Optimal Dynamic Health Insurance Contract in Presence of Moral Hazard: The Case of the Japanese Health Insurance System

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Abstract

Here I consider the design of a dynamic health insurance contract in presence of moral hazard. I have considered the case of commitment of both the principal and the agent, which is likely to be the case in the countries where health insurance policies are universal and mandatory (as in Japan and in some European countries). Using standard recursive techniques as in Hopenhayn & Nicolini (1997), I characterize the optimal contract. It is seen that optimal health insurance policy is history dependent in order to provide inter-temporal incentive. If the agent continues to be sick, his coverage in case of temporary sickness goes down. Using a numerical simulation, I compare the health insurance system proposed here with the current health insurance system of Japan. My results suggest that the gains from switching to the optimal health insurance system could be significant.

1 Introduction:

Unlike U.S., most advanced nations have health insurance systems which are heavily regulated by the government. For example, in Japan, it is mandatory for the citizens to be enrolled in either employer provided health insurance or health insurance provided by the local governments (Ikegami et al. (1999)). The premium rates and benefits are almost uniform for all citizens, in particular, they do not vary with health status of the individuals (Ikegami et al. (1996)). In Canada, though health insurance is not mandatory, premiums and benefits that firms can offer are regulated to be uniform. Health insurance systems in some European nations are heavily regulated, too (Diamond (1992)).

If the health status of an individual depends on his or her health promotion effort which is not observable, then one might wonder whether a health insurance system that insures same benefit to all individuals regardless of their past health history provides enough incentive to exert health promotion effort. The purpose of this paper is to consider the design of optimal dynamic health insurance system when health promotion effort reduces probability of sickness but is not observable.

In the health insurance literature, the type of moral hazard usually considered is the overconsumption of health care due to price reduction (Pauly (1968), Feldman (1991), Besley (1988)). Nevertheless, the fact that non-medical preventive activities, which are arguably unobservable to the insurer, affects health outcomes has been emphasized in the economics literature and medical literature as well (Phelps (1978)). The Framingham Heart Study has showed that not only cigarette smoking and cholesterol intake increase the risk of heart attacks, but also there is a negative correlation between overall mortality and cardiovascular mortality and general levels of physical activity (Kannel (1978)). A study at Harvard University has shown that physical activity is associated with frequency of heart attacks. In particular, strenous sports activity was inversely related to heart attack risk-it was reduced by 61% for those engaged in such activity (Paffenbarger (1977)). These findings suggests that moral hazard due to unobservable health promotion effort deserves attention in the study of health insurance.

Design of a dynamic health insurance contract, in general, is a complicated problem specially because one needs to consider not only the incentive problem but also the participation constraint of the agents (and of the principal as well). However if one considers only the special case of a mandatory health insurance systems like that of Japan then the problem may become simple. This is because in that case one does not need to consider whether the system provides enough incentive so that the agents do not to switch to alternative plans. In other words, one can ignore the participation constraints for the agent in that case. In this paper I consider this special case of commitment of both the principal and the agents. Hopenhayn & Nicolini (1997) uses a model of repeated moral hazard problem to study the design of optimal unemployment insurance when job search effort is not observable. What I have shown in this paper is that under the assumption of mandatory participation of the agent, the problem of designing optimal dynamic health insurance contract in presence of moral hazard can be solved using techniques similar to those of Hopenhayn & Nicolini (1997).

In my model each period the agent may remain healthy, be temporarily sick or contract a permanent illness. Probabilities of each of these states depend on agent's health promotion effort level which the principal (the government) can't observe. It is seen that the optimal contract must be history dependent. In particular, if an agent continues to be temporarily sick, his coverage in case of sickness must go down. It is also seen that coverage in case of contracting a permanent illness, which has to be the same at all periods after permanent illness has been contracted, would be lower if the individual contracts the permanent illness at a later period in the life-cycle. The intuition behind the first result is clear: To provide intertemporal incentive, the contract must punish the agents who continue to be sick by reducing their consumption in future. The intuition behind the second result is that since the agent is assumed to be risk averse, consumption should be kept as close as possible at all possible states in the future, in particular, at the states of permanent illness and temporary sickness. These results are, in essence, similar to those of Hopenhayn & Nicolini (1997) and Shavell and Wise (1979), who showed that optimal unemployment insurance contract should be history dependent.

To evaluate the advantage of switching to the optimal health insurance policy, I provide estimates of cost reduction by shifting from the current health insurance policy of Japan to the optimal one. The reason why I chose Japanese health insurance system for numerical analysis is that the Japanese health insurance system is mandatory, which makes it naturally close to the model I propose here (I provide a brief description of the Japanese mandatory health insurance system in section 3.2). These estimates show that this saving could be as large as 20%.This savings comes from the reduction in expected cost due to decreased probability of illness, since the optimal system provides enough incentive to exert effort that reduces the probability of illness.

Since the results in the numerical analysis depend on the functional forms assumed, I have also conducted a sensitivity estimate. Since a reliable estimate of the disutility from effort is hard to find, I have done the same simulation as above assuming different values of disutility from effort. The result shows that cost savings are robust (remains significantly large) for a wide range of values of this parameter.

The structure of this paper is as follows: Section 2 begins with defining the model, its basic assumptions and defining the contract. Section 2.2 defines the optimal health insurance policy problem when effort is observable. Section 2.3 defines the optimal health insurance policy problem when effort is not observable. Section 2.4 characterizes the solution to the problem defined in section 2.3.Section 3 contains the details of the numerical analysis. Some remarks conclude the paper.

2 The Model

There is a risk-neutral principal (the insurer) and a strictly risk averse agent (the insuree). Agent's preferences are given by

$$E\sum_{t=0}^{\infty}\beta^t[u(c_t)-ra_t]$$

whrere c_t is the consumption at period t and a_t is the health promotion effort at period t. Here, r represents the disutility from effort. Following Hopenhayn and Nicolini (1997), I assume that $r = 1$[1]. I also assume that $\beta < 1$, $c_t \in R_+$, $a_t \in \{0,1\}$, $u' > 0$ and $u'' > 0$.

In each period, the agent could be *healthy* , or become *temporarily sick* or become *permanently ill.* In case of being healthy, the agent's income is $y > 0$ in that period. If the agent becomes temporarily sick , his income is y_s in that period, where $y > y_s > 0$. So $y - y_s$ is the loss due to temporary sickness (or the cost of medical care treatment to recover from sickness). If the agent becomes permanently sick his income is y_p in that period and as well as all the subsequent periods, where $y > y_p > 0$. So $y - y_p$ is the loss due to permanent sickness.

In each period, after the realization of health status at that period , the agent chooses a health promotion effort level . If the agent turns out to be healthy ,or temporarily sick, then effort level taken in current period (period t) affects the probability of each possible state in the next period (period $t+1$) , but not the following periods (periods $t+2, t+3$,..). If the agent turns out to be permanently sick, he will remain sick for all following periods, no matter what level of effort is taken.

Consider the case when the agent is either healthy or temporarily sick in current period. As assumed, there are only two effort levels to choose from: high ($a_t = 1$) and low ($a_t = 0$). If he chooses effort level $a_t = 0$, then probability of being temporarily sick is $p_s^0$and being permanently ill is p_p^0 . But if he chooses effort level $a_t = 1$, then these probabilities are p_s^1 and p_p^1 respectively, where $p_s^0 > p_s^1$, $p_p^0 > p_p^1$ and $1 > p_s^0 + p_p^0 > p_s^1 + p_p^1$. That is, taking a higher level of effort decreases the probability of both types of illness. Also, an agent who chooses a lower level of effort still has positive probability of being healthy next period.

[1] Later in section 3.4, I conduct sensitivity analysis of my estimates for other values of r.

Other important assumptions are:

1. Agents have no other source of income. This assumption can be relaxed as long as that source is independent of health status. For example, this model can allow for different level of initial wealth.

2. Principal can observe consumption. If consumption is unobservable, then an optimal health insurance policy design must account for strategic reporting of consumption. However this possibility is ignored in this paper.

3. Full commitment on both side .The commitment of the agents , in general, is a an assumption that could be put into question, in the context of the health insurance practice in U.S. where people can choose from competing health insurance policy offers. But we are considering a mandatory health insurance system which ,by definition, means no other outside options are available for the agents.

2.1 The Contract:

The contract is offered at time 0 (at the beginning of life). Let $h^t = (h_0, h_1, h_2, ..., h_t)$ denote the history of health status up to period t. Given h^t, the contract specifies a consumption level for the agent, c_t, and a recommended effort level, a_t.That is, the contract is a function $\tau : h^t \to \{c_t, a_t\}$, where a_t is the effort level recommended and c_t is the consumption at period t.

The (absolute value of) net transfer, $z_t = y_t - c_t$, is the *premium* in the case of period t health status being healthy, and *coverage* in other cases (temporary sickness and permanent illness). Associated with each contract is an expected discounted utility to the agent, $V_0(\tau)$,and a cost , measured by expected discounted value of net transfers to the agent, $C_0(\tau)$. It is assumed that the agent responds to the contract rationally, maximizing its expected utility by choosing an optimal health promotion effort level for each period.

Given a level of initial value V for the agent, the optimal contract minimizes $C_0(\tau)$ subject to $V_0(\tau) = V$.

2.2 When Effort Is Observable:

In this case , no incentive problem has to be considered .The problem is that of efficient risk sharing. Given the strict concavity of u, and time-separability of expected utility functions and expected cost functions, consumption (transfer) should be smoothened over time and across states. So the optimal contract should specify a constant consumption level in all states and in all periods.

This means that the premium and coverage would remain constant for all periods and for all states. Note that a higher effort level decreases agent's expected utility. Therefore, the optimal sequence of efforts will depend on specific values of parameters of the model.

2.3 When Effort Is Not Observable:

Incentive problems arise when the principal is interested in implementing positive search effort. In the following analysis we restrict to that case. The cost of implementing positive search effort increases with the promised utility to the agent. As a consequence, for sufficiently high initial utility levels, implementing high effort may not be optimal (A more general form of the principal's cost minimization problem is given in Appendix). I specify the principal's problem in recursive form, using recursive techniques as in Hopenhayn and Nicolini(1997, 2002).

First, consider the situation for an agent when he is healthy at period 0. The contract specifies consumption c_h , action a_h and continuation values based on health status. Let the continuation values in case of being healthy, temporarily sick and permanently ill be V_h^h, V_h^s and V_h^p respectively. Suppose that V is the expected discounted utility offered by the contract at time 0. Then, since incentive constraints are assumed to be binding, it must be that for the agent, choosing $a = 1$ yields higher utility than choosing $a = 0$, that is,

$$\beta\{(p_s^1 - p_s^0)(V_h^s - V_h^h) + (p_p^1 - p_p^0)(V_h^p - V_h^h)\} \geq 1 \tag{1}$$

Also consistency of the values require that

$$u(c_h) - 1 + \beta\{(p_s^1 V_h^s + p_p^1 V_h^p + (1 - p_s^1 - p_p^1)V_h^h = V \tag{2}$$

Next, consider the situation for an agent when he is temporarily sick at period 0. The contract specifies consumption c_s , action a_s and continuation values based on health status. Let the continuation values in case of being healthy, temporarily sick and permanently ill be V_s^h, V_s^s and V_s^p respectively. Suppose that V is the expected discounted utility offered by the contract at time 0. Then, since incentive constraints are assumed to be binding, it must be that for the agent, choosing $a = 1$ yields higher utility than choosing $a = 0$, that is,

$$\beta\{(p_s^1 - p_s^0)(V_s^s - V_s^h) + (p_p^1 - p_p^0)(V_s^p - V_s^h)\} \geq 1$$

Also consistency of the values require that

$$u(c_s) - 1 + \beta\{(p_s^1 V_s^s + p_p^1 V_s^p + (1 - p_s^1 - p_p^1)V_s^h = V$$

Lastly , consider the case when the agent has contracted permanent illness at period 0. Since there is no further incentive problem, it is optimal to give the agent a constant level of consumption (which implies a constant level of coverage) from that period on, c_p,which is given by

$$V = u(c_p)/(1-\beta) \tag{M1}$$

The expected discounted cost for the principal to provide expected discounted utility V to the permanently ill agent is therefore

$$W(V) = (c_p - y_p)/(1-\beta)$$

As shown in Hopenhayn & Nicolini (1997), the following holds:

$$W'(V) = 1/u'(c_p) \tag{3}$$

therefore $W''(V) > 0$, that is W is strictly increasing and strictly convex.

Now let $C(V)$ be the minimum expected discounted cost for principal to provide a healthy agent a lifetime utility V, and $C_1(V)$ be the minimum expected discounted cost for principal to provide a temporarily sick agent a lifetime utility V. Then $C(V)$ and $C_1(V)$ must satisfy the following Bellman equation:

$$C(V) = \min_{c_h, V_h^h, V_h^s, V_h^p} c_h - y + \beta\{p_p^1 W(V_h^p) + p_s^1 C_1(V_h^s) + (1 - p_p^1 - p_s^1)C(V_h^s)\} \tag{M2}$$

$s.t.$

1. $\beta\{(p_s^1 - p_s^0)(V_h^s - V_h^h) + (p_p^1 - p_p^0)(V_h^p - V_h^h)\} \geq 1$
2. $u(c_h) - 1 + \beta\{(p_s^1 V_h^s + p_p^1 V_h^p + (1 - p_s^1 - p_p^1)V_h^h = V$

and,

$$C_1(V) = \min_{c_s, V_s^h, V_s^s, V_s^p} c_s - y_s + \beta\{p_p^1 W(V_s^p) + p_s^1 C_1(V_s^s) + (1 - p_p^1 - p_s^1)C(V_s^s)\} \tag{M3}$$

$s.t.$

1. $\beta\{(p_s^1 - p_s^0)(V_s^s - V_s^h) + (p_p^1 - p_p^0)(V_s^p - V_s^h)\} \geq 1$
2. $u(c) - 1 + \beta\{(p_s^1 V_s^s + p_p^1 V_s^p + (1 - p_s^1 - p_p^1)V_s^h = V$

(Non-negativity constraints on the choice variables are also assumed)

2.4 Characterization of Solutions:

First, note that both functions $C(V)$ and $C_1(V)$ are strictly increasing and strictly convex.

To see this, define $u(c) = u_c$ .Then $c = u^{-1}(u_c)$. Since u is strictly concave, u^{-1} must be strictly convex. Therefore, if you replace $u(c)$ with $u_c$and c with $u^{-1}(u_c)$ in (M2)and (M3), then for both problems, objective functions are strictly increasing and strictly convex in arguments and constraints are linear in arguments. Therefore, standard dynamic programming argument (Stockey, Lucas & Prescott (1989), Ch. 4) tells that both functions $C(V)$ and $C_1(V)$ are strictly increasing and strictly convex.

Also, note that both minimization problem (M2) and (M3) are identical, except for a constant term in the objective function. Since a constant term doesn't affect the solution, and since both problems have unique solution, therefore maximizing arguments for both of the problems are the same.

Let's denote solution to problem (M2) and (M3) as c, V^h, V^s, $V^p$and λ and η be the Lagrange multipliers for constraints 1 and 2 respectively. Then, first note that $C_1(V) - C(V) = y - y_s$, which implies

$$C_1'(V) = C'(V) \text{ for all } V \tag{4}$$

The F.O.C.'s are:

$$W'(V^p) = \frac{1}{u'(c)} + \eta \frac{p_p^1 - p_p^0}{p_p^1} \tag{5}$$

$$C_1'(V^s) = \frac{1}{u'(c)} + \eta \frac{p_s^1 - p_s^0}{p_s^1} \tag{6}$$

$$C'(V^h) = \frac{1}{u'(c)} + \eta \frac{p_s^1 + p_p^1 - p_p^0 - p_s^0}{1 - p_s^1 - p_p^1} \tag{7}$$

and the envelope condition is

$$C_1'(V) = C'(V) = \frac{1}{u'(c)} \tag{8}$$

From these conditions, we can immediately observe the following result:

Proposition 1: *At optimal contract, full insurance is not offered. Also, as a person continues to be healthy, his consumption increases (that is, his premium decreases). And as a person continues to be temporarily sick , his consumption decreases (that is, his coverage for temporary sickness decreases).*

Proof : See Appendix

This result is quite intuitive. In order to provide incentive to take effort, consumption in case of being healthy in the second period should be higher than consumption in the first period, and consumption in case of being temporarily sick in the second period should be lower than consumption in the first period. Given the recursive nature of the solution, if you are healthy in the second period, then your promised consumption in the third period in case of being healthy should be even higher than your consumption of the second period , and so on. This means, the net transfer to you, the premium, will continue to go down. Similarly, your consumption continues to go down if you continue to be temporarily sick. Which means that the net transfer to you, the coverage, continues to go down.

Next I turn to characterizing the optimal coverage in case of permanent illness .The next proposition shows that the level of coverage in case of permanent illness can't be independent of the health status history prior to contracting permanent illness.

Proposition 2: *V^p is not independent of health status history, which implies that optimal level of coverage in case of permanent illness can't be independent of health status history up to the period of contraction of permanent sickness.*

Proof: See Appendix.

Though the conclusion in this proposition is significant , it still doesn't tell us exactly how will depend on health status history. Now we will prove a monotonicity property of the optimal contract, which will tell us more about this history dependence.

Proposition3: *Assume that,*

$$\frac{p_p^1 - p_p^0}{p_p^1} = \frac{p_s^1 - p_s^0}{p_s^1} = \alpha > 0$$

Then, the optimal insurance contract c, V^h, V^s, V^p are all strictly increasing functions of the initial value V.

Proof: See Appendix.

The proposition below is another interesting finding:

Proposition 4: Suppose that a higher health promotion effort level doesn't decrease the probability of permanent illness (but it still decrease the probability of temporary sickness).That is, $p_p^1 - p_p^0 = 0$.

In this case yet, the optimal insurance contract c, V^h, V^s, V^p are all strictly increasing functions of the initial value V.

Proof: See Appendix.

From the propositions above, we can immediately conclude the following:

Corollary 1: *Under either conditions as in proposition 3 or 4, (except for the case of contracting permanent illness in the second period) an agent's coverage in case of permanent illness would be higher if he was healthy in all previous periods than if he was temporarily sick in all previous periods.*

Intuittively, these results show the trade-off between incentive compatibility and risk-sharing. To provide intertemporal incentive , coverage should be lowered in case of continued temporary sickness, and premium should be lowered in the event of continued healthy status. .Since agents are risk averse, the contract should also try to equalize consumption across states as much as possible. Therefore, as in case of proposition 4, even though probability of permanent illness is not affected by health promotion effort, the coverage in case of permanent illness should be differentiated on the basis of health status realization prior to contracting illness.

The implication of Proposition 4 is interesting. It might be argued that in case of some diseases, or sickness , health promotion effort hardly have any impact at all. The proposition tells that , even in that case as long as the contract covers some other types of diseases which is effected by health promotion effort, the contract must make coverage of all types of illness contingent of health status realization.

3 Quantitative Analysis:

In this section, I will solve a parameterized version of the model and provide some rough estimates of the potential advantage of the optimal health insurance contract that I provided here. In section 3.1, I will describe how I have assigned parameter values to my model, based on data on health statistics of Japan. In section 3.2 , I will present a stylized version of the Japanese health insurance system that captures some key features of the Japanese health insurance system. I find the expected discounted value that this system provides to the agent, and the (expected discounted)cost of the insurer of implementing it. In section 3.3, I will solve for the optimal contract ,where the initial expected value that the agent is offered is the same as the one that is offered under the current system.In particular, I will show the expected cost of implementing the optimal contract, and the optimal path for premium and coverage over time. In section 3.4, I will do some sensitivity analysis.I will check for sensitivity to the disutility from effort.I will check the cost savings for different parameter values of disutility from effort.

3.1 Parameters of the Model:

Utility function and discount factors: I will assume the utility function of the agent has the form $u(c) = c^{1-\sigma}/(1-\sigma)$, I will set $\sigma = 1/2$ as in Hopenhayn & Nicolini (1997), which gives an intermediate degree of risk aversion. The yearly discount factor is taken to be equal to 0.95, as in Hopenhayn & Nicolini (1997). These values are standard for most macroeconomic calibration models.

Morbidity rates are used as an approximation for probabilities of sickness. I have used the data on Japan's morbidity rate, that is how many people are receiving medical treatment at clinics and hospitals , both in-patients and out-patients. The data is from Health Care Handbook-Japan (1995). Data is available only for the years 1975, 1980, 1984,1987 and 1990. The average daily rate of patients (both in-patients and out-patients) for these years is 6768 per 100,000 population.

Since I consider years as periods, I need the data for yearly rate of morbidity. However it is not clear from the data that how many of these are new and how many of them are old patients. I am going to assume that the numbers given above are the yearly morbidity rates, that is, the probability of being sick. This is to equivalent to assuming that at the beginning of each year, 6.8% of the people randomly become sick and they are the people who remain sick for the whole year. No one else, other than who has become sick in the first day, becomes sick after the 1st day of the year. Also, though my model distinguishes between permanent and temporary sickness, there is no objective way of distinguishing between diseases as permanent and temporary (unless the data tells about exactly how many days of treatment were necessary for each type of disease for all the patients. However such detailed data was not available), from the data. I assume simply that half of these diseases are temporary and the other half is permanent.

Also in my model , there are two different level of probabilities, the one without effort and the one with effort. As I will show in the next section, under the current system (the stylized version presented in this paper), at equilibrium no effort would be chosen. Since the probabilities we are supposed to observe are the equilibrium probabilities, therefore they must correspond to $p_p^0$and p_s^0. Now the question is what is the probability of sickness with effort? This probability cannot be found out from data, because the probabilities that we see from data are the probabilities when no effort was chosen. To get an estimate of how health promotion effort improves (reduces) the probabilities of sickness, I use results from a study at Harvard University graduates (Paffenbarger (1977)) . This study associated physical study and frequency of heart attacks. Strenous sports activity was inversely related to heart attack risk-it was reduced by 61% for those engaged in such activity. Another study, The Framingham Heart Study ,also shows negative correlation between cardiovascular activity and general levels of physical activity (Kannel (1978)) . Of course I do not have a good estimate of reduction in illness probability due to other types of illness. For the purpose of quantitative analysis here, I would assume that the reduction in probability as a result of health promotion is 61%, for all types of diseases.

Now I need estimates for the expenditures, or losses, due to different types of illness. First ,I normalize income $y = 100$. Available data on health expenditure does not distinguish between expenditure for different types of diseases. For the years considered above, the average health expenditure was (5.9%) of GDP. I will assume that all types of disease have the same cost. And since I am considering a representative agent model, I also assume that every person has the same income. Therefore I divide this number with the total frequency of diseases. This gives an expenditure of 86.75 each year for both temporary and permanent diseases. Therefore, $y_p = y_s = 100 - 86.75 = 13.25$.

3.2 A Stylized Version of the Japanese Health Insurance System:

3.2.1 The Japanese Health Insurance System:

The key goal of providing a stylized version of the Japanese health insurance system is to calculate the initial value(the initial discounted expected utility value) that it provides to the agent, and the cost(expected discounted cost) of providing it. Before presenting the stylized version, I should provide a brief description of the Japanese Health Insurance System.

Japan's medical services are provided by public mandatory insurance program. The benefits and premiums in all insurance programs are strictly regulated by the government. First, the consumers have virtually no choice over selection of their plan. They must join either the one statutory plan offered by their employers, or if they are self-employed, the one administered by their local governments and trade associations. Also, consumers cannot opt out of the statutory system, and private health insurance, strictly limited by the government, remains insignificant. Secondly, neither insurers nor providers have the freedom to negotiate individually a different fee-schedule.The mandatory health insurance program is run by two systems : occupation-based and region-based. The former is called Employees' health insurance. Employers and employees of firms of a certain size and over form a health insurance society and thus these are called the Society-managed Health

Insurance. There are nearly 1,800 such societies. For those who work at smaller firms, the government provides a collective health insurance, which is called the Government-managed Health Insurance. In addition, special professions such as civil servants, day laborers and seamen form separate nation-wide professional associations. These occupation-based public health insurances cover employees and their dependents. About 65% of the population is covered by occupation-based insurance programs. In all occupation-based health insurance programs, premiums are generally paid on an equal basis between employer and employee. Together this amounts to about 8.5% of the average monthly wage , in all programs. The co-payment rate 20% for the subscriber , 20% for dependent inpatient care and 30% for dependent outpatient care.(March 2001 data). Those who are not covered by the occupation based Health Insurance are required to participate in a region-based health insurance, called the National Health Insurance, for which the municipalities (numbering more than 3,300) act as independent insurers. (See Fig 3.1) Mostly self-employed, farmers, workers of smaller firms and their family join the National Health Insurance. Premiums in this program are determined by the local governments, on the basis of income, number of individuals in the household of the insured, and assets. On average, the premium is 156,952 yen/per family (March 2001 data). The co-payment rate is 30% for both inpatient and outpatient care.

3.2.2 A Stylized Version of This System:

The stylized version that I provide captures the main features of this system. First it is assumed that the periods have a length of 1 year. At age 18, agent enters the health insurance program. The health insurance program specifies a schedule of premiums and co-payments in case of sickness, for all subsequent periods. The premium rate is assumed to be 8.5%, as in the empolyees' health insurance system. And the co-payment rate is assumed to be 20% , as in the employees' health insurance system. Now this co-payment rate looks high. But in the Japanese health insurance system, any out-of-pocket payment faced by a patient in a given month over the amount of $333 is reimbursed. Thus , out-of-pocket expenses for co-payments amount to only 12% of the total health care expenditure provided (Ikegami and Campbell(1996)). Therefore, to incorporate this limit of out-of-pocket expenditure, I will assume the co-payment rate to be equal to 12%. So, Consumption in case of healthy state is $c_h = (1 - 0.085)y = .915y$. Consumption in case of temporary sickness is $c_s = .915y - .12(y - y_s)$. Lastly, consumption in case of permanent sickness is $c_p = .915y - .12(y - y_p)$.

Given the premiums and coverage rules as specified above, agents decide, in each period, how much health promotion effort to provide. At first I calculate the expected discounted value that this health insurance system provides. To do this, suppose that the contract ends and people die after period T. Let V_t^h, V_t^s and V_t^p be the expected utility that the current system provides at the beginning of period $1 \leq t \leq T$, to a healthy, temporarily sick, and permanently sick agent respectively. Then,

$$V_T^h = c_h^{1-\sigma}/(1-\sigma),\ V_T^s = c_s^{1-\sigma}/(1-\sigma), V_T^p = c_p^{1-\sigma}/(1-\sigma)$$

And for at any period $1 \leq t \leq T$,

$$V_{t-1}^h = \max_{a\in\{0,1\}} \{u(c_h) - a + \beta(p_p^a V_t^p + p_s^a V_t^s + (1 - p_p^a - p_s^a)V_t^h)\}$$

$$V_{t-1}^s = \max_{a\in\{0,1\}} \{u(c_s) - a + \beta(p_p^a V_t^p + p_s^a V_t^s + (1 - p_p^a - p_s^a)V_t^h)\}$$

$$V_{t-1}^p = u(c_p) + \beta V_t^p$$

Since I assume that in the beginning period agents are healthy, therefore V_0^h will be the initial expected utility value that is provided by the current health insurance contract. We can calculate the actual value of V_0^h by taking the limit of V_0^h as $T \to \infty$.

Expected cost of providing this insurance can be computed in similar way. Let C_0^h, C_0^s and C_0^p be the expected utility that the current system provides at the beginning of period $1 \leq t \leq T$, to a healthy, temporarily sick, and permanently sick agent respectively. Then,

$$C_T^h = c_h - y,\ C_T^s = c_s - y_s,\ C_T^p = c_p - y_p$$

Let me denote the optimal level of effort chosen by the agent at period t as a_t .Then, for period $1 \leq t \leq T$,

$$C_{t-1}^h = c_h - y - a_{t-1} + \beta(p_p^{a_{t-1}} C_t^p + p_s^{a_{t-1}} C_t^s + (1 - p_p^{a_{t-1}} - p_s^{a_{t-1}})C_t^h)$$

$$C_{t-1}^s = c_s - y_s - a_{t-1} + \beta(p_p^{a_{t-1}} C_t^p + p_s^{a_{t-1}} C_t^s + (1 - p_p^{a_{t-1}} - p_s^{a_{t-1}})C_t^h)$$

$$C_{t-1}^p = c_p - y_p + \beta C_t^p$$

Here, will give us the (expected discounted) cost of the insurer (the government) of implementing this health insurance contract.

Again, We can calculate the actual value of C_0^h by taking the limit of C_0^h as $T \to \infty$.

The computed values of V_0^h and C_0^h were 373.3 and 459 respectively. Also, it turns out that the current system in fact doesn't provide incentive to take effort (at any period). Though the current system doesn't provide full insurance, the expected benefit from taking effort (the reduction in expected loss from taking effort) does not compensate for the disutility from taking effort.

3.3 Optimal Health Insurance Contract:

In this section, I will numerically solve the optimal health insurance system that provides the same level on initial expected utility that the current system gives , and find out the (expected discounted) cost of providing this contract .For solving this model, I have allowed for the possibility that giving incentive to exert effort may not be optimal for the principal, that is , the optimal system is designed in the following way:It first finds out, among the contracts that provides incentive to the agent for taking effort, the contract that minimizes the cost of providing a given initial value .Then, it finds out the contract, among the contracts that doesn't provide incentive for the agent to take effort, the contract that minimizes the cost of providing a given initial value (obviously the solution for this is a constant consumption stream in all states and all periods). The contract then finds out the minimum of these two minimized costs and therefore also tells us whether or not providing incentive to agent to take effort is optimal (a description of this program is in the appendix).

The solution for this cost function is shown in figure1. It turns out that providing effort is optimal for the range of V of $200 < V <= 400$ (other values of V were not considered), so for the initial expected utility that is provided by the current Japanese system, which is 373.3, providing effort is optimal in the optimal health insurance contract. Let's look at the solution to the optimal contract . Figure 1 shows the expected discounted cost of providing different levels of initial expected utility. This cost function is increasing and convex. Figures 2, 3, and 4 show the optimal level of V_0^h, V_0^s and V_0^p as functions of V. As explained in Proposition 3, they are increasing. Figure 5 shows the optimal path of premium for an agent who continues to be healthy , and figure 6 shows the consumption of an agent in case of temporary sickness, when he continues to be temporarily sick[2]. Figures 1-6 altogether give us an idea of what an optimal health insurance policy should look like. Initially, the system is very generous, it actually only requires to pay a tiny amount of premium, and coverage in case of temporary sickness is also very high. Premium continues to be the small (actually it should decrease, as far as our theory says) as one continues

[2]While figure 6 matches the predictions of the theory that it goes down over time, figure 5 doesn't match with prediction from the theory, because it was supposed to go up, rather than remaining constant. If we look at the f.o.c.'s and envelope conditions, it can be seen that while V^h is supposed to be larger than V and V^s is supposed to be smaller than V, given the parameter values of probabilities, the difference between V^h and V is far smaller than the difference between V^s and V.Given my computation method (finite number of grids), it is possible that the optimal level of V^hchosen is the same as V.

to be healthy. On the other extreme, a person who continues to be temporarily sick will receive only 20% coverage after 8 periods. But given our estimates of probability of illness, the probability of such event is very small.

From figure 1 we see that at the value of initial expected utility of 373, the(expected discounted) cost of providing it was 272. This means that cost saving by switching to the optimal system I proposed here could be around 40%. This significant gain in cost saving is explained by the fact that the current system fails to provide incentive to the agents to exert health promotion effort .The optimal system is designed in such a way that people exert health promotion effort in all periods. This reduces the probability of sickness in all periods, which in turn reduces the expected cost of providing health insurance.

3.4 Sensitivity Analysis:

In this section, I examine how much sensitive my results are to the assumptions that I have made. One major handicap in any analysis of moral hazard is that it is hard to estimate the disutility from effort, since effort itself is unobservable. Although the assumptions about the forms of the utility functions that I made here are pretty much standard in the literature, it is still worth investigating how our results change as we change some parameters of it. I would specially see what happens if we change the value of r, the coefficient of effort in utility function (which represents the disutility of agent from effort), since we don't have estimate of agent's disutility from effort .

Table1 summarizes the results from this analysis. At our benchmark case, $r = 1$, in the current policy agent does not exert effort .The optimal policy reduces cost by reducing the probabilities of loss(illness) by making the agent exert effort, and that explains the cost saving.

If the value of r is high, that would mean that disutility from effort is high. To make the agent exert effort, the current policy has to make more variation in consumptions in case sickness and in case of being healthy. But since the agent's utility function is concave, more variation in consumption would reduce utility. Therefore to provide the same initial expected utility, now the agent has to be provided with higher level of consumption. This would drive the cost of implementing the optimal policy high, if incentive to exert effort is to be provided. As we can see in the table, at $r = 1.5$, the cost saving has reduced to 22%. At $r = 2.1$, there is almost no cost saving. When $r \geq 2.3$, taking effort is not optimal even in the optimal policy. There is still small cost saving from switching to optimal policy, through consumption smoothing.

A lower value of r represents a lower level of disutility from effort. So by similar reasoning as before, as long as the current system does not provide incentive to take effort, the cost saving would be higher . At $r = .29$, cost saving is as high as 68%. But note here that the current system does not necessarily provide full insurance to the agent. Therefore if the disutility from effort is low enough, the agent might choose to take effort even under the current system. But if that is true, then the cost saving from the optimal system should be minimal. This is seen at $r = .28$, taking effort (in most of the periods) is optimal even under the current system, and consequently the cost of implementation under the current system suddenly decreases to 147.54. Therefore the cost saving from switching to the optimal system is tiny.

However, at further lower values of r, the optimal system can provide enough incentives for taking effort and can yet design the insurance system close to full insurance.Therefore, it can implement the optimal system at a lower cost than the current system, through consumption smoothing.

4 Conclusion:

In this paper I have investigated the optimal structure of a multi-period health insurance policy under moral hazard. The results here have shown us an extent of how large the cost of this moral hazard may be. However it was done in the context of a mandatory health insurance system which is, theoretically, simpler to analyze. A more sophisticated model would consider a health insurance system which provides incentives so that the agent do not switch to alternative plans. Further research can be done in that direction.

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Appendix

1. The Cost Minimization Problem:

$$C1(V) = \min_{c,V^h,V^s,V^p} c - y + \beta\{p_p^1 W(V^p) + p_s^1 C_1(V^s) + (1 - p_p^1 - p_s^1)C(V^s)\}$$

$s.t.$

1. $\beta\{(p_s^1 - p_s^0)(V^s - V^h) + (p_p^1 - p_p^0)(V^p - V^h)\} \geq 1$

2. $u(c) - 1 + \beta\{(p_s^1 V^s + p_p^1 V^p + (1 - p_s^1 - p_p^1)V^h = V$

$$C2(V) = \min_{c,V^h,V^s,V^p} c - y + \beta\{p_p^0 W(V^p) + p_s^0 C_1(V^s) + (1 - p_p^0 - p_s^0)C(V^s)\}$$

$s.t.$

$$u(c) + \beta\{(p_s^0 V^s + p_p^0 V^p + (1 - p_s^0 - p_p^0)V^h = V$$

$$C(V) = \min\{C1(V), C2(V)\}$$

$C_1(V)$ is also calculated in asimilar way.

2. Proof of Proposition 1:

The following lemma needs to be proved for proving this proposition:

Lemma 1: η is positive.

Proof: Suppose not. Then that immediately implies that $V^h = V^s = V$. Incentive compatibility then requires that $V^p < V$. Given (3) and (5) and the fact that u is strictly cancave, it must be that $c_p = c$. Now, putting (M1) into constraint 1, and after some algebra ,we get,

$$-1 + \beta p_p^1 (V^p - V) = (V - V^p)(1 - \beta)$$

The left hand side of this equation is negative , while the right hand side should be strictly positive, which is a contradiction.

Q.E.D.

Proof of the proposition: Since $\eta > 0$, it follows that $C_1'(V^s) < C_1'(V)$. Now if we denote the consumption at the second period in case of temporary sickness as c_s, then envelope condition tells us that,

$$C_1'(V^s) = \frac{1}{u'(c_s)}, \text{ and } C_1'(V) = \frac{1}{u'(c)}$$

Strict concavity of u then implies that $c_s < c$.Similarly one can prove that $c_h > c$, where c_h is the consumption at the second period in case of being healthy. Therefore $c_h > c_s$, which implies that full insurance for the second period will not be offered.

Now let c_{hh} be the consumption promised in the third period in case of being healthy in that period, given that the second period health status was healthy. Also define c_{ss} similarly. Then the analysis above implies that $c_{hh} > c_h > c$ and $c_{ss} < c_s < c$. This result, together with the fact that state dependent income and sickness probabilities do not change over time, establishes the claim above.

Q.E.D.

3. Proof of Proposition 2:

Let $V_t^{h_1 h_2 h_3..h_t}$ be the value promised to the agent in the optimal contract at period $t >= 1$ when health status history up to period t is $(h_1, h_2, h_3, .., h_t)$. Then, from equations (5)-(8), we get,

$$C'(V_0) = p_p^1 W'(V_1^p) + p_s^1 C_1'(V_1^s) + (1 - p_p^1 - p_s^1) C'(V_1^h) \tag{A1}$$

$$C'(V_1^h) = p_p^1 W'(V_2^{hp}) + p_s^1 C_1'(V_2^{hs}) + (1 - p_p^1 - p_s^1) C'(V_2^{hh}) \tag{A2}$$

$$C_1'(V_1^s) = p_p^1 W'(V_2^{sp}) + p_s^1 C_1'(V_2^{ss}) + (1 - p_p^1 - p_s^1) C'(V_2^{sh}) \tag{A3}$$

and so on.

Suppose now, to the contrary of the proposition, that the value promised in case of permanent sickness is independent of time and history. That is,

$$\forall t, V_t^{h_1 h_2 h_3..h_t} = V \text{ if } h_t = p$$

Then , by replacing equations (A2),(A3) and all the corresponding equations for the later periods into (A1), we get,

$$\begin{aligned} C'(V_0) &= p_p^1 W'(V) + (1 - p_p^1) p_p^1 W'(V) + (1 - p_p^1)^2 p_p^1 W'(V) + ... \\ &= W'(V) \end{aligned} \tag{1}$$

Equation (5) then tells us that $\eta = 0$, which is a contradiction (to lemma1).

Q.E.D.

4. Proof of proposition 3:

Suppose that the optimal solution to the minimization problem (M2) (or (M3)) given initial value V is V^h, V^s, V^p, c, η . And for a higher initial value $\overline{V}$, these solutions are $\overline{V^h}, \overline{V^s}, \overline{V^p}, \overline{c}, \overline{\eta}$ respectively.

Since C is strictly convex, thereofore $C'(\overline{V}) > C'(V)$. Then from (8), we have $\overline{c} > c$. From (5)-(8),we get

$$W'(V^p) - W'(\overline{V^p}) = C'(V) - C'(\overline{V}) + (\eta - \overline{\eta})\frac{p_p^1 - p_p^0}{p_p^1} \tag{10}$$

$$C'(V^s) - C'(\overline{V^s}) = C'(V) - C'(\overline{V}) + (\eta - \overline{\eta})\frac{p_s^1 - p_s^0}{p_s^1} \tag{11}$$

$$C'(V^h) - C'(\overline{V^h}) = C'(V) - C'(\overline{V}) + (\eta - \overline{\eta})\frac{p_p^1 + p_s^1 - p_s^0 - p_p^0}{1 - p_s^1 - p_p^1} \tag{12}$$

Now given our assumption here, the incentive compatibility constraint can be written as

$$\beta\{p_s^1(V^s - V^h) + p_p^1(V^p - V^h)\} = \frac{1}{\alpha}$$

Now note that given our assumption the right hand sides of equations (10) and (11) are identical. Therefore left the hand sides of both equations (10) and (11) should have the same sign. Given strict concavity of and this would imply that,

$$\overline{V^p} \leq V^p \text{ if and only if } \overline{V^s} \leq V^s$$

Now suppose that $\overline{V^p} \leq V^p$. Then, from (10), it must be that $\eta - \overline{\eta} < 0$. But then the left hand side of (12) is negative, which implies that $\overline{V^h} > V^h$ .But then

$$\beta\{p_s^1(\overline{V^s} - \overline{V^h}) + p_p^1(\overline{V^p} - \overline{V^h})\} < \frac{1}{\alpha}$$

that is, the incentive constraint is violated.

Therefore it must be that $\overline{V^p} > V^p$. Then $\overline{V^s} > V^s$. Incentive constraint then requires that $\overline{V^h} > V^h$.

Q.E.D.

5. Proof of Proposition 4:

Suppose that the optimal solution to the minimization problem (M2) (or (M3)) given initial value V is V^h, V^s, V^p, c, η . And for a higher initial value $\overline{V}$, these solutions are $\overline{V^h}, \overline{V^s}, \overline{V^p}, \overline{c}, \overline{\eta}$ respectively.

Since C is strictly convex, thereofore $C'(\overline{V}) > C'(V)$. Then from (8), we have $\overline{c} > c$.Then , from (10), and given strict concavity of W and C, its clear that $\overline{V^p} > V^p$. Now suppose $\overline{V^s} \leq$

V^s.Using the same logic as in the proof of proposition 3, it can be shown that $\overline{V^h} > V^h$. But then $\beta\{(p_s^1 - p_s^0)(\overline{V^s} - \overline{V^h})\} < 1$, which violates the incentive compatibility constraint. Therefore it must be that $\overline{V^s} > V^s$.

Q.E.D.

Table 1: Cost savings from switching to the optimal contract, for different values of r (disutility from effort):

Value of r	U_0	C_0	C	$(C_0-C)/C_0$
3	373.3	459.2	457	.5%
2.5	373.3	459.2	457	.5%
2.1	373.3	459.2	451	2%
1.5	373.3	459.2	352	23%
1 (benchmark)	373.3	459.2	271	40%
.5	373.3	459.2	185	60%
.29	373.3	459.2	147	68%
.28	373.3	147.5	145	1%
.25	373.9	147.5	147	.0%
.1	376.3	147.5	147	.3%
0	377.9	147.5	143	3%

Here,

U_0= Initial expected utility that current policy generates.

C_0= Expected cost of providing this utility in current policy.

C= Expected cost of providing the same utility in the optimal policy.

$(C_0-C)/C_0$= Cost saving from switching to the optimal policy.

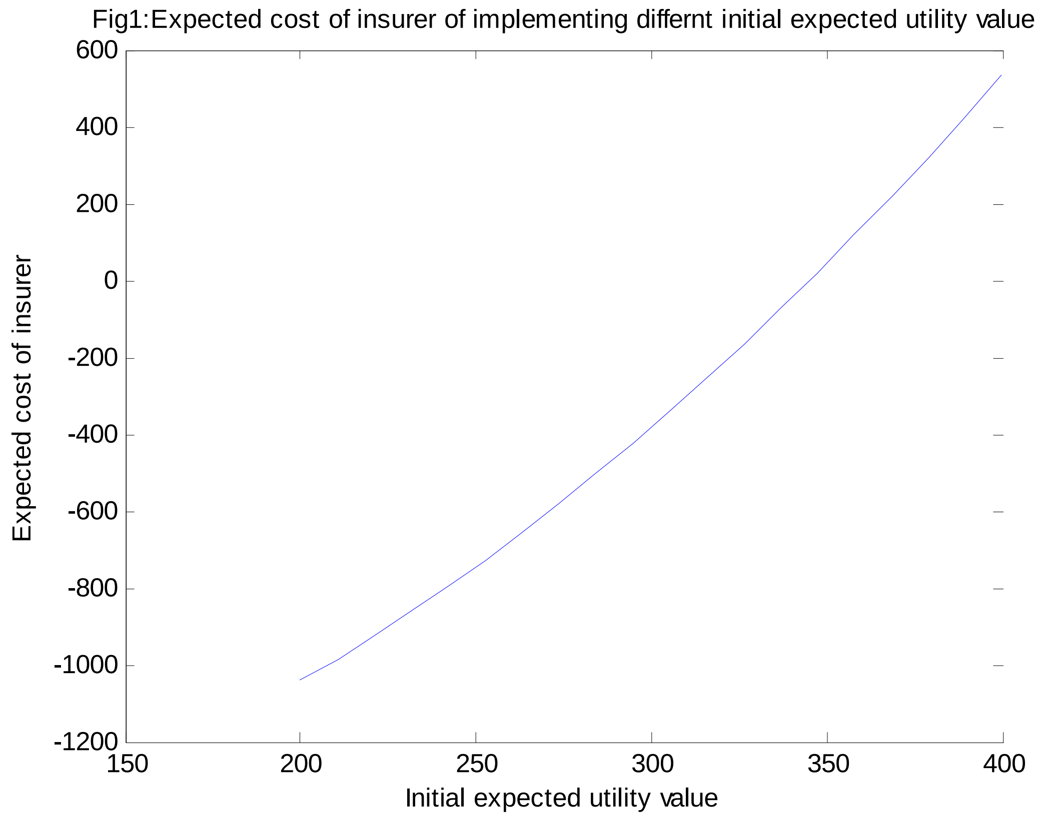


Fig1:Expected cost of insurer of implementing differnt initial expected utility value
Expected cost of insurer
600
400
200
0
-200
-400
-600
-800
-1000
-1200
150
200
250
300
350
400
Initial expected utility value

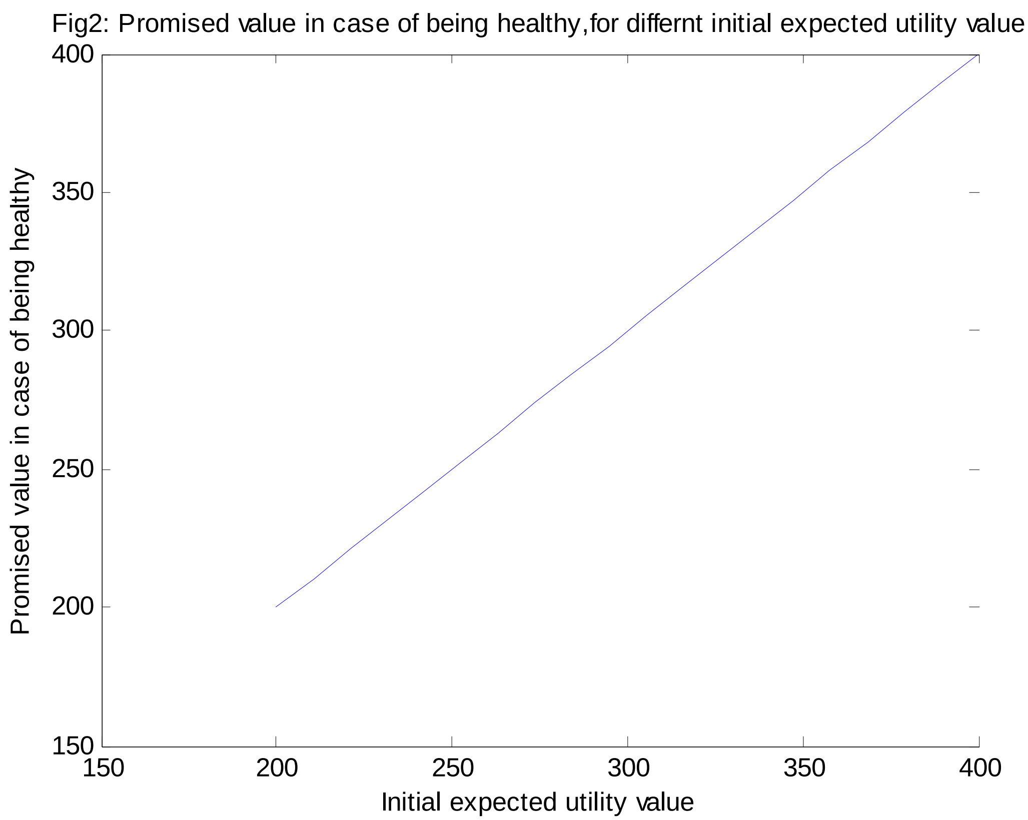


Fig2: Promised value in case of being healthy,for differnt initial expected utility value
Promised value in case of being healthy
400
350
300
250
200
150
150
200
250
300
350
400
Initial expected utility value

Fig3: Promised value in case of temporary sickness,for differnt initial expected utility value

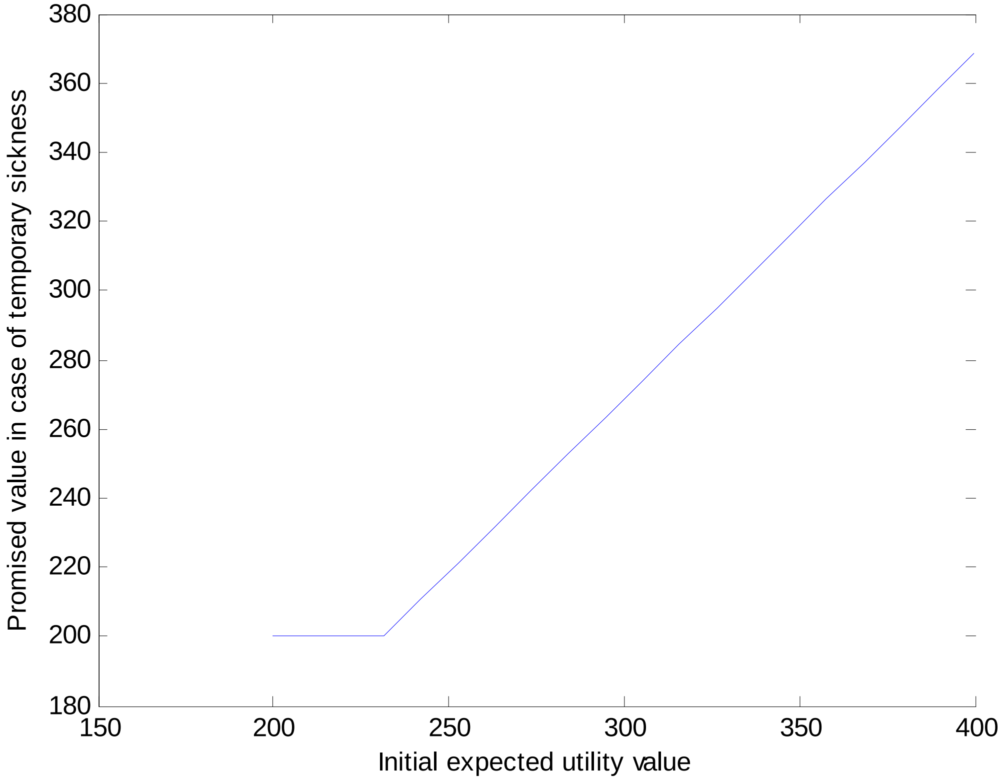
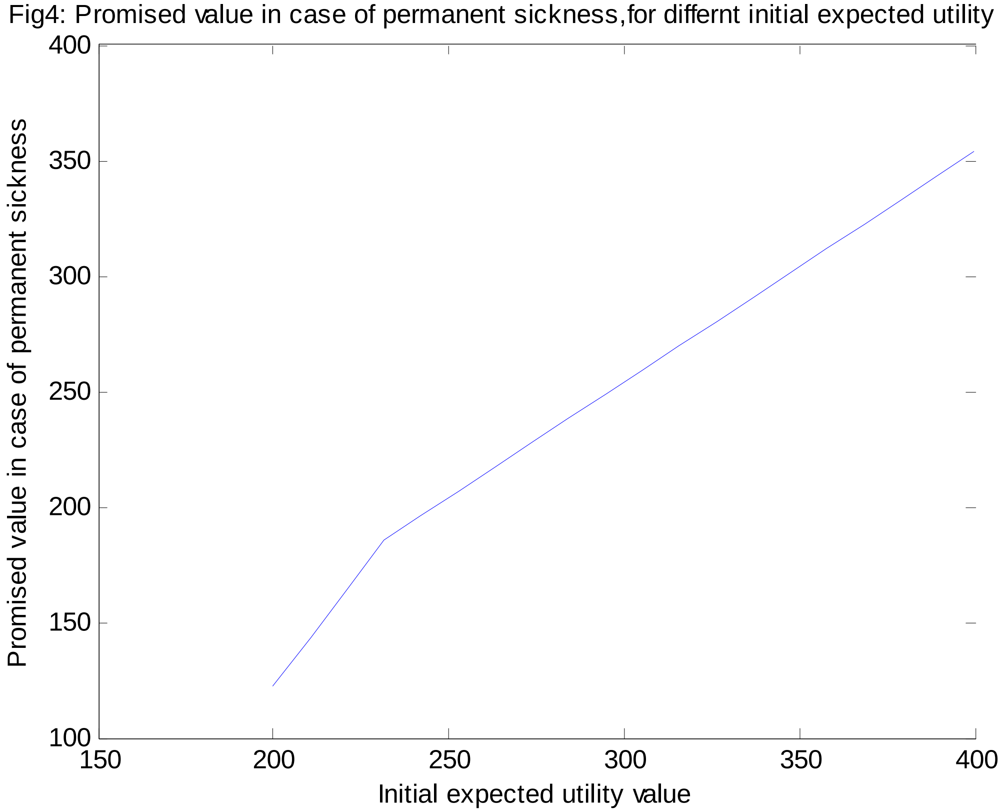


Fig4: Promised value in case of permanent sickness,for differnt initial expected utility value



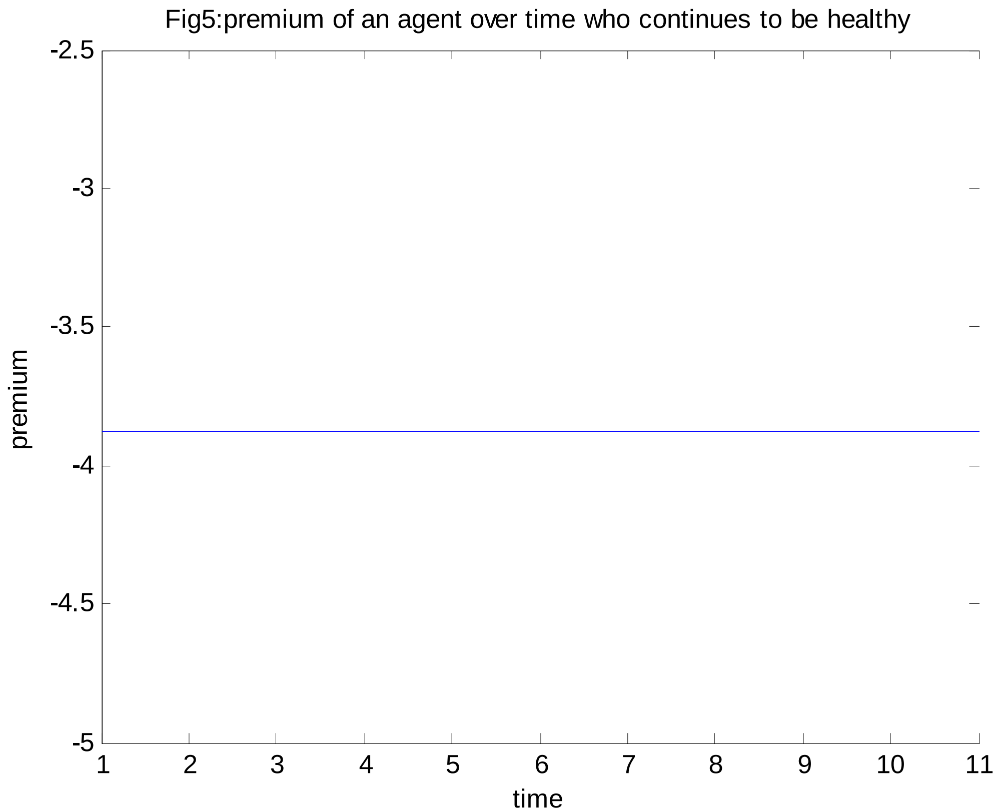


Fig5:premium of an agent over time who continues to be healthy
premium
time
-2.5
-3
-3.5
-4
-4.5
-5
1
2
3
4
5
6
7
8
9
10
11

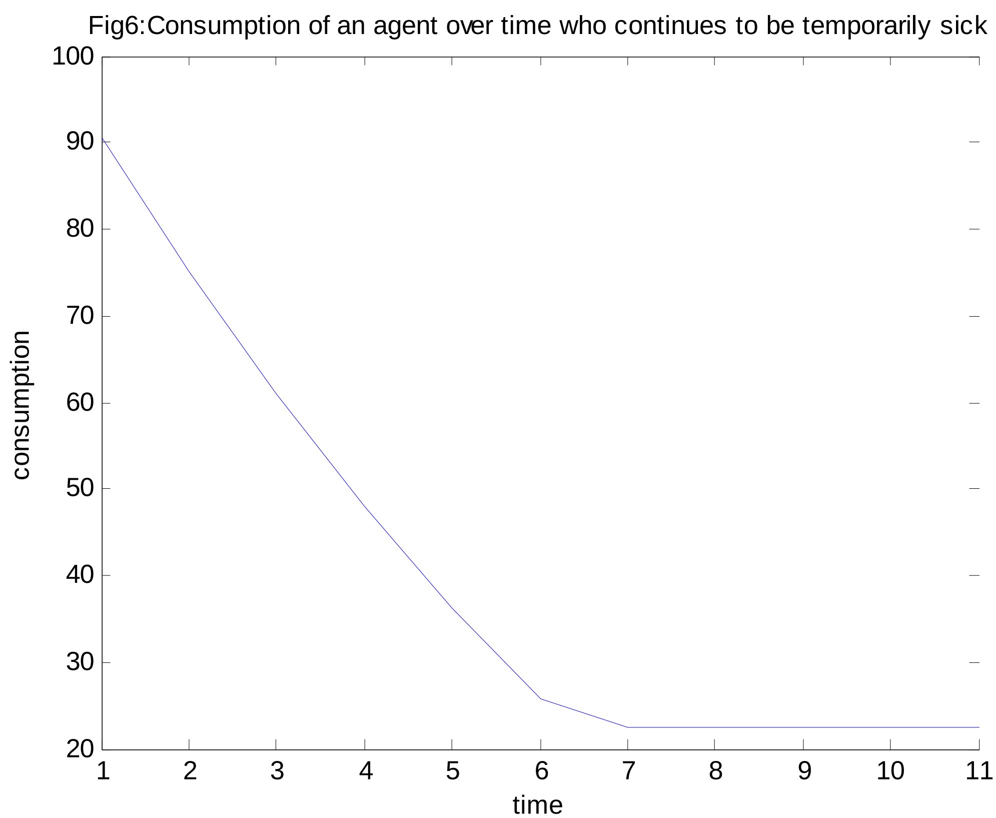


Fig6:Consumption of an agent over time who continues to be temporarily sick
consumption
time
100
90
80
70
60
50
40
30
20
1
2
3
4
5
6
7
8
9
10
11