CSCanada
International Business and Management
Vol. 4, No. 1, 2012, pp. 92-96
DOI:10.3968/j.ibm.1923842820120401.1005

ISSN 1923-841X[Print]
ISSN 1923-8428[Online]
www.cscanada.net
www.cscanada.org

The Application of the Fuzzy Probability Model in Basic Medical Insurance Hazard Assessment in China

WANG Ling[1,*]; ZHONG Junsheng[2], ZHANG Qian[3]

[1]Department of Economics and Business, Liaoning Shihua University, 113001, China; School of Humanities and Law, Northeastern University, Shenyang, China, 110819
[2]Department of Economics and Business, University of Liaoning Shiyou Huagong, 113001, China; School of Humanities and Law, Northeastern University, Shenyang, China, 110819
[3]Department of Economics and Business, University of Liaoning Shiyou Huagong, 113001, China
[*]Corresponding Author.
Address: Department of Economics and Business, Liaoning Shihua University, 113001, China
Email: yoyothing@126.com

Received 10 December 2011; Accepted 12 January 2012

Abstract
Since 1980s, Chinese government has taken a series of reforms to the traditional medical insurance system, but it still remained to get medical service unaffordably. The high medical fees and the decreasing balance of medical insurance fund are existed at the same time, thus the problem of researching social medical insurance hazard is becoming an urgent task. The article brings the theory of fuzzy probability in fuzzy math applied to social medical insurance hazard assessment. The model has fully considered the fuzziness and randomness of medical insurance with clearly rationality and reliability, providing new views for establishing effective medical insurance against hazard system.

Key words: Basic medical insurance; Fuzzy probability; Moral hazard

WANG Ling, ZHONG Junsheng, ZHANG Qian (2012). The Application of the Fuzzy Probability Model in Basic Medical Insurance Hazard Assessment in China. *International Business and Management, 4*(1), 92-96. Available from: URL: http://www.cscanada.net/index.php/ibm/article/view/j.ibm.1923842820120401.1005
DOI: http://dx.doi.org/10.3968/j.ibm.1923842820120401.1005

INTRODUCTION

The basic medical insurance system in our country has widespread the whole country since 2001 and during this period, the fund operate stable. Up to December in 2006, the amount of 157,370,000 has attended this system. The annual income of the basic medical insurance fund was 172,781 billion RMB and the payout was 127,489 billion RMB, comparing to last year increase 22.98% and 18.15% respectively. At the end of the year, the basic medical insurance fund balance accumulated 172, 01 billion, of which the overall fund balance of 105, 594 billion Yuan and the accumulation of individual accounts were 66, 416 billion Yuan. The basic medical insurance system has get fantastic results in the reforming research.

Nevertheless, there are many problems seriously threatening the both ends meet of the medical insurance fund recently, such as the bigger pressure and hazard of basic medical insurance fund for the urban workers, the irrationally rise in concealed base pay and medical fee, the rapid in aging population. According to statistical results, from 2002 to 2006, the annual rate of our basic medical insurance fund payout has increased to 39.2%., while the income rate is 35.09%. Every year the payout increase rate is always bigger than those of income. Therefore, it has become a focus issue of the whole society to know how to prevent basic medical insurance fund hazard.

In the national literature about basic medical insurance hazard, mostly discussing how to prevent but rare in evaluate the degree of it. Meanwhile, when it comes to medical hazard, we often adopt fuzzy analysis while they adopt probability analysis in foreign countries. Because medical insurance hazard problem is uncertain and complicate, and the uncertain includes probability and randomicity, basing the theory of fuzzy probability in fuzzy math to handle this problem is very rational and necessary.

This article introduces fuzzy probability evaluate model to provide a new thought to the establishment of basic medical insurance hazard prevention system.

1. MATHEMATICAL MODEL

1.1 Fuzzy Probability Theory and Evaluate Model

1.1.1 Fuzzy Probability Theory

There are three relations between fuzzy and probability: the first one is that the event is fuzzy itself but the probability is numerical value so-called the probability of fuzzy event. The second is that the event is certain itself but probability is fuzzy so-called the fuzzy probability of event. The third is that both of the event and probability are fuzzy so-called fuzzy probability of the fuzzy event.

As for the probability of the fuzzy event A, if the $U=\{u_1,u_2,\cdots,u_n\}$ is finite set, so its definition is

$$P(\underline{A})=\sum_{i=1}^{n}\underline{A}(u_i)p_i \tag{1}$$

Among it, $p_i=p(u_i)$,i =1, 2, …, n, Therefore, finding the probability of fuzzy event is actually the expected value calculated, when the membership function of the event is known, the problem is solved.

For a fuzzy probability of clear events, like the classical probability cannot be used to indicate the number $[0,1]$, but the words can; that is to fuzzed the normal probability, expressing in fuzzy language. Therefore, the probability of fuzzy event, also known as the probability of fuzzy language, referred to as the language of probability.

Because of the probability $p\in[0,1]$ the language probability is based on domain of $[0,1]$ and its range of values known as the language of probability space as ε The value of the language probability space must meet two conditions: (a) it has a certain linguistic characteristics, (b) the probability that it can meet the computing requirements.

In conclusion, ε is a probability language system includes many original words which closed to fuzzy operator. That is in the system that the probability of any linguistic value, the fuzzy logic operation and the role of operator and is still in the system is still the language of probability values.

In order to limit the probability language branch in $[0,1]$ Probability language value algorithms are defined as Suppose $\pi_i\in_\varepsilon$, $a_i\in[0,1]$,i =1, 2,…, n; then the linear combination of $\{\pi_i\}$ can be defined as probability language value:

$$(a_1\pi_1+a_2\pi_2+\cdots+a_n\pi_n)(P) \triangleq \bigvee_{\substack{a_1p_1+\cdots+a_np_n=p\\ p_1+\cdots+p_n=1}}\left(\pi_1(P_1)\wedge\cdots\wedge\pi_n(P_n)\right) \tag{2}$$

At this point, π_1 ,…, π_n a linear combination will set limits in $[0,1]$, that is the probability value for the language specified operation is closed. This language defines the probability of fuzzy event to create the conditions.

For the language of fuzzy event probability is the probability of fuzzy events, based on the common language of probability p_i into the probability of fuzzy events π_i can be fuzzy probability. That set $\underline{A}$ is a fuzzy event, $p(u_i)=\pi_i$ defines

$$\mathrm{P}(\underline{A})=\underline{A}(u_1)\pi+\underline{A}(u_2)\pi_2+\ldots+\underline{A}(u_n)\pi_n \tag{3}$$

as the fuzzy probability of probability events.

1.1.2 Fuzzy Probability Evaluate Model

According to the above fuzzy probability theory, the main steps of fuzzy probability evaluate are:

(1)Be certain the effect factor of main evaluation $u_i(i=1,2,\cdots,n)$,and evaluatedegree $v_j\ (j=1,2,\cdots,m)$,so that establish the evaluate affection factor U and degree evaluation V, that is defined two domains:

$$U=\{u_1,u_2,\cdots,u_n\} \tag{4}$$

$$V=\{v_1,v_2,\cdots,v_m\} \tag{5}$$

(2)Defined the evaluate affection factor u_i ($i=1,2,\cdots,n$)in U as the single factor evaluation ,that is based on the relations between u_i and the evaluate degree v_j ,to define or choose its membership function $v_j(u_i)$ to define v_j as the probability subset of domain U:

$$v_j=\frac{v_j(u_1)}{u_1}+\frac{v_j(u_2)}{u_2}+\cdots+\frac{v_j(u_n)}{u_n} \tag{6}$$

(3)To certain the fuzzy weight of the evaluate affection factor u_i is π_i ($i=1,2,\cdots,n$), that means to regard weight as fuzzy number:

$$\pi_i=\text{“close to }\lambda_{i,0}\text{”}=$$

$$\frac{\beta_{i,1}}{\lambda_{i,1}}+\cdots+\frac{\beta_{i,k}}{\lambda_{i,k}}+\frac{\beta_{i,k+1}}{\lambda_{i,k+1}}+\cdots\frac{\beta_{i,2k}}{\lambda_{i,2k}} \tag{7}$$

Among it , $\lambda_{i,0}$ is weight respectively, can be certained by Analytic Hierarchy, and to meet $\sum_{i=1}^{n}\lambda_{i,0}=1$;coefficient $\beta_{i,1}(i=1,2,\cdots,n,l=1,2,\cdots,2k)$ can be chosen by the reality. Based on probability theory, we can be chosen one of 0.5, 0.6, 0.7, 0.8, 0.9; the value of $\lambda_{i,1}(l=1,2,\cdots,2k)$ can be rational curtained by $\lambda_{i,0}$.

(4)To make use of the language probability formula of probability event (2)、(3):

$$(a_1\pi_1 + a_2\pi_2 + \cdots + a_n\pi_n)(P) \triangleq \bigvee_{\substack{a_1p_1+\cdots+a_np_n=p \\ p_1+\cdots+p_n=1}} \left(\pi_1(P_1)\wedge\cdots\wedge\pi_n(P_n)\right) \tag{8}$$

$$P(v_j) = v_j(u_1)\pi_1 + v_j(u_2)\pi_2 + \cdots + v_j(u_n)\pi_n \tag{9}$$

Among it , π_i is the fuzzy weight of the evaluate affection factor, p_i is the random value of respective domain$\{\lambda_{i,1},\cdots\lambda_{i,k},\lambda_{i,0},\lambda_{i,k}+1,\lambda_{i,2k}\}$, a_i is the i branch degree of evaluate degree; For the evaluate degree of j , a_i is $v_j(u_i)$. Therefore, we can conclude the fuzzy probability $P(v_j)$ of every evaluate degree of v_j

(5)According to focused information principle, we can get the integrate evaluation.

Focused information principle: If regard the fuzzy probability $P(v_j)$ of every evaluate degree of v_j :

$$P(v_j) = \frac{\alpha_{j1}}{x_{j1}} + \frac{\alpha_{j2}}{x_{j2}} + \cdots + \frac{\alpha_{jp}}{x_{jp}} \tag{10}$$

$$\sigma_j = \sum_{l=1}^{p} \alpha_{jl} x_{jl} \qquad j = 1,2,\cdots,m \tag{11}$$

Among it, α_{jl} is the branch degree of $(l=1,2,\cdots,p)$ of x_{jl} To deal with formula (11):

$$\overline{\sigma_j} = \frac{\sigma_j}{\sum_{j=1}^{m}\sigma_j}\ ,\ \overline{\sigma_N} = \max_j[\overline{\sigma_j}] \tag{12}$$

So the evaluate degree is N.

2. ANALYSIS

2.1 The Basic Medical Insurance Hazard Evaluation Index System

The evaluation of the basic medical insurance hazard indexes can be divided into subjective and objective.

Subjective hazard:moral hazard, adverse selection, doctors and hospital management of hazard, the insured hazards, health insurance institutions to manage hazards, insurance unit hazards.

Objective hazard: medical insurance payment hazard, medical technology hazard, health insurance payment hazard, age structure and old age aspect hazard, disease aspect hazard, financial aspect hazard, accidental disaster aspect hazard

We use the model of fuzzy probability to the basic medical treatment insurance hazard evaluation.Affection of evaluation factors set includes 13 sub factors,divided according to their properties U={U1,U2}={subjective hazard}objective hazard}.In which,U1={u1,u2,u3,u4, u5,u6}={moral hazard,adverse selection,doctors and hospital management of hazard,the insured hazards, medical insurance hazard management institutions,insurance unit hazards};U2={u7,u8,u9,u10,u11,u12,u13}={medical insurance payment hazard, medical technology hazard, health insurance payment hazard, age structure and old age aspect hazard, disease aspect hazardfinancial aspect hazard, accidental disaster aspect hazard}, Specific as shown in Table 1.

Table 1
Basic Medical Insurance Risk Evaluation Index System

		First-level evaluating indicator and weight	Second-level evaluating indicator and weight	The relative weight of evaluation index
Basic medical insurance hazard evaluation index system	subjective hazard 0.6	Moral hazard	0.2	0.12
		Adverse selection	0.1	0.06
		Doctors and hospital management of hazard	0.3	0.18
		The insured hazards	0.2	0.12
		Health insurance institutions to manage hazards	0.1	0.06
		Insurance unit hazards	0.1	0.06
	objective hazard 0.4	Medical insurance payment hazard	0.2	0.08
		Medical technology hazard	0.2	0.08
		Health insurance payment hazard	0.2	0.08
		Age structure and old age aspect hazard	0.1	0.04
		Disease aspect hazard	0.1	0.04
		Financial aspect hazard	0.1	0.04
		Accidental disaster aspect hazard	0.1	0.04

Evaluation setV={v1,v2,v3}={Light warning, Moderate warning, high warning}.

2.2 Basic Medical Insurance Hazard Fuzzy Probability Evaluation

Recently acts according to some banks in 2003 each target announcement the data as well as our country macroscopic finance overall target,carrying on the evaluation to this bank hazard. Table 2 have given each influencing factor ui regarding each opinion rating vj fuzzy relationship,namely degree of membership vj(ui),on the basis of the relative weights are determined,according to the theory of fuzzy probability,may suggest that each appraisal influencing factor ui(i=1,2,…,9) fuzzy weight is:

$$\pi_{i=\text{“close to}\,\lambda_{i,0}\text{”}} = \frac{\beta_{i,1}}{\lambda_{i,1}} + \frac{1_i}{\lambda_{i,0}} + \frac{\beta_{i,2}}{\lambda_{i,2}} \quad (13)$$

Table 2
The Evaluation Factors and Evaluation of the Fuzzy Equivalence Relations

Serial number	Hazard assessment index	Evaluation level		
		Light warning	Moderate warning	High warning
1	Moral hazard	0.1	0.6	0.3
2	Adverse selection	0.2	0.6	0.2
3	Doctors and hospital management of hazard	0.0	0.4	0.6
4	The insured hazards	0.0	0.3	0.7
5	Medical insurance hazard management institutions	0.3	0.5	0.2
6	Insurance unit hazards	0.2	0.5	0.3
7	Medical insurance payment hazard	0.4	0.5	0.1
8	Medical technology hazard	0.1	0.3	0.6
9	Health insurance payment hazard	0.1	0.5	0.4
10	Age structure and old age aspect hazard	0.0	0.6	0.4
11	Disease aspect hazard	0.2	0.6	0.2
12	Financial aspect hazard	0.3	0.6	0.1
13	Accidental disaster aspect hazard	0.3	0.6	0.1

Among it，relative weights the results of as shown in Table 1；considering the the fluctuation range of relative weights，the coefficient $\lambda_{i,1}=\lambda_{i,0}$-0.04，$\lambda_{i,2}=\lambda_{i,0}$+0.04；at the same time，according to the theory of fuzzy probability，take the coefficient $\beta_{i,j}$= 0.8(i=1,2,…,9; j=1,2).

At this point,we can use the formula (2)、(3) to calculate the fuzzy probability P(vj)of each evaluation level vj(j=1,2,3),again by information centralized principle ,then obtains the normalized information centralized value of each opinion rating vj,namely:(0.188, 0.447, 0.365).Therefore,comprehensive evaluation of the basic medical insurance is high hazard. What needed to point out is the calculation process can be realized using Matlab programming,thus obtain the evaluation results.

CONCLUSION

This model's establishment has applied in the fuzzy probability theory in fuzzy mathematics. Full consideration of the specific circumstances of Chinese basic medical insurance, which had determined the numerous factors that affects our country basic medical insurance, including moral hazard, adverse selection, doctors and hospital management of hazard, the insured hazards, medical insurance hazard management institutions, insurance unit hazards medical insurance payment hazard, medical technology hazard, health insurance payment hazard, age structure and old age aspect hazard, disease aspect hazard, financial aspect hazard, accidental disaster aspect hazard. When managing the basic medical insurance for its hazard. considering the factors comprehensively, thus formulates the related policy is very essential. In this way, we can guarantee the basic medical insurance that meets the insured medical expenses, there may be sufficient to resist the accumulation of hazard, thus serving to reduce the insured the burden of excessive fees.

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