pseudo-competence with perfect information. Knowledge about full incompetence delivers knowledge about the correct diagnosis as a simple reflection of a perfectly

probabilities are relevant. The individual calculates the expected utility for each signal to choose between c and sc. These are only two, one for I_1 and the other for I_2. Then, similar to (28) the ex-ante expected utility can be calculated with use of fig. 4:

- figure 4 -

$$EU(p(I_i), p_{si}) = \sum_{i=1}^{2} p(I_i) max \left\{ \sum_{s=1}^{2} p_{si} u_c^{H_s}; \sum_{s=1}^{2} p_{si} u_{sc}^{H_s} \right\} \tag{36}$$

with $s = 1, 2$ and $i = 1, 2$. The expected utilities of c and sc are based on p_{11} and p_{21} if I_1 arises and on p_{22} and p_{12} for signal I_2. From an ex-ante point of view the occurrence of I_i is uncertain with $p(I_i)$. Hence, the patient's quality of self-diagnosis is of specific importance. Given the signal, a threshold level can be calculated to choose c or sc. The threshold for choosing sc for each indicator I_1 and I_2 is:

$$p_{1i} < b/(a + b) \tag{37}$$

Let us assume that the individual consciously affords I_i as a further information. Then, an information value IV can be calculated as a difference between (28) and (36) in which $EU(\pi) - EU(p(I_i), p_1, p_2, E_0) \leq 0$ is strictly valid, which can be easily shown (see app. dev. 2). IV represents the (conditional) increase of expected utility through the knowledge about quality of self-diagnosis. To show IV more ostensively the representation from Eeckhoudt (1984) is used. The situation is printed in fig. 5a and 5b. Fig. 5a shows the

π	IV
$0 \leq \pi^* \leq \underline{z}$	0
$\underline{z} \leq \pi^* \leq \frac{b}{a+b}$	$a\pi_1\pi - b(1-\pi_2)(1-\pi)$
$\frac{b}{a+b} \leq \pi^* \leq \overline{z}$	$a(\pi_1 - 1)\pi + b\pi_s^2(1-\pi)$
$\overline{z} \leq \pi^* \leq 1$	0

Table 4: Function of the information value

differences between the expected utility with and without further diagnosis information, e.g. IV_1 and IV_2. Fig. 5b represents tab. 5 in which IV depends on π.

- Figure 5 a/b -

It is assumed that $p_{12} < p_{11}$ with $\pi_1 + \pi_2 > 1$.[21] It is reasonable to assume $\pi_1 < \pi_2$. Then, $\underline{z} = \frac{b(1-\pi_2)}{\pi_1 a + b(1-\pi_2)}$ and $\overline{z} = \frac{b\pi_2}{(1-\pi_1)a + b\pi_2}$ is valid. Following Pauker and Kassirer (1980),

wrong diagnosis. However, in these cases education makes no sense according to improve competence self-diagnosis, but only to increase the productivity of self-care. This is different to the case without any ex-post knowledge about probabilities. There, education could make sense for low values π_i because the individual could not infer something from π_i ex-post.

[21] $p_{12} > p_{11}$ is also thinkable. However, to hold the analysis as simple as possible only $p_{12} < p_{11}$ is discussed which does not influence the results significantly.

$\pi < \underline{z}$ ($\overline{z} < \pi$) represents a threshold for which sc (c) is chosen independently from a self-diagnosis. $\underline{z}$ can be easily calculated with p_{11} smaller than the threshold (37). The decision is in aid of sc independently of the signal. Without the use of I_i, (6) also delivers sc as optimal, hence, $IV = 0$ and sc is dominant. This kind of dominance was not possible without information ex-post. But now, dominance can exist according to an expected value. In fig. 5a this is valid for $p_{11} < \pi_0^*$ and the corresponding expected utility value on curve EU_{sc}.

Not before π rises above $\underline{z}$, IV increases as long as the threshold level of π is in the interval of line two in tab. 4. If I_1 occurs c is chosen, but sc remains optimal for the individual if I_2 occurs. Without a signal the decision is also sc. In that case a line $EU(I_i)$ (or (36)) can be drawn in fig. 5a between p'_{11} and p'_{12} on EU_c and EU_{sc}, representing the expected utility under use of imperfect information. At π', the second line in tab. 4 can be represented as IV_1. Then, it can also be seen that an increase of π to π'' shifts $EU(I_i)$ due to an increase of p''_{11} and p''_{12}. IV also increases until $\pi = \pi_0^*$. The printed example shows $\pi'' > \pi_0^*$. The choice without a signal is c and it remains c with signal I_1 but is sc with I_2. IV takes on the value of the third line in tab. 4 and IV_2 in fig. 5a. If line four becomes relevant p_{11} and p_{12} are above the threshold and c is chosen definitely with $IV = 0$, which means dominance of c.

Please note, dominance can exist again through $u_c^{H_2} > u_{sc}^{H_2}$ as in the chapter before. Then of course, IV becomes also zero for every value of π.

Tab. 4 can be translated into fig. 5b, which represents the differences between the curves EU_c, EU_{sc} and $EU(I_i, \pi)$. The maximum is $IV_{max} = \frac{ab(\pi_1+\pi_2-1)}{a+b}$, which increases in π_1 and π_2 with $IV_{max} = \frac{ab}{a+b}$ under perfect information. Fig. 5b shows also the curve for perfect information IV^{perf}, which must always dominate $IV^{nonperf}$. In fig. 5a $EU(I_i)$ shifts to $p_{11} = 1$ and $p_{12} = 0$. Given a value π the relation $IV(\pi)^{nonperf}/IV(\pi)^{perf}$ can be interpreted as a measure of the competence of self-diagnosis.

As can be seen in fig. 5a/b and tab. 4, if a positive information value arises, the differences a and b are relevant according to the attitude of $EU(I_i)$ and the amount of IV. Hence, due to the implementation of conditional probabilities including π_i the loss within one health stage based on a false self-diagnosis is of importance for IV.

Finally, if the individual is risk neutral, a and b increase (see fig. 2/3). It follows, that the thresholds $\underline{z}$ and $\overline{z}$ must increase leading to a shift of a positive information value to the right. The reason is that sc is more attractive and often chosen, hence, sc becomes relevant independent of the diagnosis for a higher range of π.

Education and the information value

Now, the influence of education under an imperfect quality of self-diagnosis is analysed.

Education influences $p(I_i)$, p_{si} with $s = 1,2$ and $i = 1,2$ based on $\pi_i'(E) > 0$ as well as a and b. As long as $IVA^{nonperf} < IVA^{perf}$ education can increase IV due to an increase of p_{11} and p_{22}. However, if a (b) decreases (increases), IV also decreases (increases). The reason is the reduced (increased) loss in the case of false self-diagnosis. The thresholds in tab. 4 are calculated with subject to E:

$$\frac{\partial \underline{z}}{\partial E}\begin{cases} > 0 \;\; if \;\; (1-\pi_2)/\pi_2\,(\eta_{b,E}-\eta_{a,E}-\eta_{\pi_1,E}) > \eta_{\pi_2,E} \\ = 0 \;\; if \;\; (1-\pi_2)/\pi_2\,(\eta_{b,E}-\eta_{a,E}-\eta_{\pi_1,E}) = \eta_{\pi_2,E} \\ < 0 \;\; if \;\; (1-\pi_2)/\pi_2\,(\eta_{b,E}-\eta_{a,E}-\eta_{\pi_1,E}) < \eta_{\pi_2,E} \end{cases} \tag{38}$$

$$\frac{\partial \overline{z}}{\partial E}\begin{cases} > 0 \;\; if \;\; (1-\pi_1)/\pi_1\,(\eta_{a,E}-\eta_{b,E}-\eta_{\pi_2,E}) < \eta_{\pi_1,E} \\ = 0 \;\; if \;\; (1-\pi_1)/\pi_1\,(\eta_{a,E}-\eta_{b,E}-\eta_{\pi_2,E}) = \eta_{\pi_1,E} \\ < 0 \;\; if \;\; (1-\pi_1)/\pi_1\,(\eta_{a,E}-\eta_{b,E}-\eta_{\pi_2,E}) > \eta_{\pi_1,E} \end{cases} \tag{39}$$

with $\eta_{\pi_2,E}, \eta_{\pi_1,E} > 0$ and $\eta_{b,E} > 0$, $\eta_{a,E} < 0$. $\underline{z}$ and $\overline{z}$ increase in an increasing $\eta_{b,E}$ and $|\eta_{a,E}|$. As can be seen in (37) an increase of the utility difference between c and sc for H_2 (value b) increases the threshold level p_{1i} for which sc is chosen. sc increases in its attractiveness. This is also valid for a decrease of the utility difference between c and sc for H_1 (value a) due to a decreasing value of loss in the case of a wrong self-diagnosis according to H_1. Hence, $\underline{z}$ is shifted to the right by education if a and b are sensitive. As can be seen in fig. 5a, if EU_{sc} is shifted upwards and EU_c downwards the range for which $EU(I_i)$ is located completely on EU_{sc} increases. Otherwise, the range of $IV > 0$ shifts to the left if the sensitivities of a and b are too low. $\underline{z}$ is shifted to the left if π_1 or π_2 increases strongly because p_{11} increases and p_{12} decreases as an improvement of the quality of self-diagnosis. Therefore, given π, IV must increase. The later is also valid for $\overline{z}$, which is shifted to the right. Summarized, a high sensitivity of a and b shifts the whole triangle to the right. A high effectiveness of education according to an increase of π_i broaden the basis of the triangle.[22] The relation between these sensitivities determines the final layer of the triangle. Finally, the change of IV_{max} can be shown as $\frac{\partial IV_{max}}{\partial E} \gtreqless 0$. The relation depends on the relative effectiveness according to a and b.

In the case of pure self-insurance with $\eta_{\pi_2,E} = \eta_{\pi_1,E} = 0$, (38) and (39) are positive and the area of a positive information value shifts to the right. The reason is that only the advantageousness of sc increases relative to c and the range for which sc is chosen independently of the indicator increases. If only self-protection is implemented with $\eta_{a,E} > 0$ and $\eta_{b,E} > 0$, the potential of a negative value of (38) and (39) increases in which $\underline{z}$ and $\overline{z}$ decrease if $\eta_{a,E} > \eta_{b,E}$. The final direction of the shift of the range of a positive IV depends on the relative effectiveness of the conditional probabilities.

[22] In the case of $p_{12} > p_{11}$ education shifts $\underline{z}$ to the right and $\overline{z}$ to the left which reduces the area of $IV > 0$. However, $p_{12} < p_{11}$ is achieved for a correspondent impact of education on π_i.

The structure of both IV-functions in tab. 4 remains after education. As can also be seen, the critical values for $IV = 0$ are $\pi = 0$ and $\pi = 1$ for perfect information, which cannot be changed by education. However, IV_{max}^{perf} increases in b and decreases in a. The reason is the decrease of the potential loss between c and sc in stage H_1, which makes it less worthwhile to have further information e. g. the interpreted symptom.

Education under imperfect information

After discussing the principle exposure of IV and its dependence on π the incentive to invest in education shall be discussed. As it was already shown E influences the threshold of the decision between c and sc and also the area in which the implementation of the symptoms' interpretation increases the value of information. However, fig. 5b is not adequate enough to analyze the impact of education according to a welfare gain because only the relation between utilities with and without information are indicated. To show the satisfying conditions for education I derive them graphically at first. Let us use the case in fig. 3 plotted again in fig. 5.

- figure 6 -

Education shifts the expected utility curves from EU_k to $EU_k(E)$ with $k = c, sc$ due to an increase of $u_{sc}^{H_i}$ and a decrease of $u_c^{H_i}$. Furthermore, education decreases p_{12} to p_{12E} and increases p_{11} to p_{11E}. Hence, the curve of the conditional expected utility shifts from $EU(I)$ to $EU_E(I)$ for a *given* value π. Now, the bold line represents the maximum expected utility for a given value of π. Education is not optimal for each π.[23] Necessarily, $EU_{sc}(E)$ or $EU(I, E)$ must have an intersection with EU_c or $EU(I)$ for a beneficial education with a corresponding maximum value of $\pi^{**} > \pi$. Then, an intersection of $EU_{sc}(E)$ is sufficient for education because $EU(I, E)$ is equal or higher than $EU_{sc}(E)$. This also means that as long as $IV > 0$ under education and $EU_{sc}(E)$ has any intersection, π^{**} increases through the use of a symptom as an indicator for self-diagnosis.[24]

Fig. 6 shows a specific situation after education in which $\pi < \pi^{**}$ is the range in which education is utility maximizing. In this case $EU(I, E)$ has an intersection with $EU(I)$:

$$\frac{b_E\pi_{2E} + u_c^{H_2}(E) - b\pi_2 - u_c^{H_2}}{b_E\pi_{2E} - b\pi_2 - u_{sc}^{H_1}(E) + u_c^{H_2}(E) + u_{sc}^{H_1} - u_c^{H_2} + a\pi_1 - a_E\pi_{1E}} > \pi^{1**} \tag{40}$$

[23]Only EU_k and $EU_k(E)$ remain constant when π changes. However, $EU(I)$ and $EU(I, E)$ shift to the right when π increases as it was indicated in tab. 4. An increase or decrease of π increases or decreases IV in which $EU(I)$ must lie within the range of $EU(I, E)$. For very high and very low values of π both areas of positive IV are zero and $EU_k(E)$ is of relevance after education. The value π^{**} as critical probability for effort in education also shifts with π due to a shift of $EU(I, E)$.

[24]This does not mean another π compared to the situation without education. π is not influenced by education. A shifted π changes the whole position of $EU(I)$ and $EU(I, E)$. Hence, given an identical value π before and after education, education becomes beneficial only due to the use of further information.

$\pi^{1**\prime}$	$\Delta\pi_i$	$b_E - b$	$a - a_E$	$\lvert\Delta u_c^{H_2}\rvert$	$\lvert\Delta u_{sc}^{H_1}\rvert$
SI and SP	+	+	-	-	+
only SI	0	+	-	-	+
only SP	+	+	+	-	-

Table 5: Education threshold and its derivative

Condition (40) is valid for $IV > 0$ and line two and three in tab. 4 respectively. Tab. 5 shows the derivatives of (40). Under self-insurance and self-protection the threshold of education π^{1**} increases in $\Delta\pi_s^i$ or the effectiveness of education on the quality of diagnosis. In addition, π^{1**} increases (decreases) in $b_E - b$ $(a - a_E)$ or the change of the potential loss in stage H_2 (H_1). This does not mean a necessary increase of the expected utility due to an increase of the differences between the health stages.[25] Specifically, a decreases in which $u_{sc}^{H_1}$ increases but $u_c^{H_1}$ decreases. b increases with a decreasing $u_c^{H_2}$ but an increase of $u_{sc}^{H_2}$. As can be seen in fig. 6 a decrease of $u_c^{H_i}$ decreases π^{1**} but an increase of $u_{sc}^{H_i}$ increases π^{1**}. The decreasing effect of $u_c^{H_1}$ and the increasing effect of $u_{sc}^{H_2}$ is already considered in (40) by $b_E - b$ and $a - a_E$. However, these potential losses must be adjusted by $|\Delta u_c^{H_2}|$ and $|\Delta u_{sc}^{H_1}|$. π^{1**} decreases in the first and increases in the latter. This point more specifically concerns the income effect for the relevant values given the intersection (40). Education becomes more relevant if the negative income effect is low and the positive is high. In other words the threshold depends on the level of income and illness severity respectively in which risk aversion must be considered. Summarized, the increase of a potential loss as a stimulation of education cannot be observed in isolation but opposed to the income loss through education. A decrease of utility must be compensated by an increase of $u_{sc}^{H_i}$ similar to condition (19). The potential loss through a false self-diagnosis is of relevance for education if the probabilities of error are of relevance as it is the case in (40).

In the case of pure self-insurance, π^{1**} decreases due to $\pi_{iE} = \pi_i$. In addition, the potential loss of utility remains relevant also for self-insurance due the use of information, specifically within the intersection between $EU(I, E)$ and $EU(I)$. The reason for this is the information value, which is influenced by a potential utility loss. In the previous chapter the value of loss was not of importance for self-insurance. If only self-protection is implemented, the threshold increases in $b_E - b$ and $a - a_E$ due to risk-aversion and decreases in $|\Delta u_{sc}^{H_1}|$ due to $u_{sc}^{H_1} - u_{sc}^{H_1}(E) > 0$. In the case of pure self-insurance education is beneficial due to the decrease of the negative income-effect through education. On the other hand, if only self-protection is possible the decrease of the risk of a potential loss stimulates education in which a positive effect on the information value increases this kind

[25]For $p_{12} > p_{11}$ education reduces the difference between both probabilities. Hence, the incentive to invest in education is also reduced as long as $p_{12} > p_{11}$ remains unchanged because of a reduced IV due to relative identical values p_{1i}.

of stimulation.[26]

The following conditions are alternative sufficient conditions for which education becomes utility maximizing. The principal mechanisms were explained earlier. For that reason the further explanations are condensed.

If $u_{sc}^{H_i}$ is more increased than above, risk aversion increases $u_{sc}^{H_1}$ more than $u_{sc}^{H_2}$. Then, $EU_{sc}(E)$ shifts to the right with an intersection with EU_c (not drawn). Education is utility maximizing if $EU_{sc}(E) > EU_c$ equal to (31): (31):

$$\frac{u_{sc}^{H_2}(E) - u_c^{H_2}(E)}{u_{sc}^{H_2}(E) - u_c^{H_2} - u_{sc}^{H_1}(E) + u_c^{H_1}(E)} > \pi^{2**} \tag{41}$$

(41) is sufficient for education also with $IV = 0$ and $\pi_{0E}^* > p_{11E}$ (not drawn). As can be seen neither a nor b are elements of (41). Hence, the potential loss of utility and therefore an element, which stimulates education is not relevant. However, due to the intersection with EU_c only the utility after education for $sc(H_i)$ is of specific relevance. This is clear because in this specific intersection, $IV = 0$ and π_i is not relevant for a decrease of the expected loss as in (40) which also means that self-protection is not relevant. For $\pi_{0E}^* < p_{11E}$ and $\pi_{0E}^* > p_{12E}$ ($\pi^{3**} > \overline{z}$ must not be valid) a value $\pi^{3**} > \pi^{2**}$ exists because $EU(I,E)$ is necessarily located right to $EU_{sc}(E)$. π^{3**} can be calculated as intersection between $EU(I,E)$and EU_c:

$$\frac{b_E\pi_{2E} + u_c^{H_2}(E) - u_c^{H_2}(E)}{b_E\pi_{2E} + u_c^{H_2}(E) - u_c^{H_2} - u_{sc}^{H_1}(E) + u_c^{H_1} - a_E\pi_{1E}} > \pi^{3**} \tag{42}$$

The use of the symptom as information increases the range of π for which education is utility maximizing. Now, $a_E\pi_{1E}$ and $b_E\pi_{2E}$ and the income loss through education but not a and b are relevant. The reason is that in (40) curve $EU(I_i)$ is influenced by a and b, which is, however, not relevant in the specific intersection of (42). Of course, (42) can remain valid if (41) is invalid due to an intersection of $EU_{sc}(E)$ and $EU(I)$ with π^{4**} (not drawn):

$$\frac{u_{sc}^{H_2}(E) - b\pi_2 - u_c^{H_2}}{u_{sc}^{H_2}(E) - b\pi_2 - u_c^{H_2} + a\pi_1 + u_{sc}^{H_1} - u_{sc}^{H_1}(E)} > \pi^{4**} \tag{43}$$

As can be seen for this specific intersection $a\pi_2$ and $b\pi_1$ have a negative impact on π^{4**} but $a_E\pi_{1E}$ and $b_E\pi_{2E}$ are not of relevance. $EU(I_i,E)$ has no impact on this specific intersection for which reason an increase of π_i to decrease the impact of a potential loss is not relevant.

Finally, as already mentioned an intersection between $EU_{sc}(E)$ and EU_{sc} is impossible due to an increase of $u_{sc}^{H_1}$.

[26]Please note, as already discussed in ch. 3, a partially substitution takes place between self-insurance and self-protection, however, also a partially complementary relation arises for H_2. The increase of π_1 is compensated partially by decrease of a.

Summarized, in the case with knowledge about probabilities ex-post as decision support a welfare rising education can be calculated with a threshold condition according to π. The lower the productivity gain to compensate the negative income effect in strategy c the lower the range of π for which a positive education effect takes place. Furthermore, due to risk aversion the level of illness severity and therefore net-income are of importance. Beside effects on productivity, subjective error probabilities can be implemented. These are decreased by education with $p(I_1) = \pi$, $p(I_2) = 1 - \pi$, $p_{11} = p_{22} = 1$, $p_{21} = p_{12} = 0$ as maximum values which produce a maximum expected utility (4) (with a reduced net-income). An information value can be calculated, influenced by risk aversion and education. The increase of π_i (self-protection) stimulates effort in education through an increase of $\overline{z} - \underline{z}$ or the information value respectively. On the other hand, the increasing or decreasing values of a potential risk through education (self-insurance) increase or decrease the information value. A threshold of a maximum value π for which education is beneficial can be calculated. This value increases through the use of symptoms as an indicator as long as the information value is positive.

Furthermore, dominance of sc due to dominance of an expected value does not inhibit education. Otherwise, if c is dominant with $EU_c > EU_{sc}$, which depends on π, education is inhibited. Then, π_i or $u_{sc}^{H_2}$ must increase sufficiently to make education beneficial. Furthermore, if c becomes dominant, as in the previous chapter, education only makes sense if $u_{sc}^{H_2}(E)$ exceeds $u_c^{H_2}$ in which a threshold value π^{**} exists again for which $EU_{sc}(E) > EU_c$. Then, $EU(I, E)$ can become relevant again as explained earlier.

5 Conclusion

Summarized, as it is intuitively clear, as long as specific medical education increases self-care productivity (self-insurance) and the competence of self-diagnosis (self-protection), patient autonomy is supported and a welfare gain becomes possible through a more efficient allocation of resources. Education is inhibited if consultation is a dominant strategy either through subjective pessimism and quality of self-diagnosis or an objective superior consultation. However, education can induce the risk of utility loss. A situation is possible, where dominance should remain and education should be left undone. Then, investments in education or in a specific measure in general could also be used to induce a dominance of consultation as a superior solution to non-dominance to maximize individual welfare. More specifically, the risk and the level of a severe illness and also specific fixed costs for self-care, which is typically the reason for the choice of consultation, reduces the incentive of self-care and education, particularly if dominance exists before education is conducted. Under uncertainty ex-post, an information value can be generated, which is extended by education. The education threshold can be extended by the use of symptoms as an information source.

There are some limitations and needs for further research. In the case of illness, a total isolation of the individual seems to be unrealistic, specifically the assumption of the extreme strategy of pure self-care. The influence of the health care system and its professionals must be attended. Concepts of PPR developed as a form between pure paternalism and pure autonomy as partnerships are currently the most realistic scenarios. However, a possible transfer of competence from physician to the individual, also in case of prevention, is often a target of these concepts. The physician plays an active role in promoting this competence to generate a more autonomous behaviour in the individual. The question must be answered to what extent a release of the individual from actors of the health care system in the sense of a real autonomy, including responsibility and productivity, can be a realistic and also a desirable target. From an ethical perspective, self-responsibility must actually be encouraged, however, characteristics of medical care can have a serious inhibiting impact. These impacts must be analyzed more extensively than in the framework I have used in this paper. In this context, uncertainty and information on the side of the medical professionals according to appropriate treatments discussed by Phelps (1992) is another interesting element. In this context, certainty about quality of treatment was assumed in the ex-post case. However, this element is often discussed as uncertain. In addition, the problem of liability in the case of medical malpractice is of interest, either for self-care or consultation. Liability can inhibit self-care if it is asymmetric. Furthermore, time and discounting of prospective utilities play also an important role for individual decision processes in health care and are interesting elements to extend on. Finally, the implementation of prevention as an influence of objective probabilities is reasonable as well as the impact of insurance coverage either for consultation or self-care as well.

Another important point is the real capacity to assess objective and subjective probabilities as a laymen with and without education. Different kinds of risks are different in their ability to be assessed and their potential to improve assessment through adequate education measures. Hence, the rational choice is of course a point, which is not able to be realized. However, the question arises which level of knowledge is achievable; are the costs for this justifiable and is knowledge alone sufficient for rational behaviour in health care.[27]

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[27]See amongst others Weinstein and Klein (1995), Watson et al. (1999), Kahn and Tsai (2004), Adriaanse et al. (2008).

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Appendix

Deviation 1

To calculate the sufficient condition for a maximum, using (19), $u_c^{H_1}(E) - u_{sc}^{H_1}(E) = z$ in (23) is substituted by

$$z = \frac{1}{\pi\pi_1'}\left[\underbrace{\pi EU_{H_1}'}_{z1}\underbrace{+(1-\pi)EU_{H_2}'}_{z2}\underbrace{-(1-\pi)\pi_2'(u_{sc}^{H_2}(E) - u_c^{H_2}(E))}_{z3}\right]$$

under use of (20) and (21), (23) can be written as

$$EU'' = \pi\left[\underbrace{\pi_1 u_c^{H_1}{}''}_{1.}\underbrace{+(1-\pi_1)u_{sc}^{H_1}{}''}_{2.}\underbrace{+2\pi_1'(u_c^{H_1}{}' - u_{sc}^{H_1}{}')}_{3.}\underbrace{+\pi_1'' z}_{4.}\right]$$

$$+(1-\pi)\left[\underbrace{(1-\pi_2)u_c^{H_2}{}''}_{5.}\underbrace{+\pi_2 u_{sc}^{H_1}{}''}_{6.}\underbrace{+2\pi_2'(u_{sc}^{H_2}{}' - u_c^{H_2}{}')}_{7.}\underbrace{+\pi_2''(u_{sc}^{H_2}(E) - u_c^{H_2}(E))}_{8.}\right]$$

Given $u_k'' < 0$, z and terms three, seven and eight must be analyzed. $z1$ and three can be written as A:

$$A = 2\pi_1'(\underbrace{u_c^{H_1}{}'}_{A1}\underbrace{-u_{sc}^{H_1}{}'}_{A2}) - \frac{\pi_1''}{\pi_1'}(\underbrace{\pi_1 u_c^{H_1}{}'}_{A3}\underbrace{+(1-\pi_1)u_{sc}^{H_1}{}'}_{A4})$$

Firstly, $2\pi_1' A1$ and $-\frac{\pi_1''}{\pi_1'}A3$ combined are negative. For that reason $|u_c^{H_1}{}'|$ has a positive impact for a maximum expected utility. Secondly, $2\pi_1' A2$ and $-\frac{\pi_1''}{\pi_1'}A4$ combined deliver $\frac{2\pi}{(1-\pi_1)} > -\frac{\pi_1''}{\pi_1'^2}$ as necessary for a positive impact of $u_{sc}^{H_1}{}'$.

The combination of $z2$ and seven delivers B:

$$B = 2\pi_2'(1-\pi)(\underbrace{u_{sc}^{H_2\prime}}_{B1}\underbrace{-u_c^{H_2\prime}}_{B2}) - \frac{\pi_1''}{\pi_1'}(1-\pi)(\underbrace{\pi_2 u_{sc}^{H_2\prime}}_{B3} + \underbrace{(1-\pi_2)u_c^{H_2\prime}}_{B4})$$

Then, $2\pi_2'(1-\pi)B1$ and $\frac{\pi_1''}{\pi_1'}(1-\pi)B3$ deliver $\frac{2\pi_2'}{\pi_2} < \frac{\pi_1''}{\pi_1'}$ for a positive impact of sign of $u_{sc}^{H_2\prime}$, which, however, cannot be fulfilled for which reason $u_{sc}^{H_2\prime}$ should be small for realizing a maximum. Bringing together $2\pi_2'(1-\pi)B2$ and $\frac{\pi_1''}{\pi_1'}(1-\pi)B4$, $\frac{2\pi_2'}{1-\pi_2} < \frac{\pi_1''}{\pi_1'}$ is generated as necessary for a positive impact of $u_c^{H_2\prime}$, which can also not be fulfilled. Hence, $u_c^{H_2\prime}$ should be small.

Finally, $z3$ and eight deliver C:

$$C = \pi_2''(1-\pi)(u_{sc}^{H_2}(E) - u_c^{H_2}(E) - \frac{\pi_1''}{\pi_1'}(1-\pi)\pi_2'(u_{sc}^{H_2}(E) - u_c^{H_2}(E))$$

C is negative if $|\frac{\pi_2''}{\pi_2'}| > |\frac{\pi_1''}{\pi_1'}|$. Hence, the potential loss for H_2 supports a maximum of the expected utility if the degree of diminishing returns π_2'' is high.

Deviation 2

$EU(\pi_s)$ can also be written as:

$$EU(\pi_s) = max\{EU_c; EU_{sc}\} = \sum_{i=1}^{2} p(I_i) max\left\{\sum_{s=1}^{2} p_{si}u_c^{H_s}; \sum_{s=1}^{2} p_{si}u_{sc}^{H_s}\right\}$$

This condition is equal to (36). However, if information are implemented the optimal strategy can differ compared to a case without information. If c or sc is optimal without information, IV as the information value can be written as:

$$IV = \sum_{i=1}^{2} p(I_i)\left[max\left\{\sum_{s=1}^{2} p_{si}u_c^{H_s}; \sum_{s=1}^{2} p_{si}u_{sc}^{H_s}\right\} - \sum_{s=1}^{2} p_{si}u_{\tilde{k}}^{H_s}\right]$$

with $\tilde{k} = \tilde{c}, \tilde{sc}$ as optimal choice without information. The value within the brackets for both I_1 and I_2 is zero and therefore also IV in its minimum if the chosen strategy does not differ between the different levels of information. Further information does not influence patient's choice. If the information about quality of self-diagnosis is implemented a different strategy is chosen if the expected utility exceeds the value generated without information and the value within the brackets becomes positive.

Figures

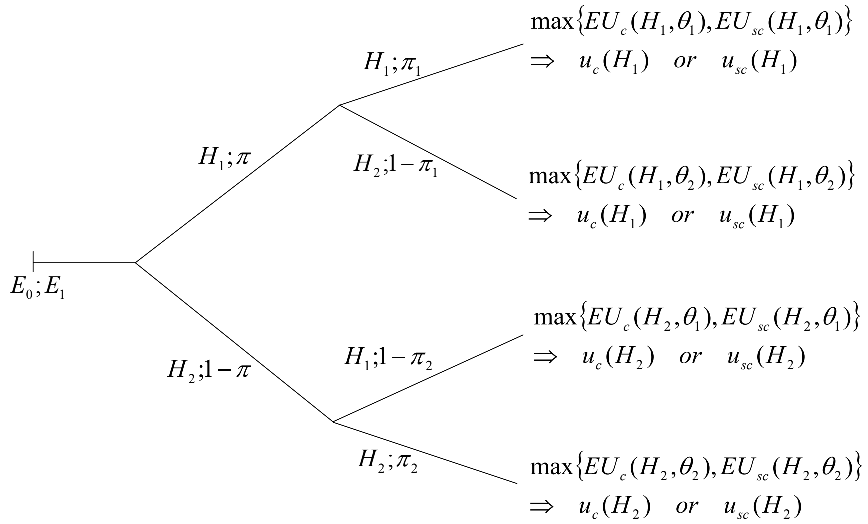

Figure 1

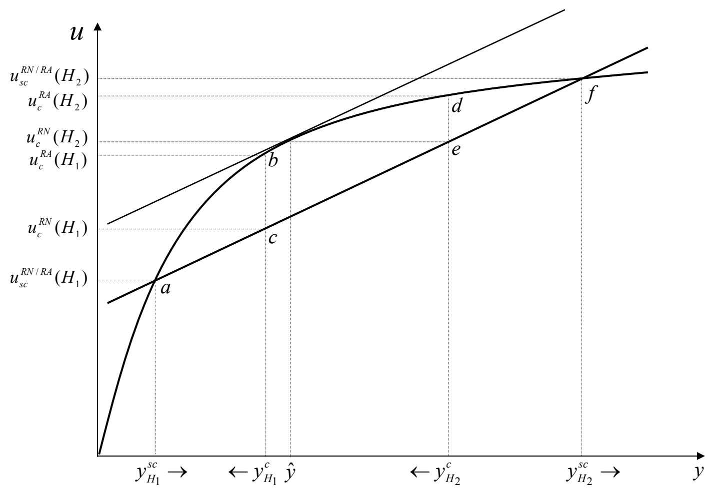

Figure 2

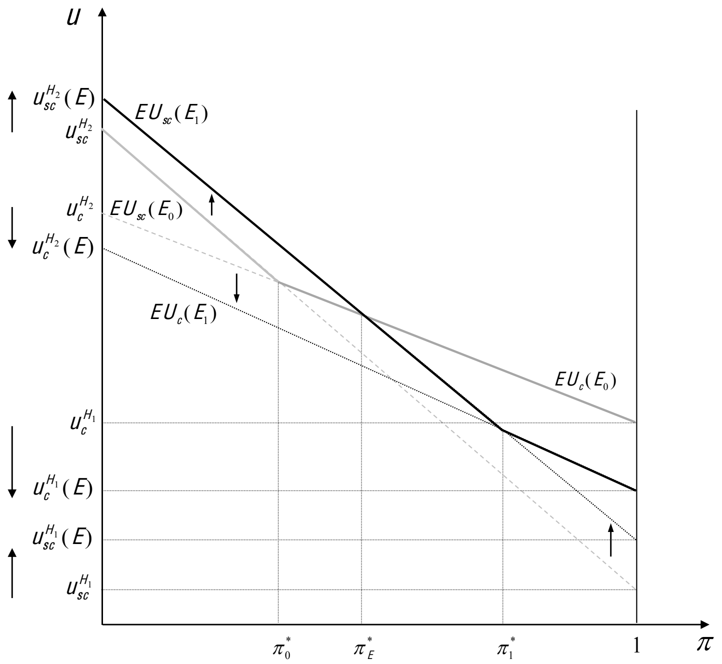

Figure 3

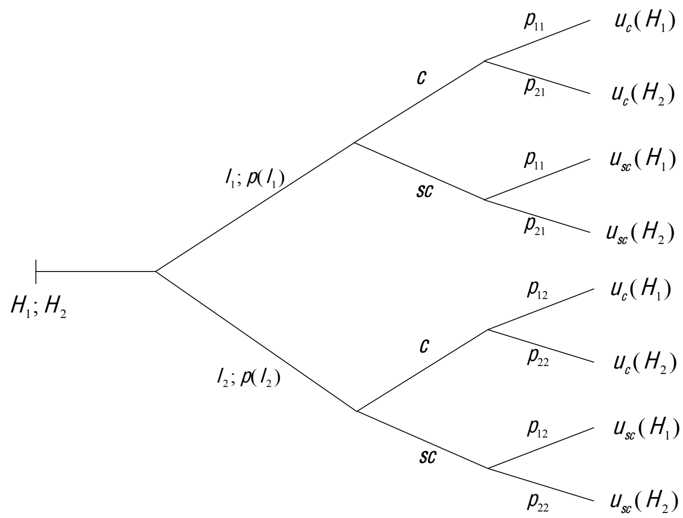

Figure 4

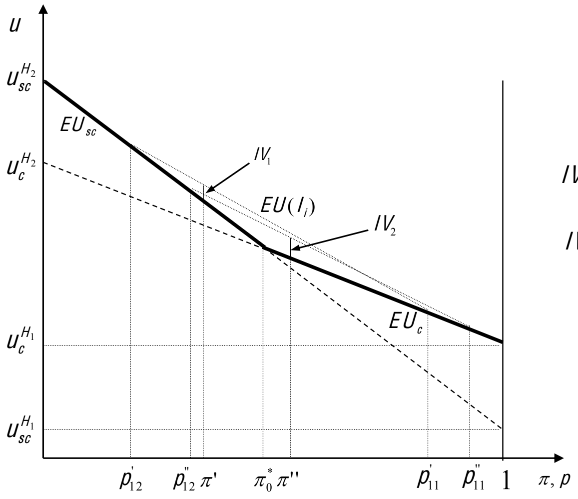

Figure 5a

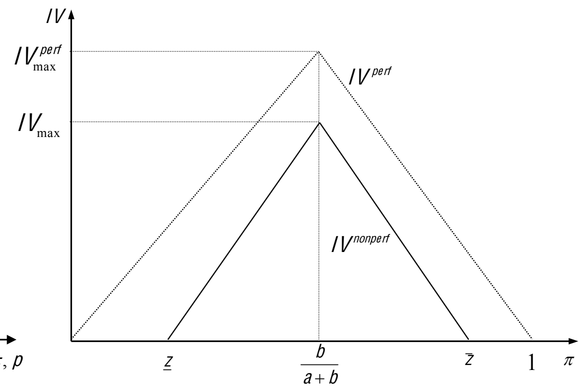

Figure 5b

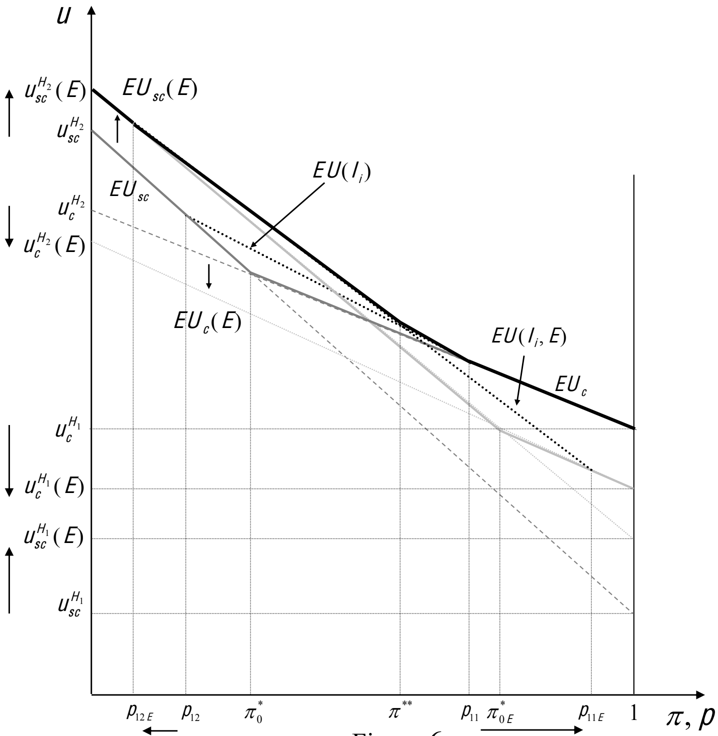

Figure 6

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