Analysis of Determination of Adjusted Premium Reserves for Last Survivor Endowment Life Insurance Using the Gompertz Assumption

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Abstract

Disasters can come suddenly, against our will. Therefore, humans must be aware of the losses caused by these disasters. One solution to minimize the risk of loss is to transfer the risk to an insurance company. As a result of these circumstances, insurance companies have the possibility or opportunity to pay claims suddenly. Thus, companies must always have funds to meet their obligations, so there is a need for premium reserves. This paper will discuss the analysis of determining the amount of premium reserves adjusted for last survivor endowment life insurance, with a retrospective principle. Previously, the probability of death was determined using the Gompertz Assumption, whose parameters refer to the 2011 Indonesian Mortality Table (TMI). From the results of this analysis, the expected premium price is based on the Gompertz Assumption Mortality Table. The results are also compared to the price of the premium using the 2011 Mortality Table (TMI) in which, after getting the price of the premium, the next step is to determine the amount of reserves. Reserves obtained will be analyzed, whether accurate or not. The calculation results show that the adjusted premium reserve value is greater when calculated using the 2011 Indonesian Mortality Table (TMI). Therefore, using this Gompertz assumption will reduce the amount of reserves, when compared to using the 2011 Indonesian Mortality Table (TMI).

Keywords: Last survivor, premium reserves, retrospective method, Gompertz assumption.

1. Introduction

Every human being must have been struck by a disaster, ranging from small things, such as losing a pen, to a large one like death. Disasters usually come suddenly, therefore, humans must be vigilant wherever and whenever. To anticipate these losses, humans will do a variety of ways, so that losses in terms of material or soul experienced can be minimized. One solution that can minimize losses is to transfer risk to insurance companies.

In general, insurance companies will incure a greater loss at the end of the policy year. This is because, the more the age of the insured, the higher the death rate. Conversely, at the beginning of the policy year, the company will experience a lower loss and the premium paid will be greater than the expenses incurred by the company. Therefore, premiums received by insurance companies will be excessive at the beginning of the policy year. The excess premium funds will be saved to pay compensation when the insured uses the insurance policy claim. To prepare for the possibility if the insured suddenly uses his claim. Thus, insurance companies

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need to know the forecast of the insured mortality rate and need to have premium reserves to avoid losses for the company, Ramadani, D. 2014.
In previous studies discussed about the calculation of premium reserves using prospective methods and Gompertz assumptions by Fiyan Handoyo, et. all. 2019, the study is devoted to one insured person and uses the gross premium assumption. In addition, earlier studies have also been discussed by Promislow, 2011, regarding the determination of premium reserves for life insurance products using a prospective method, using the de moivre assumption. This study will discuss the adjusted premium reserves for last survivor endowment life insurance products with the method used is a retrospective method, but the number of insured is two people and based on Gompertz assumptions, Frostig, E. B. L. 2003.

2. Methodology

Premium
Premium is the amount of money paid by policyholders to insurance companies to get benefits in return, Larson, R. E. Premiums that are paid in one go or are paid only once in the specified insurance period are called single premiums. Premiums can also be paid periodically at the beginning of the year called the annual premium, Futami, T. 1993.
A single net premium in last survivor endowment life insurance with a compensation of B is paid at the end of the policy year, namely:

$$A_{\overline{\mathrm{xy:n}}|} = B\left(A^{1}_{\overline{\mathrm{xy}:n}|} + A_{\overline{\mathrm{xy}:n}|}^{\;1}\right) = B\left(1 - d\ddot{a}_{\overline{\mathrm{xy}:n}|}\right) \tag{1}$$

Large annual net premiums on last survivor endowment life insurance, namely:

$$P_{\overline{\mathrm{xy}:n}|} = \frac{A_{\overline{\mathrm{xy}:n}|}}{\ddot{a}_{\overline{\mathrm{xy}:n}|}} = B\left(\frac{1}{\ddot{a}_{\overline{\mathrm{xy}:n}|}} - d\right) \tag{2}$$

Premium Reserves
Premium reserve is the amount of funds collected from insurance premiums paid by policyholders to insurance companies. Premium reserves can be calculated by two methods from the point of view, namely the retrospective method and the prospective method, Futami, T. 1994.
Adjusted Premium Reserves
Adjusted premium reserves, has a premium value for the initial year called α, which is smaller than the value of premiums in the following year called β. The present value at the time of payment of the net premium value is the same as the present value of the net premium. For example, the insured who is aged x years with a payment period of n years and with an annual premium value of P base on, Ghufron. 2014, meets the following equation:

$$P.\ddot{\mathrm{a}}_{x:\overline{n}|} = \alpha + \beta.\mathrm{a}_{x:\overline{n-1}|} \tag{3}$$

Calculation of α for the insured aged x and y with a compensation of Rp1 based on a full preliminary term, namely:

$$\alpha = \frac{C_{xy}}{D_{xy}} \tag{4}$$

Based on equation (3), β can be calculated, as follows:

$$\beta = P + \frac{P - \alpha}{\mathrm{a}_{xy:\overline{n-1}|}} \tag{5}$$

Mortality Model of Gompertz Assumptions
According to Fiyan Handoyo, et. all. 2019, Ghufron. 2014., in 1825, Gompertz stated that the acceleration of mortality was

$$\mu_x = Bc^x \tag{6}$$

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so it is obtained

$$l_x = kg^{c^x} \tag{7}$$

Definition: Based on Valdez, E. A., Vadiveloo, J., Dias, U., 2014, The Gompertz distribution is denoted by $G(x \mid \mu, \sigma)$ where μ is the average and is the standard deviation, defined as follows:

$$G(x \mid \mu, \sigma) = W\left(\frac{x-a}{b}\right) \tag{8}$$

where $W(x) = 1 - e^{-e^x}$ and the constant *a* and *b* satisfy,

$$\sigma = \left(\frac{\pi}{\sqrt{6}}\right) b \text{ and } \mu = a - b\gamma \tag{9}$$

B and *c are* Gompertz constants whose values can be found using the Gompertz distribution $G(x \mid \mu, \sigma)$ because it can be stated, Dey, S., Moala, F. A., & Kumar, D. 2018,

$$G(x \mid \mu, \sigma) = 1 - \mathrm{g}^{c^x} \tag{10}$$

where

$$\mathrm{g} = e^{-e^{\frac{-a}{b}}} \text{ dan } c = e^{\frac{1}{b}} \tag{11}$$

Equation of premium reserves with retrospective methods for the last survivor model at the end of the t year base on, Bowers, N. L., Gerber, H. U., Hickman, J. C., Jones, D. A., Nesbit, C. J. 1997, namely:

$${}_tV_{xy} = \frac{\left(\left(l_{x+t-1,y+t-1}\right)\left({}_{t-1}V\right)\right) + \left(\left(l_{x+t-1,y+t-1}\right)(P)\right)(1+i) - \left(B\left(d_{x+t-1,y+t-1}\right)\right)}{l_{x+t,y+t}} \tag{12}$$

or

$${}_tV_{xy} = \left({}_{t-1}V + P\right) u_{x+t-1,y+t-1} - \left(B\left(k_{x+t-1,y+t-1}\right)\right) \tag{13}$$

Premium reserves adjusted for the retrospective method for the last survivor model in the first year (t = 1) can be calculated as follows:

$${}_1V_{xy} = (\alpha) u_{x,y} - \left(B\left(k_{x,y}\right)\right) \tag{14}$$

and for premium reserves adjusted to the retrospective method for the last year survivors of the second year and beyond (t > 1) can be calculated as follows:

$${}_tV_{xy} = \left({}_{t-1}V + \beta\right) u_{x+t-1,y+t-1} - \left(B\left(k_{x+t-1,y+t-1}\right)\right) \tag{15}$$

3. Results and Discussion

The data used in this study are simulation data, there are 5 pairs of policyholders (male and female). The amount of benefits for each policyholder is the same, in the amount of Rp 200,000,000.00 with the life insurance coverage for each spouse for 20 years. This study also uses secondary data taken from the 2011 Indonesian Mortality Table (TMI) issued by the Indonesian Life Insurance Association (AAJI). The interest rate used is 2.5%.

Based on the Gompertz distribution equation, the Gompertz constant can be determined for the 2011 Indonesian Mortality Table (TMI). Previously, the average (μ) and standard deviation (σ) must be determined, obtained μ = 56 and σ = 32.47951537. Both of these values can be substituted into equation (9) so that a value is obtained *a* = 70.62492429 and *b* = 25.33701903. Furthermore, the values of g and c can be found by substituting into equation (11), so that values g = 0.940277853 and c = 1.04025715, obtained for men and women that can be used in the formation of the Gompertz Assumption Mortality Table. Therefore, the Gompertz constant values for men and women are the same, resulting in the Gompertz Assumption Mortality Table for men and women will be the same.

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Furthermore, based on the 2011 Indonesian Mortality Table (TMI), the age limit of a person (x) is 111 and the number of people living (l_0) is 100,000. With equation (7), it can be calculated the number of people living at age x years, for age = 1:

$$\begin{aligned} l_1 &= k\left(g^{(c)^t}\right) \\ &= 100{,}000\left(0.940277853^{1.04025715^t}\right) \\ &= 93794.97631 \end{aligned}$$

Based on the above calculation, it means that the number of people who lived at the age of 1 year was 93794,97631 people. Calculations are made up to x = 111. Meanwhile, to get the value ${}_t p_x$ and ${}_t q_x$ can be calculated:

$$\begin{aligned} {}_1p_1 &= g^{c^t(c^t-1)} \\ &= 0.940277853^{(1.04025715)^t(1.04025715)^t-1} \\ &= 0.997424494 \end{aligned} \qquad \begin{aligned} {}_1q_1 &= 1-{}_1p_1 \\ & 0.002575506 \end{aligned}$$

Calculating Annuities in Last Survivor Life Insurance. Last Survivor initial n-year life annuity, denoted by $\ddot{a}_{\overline{xy:n}|}$ can be calculated using equation (11), based on the data in Table 1, the calculation of the 1st policyholder annuity based on TMI 2011 can be written as follows:

$$\ddot{a}_{\overline{20,22}:\boxed{20}} = \sum_{t=0}^{19} v^t \; {}_tp_{\overline{20,22}} = 15.97820592$$

By using the same method, we can calculate the amount of the last survivor life insurance annuity for other policy holders, which can be seen in Table 1.

Table 1. Life Survivors Last Survivor Life Insurance

No	Policy Holder	$\ddot{a}_{\overline{xy:n}\rceil}$	
		TMI 2011	Mortality Table Gompertz assumption
1	Justin & Selena	15.97820592	15.89133283
2	Adam & Behati	15.97801402	15.86951166
3	Zayn & Gigi	15.97460437	15.7679679
4	Alif & Nada	15.97129978	15.7177363
5	Morgan & Bella	15.96013605	15.63321097

Calculate the Single Net Premium of Last Survivor Endowment Life Insurance, the single net premium denoted $A_{\overline{xy:n}\rceil}$ can be calculated using equation (2), based on Table1 and Table2 with compensation (B) of Rp200,000,000.00 and interest (v) of 2.5%. then the calculation of the first net premium of the first policyholder based on TMI 2011 can be written as follows:

$$A_{\overline{20,22}:\boxed{20}} = B(1 - d\ddot{a}_{\overline{20,22}:\boxed{20}}) = 122{,}057{,}532$$

Using the same method, a single net premium for last survivor life insurance can be calculated for other policy holders, which can be seen in Table 2.

Table 2. Single Net Premium of Endowment Life Insurance Last *Survivor*

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No	Policy Holder	$A_{\overline{xy:n}\rceil}$	
		TMI 2011	Mortality Table Gompertz assumption
1	Justin & Selena	122,057,532	122,481,303
2	Adam & Behati	122,058,468	122,587,748
3	Zayn & Gigi	122,075,101	123,083,083
4	Alif & Nada	122,091,221	123,328,116
5	Morgan & Bella	122,145,678	123,740,434

Calculate the Annual Net Premium of Last Survivor Endowment Life Insurance, Calculation of the annual net premium denoted can be calculated using equation (3), based on Table 1 and Table 2, the 1st annual policy premium obtained by the policyholder is based on TMI 2011 as follows:

$$P_{\overline{20,22}:\boxed{20}} = \frac{A_{\overline{20,22}:\boxed{20}}}{\ddot{a}_{\overline{20,22}:\boxed{20}}} = 7{,}639{,}001$$

By using the same method, the annual net premium of endowment survivor life insurance can be calculated for other policy holders, so that it can be written in Table3.

Table 3. Annual Net Insurance Premium for Last Survivor Endowment Life Insurance

No	Policy Holder	$P_{\overline{xy:n}\rceil}$	
		TMI 2011	Mortality Table Gompertz assumption
1	Justin & Selena	7,639,001	7,707,428
2	Adam & Behati	7,639,151	7,724,733
3	Zayn & Gigi	7,641,823	7,805,894
4	Alif & Nada	7,644,414	7,846,430
5	Morgan & Bella	7,653,173	7,915,228

Calculate adjusted premium reserves based on the 2011 Indonesian Mortality Table (TMI) and the Gompertz Assumption Mortality Table. First, the premium value for the first year (α) and the next year premium (β) will be calculated using the Full Preliminary Term valuation in equations (4) and (5). The calculation for the 1st policy holder is based on the 2011 Indonesian Mortality Table (TMI), namely:

$$\alpha = (2 \cdot 10^8)\frac{C_{20,22}}{D_{20,22}} = 159{,}657 \qquad \beta = P + \frac{P-\alpha}{a_{20,22:\boxed{19}}} = 8{,}118{,}805$$

Using the same method, values (α) and (β) can be calculated for each policyholder and can be written in Table 4.

Table 4. First year premium (α) and next year premium (β)

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No	Policy Holder	α		β	
		TMI 2011	Mortality Table Gompertz assumption	TMI 2011	Mortality Table Gompertz assumption
1	Justin & Selena	159,657	2,200,891	8,118,805	8,062,992
2	Adam & Behati	225,847	2,481,522	8,114,726	8,063,850
3	Zayn & Gigi	297,851	3,516,415	8,113,084	8,085,455
4	Alif & Nada	383,457	3,956,015	8,110,473	8,100,944
5	Morgan & Bella	673,443	4,589,953	8,101,579	8,134,165

After obtaining a value (α) and (β) from each policy holder, then the premium reserves can be calculated adjusted for End Survivor Endowment life insurance products, with compensation for both policyholders of Rp200,000,000.00 with a 20 years coverage period Premium reserves are calculated using the retrospective method based on equations (13) and (15), for the first policy holder of the large premium reserves adjusted in the first year based on the 2011 Indonesian Mortality Table (TMI) as follows:

$$ {}_1V_{20,22} = (\alpha)u_{20,22} - \left(B\left(k_{20,22}\right)\right) = (\alpha)\frac{D_{20+1-1,22+1-1}}{D_{20+1,22+1}} - \left(B\left(\frac{C_{20+1-1,22+1-1}}{D_{20+1,22+1}}\right)\right) = 0 $$

The adjusted premium premium for the 2nd year is as follows: ${}_2V_{20,22} = \left({}_{2-1}V + \beta\right)u_{20+2-1,22+2-1} - \left(B\left(k_{20+2-1,22+2-1}\right)\right) = \left({}_{2-1}V + \beta\right)\frac{D_{20+2-1,22+2-1}}{D_{20+2,22+2}} - \left(B\left(\frac{C_{20+2-1,22+2-1}}{D_{20+2,22+2}}\right)\right) = 8{,}153{,}882$

Using the same method, we can calculate the adjusted premium reserve. Using the Gompertz Assumption Mortality Table for other policyholders, Table 5 to Table 9 can be formed which contains the amount of premium reserves adjusted for each policy holder from the first year to the end of the policy year.

Table 5. Reserve of premium for the 1-st policyholder

T	TMI 2011 (Rupiah)	Mortality Table for Gompertz (Rupiah)
1	0	0
2	8,153,882	6,000,449
3	16,513,934	12,146,811
4	25,089,736	18,447,371
5	33,894,277	24,911,206
6	42,941,750	31,548,277
7	52,245,691	38,369,515
8	61,814,752	45,386,933
9	71,656,251	52,613,741
10	81,774,156	60,064,484
11	92,173,476	67,755,182
12	102,862,285	75,703,506
13	113,850,986	83,928,964
14	125,149,993	92,453,112
15	136,765,921	101,299,800
16	148,706,890	110,495,439
17	160,985,116	120,069,313
18	173,613,553	130,053,931
19	186,607,812	140,485,424
20	199,984,194	151,404,003

Table 6. Reserve of premium for the 2-nd policyholder

T	TMI 2011 (Rupiah)	Mortality Table for Gompertz (Rupiah)
1	0	0
2	8,111,289	5,706,765
3	16,454.930	11,545,140
4	25,030,127	17,523,025
5	33,840,428	23,649,125
6	42,890,043	29,933,041
7	52,188,324	36,385,367
8	61,744,647	43,017,807
9	71,565,828	49,843,296
10	81,656,843	56,876,147
11	92,023,784	64,132,209
12	102,675,891	71,629,048
13	113,623,097	79,386,154
14	124,873,056	87,425,172
15	136,434,231	95,770,166
16	148,317,998	104,447,924
17	160,542,448	113,488,296
18	173,124,170	122,924,587
19	186,082,282	132,794,006
20	199,438,054	143,138,183

Table 7. Reserve premium for 3th policyholder

T	TMI 2011 (Rupiah)	Mortality Table for Gompertz (Rupiah)

Tabel 8. Reserve premium for 4th policyholder

T	TMI 2011 (Rupiah)	Mortality Table for Gompertz (Rupiah)

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1	0	0
2	8,013,559	4,672,248
3	16,231,410	9,454,809
4	24,656,515	14,355,650
5	33,292,787	19,383,719
6	42,141,997	24,549,067
7	51,210,452	29,862,992
8	60,502,851	35,338,207
9	70,028,258	40,989,022
10	79,791,107	46,831,568
11	89,801,947	52,884,041
12	100,070,539	59,166,992
13	110,608,982	65,703,656
14	121,433,965	72,520,336
15	132,564,640	79,646,848
16	144,024,404	87,117,042
17	155,842,704	94,969,398
18	168,056,409	103,247,736
19	180,706,575	112,002,042
20	193,840,355	121,289,429

1	0	0
2	7,926,305	4,237,526
3	16,052,433	8,574,325
4	24,378,260	13,017,958
5	32,908,387	17,576,992
6	41,648,481	22,261,133
7	50,603,847	27,081,392
8	59,775,620	32,050,266
9	69,168,755	37,181,949
10	78,791,876	42,492,578
11	88,659,336	48,000,521
12	98,783,207	53,726,704
13	109,174,036	59,694,998
14	119,844,685	65,932,672
15	130,816,159	72,470,919
16	142,117,466	79,345,477
17	153,784,864	86,597,357
18	165,859,355	94,273,704
19	178,383,881	102,428,817
20	191,406,303	111,125,355

Table 9. Reserve premium for 5th policyholder

t	TMI 2011 (Rupiah)	Mortality Table for Gompertz (Rupiah)
1	0	0
2	7,566,434	3,638,267
3	15,265,851	7,378,152
4	23,102,159	11,228,328
5	31,075,752	15,198,747
6	39,187,608	19,300,838
7	47,436,682	23,547,745
8	55,828,172	27,954,592
9	64,379,993	32,538,811
10	73,111,993	37,320,510
11	82,047,352	42,322,924
12	91,209,195	47,572,934
13	10,622,473	53,101,695
14	110,317,322	58,945,368
15	120,327,875	65,146,008
16	130,686,653	71,752,613
17	141,428,923	78,822,390
18	152,594,068	86,422,270
19	164,231,971	94,630,741
20	176,406,736	103,540,059

4. Conclusions

Based on the results of the discussion that has been done, it can be concluded several things. First, the results of calculations in determining the last survivor endowment life insurance premiums based on the 2011 Indonesian Mortality Table (TMI) are smaller than those based on the Gompertz Assumption Mortality Table. So that the determination of premiums is better with the 2011 Indonesian Mortality Table (TMI). Second, the results of the calculation of adjusted premium reserves for last survivor endowment life insurance products using the 2011 Indonesian Mortality Table (TMI) are closer to the benefits to be provided compared to the Gompertz Assumption Mortality Table. Furthermore, adjusted premium reserves for end survivor last survivor life insurance products using the 2011 Mortality Table of Indonesia (TMI) is greater than the Gompertz Assumption Mortality Table, so that the use of Gompertz assumptions is not good for insurance companies.

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Acknowledgements
The Authors would like to thank to Universitas Padjadjaran, who gave funding for the RDDU research and preparation of this paper.

References

Bowers, N. L., Gerber, H. U., Hickman, J. C., Jones, D. A., Nesbit, C. J. 1997. Actuarial Mathematics. The Society of Actuaries, United States of America.

Dey, S., Moala, F. A., & Kumar, D. 2018. Statistical Properties and Different Methods of Estimation of Gompertz Distribution with Application.Journal of Statistics and Management Systems, 21(5): 839–876. https://doi.org/10.1080/09720510.2018.1450197.

Frostig, E. B. L. 2003. The Impact of Statistical Dependence on Multiple Life Insurance Program.Departement of Statistics, University of Haifa.

Futami, T. 1993. Oriental Life Insurance Cultural Development Center, Inc. Tokyo. Japan.

Futami, T. 1994.Oriental Life Insurance Cultural Development Center, Inc. Tokyo. Japan.

Fiyan Handoyo[1],*, Riaman[2], Nurul Gusriani[2], Sudrajat Supian[2], Subiyanto[3], 2019, Joint Life Term Insurance Reserves Use the Retrospective Method Based on De Moivre Law, Available online at www.worldscientificnews.com (Received 22 April 2019; Accepted 08 May 2019; Date of Publication 09 May 2019)

Ghufron. 2014. Prospective Reserve of Last Survivor with Gompertz Assumptions. JOM FMIPA October 2014,1(2): 466-474.

Larson, R. E., & Gaummnitz, E. A. 1962.Life Insurance Mathematics (Fourth ed.). New York: John Wiley and Sons Inc.

Promislow, S. David. 2011. Fundamental of Actuarial Mathematics (Second ed.). United Kingdom: John Wiley and Sons Inc.

Ramadani, D. 2014. Prospective Reserves for Life Insurance with De Moivre Law. Journal of Online Students (JOM) FMIPA February 2014, 1 (2): 1-7.

Valdez, E. A., Vadiveloo, J., Dias, U., 2014. Life Insurance Policy Termination and Survivorship.Insurance: Mathematics and Economics, 58: 138-149. http://dx.doi.org/10.1016/j.insmatheco.2014.06.011.

Willemse, W. J. & H. Koppelaar. 2000. Knowledge Elicitation of Gompertz Law of Mortality. Scandinavian Actuarial Journal, 2: 168-179. https://doi.org/10.1080/034612300750066845.

Biography / Biographies

Riaman is a teaching staff in the mathematics study program at the Mathematics Department of the University of Padjadjaran since 1997. The mathematics degree was won from the Mathematics Department of the University of Padjadjaran in 1995, while the Masters of Actuarial Science was obtained from the Bandung Institute of Technology in 2000. The field of research currently being undertaken is the field of applied mathematics. More specifically are: fields of financial mathematics, actuarial mathematics, survival models, mathematical statistics, and reliability. Since 2001 until now he has joined as a member of IndoMS, and since 2017 joined IAENG.

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