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PHYSICIAN BEHAVIOUR

DEMAND INDUCEMENT AS CHEAP TALK

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SUMMARY

The doctor–patient interaction is analysed in a game of cheap talk. Causes and consequences of imperfect agency are examined. One form of imperfect agency, supplier-induced demand, is a feature of neologism proof equilibria with some parameter values but not with others. The model is used to evaluate two tests that have been used to test for the existence of supplier-induced demand. The analysis suggests that the two tests, which compare the medical utilization of informed and uninformed consumers, are not valid. Copyright © 1999 John Wiley & Sons, Ltd.

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The possibility that doctors induce demand for their services has been explored in a variety of neoclassical models. In this paper the neoclassical perspective on supplier-induced demand (SID) will be updated, by incorporating developments in the economics of information and games. A model will be presented, in which demand inducement is represented as cheap talk. This model will be used to examine factors which determine the level of opportunism, to identify possible outcomes of such opportunism and to evaluate two suggested tests for the existence of SID.

SID will be characterized as treatment that the consumer would not have demanded, if he or she had as much information as the doctor. This possibility will be explored in an agency model in which both the decisions of the doctor and the patient satisfy the requirements for Bayesian rationality. A Bayesian patient would revise his or her assessment of the need for medical treatment in the light of the advice given by the doctor. However, the patient would not necessarily accept this advice.

Doctors' advice can be modelled as signals to patients which provide information about the need for treatment. In traditional models of signalling, there is a direct cost to sending more intense signals. This assumption is not very natural for purely verbal advice, which is important in doctor–patient interactions. A doctor does not necessarily get disutility from giving a stronger recommendation for treatment. When more intense signals do not have direct costs to the sender, they are classed as 'cheap talk' (see Farrell and Rabin [1]). Models of cheap talk have been considered problematic because they tend to have multiple equilibria and indeterminate predictions. However, recent work has suggested equilibrium refinements that can lead to more determinate implications [2,3]. In the present paper, the 'neologism-proof' refinement will be employed in a model of SID in a game of cheap talk.

Although this approach is new to the analysis of SID, there is a substantial theoretical literature on the doctor–patient interaction. Various aspects of this relationship are emphasized by

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different authors, and the decisions of the patient are not always explicitly modelled. However, there is a strand in this literature in which Bayesian rationality is attributed to the patient as well as the doctor. Patients are assumed to make rational decisions about whether to consult a doctor (e.g. Dranove [4], Lee [5], Garcia Mariñoso [6]) or whether to accept the doctor's recommendation (e.g. Dranove [4], Pauly [7], Blomqvist [8], Rochaix [9]).

It is important to acknowledge decision-making by the patient when addressing issues such as treatment refusal and non-compliance, the potential limits on doctor opportunism provided by patient consent and the effects of patients' information. The latter issue has been given some attention in previous work.

Pauly and Dranove argue that doctors will be more successful in inducing demand by less-informed patients. They suggest that the existence of SID can be tested for, by comparing the utilization of patients with different levels of information. Although Pauly does not have an integrated model that combines doctor and patient choices, and does not provide determinate implications for utilization, his discussion is fairly optimistic about testing for SID. Dranove's results are less ambivalent than those of Pauly. In his model there will be SID whenever doctors have more information than patients. He concludes that informed patients will be subject to less inducement than less informed patients. This conclusion is presented as a general result, in contrast to Pauly who only derived this result for polar cases. Unlike Pauly and Dranove, Rochaix does not explicitly consider testing for SID, although she does examine the theoretical effects of information. However, the complete version of her model is not simple, and she relies on simulation to illustrate these effects. She presents some results in which a decrease in patient information leads to an increase in utilization. This might be interpreted as support for the position of Pauly and Dranove.

In this paper a new neoclassical model of SID will be presented. It differs from previous work in a number of respects. The first difference is that it formally models SID as cheap talk. Second, it is very tractable. Unlike previous models, it is a simple matter to characterize equilibrium analytically, even though patients are assumed to make two separate decisions. Third, it incorporates a richer informational structure. The patient is assumed to gain some information from his or her symptoms, and also to learn from the results of diagnostic tests. Furthermore, it contains a more general characterization of improvements in information.

The intention behind the model is to provide an articulation of the neoclassical view of the doctor–patient relationship, rather than to suggest a new perspective. The model reveals new implications of a familiar hypothesis (that doctors induce demand). For example, it suggests a classification of possible outcomes, which leads to a more general understanding of the costs of imperfect agency. Furthermore, it throws light on some conceptual problems with suggested tests for SID.

The structure of the paper is as follows. In the following section, the model will be presented. Then the equilibrium refinement will be imposed and possible outcomes will be assessed in terms of their implications for SID. Two factors that determine whether there will be perfect agency will be distinguished, and the potential effects of imperfect agency discussed. The model will then be illustrated with a simple example. An evaluation of two tests for SID follows. In the final section, the significance of the conclusions will be discussed, and a suggestion will be made about the design of future tests.

THE MODEL

There is a doctor (she) and a patient (he). The patient does not observe his health state, but he does observe some symptoms. In the light of these symptoms, he decides whether to seek medical advice. If he does seek advice, then a diagnostic test is performed. Both the patient and the doctor receive some information from this test, but the doctor receives more information. The doctor gives the patient a recommendation and then the patient decides whether to accept treatment.

This story can be formalized as a game with the following steps:

1. Nature chooses a symptom $s \in S = \{s_1, \ldots, s_K\}$.
2. The patient observes s. He chooses whether or not to visit the doctor, i.e. $a_1 \in \{N, V\}$.
3. If he does not visit the doctor ($a_1 = N$), then nature chooses the patient's health outcome $h \in \{B, G\}$ (bad or good), where the probability of the bad health state is given by the function

$\pi_1(s)$. Then the game finishes. But if he does visit the doctor, then he pays a fee, a diagnostic test is performed, and . . .
4. Nature chooses a test result with two dimensions $r \in R = \{r_1, \ldots, r_J\}$ and $t \in T = \{t_1, \ldots, t_Q\}$, according to the probabilities $\Pr(t|s)$ and $\Pr(r|t, s)$. The doctor observes r, s and t. The patient observes t (and s) but not r.
5. The doctor chooses a message $m \in M = \{m_1, \ldots, m_N\}$ to give the patient.
6. The patient observes m. He chooses whether to decline or accept treatment, i.e. $a_2 \in \{D, A\}$. If he declines, then nature chooses a health outcome $h \in \{B, G\}$, where the probability of the bad health state is given by the function $\pi_3(s, t, r)$. If he accepts then he pays another fee, treatment is provided and the health outcome is good ($h = G$).

The specification of the game includes four conditional probabilities. However, these probabilities are not independent. This can be shown simply, by defining a function $\pi_2(s, t)$ to represent the probability of a bad health outcome conditional on s and t. This probability is related to π_3 by the following expression:

$$\pi_2(s_k, t_q) = \sum_j \pi_3(s_k, t_q, r_j) \cdot \Pr(r_j|s_k, t_q) \qquad \forall k, q.$$

Furthermore π_1 can be characterized in terms of π_2:

$$\pi_1(s_k) = \sum_q \pi_2(s_k, t_q) \cdot \Pr(t_q|s_k) \qquad \forall k.$$

Consequently π_1 is determined by π_3, $\Pr(t|s)$ and $\Pr(r|t, s)$.

It will be assumed that the patient's utility is additively separable in consumption and health. (This assumption is made purely to for notational simplicity, the following discussion can be generalized for non-separable utility.) His consumption is reduced by one part charge when visiting the physician and another when receiving treatment. His utility from consumption is v_0 if he does not seek medical advice, v_1 if he seeks medical advice but does not receive treatment, and v_2 if he seeks medical advice and receives treatment. If he suffers the bad health outcome, he will also incur a further disutility of δ. The part-charges are set so that:

$$v_0 > v_1 > v_2 > v_0 - \delta. \qquad (1)$$

Assuming that the patient has already paid for a consultation with the doctor, treatment would increase his expected utility if the (conditional) probability of the bad health outcome was higher than:

$$\varphi = \frac{v_1 - v_2}{\delta}.$$

Assumption (1) ensures that φ is less than one, and so there are some conceivable probabilities of the bad health outcome that would be high enough to justify medical treatment.

The doctor's objective is a convex combination of two components. The first component is w, which is her current (net) income. She gets $w = w_2$ if she provides treatment to the patient, $w = w_1$ if she provides a consultation but no treatment and $w = 0$ if the patient does not even seek medical advice. It will be assumed that $w_2 > w_1 > 0$, which implies a financial incentive to recommend treatment. However, this incentive may be counterbalanced by the other component of her payoff. This second component is the utility of the patient. Patient satisfaction could affect the doctor's payoff if she has some altruistic feelings toward her patients or if her future custom depends on the satisfaction of her current patients. The payoff to the doctor is a weighted average of w and patient utility, where θ is the weight on w. She expects to get $\theta \cdot w_1 + (1 - \theta) \cdot [v_1 - \delta \cdot \pi_3(s, t, r)]$ if the patient is not treated and $\theta \cdot w_2 + (1 - \theta) \cdot v_2$ if he is treated. As a consequence, the doctor will prefer that the patient receive treatment when she assesses that the probability of the bad health state is greater than:

$$\gamma = \frac{v_1 - v_2}{\delta} - \frac{\theta}{1 - \theta} \cdot \frac{w_2 - w_1}{\delta}.$$

When $\gamma < 0$, π_3 will always be greater than γ, and so the doctor would prefer that the patient accepts treatment, whatever the results of the diagnostic test are. But if $\gamma > 0$, then π_3 may be less than γ, and the doctor may sometimes not wish to provide treatment. In either case, the doctor will prefer that treatment be accepted in a (weakly) wider range of circumstances than would be in the patient's interests. This is because φ will be higher than γ whenever the doctor gives any consideration to w (whenever θ is greater than zero). This divergence between the interests of the doctor and the patient provides a potential motivation to induce demand. However, SID also requires that the doctor is able to persuade the patient to accept treatment.

EQUILIBRIUM

The objective of this section is to characterize equilibrium outcomes of the model outlined in the previous section. The analysis of equilibrium must account for decisions about each of a_1, m and a_2. The decisions about m and a_2 now will be addressed, and then a_1 will be considered.

The doctor's choice of recommendation (m) and the patient's decision about treatment (a_2) are made in steps 5 and 6 of the game. After the preceding four steps, we are left with subgames that are sender–receiver games of cheap talk. As discussed by Farrell [2], this is a class of games in which a sender sends a message and then a receiver chooses an action, and in which payoffs do not depend directly on the message. After step 4, the doctor has observed s, r and t and the patient has observed s and t. As s and t are common knowledge in the subgame, they can be suppressed in the conditional probabilities. All that remains is for the doctor to send a message and the patient to choose an action. This satisfies the requirements for a sender–receiver game, where the doctor is the sender and the patient is the receiver.

Farrell demonstrates that this kind of game can have perfect equilibria, which are not credible. For example, there is a possibility of a 'babbling' equilibrium in which communication is not informative. In response to the problem of equilibria with impeded communication, Farrell proposes an equilibrium refinement for sender–receiver games called 'neologism-proofness'. The idea is that if the language is rich enough, any statement can be effectively communicated. Although the possibility of deceit may be a barrier to the receiver believing the statement, there is no barrier to the statement being understood. This requires the set of possible messages (M) to be very large. Farrell assumes that the sender can successfully communicate about his or her type. For any subset of types of sender, the sender can always send a message (a 'neologism') with the literal meaning that his or her type is in that set. He argues that this kind of message would be credible when these types, and only these types, would prefer that the message is believed. A neologism proof equilibrium is a perfect Bayesian equilibrium in which no type of sender has an incentive to send a credible neologism that would disturb this equilibrium.

The next task is to apply Farrell's equilibrium refinement to the subgames defined by steps 5 and 6. There are J possible values of r, so there may be up to J possible 'types' of sender. However, the only aspect of type r that matters to the doctor's decision (or the patient's welfare), is how high $\pi_3(r)$ is. The doctor will want to provide treatment unless $\pi_3(r) < \gamma$. However, the patient will only accept treatment if he believes the probability of a bad health outcome to be greater than φ.

When the doctor does not wish to provide treatment ($\pi_3(r) < \gamma$), it will not be in the patient's interests either (i.e. $\pi_3(r) < \varphi$). If the patient requested treatment, then the doctor could dissuade him by credibly claiming that $\pi_3(r) < \gamma$. If this message was credible (and therefore believed) the patient would not want to be treated. It would be credible because if it was true, then the doctor would prefer that it was believed, but if $\pi_3(r) > \gamma$ then she would prefer that it was not believed. Consequently, the patient's belief (after hearing the doctor's advice), $\Pr(h = B|m)$, will be $\Pr(h = B|\pi_3 < \gamma)$ which must be less than γ and therefore less than φ. Treatment will be declined.

Now imagine that $\pi_3(r) > \gamma$. In this case, whether the patient receives treatment will depend on the circumstances. It is possible that the patient would accept treatment if he knew that $\pi_3(r) > \gamma$ (but not what r is). He would make this decision if φ was less than the probability of the bad health state, conditional on this information. Reintroducing the implicit s and t, the requirement is that:

$$\Pr(h = B|\gamma < \pi_{3,} s, t) > \varphi \tag{2}$$

where

$$\Pr(h = B|\gamma < \pi_3, s, t) = \frac{\sum_{\{j|\pi_3(s, r_j, t) > \gamma\}} \pi_3(s, r_j, t) \cdot \Pr(r = r_j|s, t)}{\Pr(\pi_3(s, r_j, t) > \gamma|s, t)}.$$

If (2) was satisfied, then a doctor who observed that $\pi_3(r) > \gamma$ would be able to report this credibly. This is because it is only when $\pi_3(r) > \gamma$ that the doctor wants treatment to proceed. Furthermore, when (2) is also true the patient would accept treatment if he believed that $\pi_3(r) > \gamma$. So only a doctor who knows that $\pi_3(r) > \gamma$ is true would want the patient to believe it was true. This means that the message '$\pi_3(r) > \gamma$' would be credible. Treatment would be accepted.

Now consider the case where $\pi_3(r) > \gamma$, but (2) does not hold. The patient would not accept treatment if he knew that $\pi_3(r) > \gamma$ but did not know r. Therefore the message that '$\pi_3(r) > \gamma$' would not lead to treatment being accepted, even if it was believed. Although treatment would be accepted if the patient believed that $\varphi < \pi_3(r)$, a message to this effect would not be credible. The doctor would also like the patient to believe that $\varphi < \pi_3(r)$, whenever $\varphi > \pi_3(r) > \gamma$. Therefore, for s and t for which (2) does not hold, the patient will not receive treatment no matter what r is.

Proposition 1: In any perfect Bayesian equilibrium in which all subgames are assigned neologism-proof equilibria, if medical advice is sought then the patient will not receive treatment when either $\pi_3 < \gamma$ or $\Pr(h = B \mid \pi_3 > \gamma, s, t) < \varphi$ hold, but will receive treatment when $\pi_3 > \gamma$ and $\Pr(h = B \mid \pi_3 > \gamma, s, t) > \varphi$.

This proposition only deals with subgames in which the patient has visited the doctor. However, the patient may sometimes decide not to do so. This possibility is allowed for in the model, so that the effects of information on utilization can be examined. These effects could be mediated, not only by changes in patients' propensity to accept advice, but also changes in their propensity to *seek* advice. Consequently the decision whether to seek advice should be endogenous.

A formal analysis of the decision whether to seek medical advice is contained in Appendix A. But the main idea is simple enough. The patient compares the expected utility from a visit (given his symptom and the strategy of the doctor):

$$\Pr(a_2 = D \mid s) \cdot (v_1 - \delta \cdot \Pr(h = B \mid a_2 = D, s) + \Pr(a_2 = A \mid s) \cdot v_2$$

with his reservation utility (given his symptom):

$$v_0 - \delta \cdot \pi_1(s).$$

However, without further restrictions on the model, the patient may not be faced with a substantive decision. In some cases the patient would never seek advice (such as when δ is too small). In other cases he would always seek advice (and may always accept treatment). However, in the most interesting cases, the patient would seek medical advice in response to some symptoms but not others, and given that advice was sought, would accept treatment in some circumstances but not others.

PERFECT AGENCY AND SID

In this section, equilibrium outcomes will be classified and interpreted in terms of perfect agency and SID, and then illustrated in a simple example. The interaction between a doctor and her patient might be said to exhibit perfect agency when it always leads to a treatment decision that is in the patient's interests given the doctor's information. So, in every subgame in which the patient requests medical advice:

$$a_2 = \begin{cases} D & \text{if } \pi_3 < \varphi \\ A & \text{if } \pi_3 > \varphi \end{cases}.$$

There can be perfect agency in two different circumstances. First, the doctor might have no desire to mislead her patient. This will be the case when the interests of the two parties are sufficiently congruent. Second, she may have no ability to mislead him. For example, in the extreme case in which there is symmetric information (the rs contain no information not included in the ts), the doctor has no power to induce demand.

Agency is imperfect if the patient accepts treatment when $\pi_3 < \varphi$, or goes without treatment when $\pi_3 > \varphi$. The first of these possibilities might be identified as SID. This is when there are subgames (that are sometimes reached in equilibrium) in which the patient receives medical treatment even though the doctor does not believe that it is in the patient's interests. More formally, SID is present when there is a combination of symptom and diagnostic results (s, t, r) which occurs with positive probability such that:

$$a_1(s) = V,\ \gamma < \pi_3(s, t, r) < \varphi$$

and

$$\Pr(h = B \mid s, t, \pi_3 > \gamma) > \varphi.$$

An immediate consequence of this criterion is that it is a necessary condition for SID, that the doctor sometimes assesses the probability of the bad health state ($\pi_3(s, t, r)$) to be between γ and φ. If there were no values of π_3 in this interval then the interests of the two parties would always coincide. (A condition under which it is also a sufficient condition, is suggested in Appendix A.)

The criterion for SID allows the treatment decision to be affected by π_3 (via m) as well as s and t directly. An equilibrium will be said to exhibit 'basic' SID, when π_3 as well as s or t may influence the treatment decision. However, there may be other types of SID, in which the patient only considers one source of information. In some cases the patient's decision will be entirely determined by the doctor's advice, and the patient will receive treatment whenever it is in the doctor's interest. In other cases, he may ignore the doctor's advice, and only consider his own information (s and t). Various possibilities will be illustrated below.

SID is not the only possible failure of perfect agency. The patient may not receive treatment despite a diagnostic result indicating that it is in his interests. Let an equilibrium involve 'impeded demand' when there is a combination (s, t, r) which occurs with positive probability, for which:

$$a_1(s) = V,\ \varphi < \pi_3(s, t, r)$$

and

$$\Pr(h = B|s, t, \pi_3 > \gamma) < \varphi.$$

The basic idea of impeded demand is that if the doctor is trying to induce demand, and the patient realizes this, then a recommendation for treatment may sometimes be discounted even when treatment would actually be beneficial. In the 'basic' case of imperfect agency, the patient makes use of his own information as well as the doctor's advice. This will normally lead him to accept treatment in some cases when it is not desirable (SID) and to decline it in some other cases when it is beneficial (impeded demand).

When agency is imperfect, patients will be less likely to seek medical advice, as the expected utility from visiting a doctor will be lower. Visits may be discouraged by the expectation that demand could be induced or impeded.

In the discussion to date, three possible effects of imperfect agency have been described—SID, impeded demand and discouraged visits. Furthermore, two factors have been identified, which bear on whether agency will be perfect—congruency of interests and patient information. In the following section, the effects of patient information will be addressed. In the remainder of this section, the importance of congruence will be illustrated in a simple example.

In this example there are two possible symptoms, three possible values of r and two of t:

$$S = \{s_1, s_2\},\ R = \{r_1, r_2, r_3\},\ T = \{t_1, t_2\}.$$

Fewer elements in S, T or R would restrict the possible types of equilibria. At least two symptoms are required if the patient sometimes prefers to seek medical advice and sometimes prefers not to. At least two elements in T and three in R are required if he is to actively weigh the doctor's advice against his own information. The model is simplified further, by assuming that test results t contain all the information provided by symptoms s (so $\pi_2(s, t)$ can be written as $\pi_2(t)$) and similarly that rs contain all the information in ts ($\pi_3(s, t, r)$ can be written as $\pi_3(r)$).

The specific assumptions about the conditional probabilities are:

$$\pi_3(r_1) = 0 \qquad \pi_3(r_2) = 0.2$$
$$\Pr(r = r_1|t = t_1) = 0.5 \qquad \Pr(r = r_2|t = t_1) = 0.4$$
$$\Pr(r = r_1|t = t_2) = 0.1 \qquad \Pr(r = r_2|t = t_2) = 0.1$$
$$\Pr(t = t_1|s = s_1) = 0.8 \qquad \Pr(t = t_1|\ s = s_2) = 0.2$$

$$\pi_3(r_3) = 1$$
$$\Pr(r = r_3|t = t_1) = 0.1$$
$$\Pr(r = r_3|t = t_2) = 0.8$$

Finally, assume that:

$$\frac{v_0 - v_1}{\delta} = 0.3 \quad \text{and} \quad \varphi = \frac{v_1 - v_2}{\delta} = 0.4.$$

These assumptions imply that treatment is only in the patient's interests when the diagnostic result is r_3. They also ensure that the patient's choices (a_1 and a_2) depend on the symptoms and diagnostic results, irrespective of whether there is SID or not. However, they do not determine whether there will be SID. That depends on γ. Recall that γ is equal to φ minus

$$\frac{\theta}{1 - \theta} \cdot \frac{w_2 - w_1}{\delta}. \tag{3}$$

The size of (3) is determined by the monetary payoff to the doctor if treatment is provided, and by the relative importance that the doctor places on her immediate monetary payoff. Consequently, it is an index of the (lack of) congruence between her interests and those of her patient.

If (3) is less than 0.2, then the outcome is perfect agency, with

$$a_1 = \begin{cases} N & \text{if } s = s_1 \\ V & \text{if } s = s_2 \end{cases}$$

and if $a_1 = V$,

$$a_2 = \begin{cases} D & \text{if } r \neq r_3 \\ A & \text{if } r = r_3 \end{cases}.$$

If (3) is over 0.2 then demand will be induced. For example, when (3) is between 0.2 and 0.4 there will be SID of the basic variety, in which the patient's decision about a_2 will depend on both t and m:

$$a_1 = \begin{cases} N & \text{if } s = s_1 \\ V & \text{if } s = s_2 \end{cases}$$

and if $a_1 = V$,

$$a_2 = \begin{cases} D & \text{if } t = t_1 \text{ or } r = r_1 \\ A & \text{if } t = t_2 \text{ and } r \neq r_1 \end{cases}.$$

If (3) is larger than 0.4 the treatment decision will not depend on r.

$$a_1 = \begin{cases} N & \text{if } s = s_1 \\ V & \text{if } s = s_2 \end{cases}$$

and if $a_1 = V$,

$$a_2 = \begin{cases} D & \text{if } t = t_1 \\ A & \text{if } t = t_2 \end{cases}.$$

These outcomes are demonstrated in Appendix A.

Although this is only one example, the pattern that it illustrates holds quite generally. As congruence falls, the patient would refuse treatment (despite believing that $\pi_3 > \gamma$) for a wider range of ts. This is demonstrated in Appendix A. Note that this does not imply that utilization will necessarily fall, as $\pi_3 > \gamma$ will be true more often. The possibility of impeded demand means that utilization may be lower when there is SID than when agency is perfect. It is implicit in the analysis of Blomqvist [8] that SID, in which patients are not influenced by doctors' advice, could involve either higher or lower utilization than perfect agency. In the current example, there is higher utilization with basic SID than when there is perfect agency. However, an example with the opposite result is suggested in Appendix A.

One possibility that is not represented in this example, is SID in which the patient does not base his treatment decision on direct information about the test results (t):

$$a_1 = \begin{cases} N & \text{if } s = s_1 \\ V & \text{if } s = s_2 \end{cases}$$

and if $a_1 = V$,

$$a_2 = \begin{cases} D & \text{if } r = r_1 \\ A & \text{if } r \neq r_1 \end{cases}.$$

However, it is not difficult to generate this result in alternative examples.

TESTING FOR SID

In this section, the model will be employed to evaluate two tests for the existence of SID. The model is well suited to this task, as it provides characterizations of equilibria with and without SID. Two broad approaches are suggested by the previous section—those based on congruence of interests and those based on patient information. The first approach could make use of variations in doctors' incentives to treat. However, in this section the latter approach will be discussed, which draws on variations in patients' information.

There is some plausibility to the idea that patients with little information may be more vulnerable to SID than well-informed patients. SID is only possible because of an information asymmetry between the doctor and the patient. If demand is being induced then perhaps patients with little information may have high utilization. This is the rationale for the first type of test to be examined. Information could be proxied with education [10], the results of a survey [11,12], or by whether the consumer is a health professional [13–15]. Higher utilization for less informed patients would be interpreted as support for the existence of SID. Kenkel [11] uses a variation of this approach. He suggests a second type of test, which examines whether poorly informed consumers have higher utilization than well informed ones, *given that* medical advice has been sought (higher conditional utilization).

The bulk of the studies that follow either of these approaches have not supported the existence of SID, although Domenighetti *et al.* [15] is an exception. However, it is possible to challenge these studies. One challenge emphasizes the practical difficulty of isolating the effect of information. The following discussion will provide a different kind of challenge. It examines the theoretical basis of the tests—the predicted effect of information on utilization.

The tests are based on a presumption that a negative association between patient information and utilization can identify SID. The general validity of this presumption will be disputed. But it is clear from previous sections, that it has some basis. This is transparent in the simple case in which a change in information does not change the number of ss or ts. An improvement in information may lead a patient to be confident enough to disregard advice from the doctor, and decline treatment more often (i.e. on observing any of a greater number of possible combinations of s and t). The result would be lower utilization. Unfortunately there are two reasons why this possibility does not justify the suggested tests.

The first reason is that an increase in information can actually lead to rejection over a *smaller* range of ss and ts. This is demonstrated in Appendix A. However, the following discussion will illustrate a second, and perhaps more serious conceptual problem. The problem is that improvements in information can also affect utilization by allowing the patient to reclassify test results and symptoms. This could either increase or decrease utilization.

In order to formally model this problem, assumptions must be made about the type of information at issue and on how informational differences will be represented. There are many aspects of health care that patients have information about. Information about prices, location, and quality of medical care can all be important. However, the information that is pertinent for the above two tests is information about the implications of symptoms and diagnostic tests. Both symptoms and test results are modelled as message services. Consequently a more informed patient can be represented as one with a more informative message service.

Blackwell [16] characterizes a message service with more information, as one that would be preferred by the recipient, whatever his or her utility function. It is not difficult to show [16–18] that a decrease in information can be represented as an introduction of noise. A new and less informative message service is a 'garbled' version of the old one. The probability of receiving a given garbled message depends on the probabilities of the original messages, but not (directly) on the states that the messages reflect. Consequently the theoretical effects of a decrease in information can be investigated by assuming a garbling of S or T. This can be illustrated using the simple example presented in the section above.

It was previously assumed that the patient could observe an aspect of the test result, with two possible values t_1 and t_2. This provides the benchmark against which a lower level of information can be compared. With less information about the implications of diagnostic results, a patient would observe some $\tilde{t} \in \tilde{T}$ rather than a $t \in T$. In the simplest case, $\tilde{T}$ would also contain only two possible values ($\tilde{t}_1$ and $\tilde{t}_2$). For example, assume that when $t = t_2$ the patient observes $\tilde{t}_2$ with probability $1 - \varepsilon$ and $\tilde{t}_1$ with probability ε (and that both the doctor and the patient are aware of the changes). Assume further, that when $t = t_1$, the patient observes $\tilde{t}_1$ for sure. The introduction of this small amount of noise means that the probability that $\tilde{t}_2$ is observed is less than the original probability that t_2 was observed (as $(1 - \varepsilon) \cdot \Pr(t = t_2) < \Pr(t = t_2)$). It also means that in equilibrium $\Pr(h = B | t = \tilde{t}_2, m)$, is equal to $\Pr(h = B | t = t_2, m)$. However, $\Pr(h = B | t = \tilde{t}_1, m)$ is a convex combination of $\Pr(h = B | t = t_1, m)$ and $\Pr(h = B | t = t_2, m)$.

This provides a counterexample to the expectation that with SID, less informed patients are more likely to receive treatment than more informed patients. Recall that in the simple example (with ts) there would be SID (of the basic type) whenever (3) was between 0.2 and 0.4. If this condition is satisfied, and ε is small enough (less than 0.13), then there would also be SID (of the same type) if the patient was less informed (i.e. if he observed $\tilde{t}$s instead of ts). The outcome for such a patient will be:

$$a_1 = \begin{cases} N & \text{if } s = s_1 \\ V & \text{if } s = s_2 \end{cases}$$

and if $a_1 = V$,

$$a_2 = \begin{cases} D & \text{if } t = \tilde{t}_1 \text{ or } r = r_1 \\ A & \text{if } t = \tilde{t}_2 \text{ and } r \neq r_1 \end{cases}.$$

A less informed patient will observe $\tilde{t}_2$ less frequently than a more informed patient will observe t_2. Consequently, in this particular example, lower information leads to a lower probability that treatment will be accepted. The utilization rate (either conditional on medical advice being sought or unconditional) is lower. Therefore, the two tests for SID are not supported. Note that an information based test for impeded demand or imperfect agency (rather than SID) would be subject to the same problem. This is because the example involves impeded as well as induced demand.

Although there is no determinate result for utilization, lower information about diagnostic results always leads to a (weakly) lower probability that medical advice is sought. If there is perfect agency there is no effect on rates of treatment or of visits to the doctor. Both these results are established in Appendix A.

Proposition 2: Assume that the patient becomes more informed about the implications of diagnostic results (but not about the implications of symptoms). If there is SID before and after the change, then the patient will seek advice more often, but may accept treatment more, less or the same as previously. If there is perfect agency before and after the change then there will be no effect on either his propensity to seek advice or accept treatment.

A similar analysis is also possible for symptoms. A patient with less information about symptoms would have a garbled version of S. But this could favour either under- or over-estimation of the value of medical care. For the example with two possible interpretations of symptoms, $\tilde{s}_2$ could be observed either more or less frequently than $s = s_2$. If there is a probability ε that the patient observes $\tilde{s}_1$ when $s = s_2$, then $\Pr(\tilde{s} = \tilde{s}_1) > \Pr(s = s_1)$. If instead he sometimes observes $\tilde{s}_2$ when $s = s_1$, then $\Pr(\tilde{s} = \tilde{s}_1) < \Pr(s = s_1)$. As with the simple example where T is garbled, if ε is small enough it will not change the types of outcome—only their probabilities. It is easy to check that in the first of these two kinds of garblings of S, the patient seeks medical advice less often, is treated less often and has unchanged conditional utilization. In the second example, the patient seeks advice more often, is treated more often and has lower conditional utilization.

Although neither of these two possibilities provides an example of higher conditional utilization associated with reduced information, this association is possible with more complicated decreases in information. Imagine that there are three possible symptoms and that the patient initially seeks medical advice when s is s_2 or s_3. One kind of garbling could involve a probability of ε that $\tilde{s}_2$ is observed when $s = s_1$. If ε is big enough, and $\Pr(s = s_1)$ is also big enough, then this change could lead to the patient only seeking advice when he observes $\tilde{s}_3$. If the probability of treatment was higher with s_3 than with s_2, then the probability of treatment, conditional on advice being sought, would increase.

Proposition 3: If the patient becomes more informed about the implications of symptoms (but not about the implications of diagnostic results), then he may seek medical advice either more or less often. The directions of the effects on the probability that he is treated and on the probability conditional on advice being sought are also ambiguous. This is true whether or not there is SID.

Although it is possible to conceptually distinguish the two types of information, in practice more informed patients are likely to know more about both symptoms and diagnostic results. Patients who are more informed in both respects could have higher or lower utilization (or utilization conditional on medical advice being sought), irrespective of whether there is SID. This result suggests a pessimistic assessment of the two tests considered.

This pessimistic conclusion contrasts with previous models of SID, that have been interpreted to give support to the two tests. In particular, Dranove's model [4] was invoked by Kenkel [11] in motivating the second test. This is not clearly justified, as Dranove does not solve his model in terms of (conditional) utilization. More importantly, Dranove (and Rochaix) only consider a restricted class of informational changes. In this class, reductions in information are equivalent to decreases in the confidence with which beliefs are held. To the extent that more informed patients may hold different opinions, rather than just more firmly held opinions, the more general characterization is of information is pertinent.

CONCLUSION AND DISCUSSION

A new model of SID is presented in this paper. The principal innovations are that some developments in games of cheap talk are incorporated and that a very general informational structure is assumed. The model is used to throw light on the logic of the SID hypothesis in three different ways. First, the roles of two determinants of the agency relationship are clarified. These determinants are the congruence of the doctor's with the patient's interests, and the level of the patient's information. Second, a broad view of the potential costs of imperfect agency is suggested. The possible effects include impeded demand and discouraged visits, as well as SID. Third, two tests for the existence of SID are evaluated. The model can be used to articulate the rationale for the tests, but it also exposes some crucial conceptual problems.

There are two general problems with the tests. First, they do not account for impeded demand, and the consequent possibility that there may be lower utilization with SID than when agency is perfect. Second, the class of improvements of information is very broad. Without plausible theoretical restrictions on the extra information that is available to patients, there is little scope for determinate predictions about the effects of this information.

Tests for SID that are based on congruence of interests rather than patient information may be more promising. Changes in payoffs to doctors from treating patients are likely to be better understood than changes in patient information. Consequently, the second problem with information based tests will not be as serious. The first problem is still relevant, but tests for SID can be adapted to deal with it. One possibility is suggested in the following discussion.

As the interests of the doctor and the patient become less congruent, utilization may be affected. It was shown above that there are two opposing effects, so that the overall impact on utilization is indeterminate. However, it is possible to look at the mechanisms of inducement rather than at consequences such as utilization.

If a doctor has an increased incentive to induced demand, then presumably she will make more positive recommendations. Therefore, the SID hypothesis might be tested by examining whether doctors with stronger incentives to treat make recommendations that are systematically more in favour of treatment.

The model developed in the present paper has been tailored for addressing issues about patient information. Although the assumptions permit a very general informational structure, little attention was given to the determinants of congruence. In order to provide a theoretical framework for congruence based tests, the model should be elaborated to acknowledge specific influences on doctors' incentives, such as price setting, the repeated nature of the doctor–patient relationship and the possibility of second opinions. Finally, there may be incentives to induce demand, not only for treatment, but also for complementary services, and this provides another point of leverage for congruence based tests [19].

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APPENDIX A

Neologism-proof equilibria

Assume that $\pi_3(s, t, r) = \pi_3(s', t', r)$ $\forall s, s' \in S$, $t, t' \in T$, so that π_3 only depends on r. Let $\Omega_A \subseteq S \times T \times R$ be $\{(s, t, r) | \pi_3(r) > \gamma \ \& \ \Pr(B | \pi_3 > \gamma, t, s) > \varphi\}$ and $\Omega_D \subseteq S \times T \times R$ be $\{(s, t, r) | \pi_3(r) < \gamma \vee \Pr(B | \pi_3 > \gamma, t, s) < \varphi\}$. Finally, let $\Lambda(s') \subseteq S \times T \times R$ be $\{(s, t, r) | s = s' \ \& \ \Pr(t \ \& \ r | s) > 0\}$.

By Proposition 1, if $a_1(s) = V$ then:

$$a_2 = \begin{cases} D & \text{if } (s, t, r) \in \Omega_D \\ A & \text{if } (s, t, r) \in \Omega_A \end{cases}.$$

So long as there is no $z = (s, t, r) \notin \Omega_A \cup \Omega_D$ that occurs with positive probability, backward induction can be applied to this expression to characterize a_1. If the patient P observes s, he expects utility

$$EU^P[N | s] = v_0 - \delta \cdot \pi_1(s)$$

when choosing N, and

$$\begin{aligned} &EU^P[V | \Omega_A, s] \\ &= (1 - \Pr(z \in \Omega_A | s) \cdot v_1 + \Pr(z \in \Omega_A | s) \cdot v_2 \\ &\quad - \delta \cdot \Pr(h = B \ \& \ z \notin \Omega_A | s) \end{aligned}$$

when choosing $a_1 = V$. Let $S_v(\Omega)$ be the subset of S for which P's expected utility is higher if he chooses to seek advice (and if treatment will be accepted when $z \in \Omega$).

$$S_v(\Omega) = \{s|EU^P(N|s) < EU^P(V|\Omega, s)\}$$

$$= \left\{s\left|\Pr(z\in\Omega|s) > \frac{v_0 - v_1}{\delta\cdot\Pr(h = B|z\in\Omega, s) - \varphi}\right.\right\}$$

if $\Omega \neq \varnothing$ and $\varnothing$ if $\Omega = \varnothing$.

Let $S_N(\Omega)$ be $\{s|EU^P(N|s) > EU^P(V|\Omega, s)\}$. So long as $S_v(\Omega_A)\cup S_N(\Omega_A) = S$ (i.e. the patient would not be indifferent between D and A with any symptom), the outcome will be:

$$a_1 = \begin{cases} N & \text{if } s\in S_N \\ V & \text{if } s\in S_V \end{cases}$$

and if $a_1 = V$ then

$$a_2 = \begin{cases} D & \text{if } z\in\Omega_D \\ A & \text{if } z\in\Omega_A \end{cases}.$$

Perfect agency

Agency is perfect when Ω_A and $S_v(\Omega_A)$ maximize the patient's expected utility. Let $\Sigma_v = \cup_{s\in S_v(\Omega_A)}\Lambda(s)$. As Ω_A will only affect P's utility when he seeks medical advice, it will be optimal when it equals:

$$\Omega_A^*(s) = \operatorname{argmax}_{\Omega\subseteq\Lambda(s)} EU(V|\Omega, s)$$

$$= \operatorname{argmax}_{\Omega\subseteq\Lambda(s)} \sum_{z\in\Lambda(s)} \Pr(z|s)\cdot[(v_1 - \delta\cdot\pi_3(z))\cdot I(z\notin\Omega) + v_2\cdot I(z\in\Omega)]$$

$$= \operatorname{argmax}_{\Omega\subseteq\Lambda(s)} \sum_{z\in\Lambda(s)} \Pr(z|s)\cdot\left[(v_2 + I(z\notin\Omega)\cdot\delta\cdot\left(\frac{v_1 - v_2}{\delta} - \pi_3(z)\right)\right]$$

$$= \left\{z\in\Lambda(s)\left|\frac{v_1 - v_2}{\delta} > \pi_3(z)\right.\right\}$$

so long as there is no $z\in\Lambda(s)$ for which $v_1 - v_2 = \delta\cdot\pi_3(z)$. Now let Ω_A^* be:

$$\Omega_A^* = \bigcup_{s\in S}\Omega_A^*(s) = \{(s, t, r)|\varphi > \pi_3(r)\ \&\ \Pr(t\ \&\ r|s) > 0\},$$

and S_v^* be $S_v(\Omega_A^*)$. Note that $\Omega_A^*\in\operatorname{argmax}_{\Omega\subseteq S\times T\times R} EU(V|\Omega, s)$ for all s. Note also that any z in $\Omega_A^*\backslash\Omega_A^*(s)$ will not be in $\Lambda(s)$.

There is perfect agency when $S_v = S_v^*$ and $\Omega_A = \Omega_A^*$.

Demand inducement

Four conceivable ways that the conditions for perfect agency can be violated are:

(a) $\exists z\in(\Omega_A\backslash\Omega_A^*)\cap\Sigma_v$ (SID),
(b) $\exists z\in(\Omega_A^*\backslash\Omega_A)\cap\Sigma_v$ (impeded demand),
(c) $\exists s\in S_v^*\backslash S_v(\Omega_A)$ (discouraged visits),
(d) $\exists s\in S_v(\Omega_A)\backslash S_v^*$.

Case (d) is not possible. This is because if $s\in S_v(\Omega) = \{s|EU^P(N|s) < EU^P(V|\Omega, s)\}$ then $s\in\{s|EU^P(N|s) < \max_\Omega EU^P(V|\Omega, s)\} = S_v^*$. Furthermore, case (b) will not usually occur unless (a) also occurs. This is a consequence of the following result.

Assume that (A1) $\exists z\in\Sigma_v$. *If* (A2) $(\forall(s, t, r)\in\Sigma_v, \forall(s', t', r')\in\Sigma_v)[(s, t, r')\in\Sigma_v]$ *and* $\exists(s, t, r)\in\Sigma_v)\ni[\gamma < \pi_3(r) < \varphi]$ *then (a) will hold. But if* $\neg(\exists(s, t, r)\in\Sigma_v)\ni[\gamma \le \pi_3(r) \le \varphi]$, *then neither (a) nor (b) will hold.*

To prove the first part, note that (A1) implies that $\exists z\in\Sigma_v\cap\Omega_A$. This is because if $\Sigma_v\cap\Omega_A = \varnothing$ then $EU^P[V|\Omega_A, s] = v_1 - \delta\cdot\pi_1(s) < v_1 - \delta\cdot\pi_1(s) = EU^P[N|s]$, for any s. It would follow that $\Sigma_v = \varnothing$. But if $\Sigma_v\cap\Omega_A \neq \varnothing$, then $(\exists(s, t, r)\in\Sigma_v)\ni[\gamma < \pi_3(r)\ \&\ \Pr(B|\gamma < \pi, s, t) > \varphi]$, and so $(\exists(s, t, r)\in\Sigma_v)\ni\forall r'\ni[(s, t, r')\in\Sigma_v\ \&\ \gamma < \pi_3(r'))][(s, t, r')\in\Omega_A]$. In conjunction with the assumption that $(\exists(s, t, r)\in\Sigma_v)\ni[\gamma < \pi_3(r) < \varphi]$, this implies that $(\exists(s, g, r)\in\Sigma_v, \exists(s', t', r')\in\Sigma_v)\ni[\varphi > \pi_3(r')\ \&\ (s, t, r')\in\Omega_A]$. But with (A2), this means that $(\exists(s, t, r')\in\Sigma_v\cap\Omega_A)\ni[\gamma < \pi_3(r')]$. Condition (a) is an immediate consequence.

To prove the second part, note that if $\neg(\exists(s, t, r)\in\Sigma_v)\ni[\gamma \le \pi_3(r) \le \varphi]$ then $\forall(s, t, r)\in\Sigma_v$ $(\Pr(B|\pi_3 > \gamma, s, t) = \Pr(B|\pi_3 > \varphi, s, t))$. But as $\Pr(B|\pi > \varphi, s, t) > \varphi$, irrespective of s and t, it follows that $\Sigma_v\cap\Omega_A = \{(s, t, r)\in\Sigma_v|\pi_3(r) > \gamma\} = \{(s, t, r)\in\Sigma_v|\pi_3(r) > \varphi\} = \Omega_A^*\cap\Sigma_v$. Therefore neither (a) nor (b) can be true.

Changes in information and congruence

Assume the outcome with S, T and R is characterized by $(S_v(\Omega_A), \Omega_A)$ and the patient receives a new message service about diagnostic results $\tilde{T}$, that is more informative than T (with no change in S or R). The new outcome is $(\tilde{S}_v(\tilde{\Omega}_A), \tilde{\Omega}_A)$. Then $S_v(\Omega_A)\subseteq\tilde{S}_v(\tilde{\Omega}_A)$ and $S_v(\Omega_A^*) = \tilde{S}_v(\tilde{\Omega}_A^*)$.

To see that $S_v(\Omega_A) \subseteq \tilde{S}_v(\tilde{\Omega}_A)$, note that $EU^P[V|\Omega_A, s] = \Sigma_{r \in R} \Pr(r|s) \cdot EU_t^P(V|r, s)$ where $EU_t^P(V|r, s) = \Sigma_{t \in T} \Pr(t|s, r)[v_2 + I[z \in \Omega_A] \cdot \delta \cdot (\varphi - \pi_3(r))]$. Now $E\tilde{U}_t^P(V|r, s) \geq EU_t^P(V|r, s)$ by the definition of an increase in information. Therefore $E\tilde{U}^P[V/\tilde{\Omega}_A, s] \geq EU^P[V|\Omega_A, s]$. It follows from the 52 definition of S_v that $S_v(\Omega_A) \subseteq \tilde{S}_v(\tilde{\Omega}_A)$.

To see that $S_v(\Omega_A^*) = \tilde{S}_v(\tilde{\Omega}_A^*)$, note that $\Omega_A^* = \{(s, t, r) \in S \times T \times R | \pi_3(r) > \varphi\}$ and $\tilde{\Omega}_A^* = \{(s, \tilde{t}, r) \in S \times \tilde{T} \times R | \pi_3(r) > \varphi\}$. Consequently, $\Pr(z \in \Omega_A^* | s) = \Pr(\tilde{z} \in \tilde{\Omega}_A^* | s)$ and $\Pr(h = B | z \in \Omega_A^*, s) = \Pr(h = B | \tilde{z} \in \tilde{\Omega}_A^*, s)$ for all $s \in S$. Substituting these results into the expression for S_v reveals that$S_v(\Omega_A^*) = \tilde{S}_v(\tilde{\Omega}_A^*)$.

Let $\Gamma_D(\gamma) \subseteq S \times T$ be $\{(s, t) | \Pr(B | \pi_3 > \gamma, t, s) < \varphi\}$. If $\gamma_0 < \gamma_1$, then $\Gamma_D(\gamma_1) \subseteq \Gamma_D(\gamma_0)$.

To see this, note that $\Pr(B | \pi_3 > \gamma, t, s) = E[\pi_3 | \pi_3 > \gamma, t, s]$, which is increasing in γ. So the criterion for membership in $\Gamma_D(\gamma)$ becomes more restrictive as γ rises (and φ stays constant).

Examples

In the example discussed in the main text, if $\pi_3(r_2) < \gamma$ then $\Omega_A = \{(s, t, r) | \pi_3(r) > \varphi\} = \{(s, t, r) | r = r_3\} = \Omega_A^*$. Therefore $\Pr(z \in \Omega_A | s)$ is 0.24 if $s = s_1$ and 0.66 if $s = s_2$. Furthermore, $\Pr(B | z \in \Omega_A^*, s) = 1$ whether s is s_1 or s_2. Consequently $S_v^* = \{s_2\}$. However, if $\gamma < \pi_3(r_1)$, then $\Pr(B | \pi_3 > \gamma, s, t) = \pi_2(s, t)$ and so $\Omega_A = \{(s, t, r) | \pi_2(s, t) > \varphi\} = \{(s, t, r) | t = t_2\}$. Therefore, $\Pr(z \in \Omega_A | s)$ is 0.2 if $s = s_1$ and 0.8 if $s = s_2$. $\Pr(B | z \in \Omega_A, s)$ is 0.82. Consequently, $S_v = \{s_2\}$ and (a) but not (b) is satisfied. Finally, consider the case where $\gamma < \pi_3(r_2) < \varphi$. Now $\Omega_A = \{(s, t, r) | t = t_2 \;\&\; r \neq r_1\}$. Therefore, $\Pr(z \in \Omega_A | s)$ is 0.18 if $s = s_1$ and 0.72 if $s = s_2$. $\Pr(B | z \in \Omega_A, s) \cong 0.911$. Consequently $S_v = \{s_2\}$. Both (a) and (b) are satisfied.

An example in which utilization is lower with (basic) SID than with perfect agency is:

$\pi_3(r_1) = 0$	$\pi_3(r_2) = 0.2$
$\Pr(r = r_1 \| t = t_1) = 0.7$	$\Pr(r = r_2 \| t = t_1) = 0.2$
$\Pr(r = r_1 \| t = t_2) = 0.1$	$\Pr(r = r_2 \| t = t_2) = 0.2$
$\Pr(t = t_1 \| s = s_1) = 1$	$\Pr(t = t_2 \| s = s_2) = 0.4$

$$\frac{v_0 - v_1}{\delta} = 0.1 \qquad \varphi = \frac{v_1 - v_2}{\delta} = 0.4$$

$$\pi_3(r_2) = 1$$
$$\Pr(r = r_3 | t = t_1) = 0.1$$
$$\Pr(r = r_3 | t = t_2) = 0.7$$

In the following example there is a decrease in information which would lead the patient to reject a doctor's recommendation to treat with a greater number of ts, and a with a greater probability. $|S| = 1$, $|T| = 3$ and $|R| = 2$:

$\pi_3(r_1) = 0$	$\pi_3(r_2) = 1$
$\Pr(r = r_2 \| t = t_1) = 0.2$	$\Pr(r = r_2 \| t = t_2) = 0.6$
$\Pr(t = t_1 \| s = s_1) = 1/3$	$\Pr(t = t_1 \| s = s_2) = 1/3$

$$\frac{v_0 - v_1}{\delta} = 0.05 \qquad \varphi = \frac{v_1 - v_2}{\delta} = 0.5$$

$$\Pr(r = r_2 | t = t_3) = 0.8$$

$$\frac{\theta}{1 - \theta} \cdot \frac{w_2 - w_1}{\delta} = 0.5$$

$$\Pr(\tilde{t} = \tilde{t}_1 | t = t_1) = \Pr(\tilde{t} = \tilde{t}_2 | t = t_1) = \Pr(\tilde{t} = \tilde{t}_1 | t = t_2) = \Pr(\tilde{t} = \tilde{t}_2 | t = t_2) = 1/2$$

$$\Pr(\tilde{t} = \tilde{t}_3 | t = t_3) = 1$$

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