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Cascade stress-strength system Reliability Estimation of Inverse Rayleigh Distribution

Hassna H. Kadem[1*] and Nada S. Karam[2]

[1,2]Mathematics Department / College of Science /Mustansiriyah University / Baghdad-Iraq

Email: uniquebelle93@gmail.com

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Abstract

The electronic devices, equipment and complex machines used in many fields such as telecommunications, medicine, astronautics and others are all subject to malfunctions, which cause material and moral losses, waste of time and other damages. Hence the importance of reliability issue in our working life by evaluating the performance and efficiency of these systems and Measuring the reliability of any device will be the basis for the development of most of these devices . Then In this paper will discussed the Estimation of Reliability Rn for cascade system when the stress and strength are Inverse Rayleigh distributed random variables. undervoltage rating.

The cascade system is a redundant component system, which is a redundant component with undervoltage rating and independently distributed power, in which the redundant component replaces the faulty component.. Cascade system is a special case of Stress-Strength models system. Also we discussed the Estimation of Marginal Reliabilities R1, R2 and R3 for Cascade system by three estimation methods (Max. likelihood, Weighted Least Square, Least Square) and Compare between the estimators of R4.

Introduction

In general the concept of the statistical for stress-strength describes the nature of the relation between two random variables representing stress and strength is to find and estimate probability that one of the two variables overrides the other variable [2]. The stress - strength reliability refers to the life of a component with random strength when subjected to random stress. Standby redundancy system is a well-known technique for increasing the reliability of a system.Here a number of redundant components are attached to one or more essential components of the system and in this system one of these components replaces the component that failed [16] .Cascade system that is a special case of standby redundancy for stress-strength models [9], this system inside there are many advanced electronic devices and equipment, it's that were first studied by Sriwastav and Pandit [5]. In most of the studies mentioned in the literature on the cascade system, the study is only carried out taking into account the effect of the stress reduction factor, this system have m-component if the first component fails to resist the strength of the second component, it is reactivated and faces the effect of the process pressure in sequence for only one-component at a time [6],This observation motivated the current work to design a reliability for a cascade model under the combined effect of stress and strength attenuation factors. The reliability of the system was achieved with the help of certain density functions of the m-standby system, in which all stress-strengths are random variables [4]. The reliability phrases of an m-cascade system are obtained when the stress-strength of the m-components follow particular distributions [7], In addition, the reliability assessment (estimation of the reliability fun.) is performed using standard methods.The paper is structured as follows. In Section 1 introduction for cascade system. In section 2 the general model is developed with the reliability expressions for cascade system is when was it received the stress strength of the components follows particular distributions. In section 3 we provided the properties of Inverse Rayleigh Distribution. In section 4 the expressions of Rm are obtained when both stress-strength are Inverse Rayleigh distribution. In section 5 Estimation of

Reliability and Marginal Reliabilities for Inverse Rayleigh distribution. In section 6 Analysis of the results of Estimation.

Ease of Use

General Mode

The reliability of the system was obtained using certain numbers for the density functions of the n-standby system , where all stress-strengths are random variables.[1]. the reliability of stress-strength system of a component is defined by R = P (stress < strength) probability that the strength for the component, X is not less than the stress Y on it. Symbolically; $R = pr(X \geq Y)$ [11], such that X and Y be random variables independent are positive representing to the strengths and stresses respectively[13], and this system totally fails if and only if the pressure of X is greater than its Y it mean the reliability of cascade system could survive with a loss of the first components (m − 1) if and only if $Xi \leq Yi$; $i = 1,2,3, \dots , m-1$ *and* $Xm > Ym$.

And the System Reliability of m-components for Cascade Model Rs of the cases s=1,2,3,4[8],is:

$$Rs = \sum_{m=1}^{s} R(m) \quad \dots(1)$$

; where R(m) is the marginal reliability of m-component to the reliability of the system and is defined by [6]:

$$R(s)=P[x1<y1, x1<ky1, \dots, 1< k^{s-2}y1, x1\geq k^{s-1}y1] \quad x1 , y1 \geq 0 \quad \dots(2)$$

Where factor k >1 and which is called " stress attenuation factor "and it is the reason why the cascade system is a special type of standby system because it introduces an improvement factor for the subsequent component on the previous [7]

R(1) is the extraction of first marginal reliability of Reliability for cascade system based on one-component only when x1 is the strength and y1 is the stress. R(2) is the extraction of the second marginal reliability of Reliability for cascade system the dependence on the second component, when the failure of the first component in the face of the stratcon effect on the first component, and x2 is the second strength affecting the second component and y2=ky1 is the dependence adopted here. R(3) is the extraction of third marginal reliability of Reliability for cascade system of the reliability based on the third component, when the failure of the second component in the face, x3 is the strength affected the component and y3= k^2y1 is the stress dependence adopted here. R(4) is the extraction of fourth marginal reliability of Reliability for cascade system based on the 3-component, after the failure of the third component in the face of the stratified component [7] .

Inverse Rayleigh Distribution

This distribution is a special type of inverse Weibull distribution [10]. This distribution has many uses in reliability studies. Units can be approximated by the it, also this distribution is an important lifetime in survival analysis that the inverse Rayleigh distribution is introduced in (1972) by Voda. [3].

pdf of the Inverse Rayleigh distribution with scale parameter θ is define as follows: [14] $f(x;\theta) = \frac{2\theta}{x^3} exp\left(-\frac{\theta}{x^2}\right); x > 0, \theta > 0$ ... (3)

And the C.D.F is given by:

$$F(x;\theta) = exp\left(-\frac{\theta}{x^2}\right); x > 0, \theta > 0 \quad \dots (4)$$

Table (1) Some properties for Inverse Rayleigh Distribution [7]

Parameter	$\theta > 0$ scale (real)
Support	$x \geq 0$

PDF	$\frac{2\theta}{x^3} exp\left(-\frac{\theta}{x^2}\right)$
CDF	$exp\left(-\frac{\theta}{x^2}\right)$
Mean	$\sqrt{\pi}$
Medium	$1/3(\sqrt{\frac{\theta}{3/2}}+2\sqrt{\pi}\ )$
Mode	$\sqrt{\frac{\theta}{3/2}}$
Variance	$not\ exist$
Skewness	$not\ exist$
Kurtosis	$not\ exist$

Reliability of Cascade stress-strength system for Inverse Rayleigh Distribution

The pdf with random variables Xi ; $i = 1,2, \dots, m$ be the strength with scale parameter θ and the probability density function random variable y1 be the stress with scale parameter ρ for Inverse Rayleigh respectively given as:

$$f(x\,i) = \frac{2\theta}{(x\,i)^3}\, e^{-\frac{\theta}{(x\,i)^2}} \quad \text{....(5)}$$

$$g(y1) = \frac{2\rho}{{y_1}^3}\; e^{-\frac{\rho}{y1^2}} \quad \text{....(6)}$$

and the cumulative distribution functions respectively, given as :

$$F(xi,\theta) = e^{-\frac{\theta}{x\,i^2}} \quad \text{.... (7)}$$

$$G(y1,\rho) = e^{-\frac{\rho}{x^2}} \quad \text{.... (8)}$$

The Marginal Reliabilities of Inverse Rayleigh Distribution [6] are:

$$R(1) = \frac{\theta}{\theta+\rho} \quad \text{...(9)}$$

$$R(2) = \frac{\rho}{k^3}\left[\frac{1}{(\theta+\rho)} - \frac{1}{(\theta+\rho+\frac{\theta}{k^2})}\right] \text{...(10)}$$

$$R(3) = \rho\left[\frac{1}{(\theta+\rho+\frac{\theta}{k^2})} - \frac{1}{\left(\theta+\rho+\frac{\theta}{k^2}+\frac{\theta}{k^4}\right)}\right] \text{...(11)}$$

Then the total reliability Rm of the m-cascade for Inverse Rayleigh Distribution [6] are: -

$$R1 = \frac{\theta}{\theta+\rho}$$

$$R2 = \frac{\theta}{\theta+\rho} + \rho\left[\frac{1}{\theta+\rho} - \frac{1}{\theta+\rho+\frac{\theta}{k^2}}\right] \quad \text{...(12)}$$

$$R3 = \frac{\theta}{\theta+\rho} + \rho\left[\frac{1}{\theta+\rho} - \frac{1}{\theta+\rho+\frac{\theta}{k^2}}\right] + \rho\left[\frac{1}{\theta+\rho+\frac{\theta}{k^2}} - \frac{1}{\theta+\rho+\frac{\theta}{k^2}+\frac{\theta}{k^4}}\right] \quad \text{...(13)}$$

Estimation: -

In this sub section, the unknown scale parameter of Inverse Rayleigh and the system reliability function R4 have been estimated by four different estimation methods; (Maximum likelihood, Weighted Least Square and Least square).

Maximum likelihood method: -

The maximum likelihood method (ML) is proposed by R.A. Fisher (1912) [15] and has been widely used since. Let $x_1, x_2 \dots, x_m$ strength random sample of Inverse Rayleigh with θ unknown scale parameter and with sample size m , then The maximum likelihood estimator $\hat{\theta}_{ML}$ of θ that that maximizes the likelihood function is defined by using equation (3) [9]:

$$L(x_1, x_2 \dots, x_m, \theta) = (2\theta)^m \prod_{i=1}^{m} {x_i}^{-3}\, e^{-\sum_{i=1}^{m}\frac{\theta}{{x_i}^2}} \quad \dots (14)$$

Then $\ln L$ for the equation (14) can be written as:

$$\ln L = m\ln\theta + m\ln 2 - 3\sum_{i=1}^{m}\ln x_i - \theta\sum_{i=1}^{m}\frac{1}{x_i^{\,2}} \quad \ldots.(15)$$

take the partial derivative to equation(15) with the unknown parameter θ then:

$$\frac{\partial \ln L}{\partial\theta} = \frac{m}{\theta} - \sum_{i=1}^{m}\frac{1}{x_i^{\,2}}$$

Equating the partial derivative to zero, then the ML estimator for θ , $\hat{\theta}_{(ML)}$is given by:

$$\hat{\theta}_{(ML)} = \frac{m}{\sum_{i=1}^{m}\frac{1}{x_i^{\,2}}} = \frac{m}{T} \quad \ldots.(16)$$

so the Maximum likelihood estimator for R_3 ,say $\hat{R}_{3(ML)}$ is given The by substituting equations (16) in equations (13), we get:

$$R3 = \frac{\hat{\theta}_{(ML)}}{\hat{\theta}_{(ML)}+\rho} + \rho\left[\frac{1}{\hat{\theta}_{(ML)}+\rho} - \frac{1}{\hat{\theta}_{(ML)}+\rho+\frac{\hat{\theta}_{(ML)}}{k^2}}\right] + \rho\left[\frac{1}{\hat{\theta}_{(ML)}+\rho+\frac{\hat{\theta}_{(ML)}}{k^2}} - \frac{1}{\hat{\theta}_{(ML)}+\rho+\frac{\hat{\theta}_{(ML)}}{k^2}+\frac{\theta}{k^4}}\right] \quad \ldots.(17)$$

Least Square Method: -

The least square method (LS) can be produced by minimizing the sum of square error between the value and its expected value [3]. This method is a combination of the parametric (F) and the non-parametric $(\hat{F})$ distribution functions .The minimizing following equation : [2]

$$S = \sum_{i=1}^{n}\left(\hat{F}(x_i) - F(x_i)\right)^2 \quad \ldots(19)$$

Suppose that x_i i= 1,2,..,m be a random sample have INR(θ) distribution with the sample size m. The procedure attempts to minimize will get as:

$$S(\theta) = \sum_{i=1}^{m}\left(\hat{F}(x_i) - \left(e^{-\frac{\theta}{x_{(i)}^{\,2}}}\right)\right)^2 \quad \ldots(20)$$

To obtain the formula of $F(x_i)$; use the equation (4) :

$$F(x_i) = e^{-\frac{\theta}{x_{(i)}^{\,2}}} \quad \ldots(21)$$

Now taking the the ln of the equation (21), we get:

$$-\ln(F(x_i)) = \frac{\theta}{x_{(i)}^{\,2}}$$

On the other hand, since $\hat{F}(x_i)$ is unknown , it better to use $\hat{F}(x_{(i)})$ as follows

$\hat{F}(x_{(i)}) = P_i$ and P_i is the plotting position

Where $P_i = \frac{i}{m+1}$; $i = 1,2,\ldots,m$

Where i: the order statistics of the random sample, to obtain the LS estimates $\hat{\theta}_{(LS)}$ of the parameter θ can be define following the function from equation (20) :

$$S(\theta) = \sum_{i=1}^{n}\left(q_i - \frac{\theta}{x_{(i)}^{\,2}}\right)^2 \quad \ldots(22)$$

Where $q_i = -\ln\hat{F}(x_{(i)}) = -\ln P_i$

By taking the derivative equation (22) with the parameter θ and equal the result to the zero :

$$\frac{\partial S(\theta)}{\partial\theta} = \sum_{i=1}^{n} 2\left(q_i - \frac{\theta}{x_{(i)}^{\,2}}\right)\left(-\frac{1}{x_{(i)}^{\,2}}\right)$$

$$-\sum_{i=1}^{n}\frac{q_i}{x_{(i)}^{\,2}} + \hat{\theta}\sum_{i=1}^{n}\frac{1}{(x_{(i)}^{\,2})^2} = 0 \quad \ldots(23)$$

By simplification the equation (23), we get:

$$\hat{\theta}_{(LS)} = \frac{\sum_{i=1}^{n}\frac{q_i}{x_{(i)}^{\,2}}}{\sum_{i=1}^{n}\frac{1}{(x_{(i)}^{\,2})^2}} \quad \ldots(24)$$

so the Least Square estimator for R_3 ,say $\hat{R}_{3(LS)}$ is given The by substituting equations (24) in equations (13), we get:

$$\hat{R}_{3(LS)} = \frac{\hat{\theta}_{(LS)}}{\hat{\theta}_{(LS)}+\rho} + \rho\left[\frac{1}{\hat{\theta}_{(LS)}+\rho} - \frac{1}{\hat{\theta}_{(LS)}+\rho+\frac{\hat{\theta}_{(LS)}}{k^2}}\right] + \rho\left[\frac{1}{\hat{\theta}_{(LS)}+\rho+\frac{\hat{\theta}_{(LS)}}{k^2}} - \frac{1}{\hat{\theta}_{(LS)}+\rho+\frac{\hat{\theta}_{(LS)}}{k^2}+\frac{\hat{\theta}_{(LS)}}{k^4}}\right] \quad ..(25)$$

Weighted Least Square Method :-

The weighted least squares method (WLS) obtain by minimizing following equation [8], with respect to the unknown parameter θ of strength random variable $x_i \sim INR(\theta)$.

$$Q = \sum_{i=1}^{m} w_i \left(\hat{F}(x_i) - F(x_i)\right)^2 \qquad \dots (26)$$

Where $w_i = \frac{1}{Var[F(x_{(i)})]} = \frac{(m+1)^2(m+2)}{i(m-i+1)}, i = 1,2,\dots,m$

suppose $x_{(i)}, i = 1,2 \dots, m$ be random variable of Inverse Rayleigh with sample size m .

The procedure attempts to minimize the following function with respect to α and β will get as :

$$Q(\theta) = \sum_{i=1}^{m} w_i \left(\hat{F}(x_i) - e^{-\frac{\theta}{x_{(i)}^2}}\right)^2 \quad \dots (27)$$

$$Q(\theta) = \sum_{i=1}^{m} w_i \left(q_i - \frac{\theta}{x_{(i)}^2}\right)^2 \qquad \dots (28)$$

Where $q_i = -\ln\hat{F}(x_{(i)}) = -\ln P_i$

By taking partial derivative to the equation (28) with parameter θ, and equating result to the zero we obtain:

$$\sum_{i=1}^{m} 2\, w_i \left[q_i - \frac{\theta}{x_{(i)}^2}\right] \frac{-1}{x_{(i)}^2}$$

$$\sum_{i=1}^{m} \frac{-w_i}{x_{(i)}^2} q_i + \hat{\theta} \sum_{i=1}^{m} \frac{w_i}{x_{(i)}^4} = 0 \quad \dots. (29)$$

Then, by simplification the equation (29), we get:

$$\hat{\theta}_{(WLS)} = \frac{\sum_{i=1}^{m} \frac{w_i}{x_{(i)}^2}}{\sum_{i=1}^{m} \frac{w_i}{x_{(i)}^4}} q_i \quad \dots. (30)$$

then $\hat{R}_{3(WLS)}$ is given by substituting equations (30) in equation (13) we get:

$$\hat{R}_{4(WLS)} = \left[\frac{1}{\hat{\theta}_{(WLS)}+\rho+\frac{\hat{\theta}_{(WLS)}}{k^2}}\right] + \rho\left[\frac{1}{\hat{\theta}_{(WLS)}+\rho+\frac{\hat{\theta}_{(WLS)}}{k^2}} - \frac{1}{\hat{\theta}_{(WLS)}+\rho+\frac{\hat{\theta}_{(WLS)}}{k^2}+\frac{\hat{\theta}_{(WLS)}}{k^4}}\right] \quad \dots.(32)$$

Analysis of the results of Estimation: -

Since the mean results of R_3 in all the tables below are nearest from R-real then the results are acceptable

Table (2)**:** Results of Mean, MSE values when (m=15)

θ, ρ, k	R₃	WLS	LS	ML	M=15	Best
(0.6,0.7,6)	0.4685	0.4009 0.0046	0.9596 0.2411	0.3143 0.0238	Mean MSE	- **WLS**
(0.5,0.7,5)	0.4266	0.2698 0.0246	0.3518 0.0056	0.3002 0.0160	Mean MSE	- **LS**
(0.4,0.7,4)	0.3787	0.4733 0.0090	0.9154 0.2880	0.4052 0.0007	Mean MSE	- **ML**
(0.3,0.7,3	0.3253	0.1510 0.0304	0.0018 0.1046	0.2041 0.0147	Mean MSE	- **ML**
(0.2,0.7,2)	0.2751	0.3231 0.0023	0.9033 0.3947	0.3785 0.0107	Mean MSE	- **WLS**

(0.1,0.7,1)	0.3636	0.4800	0.7328	0.3762	Mean MSE	**-** **ML**

Table (3)**:** Results of Mean, MSE values when (m=25)

θ , ρ , k	**R₃**	**WLS**	**LS**	**ML**	**m=25**	**Best**
(0.6,0.7,6)	0.4685	0.6002 0.0173	0.2195 0.0620	0.5356 0.0045	Mean MSE	**-** **ML**
0.5,0.7,5	0.4266	0.3295 0.0094	0.0798 0.1203	0.4753 0.0024	Mean MSE	**-** **ML**
0.4,0.7,4						**-** **ML**
0.3,0.7,3	0.3787	0.4693 0.0082	0.2072 0.0294	0.4129 0.0012	Mean MSE	**-** **ML**
0.2,0.7,2	0.3253	0.1952	0.1576	0.2439	Mean MSE	**-** **WLS**
0.1,0.7,1		0.0169	0.0281	0.0066		**-** **ML**

Table (4) **:** Results of Mean, MSE values when (m=70)

(θ , ρ , k)	**R₃**	**WLS**	**LS**	**ML**	**m=70**	**Best**
(0.6,0.7,6)	0.4685	0.3656 0.0106	0.2676 0.0404	0.4070 0.0038	Mean MSE	**-** **ML**
(0.5,0.7,5)	0.4266	0.3441 0.0068	0.9730 0.2985	0.4213 0.0000	Mean MSE	**-** **ML**
(0.4,0.7,4)	0.3787	0.3186 0.0036	0.0593 0.1020	0.3267 0.0027	Mean MSE	**-** **ML**
(0.3,0.7,3	0.3253	0.3462 0.0004	0.7425 0.1740	0.3086 0.0003	Mean MSE	**-** **ML**
(0.2,0.7,2)	0.2751	0.2108 0.0041	0.0277 0.0612	0.2421 0.0011	Mean MSE	**-** **ML**
(0.1,0.7,1)						**-** **ML,SL**

Table (5) **:** Results of Mean, MSE values when (m=90)

$(\theta\,,\rho\,,k)$	m=90	ML	LS	WLS	R_3	Best
(0.6,0.7,6)	Mean MSE	0.4131 0.0031	0.1268 0.1168	0.3478 0.0146	0.4685	- **ML**
(0.5,0.7,5)	Mean MSE	0.4469 0.0004	0.0656 0.1303	0.4066 0.0004	0.4266	- **ML,WLS**
(0.4,0.7,4)	Mean MSE	0.3238 0.0030	0.9915 0.3756	0.2822 0.0093	0.3787	- **ML**
(0.3,0.7,3	Mean MSE	0.3158 0.0001	0.3295 0.0000	0.2928 0.0011	0.3253	- **LS**
(0.2,0.7,2)	Mean MSE	0.2685 0.0000	0.0245 0.0628	0.2409 0.0012	0.2751	- **ML**
(0.1,0.7,1)	Mean MSE	0.3317 0.0010	0.7165 0.1245	0.3435 0.0004	0.3636	- **WLS**

From the tables above, we have observed that**:**

If sample size m is increasing from 15 to 90, we observed:

1- From tables (2), (3), (4) and (5) which present the simulation results by Mean for estimating R_3 for Cascade system with different cases, it appears that:

❖ When $(\theta\,,\rho\,,k) = (0.6{,}0.7{,}6)$

- The MSE values of ML is decreasing but LS and WLS are increasing by increasing sample size.

- When $(\theta\,,\rho\,,k) = (0.5{,}0.7{,}5)$

- The MSE values of ML and WLS are decreasing but LS is increasing by increasing sample size

❖ When $(\theta\,,\rho\,,k) = (0.4{,}0.7{,}4)$

- The MSE values of ML, LS and WLS are decreasing by increasing sample size.

❖ When $(\theta\,,\rho\,,k) = (0.3{,}0.7{,}3)$

- The MSE values of ML, LS and WLS are decreasing by increasing sample size

❖ When $(\theta\,,\rho\,,k) = (0.3{,}0.7{,}3)$

- The MSE values of MO, LS, RG and WLS are decreasing by increasing samples sizes.

B. If n is constant:

1- When n is small sample size (n=15), from table (2) we observe that:

❖ When $(\theta\,,\rho\,,k) = (0.6{,}0.7{,}6), (0.5{,}0.7{,}5), (0.4{,}0.7{,}4), (0.3{,}0.7{,}3), (0.2{,}0.7{,}2), (0.1{,}0.7{,}1)$

From above getting MSE values of ML and LS are decreasing but WLS is increasing by increasing the values of parameters θ, and k.

2- When n is small sample size (n=25), from table (3) we observe that:

❖ When $(\theta\,,\rho\,,k) = (0.6{,}0.7{,}6), (0.5{,}0.7{,}5), (0.4{,}0.7{,}4), (0.3{,}0.7{,}3), (0.2{,}0.7{,}2), (0.1{,}0.7{,}1)$

From above getting MSE values of ML and LS are decreasing but WLS is increasing by increasing the values of parameters θ, and k.

3- When m is large sample size (m=70), from table (3) we observe that:

- When $(\theta, \rho, k) = (0.6,0.7,6), (0.5,0.7,5), (0.4,0.7,4), (0.3,0.7,3), (0.2,0.7,2), (0.1,0.7,1)$
From above getting MSE values of ML, LS and WLS are decreasing by increasing the values of parameters θ, and k.

4- When m is large sample size (m=90), from table (5) we observe that:

- When $(\theta, \rho, k) = (0.6,0.7,6), (0.5,0.7,5), (0.4,0.7,4), (0.3,0.7,3), (0.2,0.7,2), (0.1,0.7,1)$
From above getting MSE values of ML and WLS are decreasing but LS is increasing by increasing the values of parameters θ, and k.

Conclusions to estimated for Inverse Rayleigh :-

- The performance of MLE is the best as in the table below.

Sample size and parameters value	Best method
For MSE when m=15, m=25,m=70,m=90 and ρ =0.7the MSE of ML is best in table (2),(3),(4) and(5) except when the parameter $(\theta, \rho, k)$for (0.6,0.7,6), (0.5,0.7,5), (0.2,0.7,2), (0.2,0.7,2), (0.3,0.7,3), (0.1,0.7,1).	**ML**

Table (6): The first best method estimator of MSE for Inverse Rayleigh distribution of R_4.

Recommendations :-

1. The study of the Reliability of Cascade stress-strength system to include other recent distributions.
2. In the case of an assessment for Cascade system reliability by using Inverse Rayleigh distribution We recommend to use method ML .
3. From the observation of the behavior of Cascade system of this distribution , we recommend that attention be paid to the values of strength parameter.

   Extending the study of the Cascade stress-strength system Reliability assessments to include inverted Rayleigh and Lomax distributions to find the best methods that give the best estimated value .

References

1. Khan Adil H. and Jan T R., " Estimation of Multi Component Systems Reliability in Stress-Strength Models" University of Kashmir, Srinagar, India (2014).
2- Ahmed H.Kh, " The Reliability for special (2+1) Cascade Model " M.SC. Thesis, AL-Mustansiriya University (2019).
3- Ali H.M " Comparison of some methods to estimate some of stress – strength Lomax models" M.SC. Thesis, AL-Mustansiriya University (2013).
4- Doloi C., Borah M. and Sriwastav G., " Cascade system with random attenuation factor", IAPQR Transactions 35(2), 81–90 (2010).
5- Doloi C. and Borah M.," Cascade System with Mixture of Distributions, International Journal of Statistics and Systems", Vol.7,(1):11-24 (2012).
6- Gogoi J. and Borah M, " Estimation of reliability for multi component systems using exponential, gamma and lindley stress-strength distributions", Journal of Reliability and Statistical Studies, Vol. 5, Issue 1, 33-41(2012).
7- Hassna H.K, "Reliability of Cascade Stress-Strength System" M.SC. Thesis, AL-Mustansiriya University (2018).
8- Karam N.S." One, Two and Multi-Component Gompertz Stress- strength Reliability Estimation", Mathematical Theory and Modeling, vol.6, No.3, ISSN:(2224-5804) (2016).
9- Raghavachar. A.C.N,Kesava Rao.B,and Pattabhi Ramacharyulu N.C "Survival function under stress Attenuation in cascade reliability" OPSEARCH ; Volume 20,Issue 4:190-207(1983).
10- Raghda kh. A.," Inverse Rayleigh Distribution: Properties and Different methods of Estimation" M.SC. Thesis, AL-Mustansiriya University (2017).
11- Patowary A N, Hazarika J and Sriwastav G L (2012) " Estimation of Reliability in Interference Models Using Monte Carlo Simulation ", Reliability: Theory & Applications, Vol.1, 78-84.
12- Ramk H G., " Stress- Strength Reliability Estimation for Component Under a Fixed Number of Stresses", M.Sc. Thesis, Al-Mustansiriya University (2016).
13- Salah H. Abid, " The fréchet stress- strength model " International Journal of Applied Mathematical Research-2014. 3(3) 207-213
14- Shawky, A.I., and Badr, M.M., 2012."Estimations and Prediction from the Inverse Rayleigh Model Based on Lower Record Statistics", Life Science Journal, 9(1):985-990.
15- Singh, A.K., Dalpatadu, R.and Tsang, A., 1996. "On Estimation of Parameters of the Pareto Distribution", Actuarial research clearing house, vol.1, 407-409.
16- Sriwastav, G.L. and Kakati, M.C. "A Stress-Strength Model with Redundancy ", IAPQR Trans., 6, No.1, 21-27(1981).