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Calculation of Indonesian Pension Funds Using Group Self Anuitization Method and Makeham Mortality Law

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ABSTRACT

This study aims to calculate Indonesian pension funds using the Group Self Anuitization method and Makeham's death law. The calculation of the GSA method is almost the same as the calculation of an annuity for life, so the price determination procedure includes calculating the level of annuity payments. The death rate is projected by Makeham Mortality Law based on Indonesian Mortality Table IV. Based on an analysis with the same premium amount, it is known that the benefits of male pension funds are greater than women for each age at which benefits are paid, pension funds paid to policyholders increase from 2019-2021 and decrease in 2022, the higher the entry age payment of pension funds, the benefits obtained will be even greater.

Keywords : Group Self Annuitization; Pension Fund; Makeham Law; Premiums; Annuity

ABSTRAK

Penelitian ini bertujuan untuk menghitung dana pensiun Indonesia dengan menggunakan metode Group Self Anuitization dan hukum kematian Makeham. Perhitungan pada metode GSA hampir sama dengan perhitungan anuitas seumur hidup, sehingga prosedur penentuan harga meliputi perhitungan tingkat pembayaran anuitas. Angka kematian diproyeksikan oleh Hukum Kematian Makeham berdasarkan Tabel Mortalita Indonesia IV. Berdasarkan analisis dengan besaran premi yang sama, diketahui bahwa manfaat dana pensiun laki-laki lebih besar dari perempuan untuk setiap usia masuk pembayaran manfaat, dana pensiun yang dibayarkan kepada pemegang polis meningkat dari tahun 2019-2021 dan menurun pada tahun 2022, semakin tinggi usia masuk pembayaran dana pensiun maka manfaat yang diperoleh akan semakin besar.

Kata Kunci : Annuitisasi Diri Kelompok; Dana Pensiun; Hukum Mortalita Makeham; Premil; Anuitas

INTRODUCTION

Based on several studies, the world's life expectancy has increased from year to year, including in Indonesia. Based on data from Badan Pusat Statistik Indonesia, life expectancy in Indonesia increased from 69.09 years for men and 72.80 years for women in 2016 to 69.44 years for men and 73.33 years for women in 2019. In line with the increase in life expectancy, there is a risk faced by the world of insurance and pension fund companies, namely the emergence of longevity risk (Denuit et al., 2011).

The longevity risk occurs due to the trend of increasing life expectancy among policyholders and pensioners. Thus, it makes a higher payment rate than the funds that have been provided (Li & Hardy, 2011). Practically, pension fund companies must provide larger funds to maintain the company's long-term financial balance. However, a larger supply of capital still has a risk due to the possibility of a future crisis. As a result, another way of managing longevity risk is needed (Roy, 2012) and (Summary, 2000).

Group Self Annuitization (GSA) can be used to manage longevity risks. Group Self Annuitization (GSA) is a method of collecting pension funds by participants paying contributions, then the contributions are invested in financial assets (Milevsky & Robinson, 2000). Benefit payments are made to surviving members (Cfa & Fin, 2015). The calculation of the GSA method resembles the calculation of a whole-life annuity so that the pricing procedure includes calculating the annuity payment level (Chen & Rach, 2022) and (Piggott et al., 2005).

Therefore, the formula for calculating benefit payments must include the expected future annuity mortality rate, the calculation for anticipating an increase in the death rate, the expected rate of return on the investment portfolio, and the yield curve is assumed to be flat for ease of calculation (Brown, 2001).

In general, most life insurers determine the amount of contribution regarding the mortality table. The mortality law is used because the mortality law has a simple formula that can explain phenomena that occur efficiently, and practically and tends to estimate several functions from mortality data. The Gompertz and Makeham mortality laws are the most commonly used (Mumpar-victoria et al., 2005). However, the results of the Gompertz mortality law approach are not suitable because the Gompertz mortality law only takes into account deaths caused by the age factor, whereas in the mortality table, it is recorded that deaths are not caused only by age.

While the results of the approach with Makeham's mortality law are more appropriate because Makeham's mortality law does not only take into account the age factor (Rietz, 1921). The Makeham distribution provides a better approximation for the distribution of mortality data. The Makeham distribution is an extension function from the Gompertz distribution. The difference between the two is that Makeham's distribution function uses additional parameters from the Gompertz distribution function (Mumpar-victoria et al., 2005).

The previous research calculates pension funds through some methods, for example, the projected unit credit and individual level premium method (Kusuma Wardhani et al., 2014), the Projected Benefit Cost Method (Sukono et al., 2021), and using Group self annuitization method with several mortality models, for example, dynamic mortality model (Xiao et al., 2018) and stochastic mortality model (Qiao & Sherris, 2013) and (Qiao & Minney, 2015). Another research used GSA and inflation index (Hanewald et al., 2013).

There are no researches that discuss GSA with Makehan's mortality law. Whereas Makeham's mortality law is more appropriate. This research will focus on calculating

pension funds using the Group Self Anuitization method. and Makeham's mortality law. This research also uses fixed-income mutual rates yield in the calculation.

Referring to Article 239, Article 240, Article 354, and Article 355 of Government Regulation Number: 11 of 2017 concerning the Management of Civil Servants, the retirement age for civil servants is 60 years for high-ranking officials and middle-functional officials and 65 years for civil servants who hold main functional expert. Meanwhile, according to the Law of the Republic of Indonesia Number 6 of 1966 concerning Military Pensions, the minimum retirement age for first army officers and above is 48 years and a maximum of 55 years.

Meanwhile, non-commissioned officers are under a minimum of 42 years and a maximum of 48 years. According to Law Number 14 of 2005 concerning Teachers and Lecturers, Article 30 paragraph 4 states that the retirement age for teachers and lecturers is 60 years. Adjusting these several retirement age classifications in Indonesia, the calculation of pension benefit payments will be made for ages 55 years, 60 years, and 65 years.

Then, the investment portfolio is assumed to follow the return on fixed-income mutual funds. Contributions can be made with a lump sum payment at the age of entry for pension fund benefit payments or paid each period up to the age of entry for pensio n fund benefits (Valdez et al., 2006). If the mortality rate is lower than expected, this will reduce future benefit payments. This is because the funds that have been accumulated must be shared with more annuitants. The same thing happens if the interest rate earned on investment returns is lower than expected, which will affect the reduction in benefit payments. Based on Indonesian mortality characteristics, male mortality is higher than female mortality and a longer time for preparing a pension fund makes the fund greater.

Because of that, there are two hypotheses for this research: First, the pension benefits of men's pension funds will be greater than women, The other hypothesis is higher entry age for pension fund payment the benefits obtained will b e even greater.

RESEARCH METHODS

The data in this study uses data from Indonesia's IV Death Table for 2019 (Indonesian Life Insurance Association (AAJI), 2019). The first step in data analysis is to study literature studies that examine pension funds, Makeham mortality law, and the Group Self Anuitization method. First, the death rate is projected with Makeham's death law based on TMI IV 2019. The power of death in Makeham's death law is expressed by the formula 1

$$\boldsymbol{\mu(x) = A + BC^x} \qquad \textbf{(1)}$$

With $B > 0, a \geq -B, C > 1$ and $x, t \geq 0$. Parameter A represents the risk caused by an accident and BC^x represents the risk due to age. The probability that a person aged x years will live to $x + t$ according to Makeham's law of mortality is (Bowers et al., 1997), which is shown in formula 2.

$$\mathbf{tp_x = exp\left(-At - \frac{BC^x}{\ln C}(C^t - 1)\right)} \qquad \textbf{(2)}$$

To make the Makeham mortality table, formulas 3-6 are used (Bowers et al., 1997).

$$p_x = exp\left(-A - \frac{BC^x}{ln\, ln\, C}(C-1)\right) \quad (3)$$

$$q_x = 1 - exp\left(-A - \frac{BC^x}{ln\, ln\, C}(C-1)\right) \quad (4)$$

$$l_x = l_0\left(exp\left(-Ax - \frac{B}{ln\, ln\, C}(C^x - 1)\right)\right) \quad (5)$$

$$d_x = l_0\left(ex\,p\left(-Ax - \frac{B}{ln\, ln\, C}(C^x - 1)\right)\right) - l_0\left(exp\left(-A(x+1) - \frac{B}{ln\, ln\, C}(C^{x+1} - 1)\right)\right) \quad (6)$$

A simple regression equation based on Makeham's mortality law, that is:

$$ln\left(ln\left(\frac{1}{1-q_x}\right)\right) = xln\, C + ln\left(\frac{AB}{ln\, C}(C-1)\right) \quad (7)$$

With $y_i = ln\left(ln\left(\frac{1}{1-q_x}\right)\right)$, $\alpha = ln\, C$, $\beta = ln\left(\frac{AB}{ln\, C}(C-1)\right)$.

So, we get a simple regression estimator

$$y = ax + b \quad (8)$$

To minimize the number of squared errors, the least squares method is needed, then we have:

$$R = \sum_{i=1}^{n} \varepsilon_i^2 = \sum_{i=1}^{n} (\hat{y}_i - ax_i - b)^2 \quad (9)$$

With $\hat{y}_i$ is model estimator, a is estimator α, and b = Estimator β. Parameters A, B, C can be estimated by maximizing R to be [1] $\frac{dR}{da} = 0$, so obtained $a = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sum(x_i - \bar{x})^2}$; [2] $\frac{dR}{db} = 0$, so obtained $b = \bar{y} - a\bar{x}$.

The second step is to discuss the concept of calculating pension funds in Indonesia. In this step, we determine entry ages for pension plan based on some general job in Indonesia such as TNI/POLRI, lecturer, teacher, and civil servant. Then, the contributions can be paid annually in the amount of P_0 for n years, or it can be made all at once (lump sum) in the amount of $P_{x:n}$ at the beginning of the benefit payment year.

$$P_{x:n} = P_0 \times \ddot{s}_{x:n} = P_0 \times \frac{\ddot{a}_{x:n}}{{}_nE_x} \quad (10)$$

The third step is calculating Indonesian pension funds using Group Self Anuitization method. The calculation on the GSA method is almost the same as the calculation on a wholelife annuity, so the pricing procedure includes calculating the annuity payment level.

The equation for the actuarial present value for whole life annuity with the probability Pr (K = k) = ${}_kp_x\, q_{x+k}$, is obtained:

$$\ddot{a}_x = \sum_{k=0}^{\infty} v^k \, {}_kp_x \tag{11}$$

$$\ddot{a}_{x:n} = \sum_{k=0}^{n-1} v^k \, {}_kp_x \tag{12}$$

$$\ddot{s}_{x:n} = \frac{\ddot{a}_{x:n}}{{}_nE_x} = \frac{\ddot{a}_{x:n}}{v^n \, {}_np_x} \tag{13}$$

Where $\ddot{a}_x$ is discrete whole life annuity due for age x, $\ddot{a}_{x:n}$ is discrete n-year term life annuity due for age x, $\ddot{s}_{x:n}$is sum of discrete n-year term life annuity due for age x, ${}_kp_x$ is the probability that a person aged x years will be alive k years later, v is dicount factor (Bowers et al., 1997).

Therefore, the formula for calculating benefit payments must include the expected future annuity mortality rate, the calculation for anticipating an increase in the mortality rate, and the expected rate of return on the investment portfolio. To facilitate the calculation, the yield curve is assumed to be flat. If the expectation occurs over time, the payout rate will be held constant. It is assumed that at time $t = 0$, with l_x being an annuitant aged x, will receive benefits periodically in the future. Suppose that the payment is a level payment from B_0, so the total initial funds are

$$F_0 = l_x B_0 \sum_{t=0}^{\infty} \left(\frac{l_{x+t}}{l_x}\right) v^t = l_x B_0 \ddot{a}_x \tag{14}$$

Where l_x represents the expectation of an individual living to age x, $v = \frac{1}{1+i}$ is the discount factor, and $\ddot{a}_x$ is the annuity which is interpreted as the present value of the life annuity due paid 1 at the beginning of the year.

Furthermore, it will be developed for payment of benefits in the future in cases where the actual survival pattern is different from what was expected, for example the number of individuals who survive to reach a certain age is different from what was expected. Thus, it is not possible to continue paying benefits according to what has been previously determined because it will disrupt the balance of the pension fund. The number of individuals that survive is denoted by adding $*$. At time $t = 1$, the fund will be

$$F_1 = (F_0 - l_x B_0)(1 + i) = l_x B_0 (\ddot{a}_x - 1)(1 + i) \tag{15}$$

Then, this value is divided by the annuitan who is still alive based on the value of life expectancy, so that periodic benefit payments become B_1^* in equation 16.

$$\begin{aligned} B_1^* &= \frac{1}{l_{x+1}} \left(\frac{l_x B_0 (\ddot{a}_x - 1)(1 + i)}{(\ddot{a}_x - 1)\left(\frac{1+i}{p_x}\right),} \right) \\ &= B_0 \left(\frac{l_x \, p_x}{l_{x+1}^*}\right) \\ &= B_0 \left(\frac{p_x}{p_x^*}\right) \end{aligned} \tag{16}$$

In general, at time t the calculation of benefit payments is B_t^* in equation 17.

$$
\begin{aligned}
B_t^* &= \frac{F_t^*}{l_{x+t}^* \ddot{a}_{x+t}} \\
&= \frac{l_{x+t-1}^* B_{t-1}^* (\ddot{a}_{x+t-1} - 1)(1+i)}{l_{x+t}^* \ddot{a}_{x+t}} \\
&= B_{t-1}^* \left(\frac{l_{x+t-1}^*}{l_{x+t}^*} \right) \left(\frac{(\ddot{a}_{x+t-1} - 1)(1+i)}{(\ddot{a}_{x+t-1} - 1) \frac{(1+i)}{p_{x+t-1}}} \right) \\
&= B_{t-1}^* \left(\frac{p_{x+t-1}}{p_{x+t-1}^*} \right) \qquad (17)
\end{aligned}
$$

The extension of the case is when there is a difference in interest rates. Suppose the real investment income level is $i_1^*, i_2^*, \cdots, i_t^*, \cdots$. So that at time t the fund is equal to

$$
\begin{aligned}
F_t^* &= (F_{t-1}^* - l_{x+t-1}^* (1 + i_t^*)) \\
&= l_{x+t-1}^* B_{t-1}^* (\ddot{a}_{x+t-1} - 1)(1 + i_t^*) \qquad (18)
\end{aligned}
$$

by substituting the equation we get

$$
\begin{aligned}
B_t^* &= \frac{F_t^*}{l_{x+t}^* \ddot{a}_{x+t}} \\
&= \frac{l_{x+t-1}^* B_{t-1}^* (\ddot{a}_{x+t-1} - 1)(1+i_t^*)}{l_{x+t}^* \ddot{a}_{x+t}} \qquad (19)
\end{aligned}
$$

Then, we have

$$
\begin{aligned}
B_t^* &= B_{t-1}^* \left(\frac{l_{x+t-1}^*}{l_{x+t}^*} \right) \left(\frac{(\ddot{a}_{x+t-1} - 1)}{(\ddot{a}_{x+t-1} - 1) \frac{(1+i)}{p_{x+t-1}}} \right) (1+i) \\
&= B_{t-1}^* \left(\frac{p_{x+t-1}}{p_{x+t-1}^*} \times \frac{1+i_t^*}{1+i} \right) \\
&= B_{t-1}^* \times MEA_t \times IRA_t \qquad (20)
\end{aligned}
$$

With MEA_t is mortality adjustment factor and IRA_t is interest rate adjustment factor at period $t - 1$ to t.

The GSA method works by recalculating periodic benefit payments using previous benefit payments multiplied by an adjustment factor. The fourth step is to draw conclusions and create a case study. In the case study a pension fund management scheme can be created for certain groups, for example a pension fund scheme for lecturers.

RESULTS AND DISCUSSION

In the following, a discussion will be carried out on the stages of calculating the formation of a mortality table using Makeham's mortality law and calculating pension funds using the Group Self Anuitization method:

Makeham Parameter Estimation

a is an estimator of the parameter α, so that the parameter C for male and female is 1.08394 and 1.08400, respectively. b is an estimator for the parameter β, so that the parameter A for male and female is 0.05822 and 0.04418, respectively, while the parameter B for male and female is 0.00158 and 0.00152, respectively. The parameter estimation shown in Table 1.

Table 1. Makeham Parameter

Parameter	Male	Female
A (Risks caused by accidents)	0,05822	0,04418
B (Probability of death)	0,00158	0,00152
C (Increased failure or death)	1,08394	1,08400

Source: Processed data, 2023

Then, these parameters are used to create a Makeham Mortality Table.

Makeham Mortality Table

The Makeham mortality table is formed using equations 3-6 in order to obtain a Makeham mortality table as shown in Tables 2 and 3. The tables shows probability of someone ages (x) die next year (q_x), probability (x) still alive next year (p_x), number of people alive in age (x) (l_x) and number of people ages (x) die (d_x). As shown in the table, death probability for male is greater than female and increase as long as the age increase. Makehan mortality life table shown in Table 2 and 3.

Table 2. Makeham Mortality Table for Male

Ages	q_x	p_x	l_x	d_x
0	0.0581087	0.941891283	100000	5810.871698
1	0.0582388	0.941761201	94189.1283	5485.461704
2	0.0583798	0.94162022	88703.6666	5178.50051
3	0.0585326	0.94146743	83525.16609	4888.94267
4	0.0586982	0.941301841	78636.22342	4615.80151
5	0.0588776	0.941122387	74020.42191	4358.14577
6	0.0590721	0.940927907	69662.27614	4115.096428
7	0.0592829	0.940717149	65547.17971	3885.823706
⋮	⋮	⋮	⋮	⋮
110	0.9999918899	0.000008110148043	7.56E-59	7.56E-59
111	0.9999969534	0.000003046597275	6.13E-64	6.13E-64

Source: Processed data, 2023

Table 3. Makeham Mortality Table for Female

Ages	q_x	p_x	l_x	d_x
0	0.00266	0.99734	100000	4473.165
1	0.00041	0.99959	95526.84	4285.206
2	0.00031	0.99969	91241.63	4105.538
3	0.00024	0.99976	87136.09	3933.805
4	0.00021	0.99979	83202.29	3769.666
5	0.00020	0.99980	79432.62	3612.795
6	0.00022	0.99978	75819.82	3462.878
7	0.00023	0.99977	72356.95	3319.616
⋮	⋮	⋮	⋮	⋮
110	0.58702	0.41298	3.36E-56	3.36E-56
111	1.00000	0.00000	4.01E-61	4.01E-61

Source: Processed data, 2023

Calculation of Premiums

In the context of pension funds, premiums or initial contributions for someone aged x years will be paid for n years until the age at which benefits are paid. There are two

options in premium payment: First option is pay Rp100,000 each period from 25 years of age until the age at which benefits are paid (55 years, 60 years, or 65 years). The premium is then processed in the investment portfolio. The other option is pay a lump sum of $P_{x:n}$ at the start of the pension fund benefit payment age. The lump sum premium for annuitant ages 25 shown in Table 6.

Tabel 6. Lump Sum Premiums for Anuitant Ages 25

Pension fund benefit payment age	Lump Sum Premium	
	Male	Female
55	Rp113.295.188,02	Rp77.289.072,41
60	Rp461.448.362,55	Rp285.587.545,03
65	Rp2.816.207.609,23	Rp1.557.885.652,06

Source: Processed data, 2023

Calculation of Pension Fund Benefits using the GSA method

The assumptions used in this study include: First, the initial age for payment of pension fund contributions is 25 years. Premium payments end when entering the age of payment of pension fund benefits. Then, the retirement age that applies to the TNI/Polri, civil servants and educators, the age for payment of pension funds, are 55 years, 60 years and 65 years. So that the premium payment period is 30 years, 35 years and 40 years. Then, Initial Contributions or Premiums (P_0)assumed to be Rp100.000. Then, the age range observed based on the Indonesian Mortality Table IV is 0-111 years. Pension funds for the mortality model start at t=0, namely 2019. The last assumption is Pension funds are invested in the Danamas Stable Fixed Income Mutual Fund investment portfolio. The expected rate of return on the investment portfolio in 2019 is 6% p.a, while the rate of return on the investment portfolio shown in Table 4.

Table 4. Stable Danamas RDPT Return Rate

Year	Return
2019	6.83%
2020	7.23%
2021	9.06%
2022	5.73%

Source: Processed data, 2023

The following is the original probability of death (q_x) data based on Indonesia IV Mortality Table for 2019 and the predicted mortality probability data q_x)for 2019 based on Makeham's mortality law. The probability of death in 2019 shown in Table 5.

Table 5. Probability of Death in 2019

Ages	Male		Female	
	TMI IV	Makeham	TMI IV	Makeham
55	0.00789	0.17861	0.00483	0.00483
56	0.00847	0.188106	0.00524	0.00524
57	0.00898	0.198276	0.00563	0.00563
58	0.00939	0.209155	0.00601	0.00601
59	0.00971	0.220781	0.00636	0.00636
60	0.00999	0.23319	0.00671	0.00671
61	0.01024	0.246418	0.00707	0.00707
62	0.00789	0.17861	0.00746	0.00746
⋮	⋮	⋮	⋮	⋮
110	0.59244	0.999992	0.58702	0.58702
111	1.00000	0.999997	1.00000	1.00000

Source: Processed data, 2023

Calculation of pension benefits to be received by annuitan is presented in the table 7 and 8.

Table 7. Pension fund for Male 2019-2022 per year

Pension fund benefit payment age	B_0	B_1	B_2	B_3
55	Rp1.393,2	Rp1.409,34	Rp1.450,05	Rp1.446,40
60	Rp6.851,24	Rp6.930,62	Rp7.130,84	Rp7.112,85
65	Rp51.350,06	Rp51.945,01	Rp53.445,72	Rp53.310,87

Source: Processed data, 2023

Table 8. Pension fund for Female 2019-2022 per year

Pension fund benefit payment age	B_0	B_1	B_2	B_3
55	Rp631,1	Rp638,42	Rp656,86	Rp655,2
60	Rp2.834,7	Rp2.867,50	Rp2.950,34	Rp2.942,9
65	Rp19.113,74	Rp19.335,20	Rp19.893,79	Rp19.843,6

Source: Processed data, 2023

Based on the calculation results, it is found that the benefits obtained always increase from 2019-2021 and will decrease in 2022. The highest pension fund is obtained for the entry age for benefit payments of 65 years.

Case Study

Using the assumption salary deduction for each case is IDR100.000,00. Salary deductions with other nominal amounts are calculated in a similar way. Let a 25-year-old male TNI/POLRI participates in a pension fund using the GSA method. Each period (year) his salary is always deducted by IDR 100,000.00. he plans to enter retirement age at the TNI's maximum retirement age of 55 years. Thus, the salary will be deducted for 30 years (age 25 years to 55 years), and pension funds will be paid starting at age 55 in the amount of IDR 1,393.2 in the first period, IDR 1,409.34 in the second period, IDR 656.86 in the third period, Rp. 655.2 in the fourth period, and so on until he dies.

Let a 25-year-old female civil servant joins a pension fund using the GSA method. Each period (year) the salary of the civil servant is always deducted by IDR 100,000.00. Based on the retirement age of civil servant, pension fund benefits will be paid at the age of 65. Thus, the civil servant's salary will be deducted for 40 years (age 25 years to 65 years), and pension funds will be paid starting at age 65 in the amount of IDR 19,113.74 2 in the first period, IDR 19,335.20 in the second period, IDR 19,893.79 in the third period, IDR 19,843.6 in the fourth period, and so on until he dies.

Let a 25-year-old male teacher/lecturer joins a pension fund using the GSA method. For each period (year) the salary is always deducted by IDR 100,000.00. The pension fund benefits will be paid at the age of 60. Thus, the salary will be deducted for 30 years (age 25 years to 55 years), and pension funds will be paid starting at age 60 for IDR 6,851.24 in the first period, IDR 6,930.62 in the second period, Rp7,130.84 in the third period, Rp7,112.85 in the fourth period, and so on until he dies.

CONCLUSION

Based on the calculation results, it is obtained that the benefits of male pension funds are greater than those of women for each age at which benefits are paid. Pension

funds paid to annuities increase from 2019-2021 and decrease in 2022. Then, the higher the entry age for payment of benefits, the greater the benefits obtained.

RECOMMENDATION

For further research, calculations using other mortality laws such as Gompertz-Makeham, Helligman Pollard, etc. can be used. Moreover, another pension plan method besides Group Self Anuitizaton can be used. This paper discuss about convesional pension plan, another research can replace the fund with tabaruk fund with different calculation which is focus on sharia pension plan.

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