Mortality Models for the Advanced Ages in Japan

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ABSTRACT

Japan has one of the fastest aging populations in the world. We, actuaries, have developed various models for forecasting mortality rates. One of the most important themes for actuaries is to verify which model will most appropriately apply to the mortality rates of aging populations. This paper examines two models with the intention of clarifying the degree of goodness of fit for Japanese mortality rate.

KEYWORDS

Lee-Carter Model; Japan Standard Mortality Table (JSMT); Coefficient of Determination (R^2); Goodness of Fit

1. INTRODUCTION

From the past to the present, actuaries have attempted various types of mortality rate forecasts. A typical example is the classical model developed in 1825 by Gompertz. A recent model is the Lee-Cater Model which is one of the relation models.

The purpose of this paper is to examine two types of mortality forecast models and evaluate fitness between the mortality rate forecast calculated using data from 1962 through 1995 and the experienced mortality rate for 1996 through 2004, in light of the coefficient of determination R^2.

First, section 2 surveys the history of mortality rate forecast models. Section 3 explains the method of forecasting the mortality rate; the method of formulating the Lee-Carter Model and the Japan Standard Mortality Table 2007 (Annuity Mortality Table) as handled in this paper. Section 4 describes the results, and Section 5 describes the considerations and conclusions as to which method is appropriate as a mortality model for the future.

2. THE HISTORY OF MORTALITY MODELS

As shown in Appendix 1, various types of mortality forecast have been attempted from the past to the present.

3. THE METHODOLOGY OF MORTALITY MODELS

3.1 Data used

Out of the experienced mortality rates of 1962 through 1995 based on the abridged life table and the complete life table for Japan used in this paper, Fig.1 presents data for 1962, 1970, 1980, 1990, and 1995 to grasp the trend and represents the data logarithmically. The graph shows an improving trend in the mortality rate year by year. In terms of the Lee-Carter Model for this paper, data from 1962 through 1995 were used to forecast the future mortality rate. However, the last survivor ages vary depending on the life table. Therefore, the ages with no data were extrapolated using a cubic function, and all the last survivor ages were set to 100 years old. With regard to the mortality rate forecast based on the method of the Japan Standard Mortality Table 2007 (Annuity mortality Table), the Japan Life Table 17 (based on the National Census of 1990) and the Vital Statistics of Japan (1970, 1978 and 1990) were used.

3.2 Mortality Forecasting by Lee-Carter Model

The Lee-Carter model for forecasting mortality rates is a simple bilinear model in the variables x (age) and t (calendar year) of the following form:

$$\log(m_{x,t}) = a_x + b_x k_t + \varepsilon_{x,t}$$

where $m_{x,t}$ is the observed central mortality rate at age x in year t,

a_x describes the average shape of the age profile,

b_x describes the pattern of deviations from the age profile as the k_t varies,

k_t describes the change in overall mortality, and

$\varepsilon_{x,t}$ is the residual term at age x and time t.

In order to get a unique solution, usually the following constraints are applied:

$$\sum_x b_x = 1 \text{ and } \sum_t k_t = 0 .$$

Given these constraints, the model can be fit by minimizing $\sum \varepsilon_{x,t}^2$. The simplest way to minimize the sum is to set a_x equal to the averages of the $\log(m_{x,t})$, then to get b_x and k_t from the first term of a singular value decomposition of the matrix:

$$\mathbf{R} = \left(\log(m_{x,t}) - a_x\right) .$$

In forecasting mortality rate, we need to model k_t as a stochastic time series process.

The National Institute of Population and Social Security Research, in the estimate from 2002, expressed its view that it will make a more natural assumption that the mortality rate will show a gradually improving trend rather than to assume that the mortality rate will continue to improve in the future as in the past at a pace greater than other advanced countries, in view of the fact that Japanese mortality rate improved dramatically after World War II and has already reached the world's highest level. Under the circumstances, in order to reflect this trend for change in k_t in the estimate of future value, two functions have been applied, and the average value of the two has been used as a statistically expected value.

One of the two functions is an exponential function, $\alpha_1 + \alpha_2 e^{\frac{t+\alpha_4}{\alpha_3}}$, which gets asymptotical toward the specific value based on the application to the data and the other function is a logarithmic function, $\beta_1 + \beta_2 \log(t + \beta_3)$, which continues to drop unlimitedly, though the dropping tendency gradually becomes less prominent. That is to say, as a function used to estimate k_t,

$$k_t = \frac{1}{2}(\alpha_1 + \alpha_2 e^{\frac{t+\alpha_4}{\alpha_3}} + \beta_1 + \beta_2 \log(t + \beta_3))$$

was used.

In this paper, the above-described method was applied to the data for 1962 through 1995.

3.3 Mortality Forecasting by Japan Standard Mortality Table2007 (JSMT2007)

The summary of the method for formulating the Japan Standard Mortality Table 2007 (Annuity Mortality Table) is as follows:

(1) As a basic mortality rate, the Japan Life Table 19 (based on the National Census of 2000) shall be used.

(2) Calculate the declining rate (improvement rate) per annum of mortality rate by gender and in five-year age brackets using the improvements in mortality rates by gender by each five-year age bracket and by cause of death from 1980 through 2000.

(2-a) Calculate the annual average improvement rate for 1980 through 2000 by gender, by each five-year age bracket, and by 8 causes of death, according to the Vital Statistics of Japan.

(2-b) By using the annual average improvement rate by cause of death reached by (2-a) above, the future mortality rate of the median age for each five-year age bracket was forecast by cause of death. The representative year of birth for forecasting purposes was 1960. In addition, regarding the cause of death, the average past improvement rate for which has been negative, then the future improvement rate shall be set to zero.

(2-c) Calculate the annual average improvement rate of the total causes of death for the median ages using the total value of mortality rates by cause of death calculated by (2-b) above as well as the mortality rate for 2000 (sum of causes of death), and, through the method of linear interpolation between ages, calculate the annual average improvement rate for each age.

(3) Based on the understanding that the mortality rate will continue to improve every year at the improvement rate calculated in (2) above, the future mortality rate shall be estimated. The "future" to be estimated shall, in principle, be the year when a person born in 1960 reaches each age, and the mortality rate of the Japan Life Table 19, to which the improvement was made considering the mortality rate corresponding to the number of years from 2000, shall be "the future mortality rate." (The improvement in mortality rate over at least 20 years shall be taken into account.)

(4) The future mortality rate reached by (3) above, extrapolated in terms of advanced ages and young ages, as well as further adjusted in the direction of survival risk, shall be deemed the mortality rate on the Annuity Mortality Table.

In this paper, the mortality rate based on this method has been calculated by using the data available in 1995, that is to say, the Japan Life Table 17 and the Vital Statistics of Japan (1970, 1978 and 1990).

In addition, this life table is not intended for liability valuation but for mortality rate forecasts for 1996 onward; therefore, setting the improvement rate by cause of death at no more than zero as stated in (2-b) above as well as adjustment in the direction of survival risk stated in (4) above were not implemented.

3.4 Method of comparison between models

The methods described above can be summarized in the following table: The mortality rate forecast for 1996 through 2030 was calculated using the Lee-Carter Model method, and the mortality rate forecast for 1996 onward was implemented by means of the JSMT2007 method.

	Data used	By cause of death or otherwise	Parameters / method used for forecasting for the future
Lee-Carter Model	Abridged life table and the complete life table for Japan（1962-1995）	Regardless of cause of death, the mortality rate shall be forecast based on the death as a whole.	In order to forecast k_t , application of functions has been implemented.
JSMT2007	Japan Life Table 17 and Vital Statistics of Japan (1970, 1978 and 1990)	Forecast the improvement rate by cause of death.	Setting of the improvement rate by cause of death at no more than zero and the adjustment in the direction of survival risk were not implemented.

Fig. 2 illustrates the difference between the logarithmic value of the mortality rate forecast for people 50 years and older and the logarithmic value of the experienced mortality rate (1996 through 2004), i.e. (log "mortality rate forecast" – log "experienced mortality rate").

Fig. 3 shows the coefficient of determination of all ages (zero to 89 years old) that have been calculated by type of method.

Fig. 4, after comparing the methods by coefficient of determination for all ages (zero to 89 years old) and that for advanced aged groups (50 years and older) divided into age brackets of five years, indicates the method that shows better fitness.

Fig. 5, among the logarithmic values of mortality rates forecast by the Lee-Carter Method for the period from 2005 through 2030, shows those of 2005 and 2030 in contrast with each other.

4. THE RESULT

4.1 The result of comparison of the difference in logarithmic values of mortality rates

Fig. 2 shows that the mortality rate forecast by means of the Lee-Carter Method proved to be lower than the experienced mortality rates. The mortality rate forecasts by means of JSMT 2007 are, in general, lower than the experienced mortality rates up to the late 70s and are higher than the experienced mortality rates thereafter.

4.2 The result of comparison by means of coefficient of determination

As illustrated in Fig. 4, after comparing the fitness for the experienced mortality rates of 1996 through 2004, the Lee-Carter Model showed the best fitness for both men and women over all ages. On the other hand, according to age brackets, as for men, from 1996 through 2004, over time, the age brackets where the JSMT 2007 shows better fitness than the Lee-Carter Model increase primarily at the ages of 50 through 74. As for women, at the ages of 50 through 74, the JSMT 2007 shows better fitness; however, in the advanced age brackets of 75 and above, the Lee-Carter Model showed better fitness.

4.3 Comment on the graph of the future mortality rate

Fig. 5 shows that, from 2005 through 2030 in all ages of the Lee-Carter Model, the mortality rates improve. In addition, it has turned out that the improvement value is estimated around 90‰ at maximum

5. THE CONSIDERATION AND CONCLUSION

Fig. 2 shows that, in the age brackets of 80 and above for the JSMT 2007, the range of deviation from the experienced mortality rates in the direction of worsening mortality rates expands gradually along with advancing age. Such deviation of the forecast rates in the direction of worsening mortality rates is considered to have been caused because the setting of the improvement rate by cause of death at no more than zero, which is adopted on JSMT2007 in order to estimate the mortality rate improvement in a conservative manner, is not implemented in this paper.

Fig. 3 shows that, across all age brackets, from 1996 through 2004, the fitness of the JSMT 2007, in terms of both men and women, keeps improving, which leads us to consider that the JSMT 2007 is suitable for forecasting mortality rates for the long term.

In addition, according to Fig. 4, during the period from 1996 through 2004, over time, the ages where the JSMT 2007 shows better fitness than the Lee-Carter Model tend to increase. This also implies that the JSMT2007 is a method suitable for forecasting mortality rates for the long term.

From now on, it will be necessary to increase the types of mortality models and conduct further research to find out which mortality model will be suitable for Japanese future mortality rate forecast.

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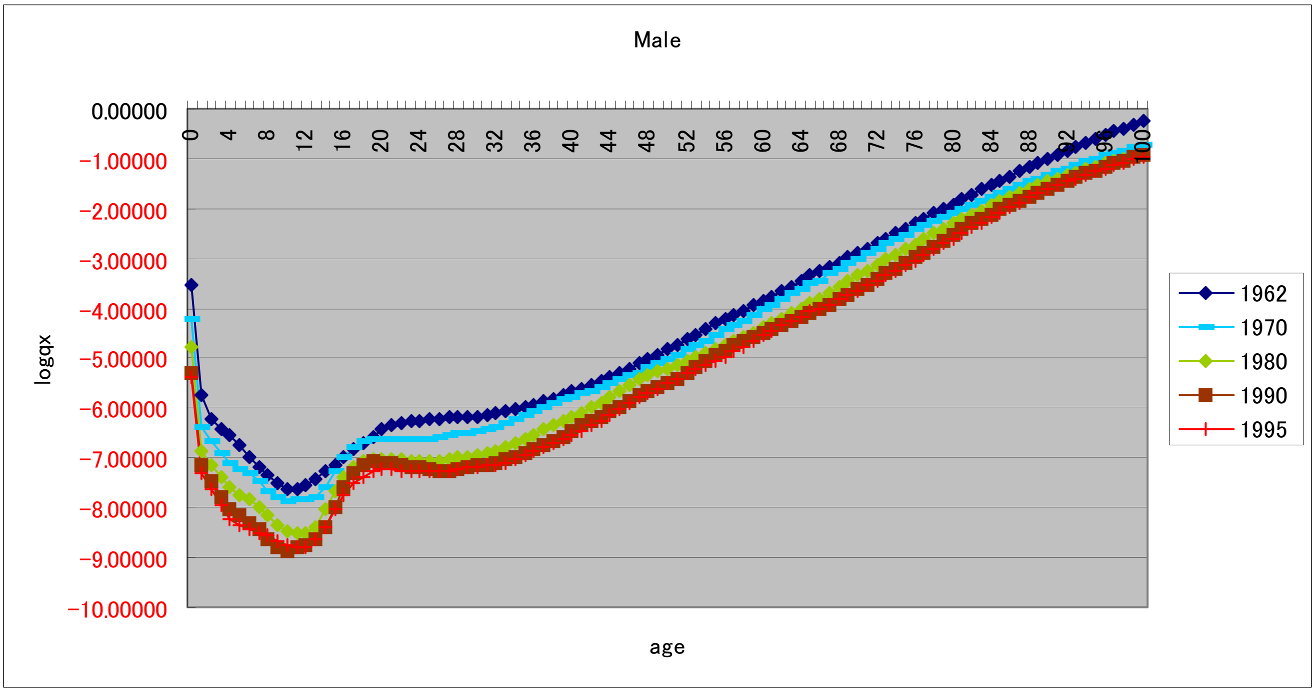
Fig.1: The trend of mortality rate(1962-1995)

Male



Female

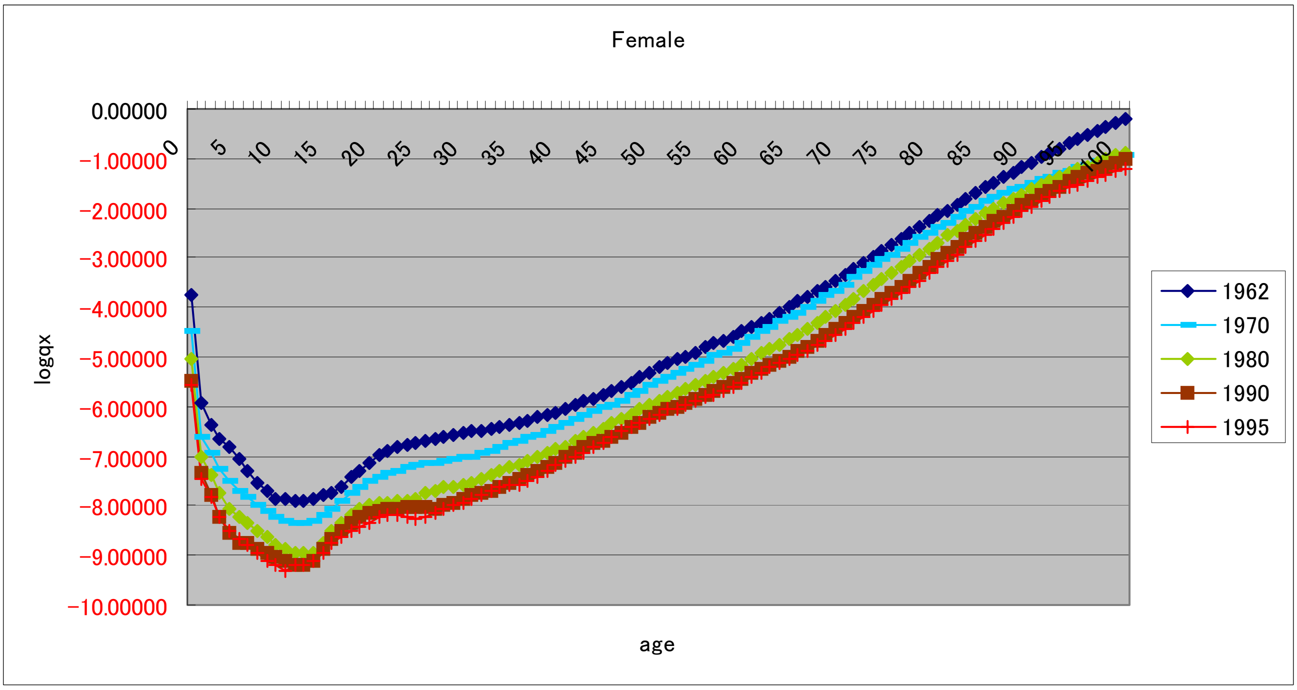
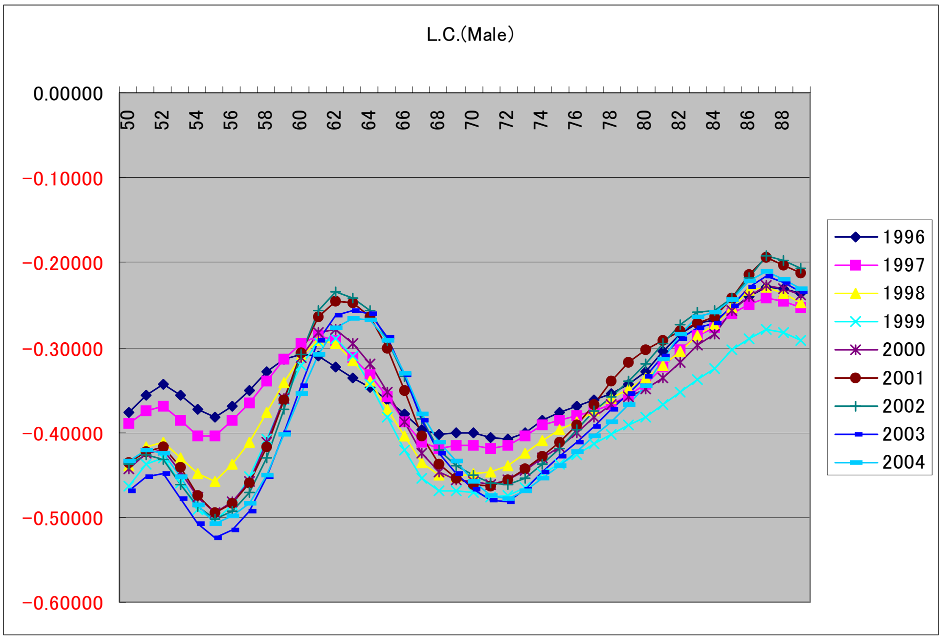
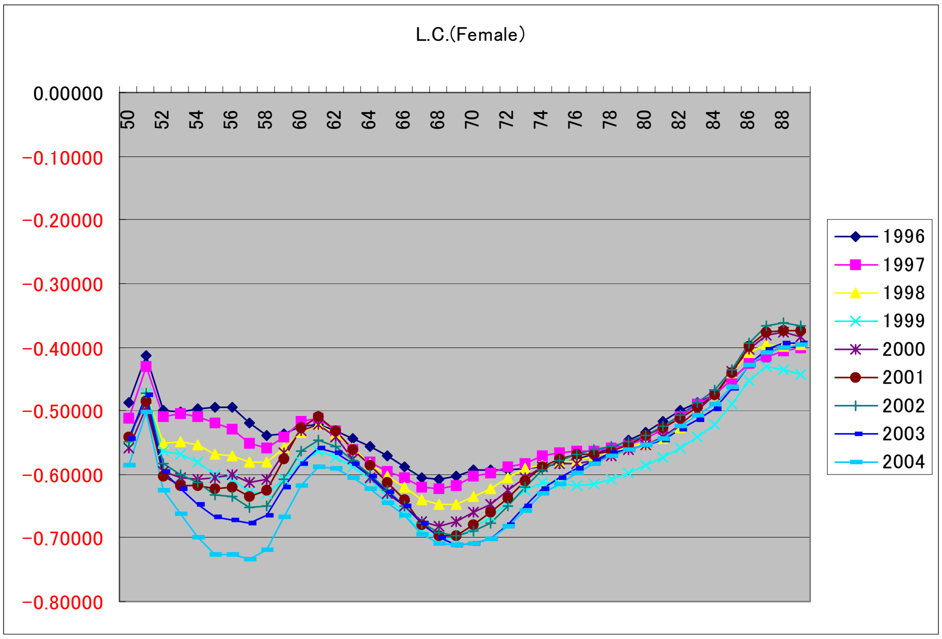


Fig.2: The difference between the logarithmic value of the mortality rate forecast and the logarithmic value of experienced mortality rate(1995-2004)

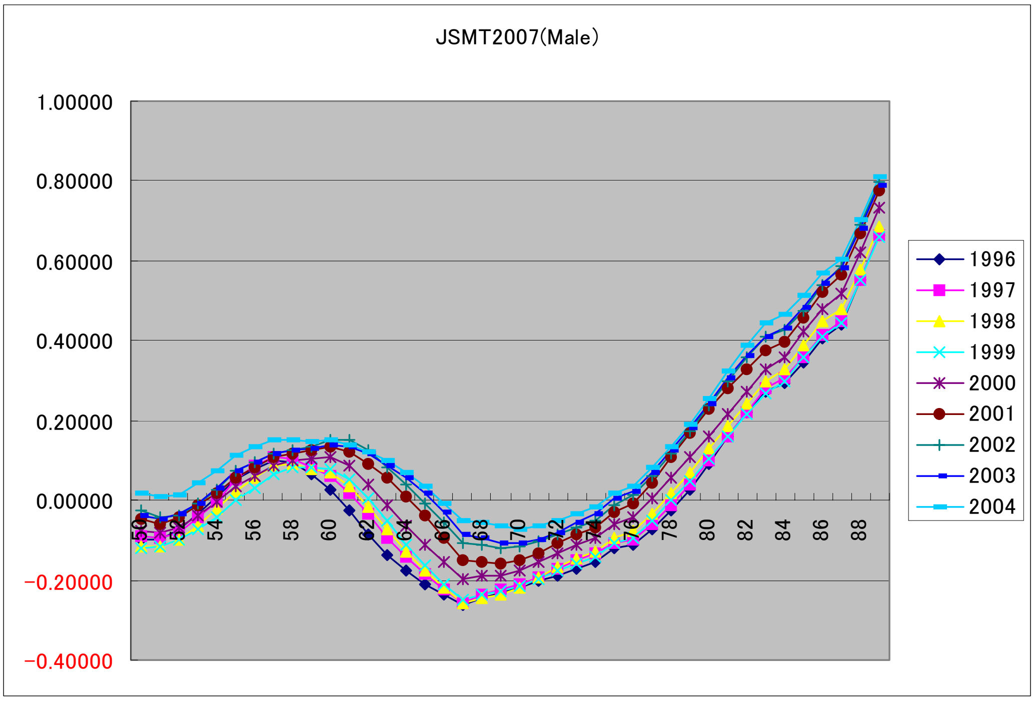
Lee-Carter Model(Male)



Lee-Carter Model(Female)



JSMT2007(Male)



JSMT2007(Female)

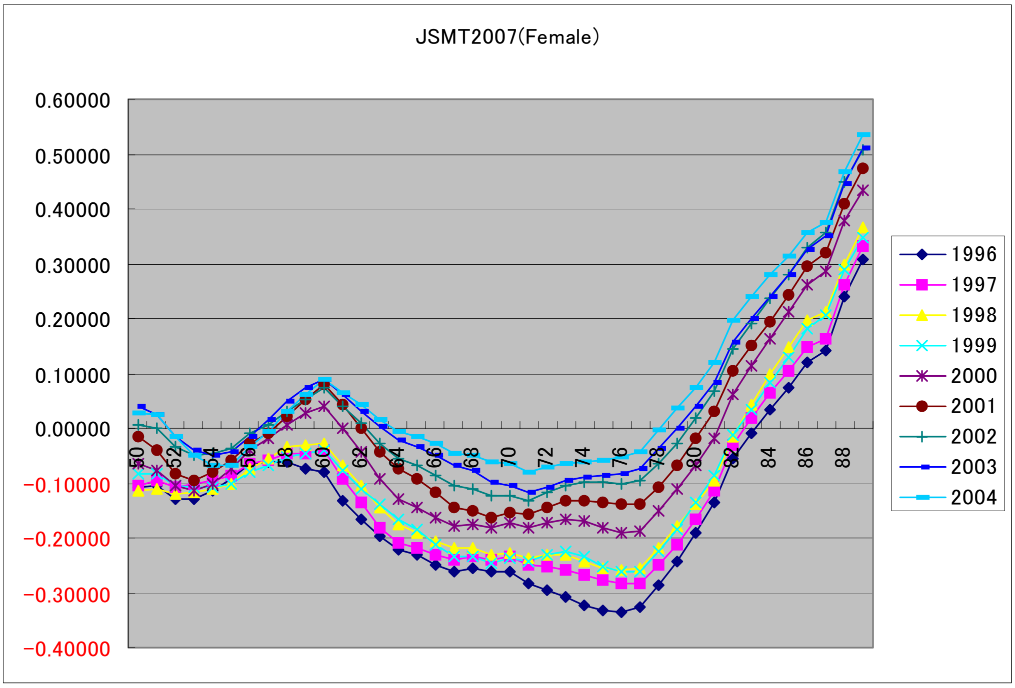


Fig.3: The R^2 between each method and experienced mortality rate(1995-2004)

Male (Age 0-89)

Female (Age 0-89)

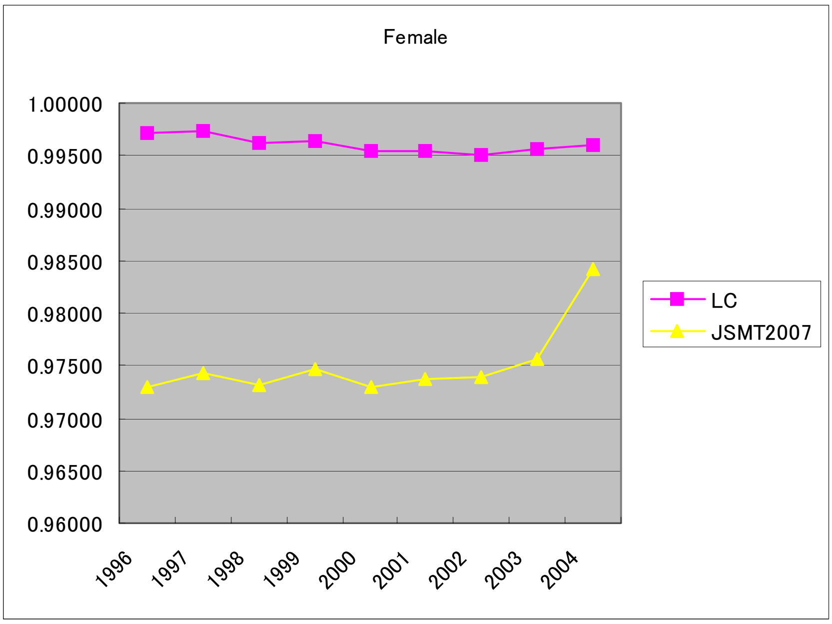


Fig.4: The Method which shows better fitness

Male

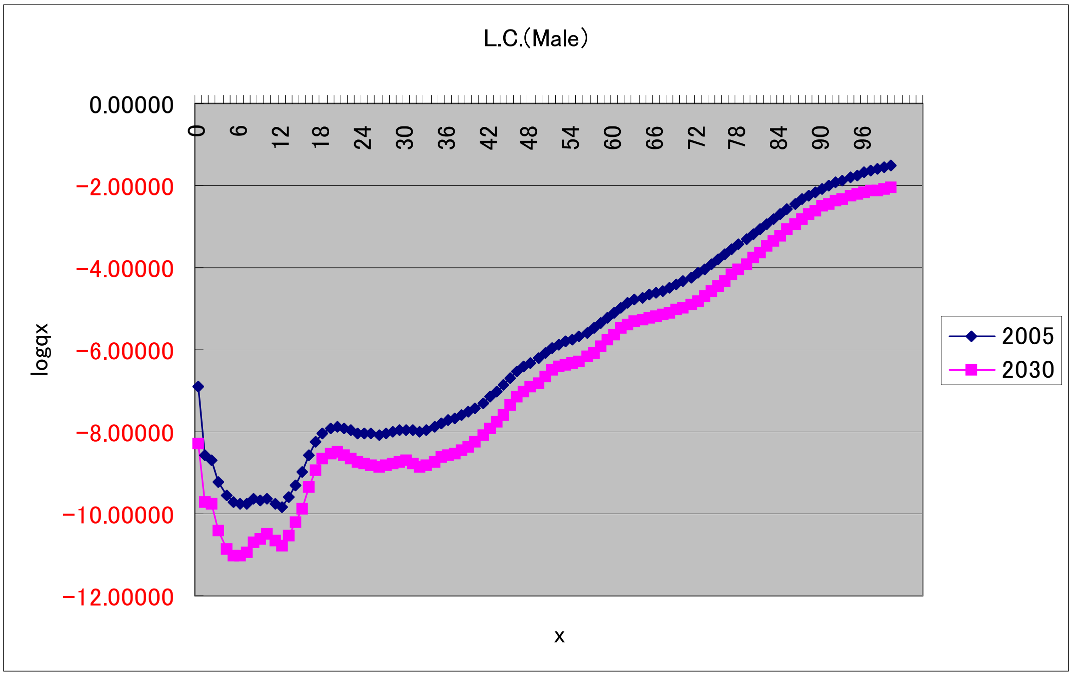
R^2	1996	1997	1998	1999	2000	2001	2002	2003	2004
0-89	L.C.	L.C.	L.C.	L.C.	L.C.	L.C.	L.C.	L.C.	L.C.
50-54	JSMT2007	L.C.	JSMT2007	JSMT2007	JSMT2007	JSMT2007	JSMT2007	JSMT2007	JSMT2007
55-59	L.C.	L.C.	L.C.	L.C.	JSMT2007	JSMT2007	JSMT2007	JSMT2007	JSMT2007
60-64	L.C.	L.C.	L.C.	JSMT2007	JSMT2007	JSMT2007	JSMT2007	JSMT2007	JSMT2007
65-69	L.C.	L.C.	L.C.	L.C.	L.C.	L.C.	L.C.	L.C.	L.C.
70-74	JSMT2007	JSMT2007	JSMT2007	JSMT2007	JSMT2007	JSMT2007	JSMT2007	JSMT2007	JSMT2007
75-79	L.C.	L.C.	L.C.	L.C.	L.C.	L.C.	L.C.	L.C.	L.C.
80-84	L.C.	L.C.	L.C.	L.C.	L.C.	L.C.	L.C.	L.C.	L.C.
85-89	L.C.	L.C.	L.C.	L.C.	L.C.	L.C.	L.C.	L.C.	L.C.

Female

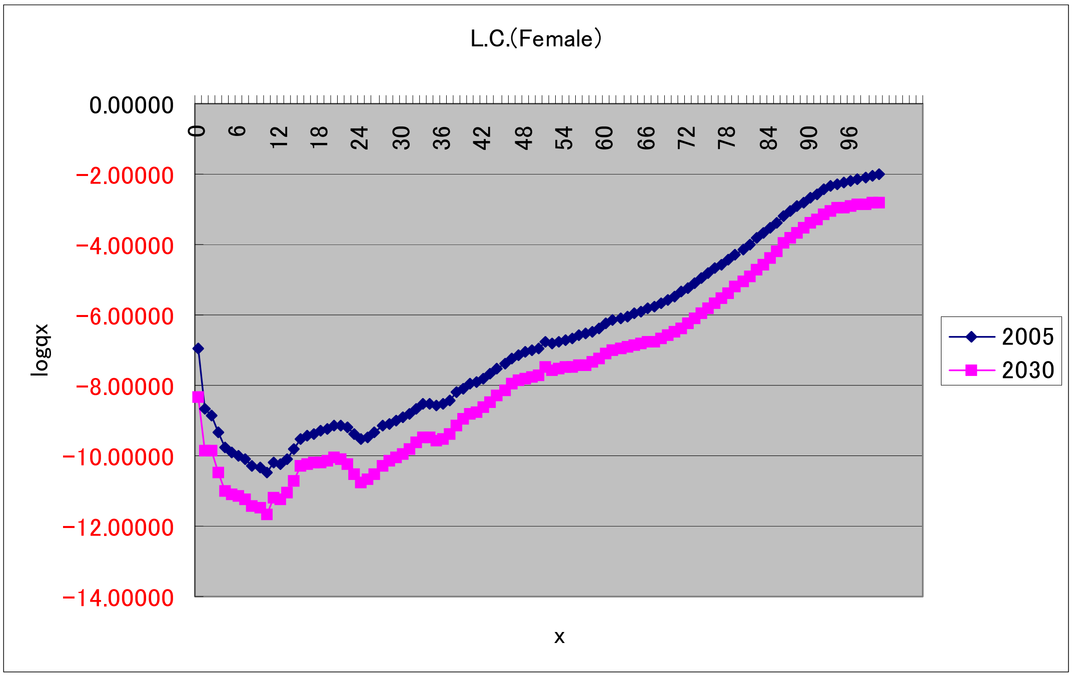
R^2	1996	1997	1998	1999	2000	2001	2002	2003	2004
0-89	L.C.	L.C.	L.C.	L.C.	L.C.	L.C.	L.C.	L.C.	L.C.
50-54	JSMT2007	JSMT2007	JSMT2007	JSMT2007	JSMT2007	JSMT2007	JSMT2007	JSMT2007	JSMT2007
55-59	L.C.	JSMT2007	JSMT2007	JSMT2007	JSMT2007	JSMT2007	JSMT2007	JSMT2007	JSMT2007
60-64	L.C.	JSMT2007	JSMT2007	JSMT2007	JSMT2007	JSMT2007	JSMT2007	JSMT2007	JSMT2007
65-69	JSMT2007	JSMT2007	JSMT2007	JSMT2007	JSMT2007	JSMT2007	JSMT2007	JSMT2007	JSMT2007
70-74	L.C.	L.C.	L.C.	L.C.	L.C.	L.C.	L.C.	JSMT2007	JSMT2007
75-79	L.C.	L.C.	L.C.	L.C.	L.C.	L.C.	L.C.	L.C.	L.C.
80-84	L.C.	L.C.	L.C.	L.C.	L.C.	L.C.	L.C.	L.C.	L.C.
85-89	L.C.	L.C.	L.C.	L.C.	L.C.	L.C.	L.C.	L.C.	L.C.

Fig.5:Logarithmic values of mortality rates forecast (2005,2030)

Lee-Carter Model (Male)



Lee-Carter Model (Female)



Appendix1

Author	Publication	Model
De Moivre	1725	$\mu_x = \frac{1}{\omega - x}$
Gompertz	1825	$\mu_x = BC^x$
Makeham	1860	$\mu_x = A + BC^x$
		$\mu_x = \alpha + \gamma x + \beta c^x$
Opperman	1870	$\mu_x = \frac{a}{\sqrt{x}} + b + c\sqrt{x}$
Thiele	1872	$\mu_x = a_1 e^{-b_1 x} + a_2 e^{-\frac{1}{2}b_2(x-c)^2} + a_3 e^{b_3 x}$
Wittstein	1883	$q_x = \frac{1}{m} a^{-(mx)^n} + a^{-(M-x)^n}$
Steffenson	1930	$\log_{10} l_x = 10^{-A\sqrt{x}-B} + C$
		$e_x = \frac{1}{A + Bc^x}$
Perks	1932	$\mu_x = \frac{A + BC^x}{KC^{-x} + 1 + DC^x}$
Harper	1936	$\log_{10} l_x = A + 10^{B\sqrt{x}+Cx+D}$
Weibull	1939	$\mu_x = \alpha x^{\beta - 1}$
Van der Maen	1943	$\mu_x = A + Bx + Cx^2 + \frac{1}{N-x}$, $\mu_x = A + BC^x + \frac{C}{N-x}$
Unnamed (in Keyfitz,1982)		$y(x) = e^{(a_0 + a_1 x + a_2 x^2 + ... + a_k x^k)}$ $y(x) = q_x, \frac{q_x}{p_x}, \mu_x, or \ e_x$
Brillinger	1960	$\mu_x = \sum_i \left(H_i (x - B_i)^{C_i - 1} + \frac{A_i}{(b_i - x)^{C_i + 1}} + E_i d_i^x \right)$
Beard	1961	$\mu_x = \frac{Be^{ux}}{1 + De^{ux}}$
Petrioli	1981	$l_x = \frac{1}{x^a (\omega - x)^{-b} e^{\frac{c}{2}x^2 + dx} \frac{1}{k} + 1}$

Martinelle	1987	$\mu_x = \frac{A + Be^{kx}}{1 + De^{kx}} + ce^{kx}$
British actuaries (in Keyfitz,1982)	1980s	$\frac{q_x}{p_x} = A - Hx + bc^{\;x}$
Siller	1979	$\mu_x = a_1 e^{-b_1 t} + a_2 + a_3 e^{b_3 t}$
Heligman-Pollard	1980	$\frac{q_x}{p_x} = A^{(x+B)^C} + De^{-E(Inx - InF)^2} + GH^x$
Brooks *et al.*	1980	$\mu_x = \mu_x^I + \mu_x^A + \mu_x^S$ $\mu_x^I = \begin{Bmatrix} Q_0 & for & x = 0 \\ Q_1^{x^r} & for & x > 0 \end{Bmatrix}$ $\mu_x^A = Q_A e^{-\frac{(\ln\ x - \ln\ x_A)^2}{\sigma^2}} \quad for \quad x \geq 0$ $\mu_x^S = \frac{Q_S e^{\frac{x}{x_S}}}{1 + Q_S e^{\frac{x}{x_S}}} \quad for \quad x \geq 0$
Rogers and Planck	1983	$q_x = A_0 + A_l e^{-\alpha_1 x} + A_2 e^{-\alpha_2 (x-\mu_2) - e^{-\lambda_2 (x-\mu_2)}} + A_3 e^{\alpha_3 x}$
Kostaki	1992	$\frac{q_x}{p_x} = \begin{Bmatrix} A^{(x+B)^C} + De^{-E_1^2 (\log\ x/F)^2} + GH^{\ x}, x \leq F \\ A^{(x+B)^C} + De^{-E_2^2 (\log\ x/F)^2} + GH^{\ x}, x > F \end{Bmatrix}$
Rogers and Little	1993	$y(x) = a_0 + m_1(x) + m_2(x) + m_3(x) + m_4(x)$ Where: $m_1(x) = a_1 \exp(-\alpha_1 x)$ $m_2(x) = a_2 \exp(-\alpha_2 (x - \mu_2) - \exp(-\lambda_2 (x - \mu_2)))$ $m_3(x) = a_3 \exp(-\alpha_3 (x - \mu_3) - \exp(-\lambda_3 (x - \mu_3)))$ $m_4(x) = a_4 \exp(\alpha_4 x)$

		$y(x) = q_x, \frac{q_x}{p_x}, \mu_x$
Hartmann	1981	ages 0 to 15 years:
		$y(x) = A_1 + B_1 \ln x$
		ages 15 to 35 years:
		$y(x) = A_2 + B_2 x$
		ages 35 to 60 years:
		$y(x) = A_3 + B_3 c^x,$
		where $Y(x) - logit\, l_x$
Mode and Busby	1982	Ages 0 to 10 years:
		$\mu_x^0 = a_0 \beta_0^{-\beta_0 x}$
		Ages 10 to 30 years:
		$\mu_x^1 = \alpha_1 - \beta_1 (x - \gamma_1)^2$
		Ages 30 and over:
		$\mu_x^2 = \alpha_2 + \beta_2 \gamma_2 e^{\gamma_2 x}$

Reference：[6]

Appendix2: The value of mortality rate forecast (1996-2005,2030)

Lee-Carter Model (Male)

age	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2030
50	0.00275	0.00269	0.00263	0.00257	0.00252	0.00246	0.00241	0.00236	0.00231	0.00226	0.00129
51	0.00309	0.00303	0.00296	0.00290	0.00284	0.00278	0.00272	0.00266	0.00261	0.00255	0.00149
52	0.00342	0.00334	0.00327	0.00321	0.00314	0.00307	0.00301	0.00295	0.00289	0.00283	0.00166
53	0.00367	0.00359	0.00351	0.00344	0.00336	0.00329	0.00322	0.00315	0.00309	0.00302	0.00175
54	0.00391	0.00382	0.00374	0.00365	0.00357	0.00349	0.00342	0.00334	0.00327	0.00319	0.00181
55	0.00420	0.00410	0.00401	0.00392	0.00383	0.00374	0.00365	0.00357	0.00349	0.00341	0.00189
56	0.00461	0.00450	0.00440	0.00430	0.00420	0.00410	0.00401	0.00392	0.00382	0.00374	0.00208
57	0.00511	0.00499	0.00488	0.00477	0.00466	0.00455	0.00445	0.00435	0.00425	0.00415	0.00232
58	0.00575	0.00562	0.00550	0.00537	0.00525	0.00514	0.00502	0.00491	0.00480	0.00470	0.00266
59	0.00651	0.00638	0.00624	0.00611	0.00597	0.00585	0.00572	0.00560	0.00548	0.00536	0.00310
60	0.00738	0.00723	0.00708	0.00694	0.00679	0.00665	0.00652	0.00638	0.00625	0.00612	0.00362
61	0.00831	0.00814	0.00798	0.00782	0.00766	0.00750	0.00735	0.00721	0.00706	0.00692	0.00415
62	0.00918	0.00900	0.00882	0.00864	0.00847	0.00830	0.00813	0.00797	0.00781	0.00765	0.00459
63	0.00999	0.00979	0.00959	0.00939	0.00920	0.00901	0.00883	0.00865	0.00847	0.00830	0.00493
64	0.01082	0.01059	0.01037	0.01015	0.00994	0.00973	0.00953	0.00933	0.00913	0.00894	0.00524
65	0.01157	0.01132	0.01107	0.01083	0.01060	0.01036	0.01014	0.00992	0.00970	0.00949	0.00544
66	0.01231	0.01203	0.01176	0.01149	0.01123	0.01097	0.01072	0.01048	0.01024	0.01001	0.00560
67	0.01308	0.01277	0.01247	0.01217	0.01188	0.01160	0.01132	0.01105	0.01079	0.01053	0.00573
68	0.01409	0.01374	0.01341	0.01308	0.01276	0.01245	0.01214	0.01184	0.01155	0.01127	0.00603
69	0.01535	0.01497	0.01460	0.01423	0.01388	0.01353	0.01320	0.01287	0.01255	0.01223	0.00647
70	0.01675	0.01633	0.01591	0.01551	0.01512	0.01473	0.01436	0.01400	0.01364	0.01330	0.00696
71	0.01830	0.01783	0.01737	0.01693	0.01649	0.01607	0.01566	0.01526	0.01486	0.01448	0.00752
72	0.02015	0.01964	0.01913	0.01864	0.01816	0.01769	0.01724	0.01679	0.01636	0.01594	0.00826
73	0.02239	0.02182	0.02126	0.02071	0.02018	0.01967	0.01916	0.01867	0.01819	0.01773	0.00922
74	0.02500	0.02437	0.02375	0.02315	0.02256	0.02199	0.02144	0.02089	0.02036	0.01985	0.01040
75	0.02792	0.02722	0.02654	0.02588	0.02523	0.02460	0.02398	0.02338	0.02280	0.02223	0.01174
76	0.03127	0.03050	0.02975	0.02902	0.02830	0.02761	0.02693	0.02626	0.02561	0.02498	0.01332
77	0.03518	0.03433	0.03351	0.03270	0.03191	0.03114	0.03039	0.02966	0.02894	0.02824	0.01527
78	0.03962	0.03869	0.03778	0.03689	0.03603	0.03518	0.03435	0.03354	0.03275	0.03198	0.01754
79	0.04459	0.04357	0.04257	0.04159	0.04063	0.03970	0.03879	0.03789	0.03702	0.03617	0.02012
80	0.05018	0.04905	0.04795	0.04688	0.04583	0.04480	0.04380	0.04281	0.04185	0.04091	0.02309
81	0.05663	0.05540	0.05420	0.05302	0.05187	0.05074	0.04963	0.04855	0.04750	0.04646	0.02669
82	0.06394	0.06260	0.06128	0.06000	0.05874	0.05750	0.05629	0.05511	0.05395	0.05281	0.03091
83	0.07190	0.07044	0.06900	0.06760	0.06622	0.06487	0.06355	0.06226	0.06099	0.05974	0.03556
84	0.08015	0.07856	0.07700	0.07547	0.07397	0.07249	0.07105	0.06964	0.06825	0.06689	0.04030
85	0.09006	0.08834	0.08665	0.08499	0.08336	0.08177	0.08020	0.07866	0.07716	0.07568	0.04648
86	0.10120	0.09934	0.09752	0.09573	0.09397	0.09224	0.09054	0.08888	0.08724	0.08564	0.05364
87	0.11253	0.11053	0.10856	0.10662	0.10472	0.10285	0.10102	0.09921	0.09744	0.09570	0.06079
88	0.12300	0.12082	0.11868	0.11658	0.11452	0.11249	0.11050	0.10854	0.10661	0.10472	0.06673
89	0.13348	0.13112	0.12880	0.12652	0.12428	0.12208	0.11992	0.11779	0.11570	0.11365	0.07243

Lee-Carter Model (Female)

age	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2030
50	0.00126	0.00122	0.00119	0.00115	0.00112	0.00109	0.00106	0.00103	0.00100	0.00097	0.00045
51	0.00146	0.00142	0.00138	0.00135	0.00131	0.00128	0.00124	0.00121	0.00117	0.00114	0.00056
52	0.00144	0.00140	0.00136	0.00132	0.00128	0.00124	0.00121	0.00117	0.00113	0.00110	0.00051
53	0.00154	0.00149	0.00145	0.00141	0.00136	0.00132	0.00128	0.00124	0.00121	0.00117	0.00053
54	0.00164	0.00159	0.00154	0.00149	0.00145	0.00140	0.00136	0.00132	0.00128	0.00124	0.00056
55	0.00173	0.00168	0.00162	0.00157	0.00152	0.00148	0.00143	0.00138	0.00134	0.00130	0.00057
56	0.00184	0.00178	0.00172	0.00167	0.00162	0.00156	0.00151	0.00147	0.00142	0.00137	0.00059
57	0.00194	0.00187	0.00181	0.00175	0.00170	0.00164	0.00159	0.00154	0.00148	0.00144	0.00061
58	0.00208	0.00201	0.00195	0.00188	0.00182	0.00176	0.00170	0.00165	0.00159	0.00154	0.00064
59	0.00231	0.00224	0.00216	0.00209	0.00202	0.00196	0.00189	0.00183	0.00177	0.00171	0.00072
60	0.00258	0.00249	0.00241	0.00234	0.00226	0.00219	0.00212	0.00205	0.00198	0.00191	0.00082
61	0.00284	0.00275	0.00266	0.00257	0.00249	0.00241	0.00233	0.00225	0.00218	0.00211	0.00090
62	0.00306	0.00296	0.00287	0.00277	0.00268	0.00259	0.00251	0.00242	0.00234	0.00226	0.00095
63	0.00330	0.00319	0.00308	0.00298	0.00288	0.00278	0.00268	0.00259	0.00251	0.00242	0.00099
64	0.00355	0.00343	0.00331	0.00320	0.00309	0.00298	0.00288	0.00278	0.00268	0.00259	0.00104
65	0.00382	0.00369	0.00356	0.00343	0.00331	0.00319	0.00308	0.00297	0.00286	0.00276	0.00108
66	0.00412	0.00397	0.00383	0.00369	0.00356	0.00343	0.00330	0.00318	0.00307	0.00295	0.00113
67	0.00444	0.00428	0.00412	0.00396	0.00382	0.00367	0.00354	0.00340	0.00328	0.00315	0.00118
68	0.00486	0.00468	0.00450	0.00433	0.00417	0.00401	0.00386	0.00371	0.00357	0.00343	0.00126
69	0.00538	0.00518	0.00498	0.00479	0.00461	0.00444	0.00427	0.00410	0.00394	0.00379	0.00139
70	0.00604	0.00581	0.00559	0.00537	0.00517	0.00497	0.00478	0.00460	0.00442	0.00425	0.00155
71	0.00678	0.00652	0.00627	0.00603	0.00580	0.00558	0.00536	0.00516	0.00496	0.00477	0.00173
72	0.00768	0.00739	0.00711	0.00684	0.00658	0.00632	0.00608	0.00585	0.00562	0.00541	0.00197
73	0.00874	0.00841	0.00809	0.00779	0.00749	0.00721	0.00693	0.00667	0.00641	0.00617	0.00227
74	0.00999	0.00962	0.00926	0.00891	0.00858	0.00825	0.00794	0.00764	0.00736	0.00708	0.00263
75	0.01137	0.01095	0.01054	0.01015	0.00977	0.00941	0.00906	0.00872	0.00839	0.00807	0.00301
76	0.01296	0.01248	0.01202	0.01158	0.01115	0.01074	0.01034	0.00995	0.00958	0.00922	0.00347
77	0.01480	0.01426	0.01374	0.01324	0.01275	0.01228	0.01183	0.01139	0.01097	0.01057	0.00401
78	0.01696	0.01635	0.01576	0.01519	0.01464	0.01411	0.01359	0.01310	0.01262	0.01216	0.00466
79	0.01945	0.01876	0.01809	0.01744	0.01682	0.01622	0.01563	0.01507	0.01453	0.01400	0.00544
80	0.02234	0.02156	0.02080	0.02007	0.01936	0.01868	0.01802	0.01738	0.01676	0.01616	0.00637
81	0.02570	0.02481	0.02395	0.02312	0.02232	0.02155	0.02080	0.02007	0.01937	0.01869	0.00748
82	0.02965	0.02865	0.02768	0.02674	0.02583	0.02496	0.02410	0.02328	0.02248	0.02171	0.00886
83	0.03428	0.03315	0.03206	0.03100	0.02997	0.02897	0.02801	0.02708	0.02617	0.02530	0.01056
84	0.03958	0.03831	0.03708	0.03589	0.03473	0.03360	0.03251	0.03146	0.03043	0.02944	0.01257
85	0.04621	0.04478	0.04340	0.04206	0.04075	0.03949	0.03826	0.03706	0.03590	0.03478	0.01537
86	0.05400	0.05240	0.05085	0.04935	0.04788	0.04646	0.04508	0.04373	0.04242	0.04115	0.01884
87	0.06208	0.06031	0.05858	0.05690	0.05527	0.05368	0.05213	0.05062	0.04916	0.04773	0.02242
88	0.07010	0.06814	0.06623	0.06436	0.06255	0.06078	0.05906	0.05739	0.05576	0.05417	0.02581
89	0.07850	0.07633	0.07422	0.07216	0.07015	0.06820	0.06630	0.06444	0.06264	0.06088	0.02932

JSMT2007

age	Male	Female
50	0.00363	0.00184
51	0.00400	0.00199
52	0.00447	0.00209
53	0.00506	0.00223
54	0.00572	0.00240
55	0.00648	0.00259
56	0.00722	0.00283
57	0.00802	0.00307
58	0.00877	0.00336
59	0.00950	0.00367
60	0.01034	0.00401
61	0.01105	0.00419
62	0.01163	0.00441
63	0.01220	0.00466
64	0.01281	0.00497
65	0.01347	0.00538
66	0.01416	0.00579
67	0.01493	0.00626
68	0.01651	0.00691
69	0.01814	0.00756
70	0.02007	0.00841
71	0.02239	0.00923
72	0.02508	0.01035
73	0.02814	0.01162
74	0.03152	0.01302
75	0.03601	0.01462
76	0.04052	0.01652
77	0.04706	0.01885
78	0.05511	0.02227
79	0.06466	0.02639
80	0.07631	0.03146
81	0.08997	0.03760
82	0.10572	0.04624
83	0.12386	0.05521
84	0.14060	0.06576
85	0.16436	0.07812
86	0.19277	0.09310
87	0.22007	0.10763
88	0.26853	0.13300
89	0.32795	0.15911