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RESEARCH ARTICLE

An agency relationship under general conditions of uncertainty: a game theory application to the doctor–patient interaction

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Abstract The supply of information, particularly of bad news, in an agency relationship is a sensitive issue. We employ a game theory approach to investigate conflicts in the particular case of the doctor–patient relationship when information affects the emotions of patients. The doctor does not know the type of agent and the patient does not know how much information he is given. Hence, the paper obtains results when there is conflict, rather than common interest in the objectives of the two parties. The perfect Bayesian equilibrium describes beliefs and strategies which guarantee adherence to the doctor's recommendation. We show also that the patient may non-adhere to the recommendation not only when the doctor fails to identify the patient's needs but also if he falsely believes that the doctor has not done so.

Keywords Doctor–patient relationship · Adherence · Psychological expected utility · Non-cooperative game theory · Perfect Bayesian equilibrium

JEL Classification D03 · I10 · C72

1 Introduction

Theoretical investigations of the doctor–patient interaction shed light on aspects of this relationship that empirical work cannot do. Emotions and feelings experienced when information is communicated makes this interaction particularly complex and the

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empirical attempts to understand it even more complicated. Yet, the understanding of this interaction has become particularly important and it is vital in explaining patients' decisions to non-adhere to medical recommendations (Osterberg and Blaschke 2005).

This paper provides a theoretical investigation of the medical consultation when information affects the emotions of the patient and both the doctor and the patient operate in an uncertain environment. Our paper contributes to a limited literature in this area of health economics, extending our previous research on the topic (Glycopantis and Stavropoulou 2011). In that paper, we investigate the case when there is uncertainty only on the part of the doctor.

Our investigation is motivated by two facts. First, patients vary in their preferences regarding information; some prefer detailed information, while others are better off when they do not receive much information about their health states (Miller and Mangan 1983). Second, information exchange during the consultation affects decisions made by the two parties and can have an impact on adherence to medical recommendations (Lambert and Loiselle 2007).

We use a non-cooperative game theory model to explain how uncertainty and conflict in the doctor–patient relation are resolved in an equilibrium which depends on the attitudes (types) of the two agents and their beliefs. In our model, patients vary in their preferences for information. The doctor does not know how much information the patient wants and the patient cannot tell with certainty how much effort the doctor has expended and how much information she passed on to him. Ultimately, our paper aims to understand under which conditions, adherence to medical recommendations can be achieved. We consider both the cases where the patient simply reacts optimally to the decision of the doctor and when the decisions are interdependent.

Our analysis shows that a perfect Bayesian equilibrium (PBE) requires that the doctor correctly predicts the type of patient, but also that the patient correctly believes that the doctor provided the information he wants. This result has policy implications with respect to how trust can be built up between the two parties to improve adherence.

The rest of the paper is organised as follows. Section 2 describes the assumptions of the model and considers the imperfect information case referring to both the doctor and the patient. Section 3 considers the implications of the analysis. Section 4 concludes the discussion.

2 The model

2.1 Preliminary remarks

This section presents a non-cooperative game to describe the interaction between a doctor ('she') and a patient ('he') when information affects the patient's emotions and this impacts on the decisions made by the two parties.

The patient can be one of two types, i.e. information-loving or information-averse. Following Miller's terminology, patients are called monitors (M) or blunters (B), respectively (Miller 1987). The patients are chosen by Nature (N).

The doctor diagnoses that given the recommended treatment, the patient's state of health in Period 2 will deteriorate to s_1 with probability q or will improve to s_2

with $1 - q$. We assume that the diagnosis is correct. The expected state of health is $E[s] = q \times s_1 + (1 - q) \times s_2$.

The doctor can decide to give full details (T), i.e. reveal the probabilities with which the patient's health can deteriorate or improve. Or she can avoid revealing the whole picture (NT) and simply tell him that his expected state of health will be $E[s]$. We register through $\epsilon_1 > 0$ the effort the doctor needs to expend to pass on the information to the blunter and $\epsilon_2 > 0$ the effort for the more persistent monitor. Both are constants and are subtracted from the doctor's utility when the doctor decides to play T. We assume that $\epsilon_1 < \epsilon_2$, following literature, which suggests that monitors are more 'difficult' (Miksanek 2008) and more demanding (Miller 1995).

The patient will decide whether to accept the information and adhere (A) or not (NA). If he non-adheres a constant $l \geq 0$ is subtracted from his utility, denoting the loss in health if he does not follow the medical recommendation. This constant is common for all types of patients. If a patient decides to ignore the doctor's advice, despite the fact that full information is provided, then he assumes that his state of health is $E[s]$ and acts accordingly.

The analysis takes into account a number of other emotions that affect the interaction. We register through $a > 0$ the anger that is experienced if a monitor realizes that the doctor has not told him all the truth. It is subtracted both from the monitor's and the doctor's utility. It is assumed that $a > \epsilon_2$. This tends to make the doctor more careful in expending effort to make her recommendation. Finally, $w > 0$ registers the worry that a monitor experiences if he decides to follow the doctor's advice even though he has realized that he has not been told the truth.

We use as our tool of analysis the concept of perfect Bayesian equilibrium (PBE) of non-cooperative, extensive form games. It consists of a set of players' optimal behavioural strategies, and consistent with these, a set of beliefs which attach a probability distribution to the nodes of each information set. Consistency requires that the decision from an information set is optimal given the particular player's beliefs and the strategies from all other sets. If the optimal play of the game enters an information set then, using the available information, updating of beliefs must be Bayesian. Otherwise appropriate beliefs are assigned arbitrarily.

Beliefs are particularly important when a player does not know precisely at which node in the game he is. Therefore, he will make the same decision from all nodes in an information set.

In an equilibrium, neither the doctor nor the patient would want to deviate from it. On the other hand, there is no reason why the original decisions might not deviate from the equilibrium. In that case it is important to consider whether repeated consultations will result in adherence.

It is important to show that the expected outcome is implemented through a PBE. In a series of papers Glycopantis et al. (2001, 2003, 2005, 2009) discuss, in the context of economies with asymmetric information, the implementation (support) of both Walrasian and pure game concepts. The cooperative concept of the private core can be given a dynamic interpretation as a PBE of a non-cooperative extensive-form game.

2.2 The utility functions

Recent attempts to enrich economic models with elements from psychology include the development of psychological expected utility (PEU) by Caplin and Leahy (2001). This has been used in analysing the doctor–patient interaction (Caplin and Leahy 2004; Köszegi 2004, 2006). However, they confine themselves to models of perfect agency.

The utility functions in our models are similar to the ones developed by Köszegi (2003). They reflect preferences of individuals regarding earlier or later resolution of uncertainty. We interpret the PEU, not as lotteries over health states, as in the von Neumann–Morgenstern specification, but as preferences over knowing these possible events. The beliefs over future health states distinguish a monitor from a blunter.

In Period 1, the present, the patient needs to decide whether to follow the doctor's advice according to what he believes his health will be in period 2, the future.

For a blunter, the utility function, $u_B(s) > 0$, is increasing and strictly concave, that is $u_B(E[s]) > E[u_B(s)]$. Knowing his expected health gives him greater utility than the utility he would get if he expects to be in state s_1 with probability q and in state s_2 with probability $1 - q$. On the other hand, the utility function of a monitor, $u_M(s) > 0$, is increasing and strictly convex, that is $E[u_M(s)] > u_M(E[s])$.

For the doctor's utility function, $u_D > 0$, we assume that it increases as the patient's health does, but she is information neutral with respect to the patient's prospects of health. This means u_D is linear as a function of s, and for simplicity we take $u_D(s) = s$. In addition, she takes into account the effort she needs to put in every time she transfers information, as well as the negative atmosphere, i.e. anger registered through $a > 0$, and the worry through $w > 0$ that are created if she does not pass on the full information to a monitor. Effort, anger and worry are all measured in disutility terms.

It is assumed that $u_M(E(s) - l) > u_M(E(s)) - w$. That is, a monitor's worry is very big if he accepts the doctor's recommendation although he realizes that he has not been given the whole truth about his state of health. He is better off by non-adhering.

Our models relax the assumption of perfect agency, that is the doctor is no longer assumed to be a perfect agent of the patient. She still wants to maximize the patient's utility but she needs to consider other elements as well, such as the effort required to pass on information to him. Furthermore, the utility function of the doctor is simply linear in the patient's state of health.

In Figs. 1 and 2 below, the probability $1 - p$ denotes the belief of the doctor that the patient is a blunter, and p her belief that she is dealing with a monitor. On the other hand, $1 - q_1$ denotes the belief of a blunter that the doctor has played NT, and q_1 his belief that she has played T. Analogously, we denote the beliefs of a monitor by $1 - q_2$ and q_2.

The calculations of the payoffs of the doctor and the patient are done by taking into account their preferences, the strategies chosen by both players, the effort expended and the probable anger and worry caused. Nature reveals the payoffs after the completion of the game. If the patient does not adhere, his health will naturally deteriorate. Parameter l will be non-zero and this will be realized by both the doctor and the patient.

2.3 The game under imperfect information for the doctor

We analyse the general game where Nature chooses arbitrarily the type of patient that visits the doctor.[1] It follows that she is not sure what type of patient she is facing.

She must decide how much information to pass on, i.e. whether to put in extra effort, T, or not, NT, taking into account the fact that she does not have exact information concerning the attitude of the patient towards information. Her ignorance is captured in Fig. 1 by the two nodes, η_1 and η_2, in information set I. However, to proceed with the consultation, she attaches probabilities expressing her beliefs, on the type of patient that is visiting her.

Hence, she finds herself in I and believes that with probability $1 - p$ she is at η_1 and with $0 < p < 1$ at η_2. She chooses the same action from both nodes and then the blunter and the monitor, having their own beliefs, each chooses their own action from their information sets. Payoffs are reached with the combined probabilities and their expectations can be calculated. For a PBE, the beliefs of the patients are updated to become consistent with the action of the doctor. For example, if the doctor plays NT the beliefs must become $q_1 = 0$ and $q_2 = 0$. The PBEs are described below. They correspond to the analysis of the graphs.

These beliefs, are expressed through $1-p$ and p, attached to the nodes, for a blunter and a monitor, respectively, and allow the analysis to proceed. We note that the beliefs of the doctor concerning the choices of Nature cannot be updated, through any information, as the game unfolds. They cannot be modified by any optimal actions of the doctor or the patient, and thus cannot be derived by a Bayesian updating. The development of the game and the equilibrium solution will depend on their initial values. Only following repeated consultations (games), which also could provide information about the development of the state of his health, could the beliefs be adjusted.

Following the doctor's action, the patient moves. He, of course, knows whether he is a monitor or a blunter, but without knowing what the doctor has done, he needs to decide whether to adhere or not to the recommendations. His ignorance implies that he is constrained to make the same move from both nodes in his information set. We conduct the analysis under alternative assumptions concerning the parameter l.

Case I. We conduct the analysis under the hypothesis that $u_B(E[s] - l) > E[u_B(s)]$.

That is, when the doctor plays T, the blunter dislikes the detailed information regarding his illness so much that he is better off by non-adhering to the doctor's recommendation, despite the loss in health from doing so. We consider this to be the basic case.

First we look at the case when the patient simply follows optimally the doctor. This highlights the idea of calculation of expected values. There is also interest in it per se, (comparative statics).

[1] If the doctor knows the type of patient, the latter will decide what action to take on the basis of his own beliefs. The equilibrium decisions will be that she provides the quality of information needed by the patient, that he has consistent beliefs with the physician's actions and he adheres (Glycopantis and Stavropoulou 2011).

If the doctor plays NT the blunter will respond with A and the monitor with NA. So, the expected utility of the doctor is:

$$E[NT] = (1-p)u_D(E[s]) + p(u_D(E[s]-l) - a) \tag{1}$$

If, on the other hand, she plays T, the blunter's best response is to play NA while the monitor is better off playing A. So, the expected utility of the doctor if she plays T is:

$$E[T] = (1-p)(u_D(E[s]-l) - \epsilon_1) + p(E[u_D(s)] - \epsilon_2). \tag{2}$$

We now consider the decision of the doctor under different values of p, i.e. under alternative beliefs. For $p = 1$ it is easy to see that $E[NT] < E[T]$. In other words, when the doctor believes with certainty that the patient she is diagnosing is a monitor, it is best for her to put extra effort into supplying all the information to him.

For $p = 0$ it is again easy to establish that $E[NT] > E[T]$. That is, if the doctor believes with certainty that the patient is a blunter it is best for her not to supply all the information. Both these cases were discussed earlier under perfect information.

It follows from the above that there is a value of p, denoted by p^*, for which $E[NT] = E[T]$. That means that for $p = p^*$ the doctor is indifferent in putting special effort or not into describing to the patient his state of health.

Next, we consider the game theory set up in which decisions are interdependent. Both the doctor and the patient act taking each other's strategies as fixed. In equilibrium, nobody has any reason to change and this is Nash equilibrium (NE). When beliefs are involved we have a PBE.

Case I.1. For values less than this, i.e. $p < p^*$, and sufficiently close to 0, the doctor, following her calculations, will be playing NT. In this case, a PBE is $\{p, NT; q_1 = 0, A; q_2 = 0, NA\}$. This is shown in Fig. 1. The final payoff for the doctor is $E = (1-p)u_D(E[s]) + p(u_D(E[s]-l) - a)$, while for the blunter the final payoff is $E_B = (1-p)u_B(E[s])$ and for the monitor $E_M = p(u_M(E[s]-l) - a)$.

For the particular p, the strategies $\{NT;\ A,\ NA\}$ form a NE: First if the doctor plays NT the optimal actions $\{A, NA\}$ follow. Now if the blunter plays A and the monitor plays NA we have for the doctor $E(NT) = (1-p)u_D(E[s]) + p(u_D(E[s]-l) - a)$ and $E(T) = (1-p)(u_D(E[s]) - \epsilon_1) + p(u_D(E[s]-l) - \epsilon_2)$, and for p sufficiently small we have $E(NT) > E(T)$.

Case I.2. For values of p above the indifference point p^*, and sufficiently close to 1, the doctor plays T and a PBE is $\{p, T; q_1 = 1, NA; q_2 = 1, A\}$. In this case, the final payoff for the doctor is $E = (1-p)[u_D(E[s]-l) - \epsilon_1] + p[E[u_D(s)] - \epsilon_2]$. The equilibrium is shown in Fig. 2. While for the blunter the final payoff is $E_B = (1-p)u_B(E[s]-l)$ for the monitor it is $E_M = pE(u_M[s])$.

Now for the particular p, the strategies $\{T;\ NA,\ A\}$ form a NE. If the doctor plays T the optimal actions $\{NA, A\}$ follow. If the blunter plays NA and the monitor plays A, we have for the doctor $E(NT) = (1-p)u_D(E[s]-l) + p(u_D(E[s]) - a)$ and $E(T) = (1-p)(u_D(E[s]-l) - \epsilon_1) + p(E[u_D(s)] - \epsilon_2)$, and for p near 1, we have $E(NT) < E(T)$.

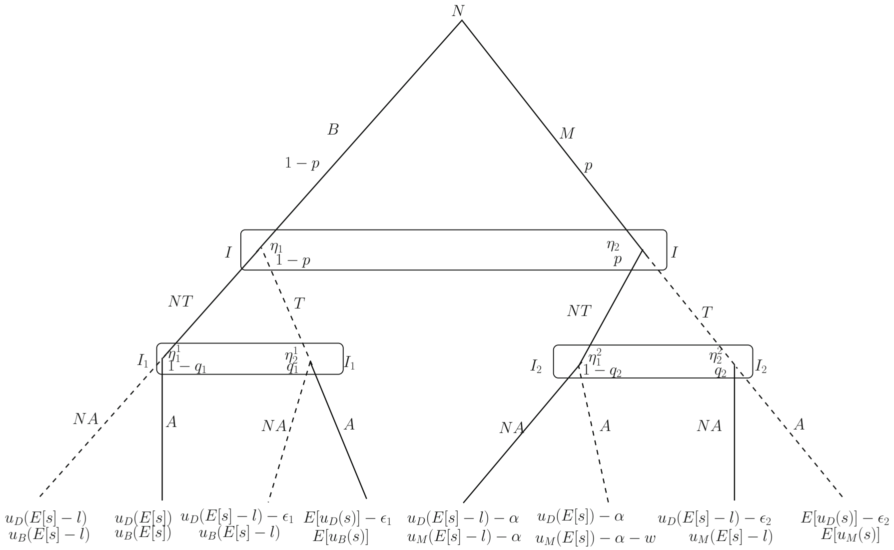

Fig. 1 The PBE for $p < p^*$

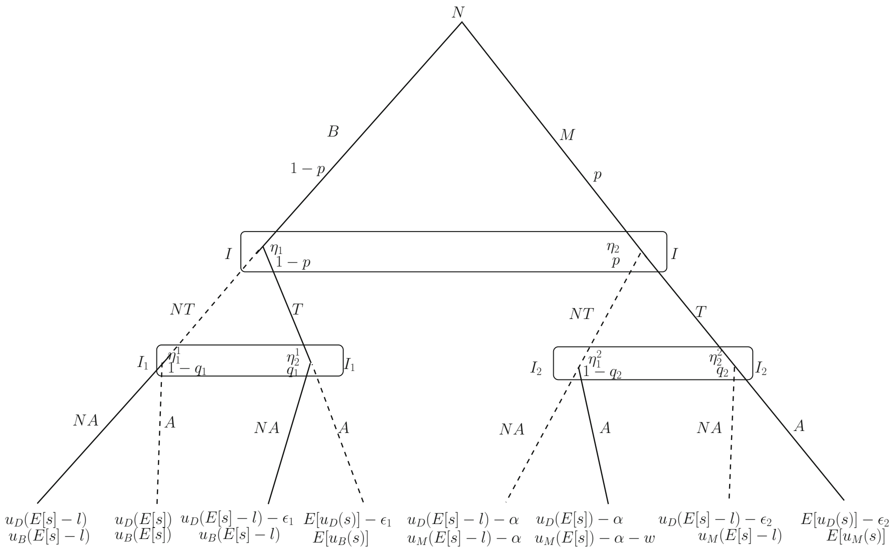

Fig. 2 The PBE for $p > p^*$

With respect to their beliefs the situation is as follows. For $q_1 = 0$ and $q_2 = 0$ a blunter chooses A and a monitor NA. Also, for beliefs $q_1 = 1$ and $q_2 = 1$ a blunter chooses NA and a monitor A. These beliefs confirm the actions of the doctor to play NT.

As a digression, we look again at the case where the doctor decides on her own and the patient simply responds. Suppose now that $p = p^*$. The expected utility of the doctor is the same irrespective of whether the patient is a blunter or a monitor. We can assume that she spins a wheel, divided into sectors of size q and $1 - q$ to decide whether to supply detailed information or not. The division of the wheel represents her mixed strategy.

In the general case, the expressions for $E[NT]$ and $E[T]$ the multiplicative terms of the mixed strategy will appear. For $0 < p < 1$ the implied general, overall expectation will be the same as for playing either NT or T.

The doctor's expectation of playing T or NT depends on the two types of effort and the psychological elements which affect her. This relation will become exact in the discussion below.

Suppose that the doctor attaches equal probability to the patient being a blunter or a monitor. There is no reason why $p = 1/2 = p^*$. Therefore, $p = 1/2$ does not necessarily imply that the doctor will be indifferent between providing and not providing full information to the patient.

Returning to the general case of interdependent decisions, the discussion above confirms the idea that an equilibrium means that if all actions and beliefs are revealed there is no reason for anyone to change any beliefs or actions. The solution concept of PBE implies consistency between beliefs and strategies. That means that the actions taken by both parties are consistent with their beliefs and what the other party has done.

Suppose now that $p < p^*$ and in particular that $p = 0$. Then, spinning a wheel with sectors of size $1 - q$ and q, the expectation of the doctor will be $E_1(NT) = (1-q)u_D(E[s])$ and $E_1(T) = q((u_D(E[s]) - l) - \epsilon_1)$. The payoff of the blunter will be $E_{1B}(NT) = (1 - q)u_B(E[s])$ and $E_{1B}(T) = q(u_B(E[s]) - l)$. The monitor will get expected payoff 0. For the doctor there will be a q_1^* such that $E_1(NT) = E_1(T)$.

For values $q < q^*$, and sufficiently close to 0 the doctor will be playing NT and the PBE will be $\{p = 0, NT; q_1 = 0, A; q_2 = 0, NA; \}$. The final payoff for the doctor is $E_1(NT) = u_D(E[s])$ while for the blunter the final payoff is $E_{1B}(NT) = u_B(E[s])$ and for the monitor 0.

The strategies $\{NT;\ A,\ NA\}$ form a NE. This is seen by considering the response of the patient(s) to NT and then of the doctor to $\{A,\ NA\}$. On the other hand, for q near 1 the doctor will choose T. But this will not lead to a NE because the blunter will choose NA to which she should respond with NT.

Analogous results can be obtained when $p > p^*$ and in particular that $p = 1$.

The relation of the PBE to the resolution that intuitively and from experience one would expect to the doctor–patient conflict is as follows. Especially, in very serious illnesses, both agents will try to reveal truthfully their strategies. If open heart operation is proposed a blunter will not really want to be shown a video, (and such exist), describing the various stages, and the doctor realizing the situation will refrain from giving distressing details. On the contrary, a monitor will ask for the video and the doctor realizing his concerns will spend time and effort to answer detailed questions.

Suppose now that the beliefs of the doctor are such that $p = p^*$. If the wheel points to considering the patient as a blunter, then, we obtain the results of Case I.1, above. On the other hand, if the wheel points to consider the patient as a monitor, then we obtain the results of Case I.2.

The discussion above confirms the idea that an equilibrium means that if all actions and beliefs are revealed there is no reason for anyone to change any beliefs or actions. The solution concept of PBE implies consistency between beliefs and strategies. That means that the actions taken by both parties are consistent with their beliefs and what the other party has done.

The PBE captures the above as equilibria situations, especially when the beliefs are with certainty. In the case $p = 0$ and $q_1 = 0$, this corresponds to the case when the patient, a blunter, does not want to know what exactly will happen during his heart operation. The doctor understands this, recommends surgery and explains the procedure in basic steps. The patient appreciates this attitude and accepts the recommendation.

In the case $p = 1$ and $q_2 = 1$, the PBE corresponds to the situation when the patient, a monitor, does want to know exactly what will happen during the operation. The doctor understands this, recommends surgery and makes maximum effort to explain the procedure in detail. The patient appreciates the information he receives and accepts the recommendation.

In both cases above, the firmly held beliefs imply full revelation of the two agents' attitudes, (preferences), and therefore that nobody has an incentive to lie.[2]

If the agents lie, this would lead to a disequilibrium situation. Suppose the doctor realizes that the patient is a blunter but she pretends that he is a monitor and plays T. The patient can either insist he is a blunter and plays NA or lie, pretend that he is a monitor and play A. In both cases, the structures of payoffs is such that playing the PBE strategies would have given a superior outcome. On the other hand, suppose the doctor realizes that the patient is a monitor but she pretends that he is a blunter and plays NT. Irrespective of whether the patient reveals his identity or lies the PBE strategies would have given a superior outcome.

The idea of PBE goes even deeper. If the doctor believes that with high probability the patient is a blunter then she will not give full details. A blunter understands, and accepts the recommendation and the outcome is a PBE. On the other hand, if the doctor believes that with high probability the patient is a monitor then she will give full details. A monitor understands this and accepts the recommendation and the outcome is again an equilibrium.

An important point is also the following. In Glycopantis and Stavropoulou (2011) uncertainty was only on the doctor's side and the analysis showed that a PBE requires that she provides the information the patient wants. If the doctor fails to understand the patient's preferences the latter will disregard the recommendation.

In the current study, uncertainty is on both parties and the patient may not adhere to the medical recommendations, not because the doctor did not cover his information needs, but because he falsely believes she did not do so. It is the interplay of beliefs which results in the new finding that the same action by the doctor leads to a different reaction by the patient. The PBE is now reached not only when the patient receives the information he wants but also if he believes the doctor has actually provided this information.

[2] A question from a reader of our paper helped us formulate this point.

The implication of a false belief by the patient can be seen, for example, in the following circumstances. Consider Fig. 1 with $p = 0$ and suppose that the doctor predicts correctly a blunter and plays NT. On the other hand, suppose that the patient believes that the doctor has played T and as a result he does not adhere to the recommendation and plays NA. Then the corresponding two pairs of payoffs at the end of NA will come up and replace information set I_1. But given these payoffs the choice NT is superior for the doctor and the belief that she has played T is not confirmed.

2.3.1 Implications of repeated consultations

We now consider whether repeated consultations will lead to an equilibrium solution. The development of the relationship will depend on the initial belief and decision of the doctor and the belief of the patient about the action taken by the doctor. We shall discuss only a number of indicative cases:

Case (i). Suppose the doctor believes that most likely the patient is a blunter. Then her optimal decision will be not to supply very detailed information about his state of health. The patient knows of course whether he is a blunter or a monitor.

Suppose that a patient realizes that the doctor has not put sufficient effort into describing his medical condition. Then, as a blunter he will adhere to the medical recommendation and as a monitor he will not. This will confirm the PBE. A reasonable outcome is that in repeated consultations the doctor and the patient will change neither their beliefs nor their actions, and therefore the equilibrium will be stable.

Next, suppose again that the doctor believes that most likely the patient is a blunter. Then her optimal decision will be not to supply very detailed information about his state of health. On the other hand, suppose that the patient, as a blunter, believes that the doctor has not put sufficient effort into describing his medical condition but as a monitor that he believes that he has. Then the initial position is not an equilibrium one because the monitor adheres to the recommendation.

If in continuous consultations, the doctor and the blunter have the same beliefs and actions and the monitor falsely believes that he obtained all the information he wanted we stay away from the equilibrium which is shown to be unstable. But there is every chance, by comparing payoffs, that the monitor realizes his mistake and decides to seek advice elsewhere. In this case, the equilibrium is shown to be stable.

Case (ii). Suppose now that the doctor believes that most likely the patient is a monitor. Then, her optimal decision will be to supply very detailed information. Suppose that irrespective of whether he is a blunter or a monitor, he realizes that the doctor has put sufficient effort into describing his medical condition.

Then, as a blunter he will not adhere to the medical recommendation and as a monitor he will. This will confirm the PBE. A reasonable outcome is that in repeated consultations the doctor and the patient will change neither their beliefs nor their actions, and therefore the equilibrium will be stable.

Next, suppose again that the doctor believes that the patient is a monitor. Then her optimal decision will be to supply very detailed information about his state of health. On the other hand, suppose that the patient as a blunter believes that the doctor has not described in detail his medical condition but as a monitor that she has. Then the initial position is not an equilibrium one because the blunter adheres to the recommendation.

If in continuous consultations, the doctor and the monitor have the same beliefs and actions and the blunter falsely believes that he was not given detailed information, then we stay away from the equilibrium which is shown to be unstable. But there is every chance, from the development of his state of health and by comparing payoffs, that the blunter realizes his mistake and decides to seek advice elsewhere, i.e. not to adhere to the proposed medication. In this case the equilibrium is shown to be stable.

In general, the most likely outcome is that the agents, either from the beginning or after a number of consultations, will take the correct decisions which will confirm the equilibrium.

2.3.2 Comparative statics

The preliminary model when the doctor decides on her own and the patient simply responds lends itself for the calculation of simple comparative statics results on the solution p^*.

For the value p^*, we obtain by equating payoffs

$$pl + pa = (1 - p)[l + \epsilon_1] + p\epsilon_2. \tag{3}$$

This is an equilibrium condition of the type that is encountered throughout economic theory.

When the doctor plays NT there are no ϵ_i's involved and $pl + pa$ measures her expected loss in utility. When she plays T both ϵ_1 and ϵ_2 appear in the payoffs and $(1 - p)[l + \epsilon_1] + p\epsilon_2$ measures her expected loss in utility. The equality implies that, for indifference, the two alternative actions must bring the same outcome.

This implies $\delta p^*/\delta a < 0$, $\delta p^*/\delta\epsilon_2 > 0$. We also have $\delta p^*/\delta\epsilon_1 = (l + a - \epsilon_2)/(2l + \epsilon_1 + a - \epsilon_2)^2$ which is positive because $l + a - \epsilon_2 > 0$. Finally, $\delta p^*/\delta l = (a - \epsilon_1 - \epsilon_2)/(2l + \epsilon_1 + a - \epsilon_2)^2$ which is inconclusive. This is due to the fact that as the possible loss in health increases, this affects the utility of both the monitor under action NT and the blunter under T. This loss is reflected in the doctor's payoff under both T and NT. Both these payoffs decrease and the strength with which they do so depends on the belief of the doctor as to the type of patient. The overall outcome is inconclusive.

We obtain from these expressions that as ϵ_1, ϵ_2 increase the doctor will be more willing to play NT, i.e. to avoid spending too much effort. On the other hand, as a goes up she will be more willing to play T.

Finally, for the case of $p = 1/2$ and indifference between NT and T we see that (3) reduces to

$$1/2(l + a) = 1/2(l + \epsilon_1 + \epsilon_2). \tag{4}$$

The interpretation is of course that for the doctor the expected disutility of playing T is equal to the expected disutility if she plays NT. The significance of $p = 1/2$ is that if there is no sufficient reason to suppose otherwise, equal probability could be attached to the patient being a blunter or a monitor, (the principle of insufficient reason).

The interpretation is that for the doctor the expected disutility of playing T is equal to the expected disutility if she plays NT.

Summarizing, there is a value p^* expressing the doctor's belief such that she is indifferent between playing NT and T. For $p < p^*$ she acts in favour of a blunter and does not provide detailed information. For $p > p^*$ she acts in favour of a monitor and provides detailed information. In both cases the patient, a blunter or a monitor, forms beliefs consistent with the doctor's actions and responds optimally. The equilibrium value p^* changes as the values of the parameters change. Finally, the most likely outcome of repeated calculations is the stability of the equilibrium decisions.

Case II. We now consider very briefly some implications of assuming $u_B(E[s]-l) < E[u_B(s)]$.

This implies that when the doctor plays T, the blunter dislikes detailed information but not so much that he is prepared to disregard the doctor's recommendation.

Taking into account the linearity of the doctor's utility function, we obtain:

$$E(NT) = u_D(E(s)) - pa - pl, \tag{5}$$

$$E(T) = u_D(E(s)) + p\epsilon_1 - \epsilon_1 - p\epsilon_2. \tag{6}$$

These equations imply that for indifference between the actions T and NT, we require

$$pl + pa = (1-p)\epsilon_1 + p\epsilon_2 \tag{7}$$

and comparative statics results can be obtained.

The interpretation of (7) is analogous to the one of (3). When the doctor plays NT the expression $pl + pa$ measures her expected utility loss. When she plays T there is no parameter l involved. The blunter is not prepared to disregard the doctor's recommendation, and $(1-p)\epsilon_1 + p\epsilon_2$ measures her expected loss in utility. The equality implies that for indifference two alternative actions must bring the same outcome.

Finally, for indifference between the actions under $p = 1/2$, we obtain

$$1/2(a+l) = 1/2(\epsilon_1 + \epsilon_2). \tag{8}$$

Again, applying the principle of insufficient reason equal probability could be attached to the patient being a blunter or a monitor.

3 Discussion of findings

This paper uses a non-cooperative game theory approach to explore the doctor–patient interaction when information affects the emotions of the patient and both parties operate in an uncertain environment. In particular, it explores how the communication between the two parties becomes more complicated when not only the doctor is uncertain about the type of the patient she is diagnosing, but also the patient cannot tell how much information she has passed on to him. The PBE characterizes the conditions on optimal strategies and beliefs which guarantee adherence to the doctor's recommendation. Hence, for adherence both parties must take the correct decisions and also guess (believe) correctly.

In an earlier exploration uncertainty regarding information preferences relied only on the doctor's side (Glycopantis and Stavropoulou 2011). It showed that when the doctor fails to understand the patient's preferences the latter will disregard completely the recommendation.

In this paper, we show that certainty regarding the type of patient is not enough to achieve adherence. The patient may not adhere to the medical recommendations, not because the doctor did not cover his information needs, but because he believes she did not do so. It is the interplay of the uncertainties, expressed as beliefs that produces the new result that the same action by the doctor leads to a different attitude by the patient.

The paper also extends previous models in exploring the impact of repeated consultations with the same doctor on the patient's decision. An equilibrium outcome repeats itself. If the initial position is not one of equilibrium, then what happens depends on how the signals received are interpreted. It is possible that the outcomes return to the equilibrium position or stay away from it. Most likely the agents, after a number of consultations, will act in a way that will confirm the PBE. Once the consultation is repeated a few times, beliefs are updated and the two parties get a better understanding of the type and actions of each other.

Our investigation incorporates elements from both psychology and economics to help us understand individual behaviours in a more comprehensive and realistic way. Recent studies are confined to models of a perfect agency relationship which assume that there is no conflict between the two parties and they do not pay attention to explanations of adherence. In these papers, the only goal of the doctor is the maximization of the patient's utility (Caplin and Leahy 2004; Köszegi 2004). We have relaxed this assumption by allowing the doctor to consider other elements in her utility function, such as the notion of effort in supplying information. Furthermore, the doctor's utility function depends on the patient's health but not linearly.

4 Concluding remarks

As a possibility, we consider the case when the patient simply responds optimally to the decisions of the doctor. Our main model explores the case of the doctor–patient interaction when uncertainty regarding each other's actions and preferences applies to both agents. Decisions are taken on the basis of beliefs about the other agent's actions. It is important to obtain the PBE strategies and beliefs profiles which guarantee the desirable outcome of adherence. On this basis we can explain also how non-adherence actually happens.

The patient may end up rejecting the doctor's recommendations not because she did not provided him with the right amount of information regarding his state of health, but because he mistakenly has formed the wrong impression. Trust, defined here as the belief in the correctness of the doctor's decisions, is vital in achieving equilibrium and adherence to recommendations.

Significant policy implications arise from our analysis. If the doctor can tell the type of the patient, she will always provide the right information. Administrative support, provided, for example, by collecting information on the patient's preferences, will help in this direction. The doctor needs also to secure a climate of trust so that the beliefs of the patient and the decisions of the doctor are positively related. What matters is that the patient trusts that the doctor has satisfied his particular needs in which case he will adhere.

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