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中央财经大学中国保险市场研究中心　编著

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目　录

Measuring the Impact of Longevity Risk on Annuity Insurance Products

Hao Yansu① Du Juan②

Abstract: It is an inevitable trend that the human life span will be extended with economic development, scientific and technological advancement, medical improvement and a change towards a healthy lifestyle. Though longevity has some positive influences on human beings, its influence on life assurance products should not be underestimated, especially the enormous solvency pressure on annuity insurance products. Using the international outstanding research achievements in relevant areas for reference, this paper firstly summarizes the overall exposure of longevity risk in China by the analysis of life expectancy and economy, and then makes a quantitative analysis of benefit payment pressure on annuity insurance products caused by longevity risk using the Lee – Carter model and annuity model in actuarial method, finally suggests the best way for the Chinese insurance industry to hedge longevity risk at present according to the analysis above.

Keywords: longevity risk, Lee – Carter model, mortality rate

1. Background and Literature Review

1.1 Background

The problem of an ageing population has been a universal focus of all countries since France first became an ageing country③ in the 1860s. With more focus on it, longevity is now a growing concern for the international community. The life expectancy of the world population was only 45.9 years during 1950 – 1955. The figure reached 65.4 during 1995 – 2000 and is expected to rise to 74.3 between 2045 and 2050. ④The report on world population in the year 2300 issued by United Nations Population Division predicts that the life expectancy will continue to extend. It is reported that the life expectancy will reach up to 95 years for men and 97 years for women in 2300, More seriously, life expectancy in some countries or regions will be over 100 years. ⑤

There are about 1.3 billion people in China, which makes China the most populous country in

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③ According to international standard, a country can be defined as an ageing country if either the population above 60 years old reaches up to 10% or the population above 65 years old reaches up to 7%.

④ Data resource: Zhang Yungang, the System of Endowment Insurance in China under the Background of Ageing, the Southwest University of Finance and Economics Press, 2005, P32.

⑤ Data resource: Zhang Yungang, the System of Endowment Insurance in China under the Background of Ageing, the Southwest University of Finance and Economics Press, 2005, P56.

the world. According to the internationally accepted standard, China has entered an ageing society. Moreover, Longevity of Chinese is a growing concern in recent years. The previous census data shows that the annual average increased population has a trend to accelerate in the number of senior citizens who are 65 years old, 80 years old, 100 years old and above. Moreover, the number of people over 80 years old grows much faster than that of other age groups.

Though longevity has some positive influences on human beings, it is also a kind of risk. At present, China is still an emerging developing country. Though the overall economy grows with a high speed, the large population base drives per capita level down a lot. With life expectancy increasing, the accumulation of wealth during the working period is often insufficient to cover the expenses after retirement, which could trigger personal financial deficit. One of the solutions is that one can transfer the risk to an insurance company by purchasing an annuity insurance product, especially the whole life annuity product. From the consumers' point of view, it can be an effective way to resist the longevity risk under the current trend of the increasing living standard and the extended life expectancy, because the longer they live, the more they receive. However, from the insurance companies' point of view, although the ageing population has led to a huge demand in endowment insurance market, it also hints at a bigger difficulty of products' pricing and an upcoming peak of the benefit payment.

The insurer prices annuity insurance products according to the experience mortality table. However, the experience mortality table is based upon the mortality rate in a certain period. With time－variation, the mortality rate changes a lot but the experience mortality table does not change at the same time. Therefore, the problem of applying experience mortality table is that there will be a lag between the calculations using the actual mortality rate and the experience mortality rate. Longevity means that the actual mortality rate is lower than the expected mortality rate, which could affect the calculation of mortality gain, and further more affect the calculation of the reserve, meantime, longevity also means an extending of the benefit payment cycle, which could make the actual payments and expenses higher than the expected ones, and thereby affecting the calculation of expense gain, interest rate gain and other profit standards. In the end, insurance companies will be confronted with solvency pressure in the original price level. If insurers do not prepare for it in advance, the liquidity of their financial resources will undergo a rigorous test. So, a study on the impact of longevity risk on annuity insurance products has become a necessity.

1.2 Literature Review

Since longevity risk has become a hot topic only in recent years, the literature in this field is relatively new. Bauer, et al. (2007) analyze longevity risk using the maximum likelihood method from the mortality rate aspect, according to the understanding of demography and epidemiology. However, it focused more on mortality model and there is no deep analysis on the impact of longevity risk. Emilia, et al. (2003), Stephen, et al. (2004), Frederik, et al. (2007) and P. Antolin (2007) all analyze longevity risk from the aspect of its impacts on others. Among them, Emilia, et al. (2003) analyze the combined effects that longevity risk and financial risk have on insurance contracts, using random mortality model in actuarial method; Stephen, et al. (2004) weigh the degree of the risk exposed to insurance companies and pension holders by analyzing longevity risk's impact on existing annuity contracts; Frederik, et al. (2007) analyze the impacts of longevity risk and investment risk on immediate annuity; P. Antolin (2007) analyze the uncertain factors which would affect the future mortality and income, and the impact of longevity risk on the defined benefit private pension plans. However, none of them was specialized in the analysis on longevity risk's impact on annuity contracts from the perspective of insurance companies. Jeffrey (2003), Samuel, et al. (2005), Andrew, et al. (2006) and Pierre, et al. (2007) all suggest some ways to hedge longevity risk. Jeffrey (2003) is through from the pensions and social security aspects while the others are through from securitization aspect. However, none of them is through from premium rate and sum insured aspects of insurance companies. Therefore, it is innovative that this paper uses Lee - Carter model to analyze the impacts longevity risk has on annuity contracts, from insurance companies' point of view. It is also innovative that this paper tries to work out the effective ways for insurance companies to hedge longevity risk, by adjusting the premium rate and the sum insured. What's more, among all the literatures above, Frederik, et al. (2007), Pierre, et al. (2007) and P. Antolin (2007) all used Lee - Carter model in their researches, but based on data from United Kingdom, Belgian and OECD① countries respectively. However, we could still use them for reference.

In China, longevity risk is such a relatively new topic that the researches on this are quite rare. Liu Anze, et al. (2007) forecats the development trend of mortality in the future, by using Lee - Carter model; Chen Bingzheng, et al. (2007) analyze how longevity risk influences the pricing of life insurance products, by using actuarial method from mortality aspect, according to both the old experience mortality table of Chinese life insurance industry (1990 - 1993) and the new table (2000 - 2003); Moreover, both Chang Ling (2006) and Zhang Jinfeng (2006) propose ways to hedge longevity risk. Chang Ling (2006) establishes a pricing model of reverse mortgage loan against longevity risk , by using interest rate risk and price volatility risk model, while Zhang Jinfeng (2006) analyzes the impact of longevity risk on pensions, using both statistical and econometrical methods combined with Excel and Spss software, and further more, establishes a premium rate model which could balance personal pension accounts. Most of the literatures above only refer to one aspect of the longevity risk, either the predictions of life expectancy or the solutions of longevity risk.

2. Basic Factors Related to Longevity Risk

2.1 Life Expectancy

The age structure of Chinese has experienced two basic stages in its development, since the foundation of the People's Republic of China. From the 1950s to the 1970s, the total population expanded blindly and developed in a younger direction. In the early 1970s, the birth rate greatly reduced due to the vigorous promotion of the family planning policy, which resulted in a great decline

① Organization for Economic Cooperation and Development.

of children's proportion, and the population developed in the ageing direction. In recent years, as living standards, public health, medical technology and personal health awareness improved, the longevity of Chinese is developing accompanied by the ageing, and the life expectancy has a very substantial growth.

It is shown that the annual mortality rate of Chinese between 1978 and 2005 in figure 1. It can be seen that the mortality rate is volatile during 1978 – 1983, which experiences a rapid decline after a short rise from 6.25‰ to 6.9‰. Though the mortality rate fluctuates slightly in 1986, 1991 and 1995, it keeps a stable decline since 1995, gradually from 6.57‰ in 1995 to 6.4‰ in 2003, maintaining a decline ratio of about 0.327%. Taking one with another, the mortality rate still keeps a downward momentum, although the curve displays a higher trend in 2004 and 2005.

It is shown that the proportion of the number of people in all ages between 1995 and 2005 in figure 2, which can be clearly seen the trend of ageing population in China. The proportion of the population among 0 – 14 years old is relatively small, about 20% – 30%, and declines continually since 1995, which has dropped to below 20% by the year 2005. In contrast, the proportion of the population above 15 years old ascends quickly. As is shown in the figure, the proportion of the population between the ages of 15 – 64 is the largest because the age group accounts for a larger range, but the proportion of the population over 65 years old increases fastest, which will break 10% soon. According to international standard, a country can be defined as an ageing country when the population above 65 years old reaches up to 7%.

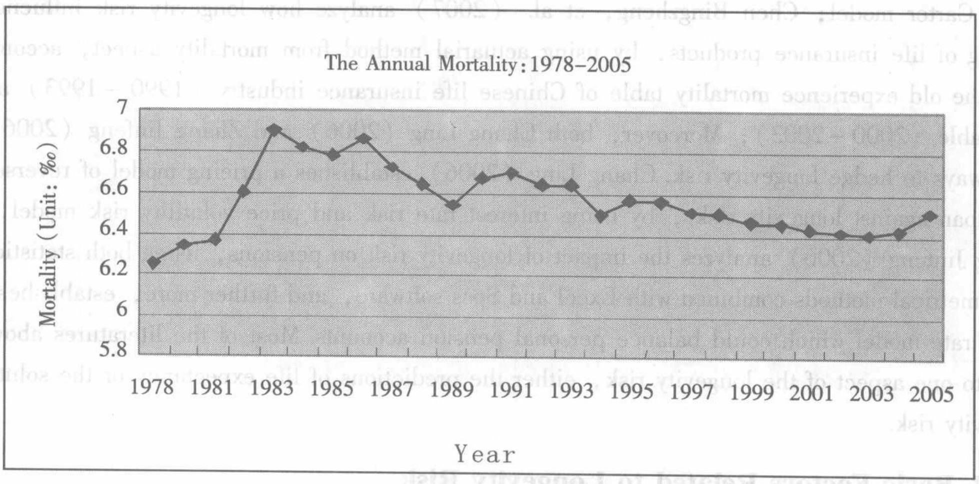

Figure 1①

Though the development trend of longevity in China has not been reflected clearly in the figure, previous census data of Chinese shows that the proportion of the population over 80 years old was

① Data resource: National Bureau of Statistics of China: http://www.stats.gov.cn/tjsj/ndsj/, "China Statistical Yearbook", 2006.

0.5% in 1982, which rose to 0.96% in 2000, and the proportion of the population over 100 years old was 0.0004% in 1982, which rose to 0.0014% in 2000. The average tempos were both higher than the world average level in the same period. What's more, it is forecast by the department concerned that the population over 80 years old in China will account for 12.37% in 2020 and 21.78% in 2050.

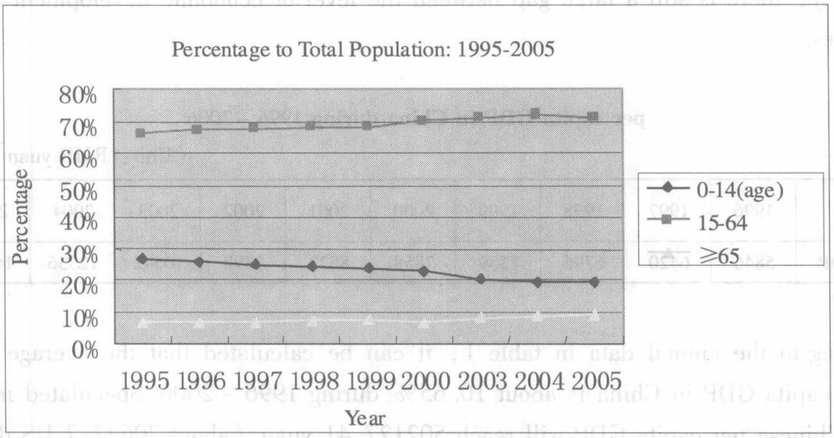

Figure 2①

All pieces of evidence above are the signs of Chinese life expectancy extending, and that is the truth. According to the report by National Bureau of Statistics of China (2003), the life expectancy of newborns in China was 67.85 years in 1987, which reached 68.55 in 1990 and 71.48 in 2000. It can be found by calculating that not only the life expectancy extends, but also its growth rate quickens. If this trend is maintained, that is, in accordance with an average speed of 0.4%, the life expectancy of Chinese will reach 77.42 years in 2020 and be expected to rise to 83.85 years in 2040. Therefore, longevity is an indisputable fact in China.

2.2 Economic Trends

Though longevity itself is a good thing, whether it is also good for human beings or not depends on whether people possess sufficient revenue to maintain the larger expenditure resulted from the longer life. In developed countries, longevity of the population emerged accompanied by urbanization and industrialization, that is, the age structure of population changed along with the highly developed economy. However, in China, longevity emerged along with the undeveloped economy, due to the implementation of family planning policy. To be exact, per capita GDP is generally more than 10,000 US dollars in developed countries when their population over 65 years old account for 7%, while it is only about 800 US dollars in China. Data from the World Bank shows that per capita GDP

① Data resource: National Bureau of Statistics of China: http://www.stats.gov.cn/tjsj/ndsj/, "China Statistical Yearbook", 1996-2006. The data is calculated according to "Age Composition and Dependency Ratio of Population by Region".

in China was 2, 460 US dollars in 2007, and it was 6, 310 US dollars in Argentina, which is an ageing country among developing countries. The figure was 56, 711 US dollars in Switzerland, which is highest in the ageing countries among the developed ones, followed by 47, 069 US dollars in Sweden, 41, 605 US dollars in Belgium, 39, 650 US dollars in Germany, 35, 386 US dollars in Italy, 34, 023 US dollars in Japan, 31, 471 US dollars in Spain and 8612 US dollars in Russia. Clearly, there is still a large gap between the level of economic development in China and other countries.

Table 1: **per capita GDP in China during** 1996－2006

(Unit: RMB yuan / person)

year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Per capital GDP	5846	6420	6796	7159	7858	8622	9398	10542	12336	14103	16084

According to the annual data in table 1, it can be calculated that the average development speed of per capita GDP in China is about 10.65% during 1996－2006. Speculated in the light of this trend, Chinese per capita GDP will reach 502127.41 yuan (about 70622.7 US dollars①) till the middle of this century (That means the year 2040). It is shown that the average expenditure of the elders in China is about 20, 000 yuan per person every year, according to the information concerned② at present (the year 2008). So, if predicted by the same pace of per capita GDP, the average expenditure of the elders will reach up to 509888.69 yuan in the middle of this century, which is more than 7500 yuan in excess of the level of per capita GDP. Therefore, the population of developed countries is getting rich first and becoming old after, but it is reverse in China. While longevity of the population is delightful, its tremendous pressure on social economy can be even more worrying, because it develops so fast that it is beyond the capacity of economy.

Table 2: **statistics of population participating in endowment insurance in China**

(unit: 10000 persons)

year	1989	1997	2004	2005
Number of Employee Joining Basic Endowment Insurance	4816.9	8671	12250	13120
Number of Retiree Joining Basic Endowment Insurance	893.4	2533.4	4103	4368
Number of Person Joining Rural Endowment Insurance	—	—	5382	5442
Total	5710.3	11204.4	21735	22930
Total Population (year－end)	112704	123626	129988	130756
Percentage to Total Population	5.067%	9.063%	16.721%	17.536%

① One dollar is equivalent to 7.11 yuan RMB, which is the lowest exchange rate of RMB against the dollar by 29 Feb, 2008.

② Reference: http://zhidao.baidu.com/question/47362625.html.

It can be seen from the data in table 2, though the proportion of Chinese participating in all kinds of endowment insurances is increasing year by year, the overall share is still relatively low, among which the maximum one is not more than 20% of the total population. This means about 80% of Chinese will need pensions from children or commercial insurance. However, to rely on the support of children solely will bring them not only a heavy economic burden, but also a tremendous spirit burden. According to the data of "China Statistical Yearbook" (2006), the old dependency ratio of population① in China rose from 10.06% in 1996 to 12.71% in 2005, furthermore, with a continuing upward trend. Great psychological pressure makes young people not wholeheartedly dedicate to work, thereby affects their contributions to the social, ultimately has an impact on the overall socio-economic development. Thus, commercial insurance becomes the main tool to hedge longevity risk. And it is indeed an excellent choice from the aspect of its high level of protection. Then, what will insurance companies face after they are transferred to the risk from the insured? That is a great pressure on solvency.

3. Forecasting the future mortality rate using Lee-Carter model

In traditional methods of forecasting mortality rate, the predicted results become rational only on the assumption that there is a ceiling of life expectancy, or a control on the growth rate of life expectancy. So, there are limitations using traditional methods to forecast mortality rate under the conditions that life expectancy is constantly changing. To overcome the shortcomings of traditional methods, Lee Ronald D. and Carter Lawrence R., who are famous demographers in the United States, proposed a new method of forecasting mortality rate in 1992. The method, called Lee-Carter for short, combines the demographic model with the random time series model and elicits the future mortality rate through the analysis of historical data. Not only does it solve the problems of using traditional methods, but also it reduces the influence of subjective factors and enhances the precision of the result, for the forecast is based on a long-term and stable trend. What's more, it has the advantage of easy operation. The Lee-Carter method has gained favor of demographers all over the world and been used in multinational experience population data since its launch, such as Canada, France, Germany, Italy, Japan, the United Kingdom, the United States and Australia and so on. In China, Hou Changrong et al. (2000) applied Lee-Carter method to the empirical data of rural male population at the early stage.

3.1 Model

Lee-Carter method belongs to extrapolation model, and it is also a kind of generalized linear models. The expression of logarithm and Autoregressive? Integrated? Moving? Average? Model (ARIMA) are the main features of Lee-Carter model. Concretely speaking, Lee-Carter model

① Old Dependency Ratio, also called old dependency coefficient, refers to the ratio of the elderly population to the working-age population, express in "%". It describes the number of the elderly population that every 100 people at working ages will take care of. Old dependency ratio is one of the indicators reflecting the social implication of population ageing from the economic perspective.

suggests a log－bilinear model in the variables x （age） and t （time） for estimating the force of mortality at age x in year t. It is assumed to follow the equation:

$$\ln m_{x,t} = \alpha_x + \beta_{x_t} + \varepsilon_{x,t}$$

$m_{x,t}$ is the force of mortality at age X in year t. α_x is the average level of the logarithm of the force of mortality surface over time, and exp （α_x） is the general shape of mortality at age x. β_x is the sensitivity of the logarithm of the force of mortality at age x to variations in , κ_t and κ_t is a time－varying index of the level of mortality that describes the change in overall mortality over time. Finally, $\varepsilon_{x,t}$ is the error term and reflects particular age－specific historical influences not captured in the model. Lee and Carter （1992） assume that the error term is normally distributed with mean zero and variance σ^2, *i. e.* $\sim N(0,\sigma^2)$.

The model cannot be estimated uniquely because β_x and χ_t appear through their product. Therefore, it is often assumed that $\sum_{allx}\beta_x = 1$ and $\sum_{t-t_1}^{t_n}\kappa st = 0$ (Renshaw and Haberman, 2003) to ensure identifiability of the model.

Let $x(age) = x_1, x_2, \cdots, x_k, t(time) = t_1, t_2, \cdots, d_{x,t}$, the forecast process of Lee－Carter model is as follows:

① $\hat{m}_{x,t} = d_{x,t}/lx,t, d_{x,t}$ is the number of dead persons who are x－year－old in year t and is exposure quantity of the risk corresponded to x and t;

② estimate $\alpha_x : \hat{\alpha}_x = \ln(\prod_{t-t_1}^{t_n}\hat{m}_{x,t}^{1/n})$;

③ estimate κ_t and β_x :

Use Singular Value Decomposition （SVD） technique on matrix $[\ln\hat{m}_{x,t} - \hat{\alpha}_x]$ by statistical software GENSTAT, then κ_t and β_x are the right－hand and left－hand singular vectors of SVD （$\ln\hat{m}_{x,t} - \hat{\alpha}_x$）, respectively;

④ re－estimate κ_t , make $\sum_{x=x_1}^{x_k} d_{x,t} = \sum_{allx} l_{x,t} * \exp(\hat{\alpha}_x\hat{\beta}_x\hat{\kappa}_t)$;

⑤ use ARIMA （p, d, q） to forecast$\hat{\kappa}_{t_{n+s}}(s > 0)$, based on the κ_t predicted above;

⑥ forecast future mortality rate $m_{x,t_{n+x}} : \hat{m}_{x,t_{n+x}} = e^{\kappa_x + \hat{\beta}_x \kappa_{t_{n+s}}}(s > 0)$.

3.2 Data

We resorted to data about death and exposure to risk of population between age 0 and 100 from mortality table measured by age and gender in "China Demographic Yearbook" （1988－2006）. Because data was lost in 1989、1990、1991、1993、1994、1996 and 2001, the data used refers to the calendar years 1986、1989、1994－1995、1997－1999 and 2001－2005. Therefore, k = 101、n = 12.

3.3 Parameter Estimation

According to the forecast process above, the estimated results are as follows:

Table 3: the estimated value of men's κ_x and β_x of all ages①

age	$\hat{\alpha}_x$	$\hat{\beta}_x$	age	$\hat{\alpha}_x$	$\hat{\beta}_x$	age	$\hat{\alpha}_x$	$\hat{\beta}_x$
0	-3.87598	0.21831	35	-6.22878	0.13507	70	-3.15323	0.07527
1	-6.14966	0.29028	36	-6.19063	0.02871	71	-3.06181	0.08702
2	-6.48498	0.29629	37	-6.30077	0.08413	72	-3.00751	0.07428
3	-6.64918	0.16023	38	-6.12033	0.03502	73	-2.91686	0.04793
4	-6.77504	0.04074	39	-6.01654	-0.04554	74	-2.85972	0.04260
5	-7.04239	0.27398	40	-5.92256	0.07590	75	-2.77645	0.04569
6	-7.38886	0.20135	41	-5.91615	0.00455	76	-2.66201	0.07538
7	-6.70973	0.18288	42	-5.91773	0.01242	77	-2.53311	0.06934
8	-7.35995	0.15300	43	-5.73775	0.00504	78	-2.44345	0.04701
9	-7.74616	-0.02361	44	-5.64426	-0.01220	79	-2.34892	0.03877
10	-7.47036	0.10967	45	-5.63765	0.04308	80	-2.29657	0.06738
11	-7.68713	0.20786	46	-5.49758	0.04954	81	-2.06862	0.02724
12	-7.83677	0.18362	47	-5.46109	0.11153	82	-2.11720	0.08880
13	-7.57235	0.16841	48	-5.32093	0.07898	83	-2.01982	0.05812
14	-7.60125	-0.03662	49	-5.24811	0.03333	84	-1.86346	0.02810
15	-7.46838	-0.17213	50	-5.21461	0.01359	85	-1.83532	0.03600
16	-7.30170	-0.04896	51	-5.06512	0.05021	86	-1.79939	0.07786
17	-6.94162	-0.08329	52	-5.06844	-0.02989	87	-1.69892	0.08949
18	-6.85740	0.17909	53	-4.99732	0.05295	88	-1.57493	0.00151
19	-6.91243	0.08876	54	-4.85650	0.00483	89	-1.48424	-0.04768
20	-6.66065	0.10523	55	-4.68327	0.01506	90	-1.37042	0.03496
21	-6.60534	0.04589	56	-4.63567	0.06518	91	-1.38369	0.04279
22	-6.60777	0.07739	57	-4.62522	0.10999	92	-1.36434	0.03052
23	-6.73204	0.11964	58	-4.38754	0.01623	93	-1.37060	0.03035
24	-6.58066	0.07922	59	-4.28181	0.06264	94	-1.35414	0.04092
25	-6.66759	0.04307	60	-4.21280	0.08937	95	-1.36479	0.01612
26	-6.71302	0.12879	61	-4.08835	0.09881	96	-1.39420	-0.01509
27	-6.72646	0.07736	62	-3.91072	0.10314	97	-1.26320	0.06575
28	-6.52059	0.04517	63	-3.87300	0.08350	98	-1.24368	0.05280
29	-6.47488	0.03861	64	-3.76891	0.08961	99	-1.37641	0.01573
30	-6.36652	0.05967	65	-3.77567	0.06967	100	-1.27721	0.03008
31	-6.33204	0.06262	66	-3.61540	0.11676			
32	-6.57097	-0.09742	67	-3.54430	0.10358			
33	-6.32286	0.14892	68	-3.41741	0.08717			
34	-6.24032	0.09234	69	-3.30103	0.07704			

① Owing to space constraints, this part lists only the estimated results of males. Men and women's final estimate results will be listed in appendix.

Table 4: the estimated value of men's ①

year	1986	1989	1994	1995	1997	1998
$\hat{\kappa}_t$	1.15469	1.72779	1.74753	1.54074	1.29008	0.88865
year	1999	2001	2002	2003	2004	2005
$\hat{\kappa}_t$	0.13495	-0.68011	-0.38690	-1.59396	-2.15026	-2.87222

3.4 Forecast results

According to the time series $\hat{\kappa}_t$ estimated above, we determined this time-index to be an ARIMA (1, 2, 1) process②, i. e. a random walk with drift. Then, the forecast results are as follows:

Table 5: the fitted results of men's

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.06263686	0.034590815	-1.810794538	0.120142695
AR (1)	-0.536111774	0.355324537	-1.508794688	0.182084615
MA (1)	-0.989872727	0.000773914	-1279.046996	1.54E-17
R-squared	0.751556748	Akaike info criterion		1.319071467
Adjusted R-squared	0.668742331	Schwarz criterion		1.384812993
Sum squared resid	1.011821709	F-statistic		9.075192129
Durbin-Watson stat	2.254328415	Prob (F-statistic)		0.015334924

Table 6: the forecast value of men's κ_t ③

year	2006	2007	2008	2009	2010
$\hat{\kappa}_t$	-3.85819	-4.70263	-5.62294	-6.50257	-7.40401
year	2011	2012	2013	2014	2015
$\hat{\kappa}_t$	-8.29376	-9.18978	-10.08244	-10.97690	-11.87039

As is shown in figure 3, the mortality of population will decline year by year, especially the ones who are in higher ages.

① In virtue of the function of "goal seek" in EXCEL.

② The time series $\hat{\kappa}_t$ of females are also applied to the ARIMA (1, 2, 1) process.

③ Reference: Xu Guoxiang, Statistics Forecast and Decision-making, Shanghai University of Finance and Economics Press, 2005, P153-155.

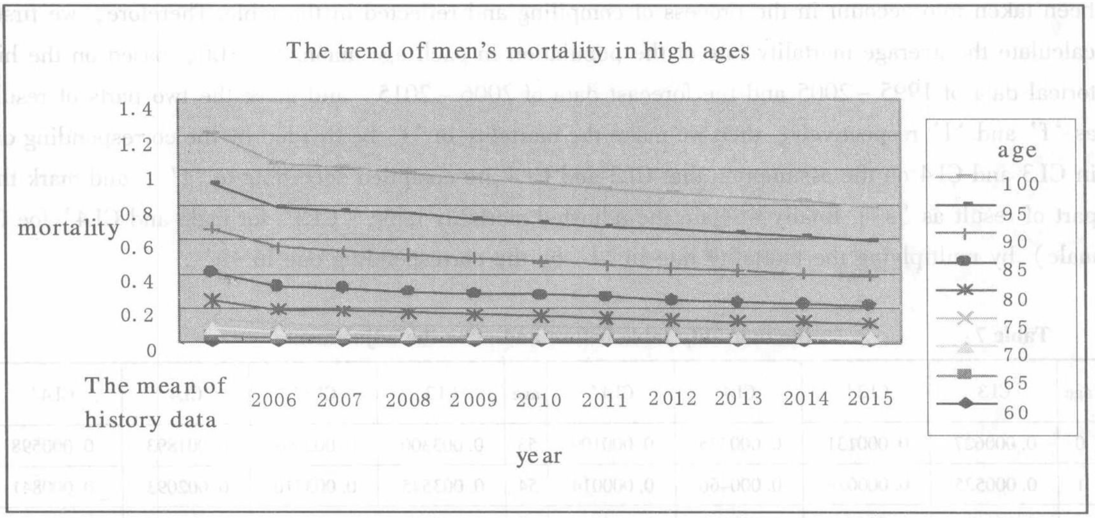

Figure 3①

4. Longevity risk pressure on annuity insurance products

The decline of the mortality rate means the rise of the life expectancy, and also implies the mortality rate in experience mortality table can not reflect the actual mortality rate any more. In the end, the insurers will face enormous pressure of solvency, for the actual benefit payment of the annuity insurance products which are priced on the basis of the mortality rate in experience mortality table will be more than the expected one. In this part, we will make adjustment on the existing experience mortality table, according to the forecast results previously. So that we can make an analysis of the pressure of longevity risk on annuity insurance products, from the aspects of mortality gain, expense gain and interest rate gain, which are the main sources of insurers' profits.

At present, it adopts the experience mortality table of Chinese life insurance industry (2000 - 2003) (pension table: CL3 for male and CL4 for female) to price the annuity insurance products in Chinese insurance industry. Because the compilation process of mortality table is extremely complicated. It is not simply based on preliminary accounting information, but compiled by converting the census data into the annual data of survivals and deaths on the basis of 100, 000 or 1 million people at the same age. Here, we only make simple adjustments for the existing mortality table, not strictly following the compilation method of mortality table. So there will be a certain error. The adjustment method is specific as follows: in accordance with the insurance industry practice that mortality table is compiled newly every 10 years, it can be assumed that the change of mortality rate during the 10 - year period, which is 5 years before the compilation year and 5 years after, has

① Owing to space constraints, here just lists the trend graph based on part of forecast results. The particular resuts are listed in appendix.

been taken into account in the process of compiling and reflected in the table. Therefore, we firstly calculate the average mortality rate of the population in each age among 0－100, based on the historical data of 1995－2005 and the forecast data of 2006－2015, and mark the two parts of results as 'f' and 'l' respectively; then we make the mortality in 'f' be divided by the corresponding one in CL3 and CL4 on the assumption that CL3 and CL4 are compiled according to 'f', and mark this part of result as 's'; finally we gain the adjusted mortality table (CL3' for male and CL4' foe female) by multiplying the mortality rate in 'l' by the corresponding one in 's'.

Table 7: the mortality table before and after the adjustment①

age	CL3	CL3'	CL4	CL4'	age	CL3	CL3'	CL4	CL4'
0	0.000627	0.000131	0.000575	0.000109	53	0.003300	0.002303	0.001893	0.000598
1	0.000525	0.000078	0.000466	0.000014	54	0.003545	0.003510	0.002093	0.000841
2	0.000434	0.000055	0.000369	0.000051	55	0.003838	0.003512	0.002318	0.000950
3	0.000362	0.000107	0.000290	0.000025	56	0.004207	0.002666	0.002607	0.000882
4	0.000311	0.000203	0.000232	0.000004	57	0.004676	0.002131	0.002979	0.000890
5	0.000281	0.000039	0.000195	0.000042	58	0.005275	0.004803	0.003410	0.001214
6	0.000269	0.000062	0.000175	0.000017	59	0.006039	0.003845	0.003816	0.001044
7	0.000268	0.000141	0.000164	0.000121	60	0.006989	0.003674	0.004272	0.003001
8	0.000270	0.000083	0.000158	0.000017	61	0.007867	0.003885	0.004781	0.003223
9	0.000271	0.000330	0.000152	0.000001	62	0.008725	0.004190	0.005351	0.002237
10	0.000272	0.000115	0.000147	0.000343	63	0.009677	0.005312	0.005988	0.003321
11	0.000271	0.000057	0.000143	0.000044	64	0.010731	0.005720	0.006701	0.004014
12	0.000272	0.000069	0.000143	0.000021	65	0.011900	0.007419	0.007499	0.004329
13	0.000278	0.000085	0.000147	0.000143	66	0.013229	0.005590	0.008408	0.003102
14	0.000292	0.000331	0.000156	0.000038	67	0.014705	0.007094	0.009438	0.009006
15	0.000316	0.001219	0.000167	0.000022	68	0.016344	0.008870	0.010592	0.005547
16	0.000351	0.000463	0.000181	0.000030	69	0.018164	0.010453	0.011886	0.005862
17	0.000396	0.000706	0.000196	0.000002	70	0.020184	0.011963	0.013337	0.007344
18	0.000446	0.000122	0.000213	0.000054	71	0.022425	0.011914	0.014964	0.007972
19	0.000497	0.000218	0.000230	0.000040	72	0.024911	0.014583	0.016787	0.006671
20	0.000540	0.000239	0.000246	0.000009	73	0.027668	0.019868	0.018829	0.010984
21	0.000575	0.000344	0.000261	0.000074	74	0.030647	0.023254	0.021117	0.010736
22	0.000601	0.000338	0.000274	0.000016	75	0.033939	0.025138	0.023702	0.011238
23	0.000623	0.000247	0.000285	0.000092	76	0.037577	0.021858	0.026491	0.013149
24	0.000643	0.000355	0.000293	0.000006	77	0.041594	0.025051	0.029602	0.028639

① The mortality rates of the population at the age of 101－105 are speculated on the basis of the changing trend of mortality rates in the existing mortality table.