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Unlocking India's Natural Disaster (Flood and Cyclone): Challenges in Terms of Indirect Losses and Probability of Reoccurrence

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Abstract: ***Due to climate change, the occurrence of natural disasters has become quite unpredictable, as the natural disasters affect human life, infrastructure, economic activities etc. The severity of the damage depends on the population's disaster preparedness and on the existing infrastructure. The tangible losses are computed after disaster events, however, a significant loss in terms of indirect losses which affect the over-all economy of a country are quite significant. Keeping in view the study aims to carry out the probabilistic modelling to undermine underwriting and risk selection, loss mitigation strategies, allocation of cost of capital, cost of reinsurance, reinsurance and risk transfer analysis, enterprise risk management. In this study, The Occurrence Exceedance Probability (OEP) and the Aggregate Exceedance Probability (AEP) are two primary metrics used in catastrophe modeling that give an insurer immediate feedback on the financial nature of a disaster. The results indicate that the exceedance probability of occurring bigger losses is quite high in comparison to smaller losses, at the same time the return period for the bigger losses is quite high in comparison to smaller losses. Also, the severity has been found ranging from 20-36% for largest loss varying from (6-30 Bn $) in a year exceeds a certain amount of loss. It is also observed from the OEP curve that the loss distribution was consistent with the starting OEPs and the claim count assumption. The occurrence-based reinsurance structures due to disasters can easily be formulated. It is also observed that severity has been found ranging from 20-36% for aggregate loss varying from (62-300 Bn $) in a year exceeds a certain amount of loss using Monte Carlo Simulation. Therefore, aggregate based reinsurance structures due to disasters and reinstatements can easily be formulated. Further, A standard Visualization of the Occurrence and Aggregate EP curves clearly indicated that the AEP was found to be always greater than OEP for a particular loss starting from max. cumulative loss i.e.30 Bn $. Therefore, concluded that aggregate based reinsurance structures will be entirely different from the occurrence-based structures.***

Keywords: Exceedance Probability, Occurrence Exceedance Probability, Aggregate Exceedance Probability, Monte-Carlo Simulation, Max. Annual Loss.

1. Introduction

All insurers must have the best possible knowledge of all the risks they face. In this directive, specific treatment is called for with respect to natural disasters, whose impacts can be devastating for insurance companies. For example, Hurricane Andrew, which occurred in Florida in 1992, caused eleven insurers to go bankrupt.

Over the past few years, the economic impact of natural catastrophes on populations has clearly increased, jeopardizing the financial strength of insurance companies. Insurers thus need to measure the underlying risk and the losses their clients would experience from it. However, due to the unpredictability of natural disasters, specific catastrophe models must be designed in order to increase insurers' understanding of these risks and their consequences in terms of insurance.

Probabilistic modelling allows insurers to: Price reinsurance policies so as to optimize the risk transfer to reinsurance; Manage and diversify risks; Estimate the level of reserves needed to cover a loss; Minimize the Solvency 2 capital requirement; Anticipate natural disasters and predict losses to increase resilience.

2. Data and Methods

In accordance with EM-DAT that contains data on the occurrence and impacts of over 26,000 mass disasters worldwide from 1900 to the present day. The database is compiled from various sources, including UN agencies, non-governmental organizations, reinsurance companies, research institutes, and press agencies. The **Centre for Research on the Epidemiology of Disasters (CRED)** distributes the data in **open access** for non-commercial use. The frequency of occurrence of floods and storm during 2015-2021.

Catastrophe Modeling is a type of estimation technique used in the Property and Casualty (P&C) industry to predict and evaluate damage caused by natural catastrophes such as hurricanes, earthquakes, tornados, hail, winter storms, floods and wild fires, as well as man-made catastrophes such as terrorism. Catastrophe models are widely used in ratemaking, portfolio management and optimization, underwriting and risk selection, loss mitigation strategies, allocation of cost of capital, cost of reinsurance, reinsurance and risk transfer analysis, enterprise risk management, as well as financial and capital adequacy analysis utilized by rating agencies, The Occurrence Exceedance Probability (OEP) and the Aggregate Exceedance Probability (AEP) are two primary metrics used in catastrophe modeling that give an insurer immediate feedback on the financial nature of a disaster.

Exceedance Probability Exceedance Probability (EP) is one of the most commonly used metrics in catastrophe modeling. It is the probability that a certain loss value will be exceeded in a predefined future time period. Exceedance probability is used in planning for potential hazards such as river and stream flooding, hurricane storm surges and droughts, reserving for reservoir storage levels and providing homeowners and community members with risk assessment. To define exceedance probability, let D1, D2, · · · be a set of natural disasters. Let pi and Xi be an annual probability of occurrence and a corresponding total loss associated with a natural disaster Di . Thus, Di is a Bernoulli random variable with P(Di occurs) = pi , P(Di does not occur) = 1 − pi If an event Di does not occur, the loss is zero. The expected loss for a given event Di in a given year is E[X] = piXi . The overall expected loss for the entire set of events is known as the average annual loss (AAL) and is defined as the sum of the expected losses of each of the individual events for a given year:

$$AAL = \sum_{1}^{\Theta} p_i X_i$$

The Exceedance Probability (EP) is the probability that a loss random variable exceeds a certain amount of loss. This probability is sometimes denoted as EP(x) and is called the Exceedance Probability Curve. Let X be a loss random variable. Then EP(x) = P(X > x) = 1 − P(X ≤ x) Using probabilistic terminology, EP(x) is the survival function of X. In particular, if x = Xi , which is a loss associated with a disaster Di , then EP(Xi) = P(X > Xi) = 1 − P(X ≤ Xi)

$$= 1 - \prod_{j=1}^{i} (1 - p_j)$$

where D1, D2, · · ·, Di are the events with higher level of losses such that X1 ≥ X2 ≥ · · · ≥ Xi . The probability that all the other events with possible losses above the value Xi have not occurred is

$$P(X \le X_i) = 1 - \prod_{j=1}^{i} (1 - p_j)$$

and is sometimes called the Non-Exceedance Probability (NEP). A characteristic sometimes associated with the Exceedance Probability is the Return Period or the Loss Return Period of a natural disaster. It is calculated as a reciprocal of the EP: RP = 1/ EP

Occurrence Exceedance Probability

The Occurrence Exceedance Probability (OEP) is the probability that the largest loss in a year exceeds a certain amount of loss. This probability is sometimes denoted as O(x) and is called the Occurrence Exceedance Probability Curve. Let X1, X2, · · · , XN be losses in a given year.

$$\text{Then } O(x) = P(\max_{1\le i\le N} (X_i) > x) = 1 - P(\max_{1\le i\le N} (X_i) \le x) = 1 - \prod_{i=1}^{n} P(X_i \le x)$$

Using probabilistic terminology, if X(1), X(2), · · · , X(N) is the ordered statistic with X(N) = max1≤i≤N X(i) , then O(x) is the survival function of X(N) . Let F(x) be the cumulative distribution function (CDF) of X. Then for a fixed N the OEP is $O(x) = 1 - (F_X(x))^N$. If N is the random claim count with the probability mass function (p.m.f.) PN ,
then by the law of total probability,

$$O(x) = \sum_{n=0}^{\infty} P(\max_{1\le i\le n}(X_i) > x | N = n)P(N = n) =$$

$$= 1 - \sum_{n=0}^{\infty} P(\max_{1\le i\le n}(X_i) \le x | N = n)P(N = n) =$$

$$= 1 - \sum_{n=0}^{\infty} (\prod P (X_i \le x)) \ P(N = n)=$$

$$= 1 - \sum_{i=1}^{n} (F_X(x))^n P(N = n) =$$

$$= 1 - E_N \ (F_X(x))^N = 1 - PGF (F_X(x)),$$

where PGF(x) is the probability generating function for N defined as

$$PGF(t) = E\, t^N = \sum_{n=0}^{\infty} t^n \cdot P (N = n).$$

Thus, $O(x) = 1 - PGF (F_X(x))$.

The expected value of $X_{(N)}$ is by definition

$$E\, X_{(N)} = \int_0^{\infty} O(x)\, dx$$

In catastrophe modeling the Occurrence Exceedance Probability is used for occurrence based reinsurance structures such as quota share or working excess.

Evaluating Severity Distribution Using the OEP

It follows from the equation (3.1) that the cumulative distribution function FX of losses X can be evaluated using the Occurrence Exceedance Probability O(x) as FX(x) = PGF−1 (1 − O(x)), (4.1)

where PGF−1 (x) indicates the inverse function of the probability generating function for N. The loss distribution will be consistent with the starting OEPs and the claim count assumption. An important property of the probability generating function is outlined in the following Lemma.

Lemma 4.1 If N and M are independent random variables, then PGFN+M(t) = PGFN (t) · PGFM(t).
Proof. By definition, $PGF_{N+M}(t) = E\, t^N . E\, t^M = E(t^N)\cdot E(t^M) = PGF_N(t) \cdot PGF_M(t)$. Following is the derivation of the cumulative distribution function FX of losses X for a few standard discrete distributions of claim counts.

6.3.1 Poisson Distribution of Claim Counts

Suppose claim counts N have a Poisson distribution with mean parameter λ. This is a common assumption when modeling a number of catastrophes. The probability mass function is defined as

$$p_n = P(N = n) = e^{-\lambda} \lambda^n / n!\,.$$

Calculating the PGF, we obtain

$$PGF(t) = \sum_{n=0}^{\infty} t^n \cdot P(N = n) = \sum_{n=0}^{\infty} t^n \cdot e^{-\lambda} \lambda^n / n! = \sum_{n=0}^{\infty} e^{-\lambda} t^n \lambda^n / n!$$

$$= e^{-\lambda} \sum_{n=0}^{\infty} (t\lambda)^n / n! = e^{-\lambda} \cdot e^{t\lambda} = e^{\lambda(t-1)}\,.$$

Then the inverse function is $y = e^{\lambda(t-1)} \Leftrightarrow \lambda(t-1) = \ln y \Leftrightarrow t = \ln y/\lambda + 1 \Leftrightarrow PGF^{-1}(x) = \ln x/\lambda + 1$ Using (4.1), cumulative distribution function FX is

$$F_X(x) = PGF^{-1}(1 - O(x)) = \ln(1 - O(x))/\lambda + 1$$

6.3.2 Bernoulli Distribution of Claim Counts

Suppose claim counts N have a Bernoulli distribution with parameter q. The probability mass function is defined as p0= P (N = 0) = 1 − q, p1= P (N = 1)

Calculating the PGF, we obtain

$$PGF(t) = \sum_{n=0}^{1} t^n \cdot P(N = n) = (1 - q) + qt \qquad (4.2)$$

Then the inverse function is $y = (1 - q) + qt \Leftrightarrow t = (y - 1 + q)/q + 1 \Leftrightarrow (y-1/q)+1 \Leftrightarrow PGF^{-1}(x) = (x - 1/q) + 1$

Using (4.1), cumulative distribution function F_X is $F_X(x) = PGF^{-1}(1 - O(x)) = (1 - O(x) - 1)/(O(x)/q) + 1$

6.3.3 Binomiali Distribution of Claim Counts

Suppose claim counts N have a Bernoulli distribution with parameter q. The probability mass function is defined as $p_0 = P(N = 0) = 1 - q$, $p_1 = P(N = 1) = q$

Calculating the PGF(t), we obtain

$$PGF(t) = \sum_{n=0}^{m} t^n \cdot P(N = n) = \sum_{n=0}^{m} t^n (m/n) q^n (1 - q)^{m-n} = \sum_{n=0}^{m} (m/n) + qt^n (1-q)^{m-n} = ((1-q)+qt))^m = (1+(q(t-1))^m$$

Note that the same PGF can be obtained using one of the properties of a probability generating function. Since a Binomial (q, m) random variable N can be expressed as a sum of m i.i.d. Bernoulli (q), N = N1 + N2 + · · · + Nm, can be expressed as a sum of m i.i.d Bernoulli (q) by Lemma (4.1), using (4.2), its PGF is

$$PGF_N(t) = \prod_{i=1}^{m} PGF_{N_i}(t) = ((1 - q) + qt)^m$$

The inverse function is

$y = ((1 - q) + qt)^m \Leftrightarrow (1 - q) + qt = y^{1/m} \Leftrightarrow t = y^{1/m} - 1 + q/q = y^{1/m} - 1/q + 1 \Leftrightarrow PGF^{-1}(x) = x^{1/m} - 1/q + 1$

Using (4.1), cumulative distribution function F_X is $F_X(x) = PGF^{-1}(1 - O(x)) = (1 - O(x))^{1/m} - 1/q + 1$

6.4 Aggregate Exceedance Probability

The Aggregate Exceedance Probability (AEP) is the probability that the sum of losses in a year exceeds a certain amount of loss. This probability is sometimes denoted as A(x) and is called the Aggregate Exceedance Probability Curve. Let X1, X2, · · · , XN be losses in a given year. Then A(x) = P(X1+ X2+ · · · + XN > x) = 1 − P(X1+ X2+ · · · + XN ≤ x) Using the terminology of the aggregate loss models, if S is the collective risk model, defined

as $S = \sum_{i=1}^{n} X_i$, then A(x) is the survival function of S.

For a fixed N this probability is

$A(x) = 1 - F^{(N)}_X(x)$, where $F^{(N)}_X$ is an N-fold convolution of $F_X(x)$, defined as $F^{(N)}_X(x) = F_X^{(N-1)} X(x - y) f_X(y)\, dy$ for N = 2, 3, · · · . For N = 1 this equation reduces to $F^{(1)}_X(x) = F_X(x)$, [5].

If N is the random claim count with the probability mass function (p.m.f.) PN , then by the law of total probability,

$$A(x) = \sum_{n=0}^{\infty} P(S > x|N = n)P(N = n) =$$

$$= 1 - \sum_{n=0}^{\infty} P(S \le x|N = n)P(N = n) =$$

$$= 1 - \sum_{n=0}^{\infty} F^{(n)}_X(x)P(N = n) = 1 - E_N\ F^{(N)}_X$$

The expected value of S is by definition

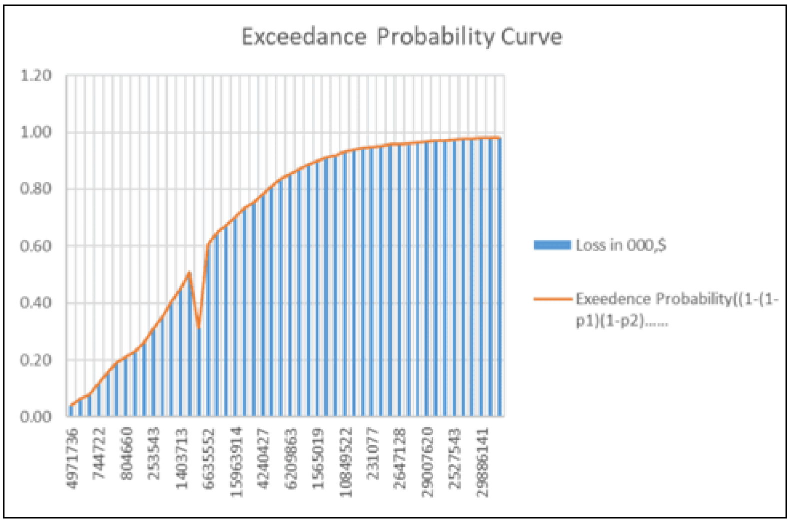
$$E[S] = \int_0^{\infty} A(x)\, dx = E[X]\, E[N]\,.$$

In catastrophe modeling the Aggregate Exceedance Probability is used for aggregate based reinsurance structures such as stop loss and reinstatements.

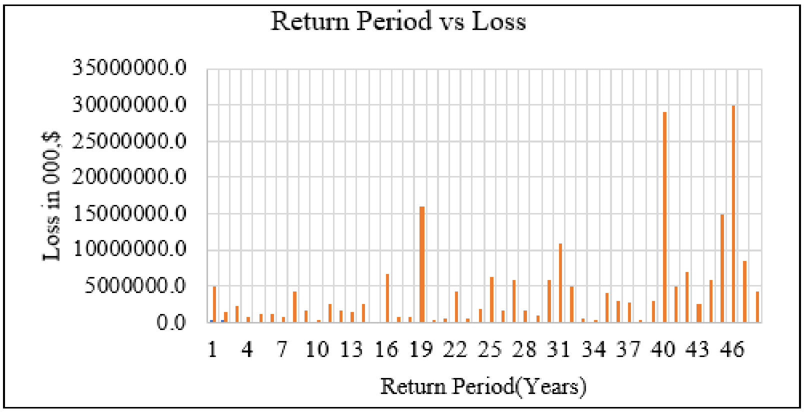
In this paper, for assessing the effect of Occurrence Exceedance Probability (OEP) and Aggregate Exceedance Probability (AEP), the data of various types of disasters occurred during 1975-2021 in India have been taken into consideration.

Year	Damage Costs(Billion$)	Recovery Costs(Billion$)	Variation	Annual Probability of Occurance(pi)	Loss(Xi)	Exeedence Probability((1-(1-p1)(1-p2)……	E[X]=piXi	Probability of non occurance(1-pi)	Non Exeedence Probability((1-p1)(1-p2)……	Exeedence Probability((1-(1-p1)(1-p2)……	Return Period(Years)-1/Ep	OEP	Rank	Provience	Year	$\sum_{i=1}$ Xi(Max.)
1975	4.971736	6.97131655	140.22	0.04	4971736	0.04	0.207	0.96	0.96	0.04	24.0	0.02	1	Lakhimpur	2020	29.97517028
1976	1.371811	2.27720626	166.00	0.03	1371811	0.07	0.034	0.98	0.93	0.07	15.2	0.04	2	Shravasti,	2014	29.03704851
1977	2.407238	3.99601508	166.00	0.01	2407238	0.08	0.033	0.99	0.92	0.08	12.7	0.06	3	Karnataka	1993	16.04740148
1978	0.744722	0.99048026	133.00	0.04	744722	0.12	0.031	0.96	0.88	0.12	8.5	0.08	4	Sitamarhi,	2019	14.88684766
1979	1.261349	1.96076849	155.45	0.04	1261349	0.16	0.056	0.96	0.84	0.16	6.4	0.10	5	Gujarat, M	2005	10.87735212
1980	1.136409	1.51142397	133.00	0.04	1136409	0.19	0.047	0.96	0.81	0.19	5.2	0.13	6		2021	8.516872751
1981	0.80466	1.0701978	133.00	0.03	804660	0.21	0.020	0.98	0.79	0.21	4.7	0.15	7		2016	6.892329075
1982	4.383515	6.57608285	150.02	0.03	4383515	0.23	0.110	0.98	0.77	0.23	4.3	0.17	8		1990	6.685603598
1983	1.742171	2.89391942	166.11	0.04	1742171	0.26	0.068	0.96	0.74	0.26	3.8	0.19	9		1999	6.25035261
1984	0.253543	0.33721219	133.00	0.06	253543	0.31	0.016	0.94	0.69	0.31	3.2	0.21	10		2001	6.011142253
1985	2.590091	3.33512319	128.76	0.06	2590091	0.35	0.158	0.94	0.65	0.35	2.9	0.23	11		2004	5.93647331
1986	1.746298	2.56533631	146.90	0.09	1746298	0.41	0.150	0.91	0.59	0.41	2.5	0.25	12		2018	5.821581622
1987	1.403713	1.86693829	133.00	0.08	1403713	0.45	0.109	0.92	0.55	0.45	2.2	0.27	13		1975	5.043801408
1988	2.520986	3.38299152	134.19	0.10	2520986	0.51	0.252	0.90	0.49	0.51	2.0	0.29	14		2006	4.978261613
1989	0	0	0.00	0.08	0	0.31	0.000	0.92	0.45	0.31	3.2	0.31	15		2015	4.956486893
1990	6.635552	10.95100794	165.04	0.13	6635552	0.61	0.885	0.87	0.39	0.61	1.6	0.33	16		1982	4.458786222
1991	0.683334	0.93075249	136.21	0.10	683334	0.65	0.070	0.90	0.35	0.65	1.5	0.35	17		1996	4.30998248
1992	0.644369	0.85701077	133.00	0.08	644369	0.67	0.048	0.93	0.33	0.67	1.5	0.38	18		2009	4.26184435
1993	15.963914	21.39529148	134.02	0.09	15963914	0.70	1.508	0.91	0.30	0.70	1.4	0.40	19		2013	4.091541153
1994	0.37769	0.49331982	130.62	0.09	377690	0.73	0.035	0.91	0.27	0.73	1.4	0.42	20		2010	3.057223812
1995	0.601222	0.83170553	138.34	0.08	601222	0.75	0.047	0.92	0.25	0.75	1.3	0.44	21		2011	2.95213004
1996	4.240427	6.8887724	162.45	0.11	4240427	0.78	0.483	0.89	0.22	0.78	1.3	0.46	22		1985	2.718123992
1997	0.512322	0.69005581	134.69	0.14	512322	0.81	0.073	0.86	0.19	0.81	1.2	0.48	23		1988	2.632761076
1998	1.808981	2.68973351	148.69	0.14	1808981	0.84	0.251	0.86	0.16	0.84	1.2	0.50	24		1977	2.632591809
1999	6.209863	9.99324378	160.93	0.10	6209863	0.85	0.638	0.90	0.15	0.85	1.2	0.52	25		2017	2.602985517
2000	1.542301	2.05126033	133.00	0.11	1542301	0.87	0.176	0.89	0.13	0.87	1.1	0.54	26		1987	2.540746017
2001	5.932777	8.95736315	150.98	0.11	5932777	0.88	0.643	0.89	0.12	0.88	1.1	0.56	27		1998	1.894232725
2002	1.565019	2.57067156	164.26	0.12	1565019	0.90	0.183	0.88	0.10	0.90	1.1	0.58	28		1986	1.816990297
2003	0.975207	1.14194698	117.10	0.13	975207	0.91	0.122	0.88	0.09	0.91	1.1	0.60	29		1983	1.783658617
2004	5.885841	8.0975711	137.58	0.08	5885841	0.92	0.441	0.93	0.08	0.92	1.1	0.63	30		2002	1.622922581
2005	10.849522	14.69735603	135.47	0.18	10849522	0.93	1.899	0.83	0.07	0.93	1.1	0.65	31		2000	1.63588065
2006	4.921334	6.54537422	133.00	0.10	4921334	0.94	0.492	0.90	0.06	0.94	1.1	0.67	32		1976	1.552773689
2007	0.530921	0.70612493	133.00	0.09	530921	0.94	0.046	0.91	0.06	0.94	1.1	0.69	33		1979	1.429805957
2008	0.231077	0.31854647	137.85	0.07	231077	0.95	0.017	0.93	0.05	0.95	1.1	0.71	34		1980	1.351495374
2009	4.002337	5.43633042	135.83	0.08	4002337	0.95	0.300	0.93	0.05	0.95	1.1	0.73	35		2003	1.240278814
2010	2.884198	3.83598334	133.00	0.09	2884198	0.96	0.256	0.91	0.04	0.96	1.0	0.75	36		1981	1.0727058
2011	2.647128	3.68161397	139.08	0.06	2647128	0.96	0.147	0.94	0.04	0.96	1.0	0.77	37		1978	0.873716768
2012	0.311018	0.41365394	133.00	0.06	311018	0.96	0.018	0.94	0.04	0.96	1.0	0.79	38		1991	0.817892251
2013	2.986724	4.36920244	146.29	0.06	2986724	0.96	0.191	0.94	0.04	0.96	1.0	0.81	39		1992	0.79613923
2014	29.00762	41.43578201	142.84	0.08	29007620	0.97	2.417	0.92	0.03	0.97	1.0	0.83	40		1997	0.794691404
2015	4.875995	6.92065322	141.93	0.08	4875995	0.97	0.406	0.92	0.03	0.97	1.0	0.85	41		2007	0.683060032
2016	6.842856	10.74132837	156.97	0.08	6842856	0.97	0.551	0.92	0.03	0.97	1.0	0.88	42		1994	0.601196233
2017	2.527543	3.36163219	133.00	0.10	2527543	0.97	0.260	0.90	0.03	0.97	1.0	0.90	43		2021	0.548889663
2018	5.837768	8.58881795	147.13	0.09	5837768	0.98	0.535	0.91	0.02	0.98	1.0	0.92	44		1984	0.435719846
2019	14.801088	20.79224724	140.48	0.06	14801088	0.98	0.822	0.94	0.02	0.98	1.0	0.94	45		2008	0.400994321
2020	29.886141	45.31600611	151.63	0.05	29886141	0.98	1.494	0.95	0.02	0.98	1.0	0.96	46		2015	0.370880455
2021	8.435019	12.84801348	152.32	0.08	8435019	0.98	0.633	0.93	0.02	0.98	1.0	0.98	47		1995	0.260052327
2022	4.2	5.586	133.00	0.03	4200000	0.98	0.117	0.97	0.02	0.98	1.0	1.00	48		2022	0.044374383
2023	0	0	0.00	0.00	0	-2.80	0.000									
	216.69535	313.8693852				AAL	17.496									

Annual average loss is calculates as 17.496 Billion $.



It is observed that exceedance probability of occurring bigger losses are quite high in comparison to smaller losses.



The return period for the bigger losses is quite high in comparison to smaller losses.

Evaluating Severity Distribution Using the OEP and AEP

In this paper, Poison distribution and Binomial distributions have been considered for the purpose, the results are given in below table.

Year	Σi=1 Xi(Max.) Bn$	Probability Mass function (Poisson Distribution)-Probability of exactly one occurance in ten years	Exp(-)10/RP	Probability Mass function (Bionomial Distribution)-Probability of exactly one occurance in ten years, P(X)=1	μ=1/RP	1-μ	(1-μ)^n-r
2020	29.95534361	27.47%	0.65924063	28.41%	0.041667	0.958333333	0.681788
2014	29.02679972	34.05%	0.518793166	35.63%	0.065625	0.934375	0.542864
1993	16.07140348	35.82%	0.455652735	37.62%	0.078602	0.921397569	0.478656
2019	14.84664669	36.31%	0.310385576	38.18%	0.116994	0.883006004	0.326342
2005	10.99429889	32.75%	0.209635059	33.87%	0.156239	0.843761293	0.216759
2021	8.52067095	28.23%	0.147495992	28.29%	0.191395	0.808604572	0.147783
2016	6.878293741	25.50%	0.120500013	24.90%	0.211611	0.788389458	0.11767
1990	6.713183094	22.89%	0.098943848	21.67%	0.23132	0.768679721	0.093693
1999	6.233681749	19.17%	0.073377804	17.13%	0.261213	0.738786621	0.065565
2001	6.04601512	14.12%	0.045769546	11.16%	0.308414	0.691586365	0.036192
2004	5.912380043	10.52%	0.029993564	7.20%	0.350677	0.649322754	0.020518
2018	5.788090752	6.97%	0.017147352	3.71%	0.406591	0.59340885	0.009124
1975	5.014630402	4.89%	0.010808183	1.99%	0.452745	0.547254828	0.004403
2006	5.027222516	3.17%	0.006252921	0.87%	0.507471	0.492529345	0.001706
2015	4.920301602	13.60%	0.043330917	10.58%	0.313889	0.686111111	0.033694
1982	4.434380089	1.41%	0.002326446	0.14%	0.606341	0.39365864	0.000227
1996	4.340148829	1.00%	0.001552316	0.06%	0.646801	0.35319928	8.55E-05
2009	4.284006793	0.80%	0.001191066	0.03%	0.673291	0.326709334	4.24E-05
2013	4.027252982	0.62%	0.000874844	0.01%	0.704147	0.295853452	1.74E-05
2010	3.054675667	0.49%	0.000667037	0.01%	0.731266	0.268733552	7.31E-06
2011	2.965867618	0.41%	0.000541223	0.00%	0.752168	0.247832054	3.53E-06
1985	2.704321684	0.32%	0.000408127	0.00%	0.780393	0.219606737	1.19E-06
1988	2.63954931	0.24%	0.000299007	0.00%	0.811504	0.188495782	3E-07
1977	2.602550856	0.19%	0.000230136	0.00%	0.837684	0.162315812	7.82E-08
2017	2.579973538	0.17%	0.000194775	0.00%	0.854367	0.145633354	2.95E-08
1987	2.464819443	0.14%	0.000165006	0.00%	0.870953	0.129047333	9.93E-09
1998	1.878910524	0.13%	0.000143478	0.00%	0.884933	0.115067205	3.54E-09
1986	1.840089693	0.11%	0.000125454	0.00%	0.898357	0.101642698	1.16E-09
1983	1.854768771	0.10%	0.000110485	0.00%	0.911063	0.088937361	3.48E-10
2002	1.65980401	0.09%	0.000103356	0.00%	0.917733	0.082267059	1.73E-10
2000	1.620885818	0.08%	8.94978E-05	0.00%	0.93213	0.067870323	3.06E-11
1976	1.428151848	0.08%	8.36251E-05	0.00%	0.938917	0.061083291	1.18E-11
1979	1.470165306	0.07%	7.93401E-05	0.00%	0.944177	0.055823341	5.26E-12
1980	1.309106672	0.07%	7.6205E-05	0.00%	0.948208	0.051791655	2.68E-12
2003	1.225223364	0.07%	7.33017E-05	0.00%	0.952093	0.047907281	1.33E-12
1981	1.076251194	0.07%	7.02457E-05	0.00%	0.956351	0.043648856	5.75E-13
1978	0.848777953	0.07%	6.85628E-05	0.00%	0.958776	0.04122392	3.44E-13
1991	0.823366617	0.06%	6.69337E-05	0.00%	0.961181	0.038819191	2E-13
1992	0.78880534	0.06%	6.52941E-05	0.00%	0.963661	0.036339076	1.11E-13
1997	0.736208043	0.06%	6.33464E-05	0.00%	0.966689	0.03331082	5.05E-14
2007	0.661111187	0.06%	6.16122E-05	0.00%	0.969465	0.030534918	2.31E-14
1994	0.605996529	0.06%	6.01152E-05	0.00%	0.971925	0.028075161	1.08E-14
2021	0.590122641	0.06%	5.84053E-05	0.00%	0.97481	0.025189658	4.08E-15
1984	0.419050215	0.06%	5.70722E-05	0.00%	0.977119	0.022880606	1.72E-15
2008	0.343215335	0.06%	5.63513E-05	0.00%	0.978391	0.021609461	1.03E-15
2015	0.31618273	0.05%	5.57457E-05	0.00%	0.979471	0.020528988	6.48E-16
1995	0.284485984	0.05%	5.4894E-05	0.00%	0.981011	0.018989314	3.21E-16
2022	0.076213112	0.05%	5.46052E-05	0.00%	0.981538	0.018461833	2.49E-16

It is evident from above table that severity from both distributions are comparable and it ranges from 20-36% for largest loss varying from (6-30 Bn $) in a year exceeds a certain amount of loss.

From the OEP curve, it is evident that the loss distribution are consistent with the starting OEPs and the claim count assumption. The occurrence based reinsurance structures such as stop loss due to disasters or working excess can easily be formulated.

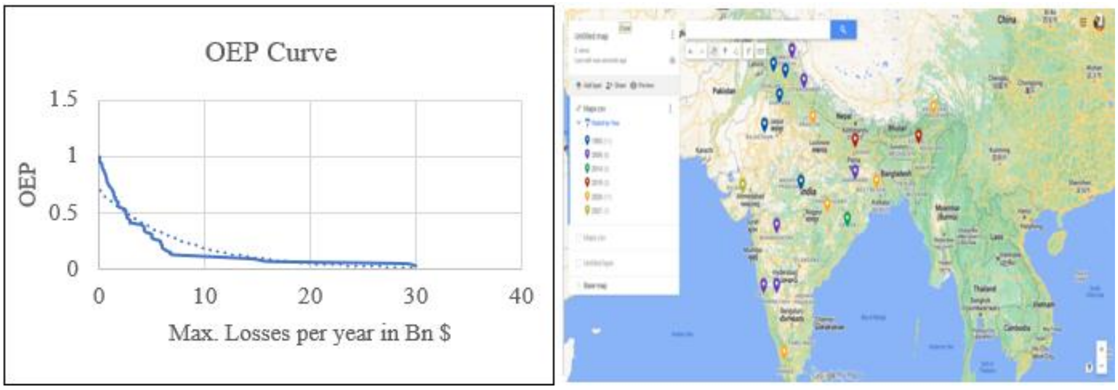


Figure: States of Max. cumulative loss (6-30 Bn $) with Exceedance Probability more than 30%

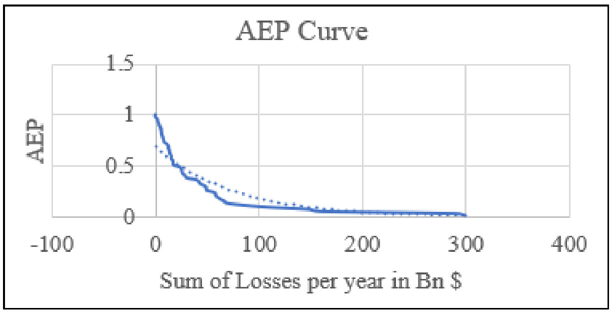
Loss(Billion $)	Monte Carlo Simulation	1		2		3		4		5		6		7
4.971736	1	4.9407893	1.371811	1.350108	2.407238	2.464819	0.744722	0.788805	1.261349	1.308064	1.136409	1.111298	0.80466	0.848778
0.95	2	4.9898336	0	1.297841	0	2.421647	0	0.669673	0	1.223267	0	1.126062	0	0.797355
0.05	3	4.9912995	0	1.370441	0	2.389412	0	0.751007	0	1.233987	0	1.225223	0	0.760709
0	4	5.0015186	0	1.425715	0	2.318207	0	0.707507	0	1.277679	0	1.114949	0	0.845855
0	5	5.0146304	0	1.313459	0	2.43542	0	0.699028	0	1.238465	0	1.128436	0	0.770664
0	6	4.9097447	0	1.299304	0	2.332101	0	0.695009	0	1.193826	0	1.082606	0	0.80047
0	7	4.9312429	0	1.346741	0	2.399625	0	0.774426	0	1.16485	0	1.143827	0	0.660443
0	8	4.9965144	0	1.397558	0	2.393392	0	0.764457	0	1.244404	0	1.093837	0	0.819024
0	9	4.9773587	0	1.38203	0	2.338999	0	0.757595	0	1.244766	0	1.211529	0	0.783442
0	10	4.9860528	0	1.470165	0	2.42526	0	0.714059	0	1.309107	0	1.180336	0	0.804434
0	Max.	5.0146304	0	1.470165	0	2.464819	0	0.788805	0	1.309107	0	1.225223	0	0.848778
0	Sum	49.738985		13.65336		23.91888		7.321566		12.43841		11.4181		7.891173
		8		9		10		11		12		13		14
4.383515	1	4.3229737	1.742171	1.682305	0.253543	0.271554	2.590091	2.639549	1.746298	1.745095	1.403713	1.380458	2.520986	2.455863
0	2	4.3267903	0	1.761059	0	0.237647	0	2.567603	0	1.688693	0	1.377194	0	2.51048
0	3	4.3075189	0	1.752145	0	0.202007	0	2.611959	0	1.84009	0	1.425047	0	2.516239
0	4	4.355796	0	1.711048	0	0.274515	0	2.572835	0	1.657762	0	1.413058	0	2.584951
0	5	4.4155014	0	1.79878	0	0.242901	0	2.608073	0	1.759335	0	1.404238	0	2.475942
0	6	4.3488497	0	1.854769	0	0.207897	0	2.548664	0	1.692678	0	1.414001	0	2.533459
0	7	4.3949189	0	1.78382	0	0.250645	0	2.593868	0	1.677033	0	1.428152	0	2.587866
0	8	4.4343801	0	1.778351	0	0.316183	0	2.542875	0	1.786982	0	1.363017	0	2.566079
0	9	4.3847087	0	1.663994	0	0.285132	0	2.519472	0	1.720927	0	1.341728	0	2.602551
0	10	4.3999586	0	1.66286	0	0.237595	0	2.608692	0	1.758368	0	1.379935	0	2.492046
0	Max.	4.4343801	0	1.854769	0	0.316183	0	2.639549	0	1.84009	0	1.428152	0	2.602551
	Sum	43.691396		17.44913		2.526075		25.81359		17.44913		13.92683		25.32547
		15		16		17		18		19		20		21
0	1	-0.01757	6.635552	6.643625	0.683334	0.590122	0.644369	0.71771	15.96391	15.99275	0.37769	0.41905	0.601222	0.581409
0	2	0.0982012	0	6.597639	0	0.610444	0	0.686034	0	15.92532	0	0.393843	0	0.636647
0	3	0.0473933	0	6.695145	0	0.694701	0	0.700108	0	15.86015	0	0.392418	0	0.661111
0	4	-0.0782844	0	6.713183	0	0.674817	0	0.582422	0	15.97405	0	0.405487	0	0.593078
0	5	0.0062421	0	6.624292	0	0.660405	0	0.736208	0	16.0714	0	0.30871	0	0.576007
0	6	-0.0376792	0	6.610141	0	0.823367	0	0.677605	0	15.97623	0	0.39992	0	0.585878
0	7	0.0022855	0	6.609528	0	0.687138	0	0.574628	0	15.86228	0	0.296659	0	0.558553
0	8	-0.019871	0	6.659402	0	0.728077	0	0.655065	0	15.91665	0	0.393996	0	0.571001
0	9	-0.0896035	0	6.637741	0	0.728393	0	0.709298	0	16.02796	0	0.333015	0	0.600095
0	10	0.0748286	0	6.675347	0	0.636891	0	0.664962	0	15.99124	0	0.39298	0	0.641527
0	Max.	0.0982012	0	6.713183	0	0.823367	0	0.736208	0	16.0714	0	0.41905		0.661111
	Sum	-0.0140575		66.46604		6.834355		6.704041		159.598		3.736078		6.005306
		22		23		24		25		26		27		28
4.240427	1	4.2489892	0.512322	0.533288	1.808981	1.774131	6.209863	6.195739	1.542301	1.49747	5.932777	5.891825	1.565019	1.59871
0	2	4.3401488	0	0.483939	0	1.794747	0	6.21531	0	1.520499	0	6.046015	0	1.589864
0	3	4.244365	0	0.590123	0	1.835391	0	6.16719	0	1.487849	0	5.984693	0	1.583736
0	4	4.2264673	0	0.54124	0	1.878911	0	6.19276	0	1.604207	0	5.940312	0	1.53942
0	5	4.2146258	0	0.559429	0	1.791966	0	6.172589	0	1.456657	0	5.891448	0	1.561484
0	6	4.3311969	0	0.547438	0	1.836642	0	6.21942	0	1.493878	0	5.918044	0	1.485066
0	7	4.1870668	0	0.470089	0	1.823875	0	6.171469	0	1.514602	0	6.019257	0	1.611043
0	8	4.2638994	0	0.543185	0	1.782909	0	6.233682	0	1.533428	0	5.861316	0	1.513483
0	9	4.1695514	0	0.497869	0	1.792464	0	6.205032	0	1.591685	0	5.894059	0	1.659804
0	10	4.1951666	0	0.445955	0	1.791651	0	6.225578	0	1.620886	0	5.935744	0	1.572971
0	Max.	4.3401488		0.590123		1.878911		6.233682		1.620886		6.046015		1.659804
	Sum	42.421477		5.212553		18.10269		61.99877		15.32116		59.38271		15.71558
		29		30		31		32		33		34		35
0.975207	1	0.975411	5.72049	5.780823	10.84952	10.83738	4.921334	4.905994	0.530921	0.540987	0.231077	0.211388	4.002337	4.02479
0	2	1.0762512	0	5.698753	0	10.80644	0	5.013071	0	0.522219	0	0.195798	0	4.014076
0	3	1.0101944	0	5.768229	0	10.90343	0	5.027223	0	0.463818	0	0.284486	0	4.018271
0	4	0.9644679	0	5.71437	0	10.88316	0	4.870744	0	0.580871	0	0.217795	0	4.01539
0	5	1.0023543	0	5.648858	0	10.85872	0	4.862123	0	0.551252	0	0.219817	0	3.985645
0	6	1.0162858	0	5.642299	0	10.74745	0	4.877661	0	0.556725	0	0.167261	0	4.027253
0	7	0.9296529	0	5.725229	0	10.78341	0	4.944602	0	0.549034	0	0.199345	0	4.001895
0	8	0.9499466	0	5.788091	0	10.82691	0	4.947678	0	0.605997	0	0.25593	0	3.915068
0	9	0.8802022	0	5.698568	0	10.89298	0	5.010688	0	0.602829	0	0.194422	0	3.990322
0	10	0.9217312	0	5.741236	0	10.9943	0	4.866626	0	0.593966	0	0.241851	0	3.985236

0	Max.	1.0762512		5.788091		10.9943		5.027223		0.605997		0.284486		4.027253
	Sum	9.7264975		57.20646		108.5342		49.32641		5.567697		2.188093		39.97795
		36		37		38		39		40		41		42
2.884198	1	2.9658676	2.647128	2.69363	0.311018	0.213944	2.986724	2.959526	29.00762	29.0251	4.875995	4.87251	6.842856	6.790712
0	2	2.9589708	0	2.671477	0	0.296828	0	3.037704	0	29.0268	0	4.920302	0	6.823519
0	3	2.8510939	0	2.704322	0	0.343215	0	2.976201	0	28.99536	0	4.859664	0	6.851842
0	4	2.8645726	0	2.664979	0	0.245511	0	3.001394	0	29.00828	0	4.907639	0	6.786314
0	5	2.8138517	0	2.637003	0	0.321536	0	2.98088	0	29.00195	0	4.887587	0	6.849571
0	6	2.8606306	0	2.638989	0	0.285677	0	3.026696	0	29	0	4.888836	0	6.807458
0	7	2.8731935	0	2.633993	0	0.322517	0	3.054676	0	28.95628	0	4.888811	0	6.83018
0	8	2.8756328	0	2.59482	0	0.326398	0	2.931636	0	28.99702	0	4.857363	0	6.822612
0	9	2.8339195	0	2.658135	0	0.332208	0	2.96389	0	29.01397	0	4.906355	0	6.836762
0	10	2.7930843	0	2.652331	0	0.326327	0	3.031396	0	28.99441	0	4.864019	0	6.878294
0	Max.	2.9658676		2.704322		0.343215		3.054676		29.0268		4.920302		6.878294
	Sum	28.690817		26.54968		3.014161		29.964		290.0192		48.85309		68.27726
		43		44		45		46		47		48		49
2.527543	1	2.5398969	5.837768	5.819964	14.80109	14.76881	29.88614	29.81189	8.435019	8.345983	4.2	4.161994	0	0.061051
0	2	2.5731798	0	5.899097	0	14.84665	0	29.94045	0	8.45055	0	4.190154	0	0.042348
0	3	2.4941874	0	5.876674	0	14.78778	0	29.95534	0	8.319176	0	4.169687	0	0.03077
0	4	2.5684311	0	5.811191	0	14.80719	0	29.87962	0	8.520671	0	4.20812	0	-0.02863
0	5	2.5799735	0	5.878795	0	14.76367	0	29.88189	0	8.454692	0	4.158181	0	0.011021
0	6	2.5085058	0	5.88544	0	14.79672	0	29.88541	0	8.446797	0	4.164242	0	0.000912
0	7	2.5408646	0	5.896291	0	14.75534	0	29.90421	0	8.42367	0	4.152481	0	-0.11978
0	8	2.5243663	0	5.91238	0	14.79344	0	29.91559	0	8.408953	0	4.211247	0	0.066861
0	9	2.5271647	0	5.835993	0	14.79216	0	29.89797	0	8.408562	0	4.284007	0	0.030016
0	10	2.4209087	0	5.744089	0	14.74697	0	29.91634	0	8.434596	0	4.172943	0	0.076213
0	Max.	2.5799735		5.91238		14.84665		29.95534		8.520671		4.284007		0.076213
	Sum	25.277479		58.55991		147.8587		298.9887		84.21365		41.87306	0	0.170778

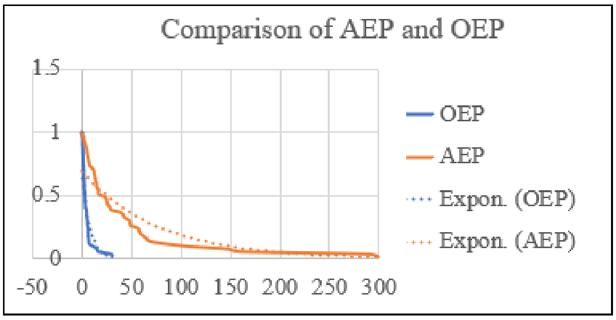
AEP	Rank	Year	Σi=1 Xi	Year	max1_ <I _< 10(Xi)	Poisson distribution	Bionomial Distribution
0.020408	1	46	298.9887	46	29.95534	27.47%	28.41%
0.040816	2	40	290.0192	40	29.0268	34.05%	35.63%
0.061224	3	19	159.598	19	16.0714	35.82%	37.62%
0.081633	4	45	147.8587	45	14.84665	36.31%	38.18%
0.102041	5	31	108.5342	31	10.9943	32.75%	33.87%
0.122449	6	47	84.21365	42	6.878294	28.23%	28.29%
0.142857	7	42	68.27726	16	6.713183	25.50%	24.90%
0.163265	8	16	66.46604	25	6.233682	22.89%	21.67%
0.183673	9	25	61.99877	27	6.046015	19.17%	17.13%
0.204082	10	27	59.38271	27	6.046015	14.12%	11.16%
0.22449	11	44	58.55991	44	5.91238	10.52%	7.20%
0.244898	12	30	57.20646	30	5.788091	6.97%	3.71%
0.265306	13	1	49.73898	1	5.01463	4.89%	1.99%
0.285714	14	32	49.32641	32	5.027223	3.17%	0.87%
0.306122	15	41	48.85309	41	4.920302	13.60%	10.58%
0.326531	16	8	43.6914	8	4.43438	1.41%	0.14%
0.346939	17	22	42.42148	22	4.284007	1.00%	0.06%
0.367347	18	35	39.97795	22	4.340149	0.80%	0.03%
0.387755	19	39	29.964	35	4.027253	0.62%	0.01%
0.408163	20	36	28.69082	39	3.054676	0.49%	0.01%
0.428571	21	37	26.54968	36	2.965868	0.41%	0.00%
0.44898	22	11	25.81359	37	2.704322	0.32%	0.00%
0.469388	23	14	25.32547	11	2.639549	0.24%	0.00%
0.489796	24	3	23.91888	14	2.579974	0.19%	0.00%
0.510204	25	24	18.10269	14	2.602551	0.17%	0.00%
0.530612	26	12	17.44913	3	2.464819	0.14%	0.00%
0.55102	27	12	17.44913	24	1.878911	0.13%	0.00%
0.571429	28	26	15.32116	9	1.854769	0.11%	0.00%
0.591837	29	28	15.71558	12	1.84009	0.10%	0.00%
0.612245	30	26	14.84665	28	1.659804	0.09%	0.00%
0.632653	31	13	13.92683	26	1.620886	0.08%	0.00%
0.653061	32	2	13.65336	13	1.428152	0.08%	0.00%
0.673469	33	5	12.43841	2	1.470165	0.07%	0.00%
0.693878	34	5	12.43841	5	1.309107	0.07%	0.00%
0.714286	35	6	11.4181	6	1.225223	0.07%	0.00%
0.734694	36	7	8.520671	29	1.076251	0.07%	0.00%
0.755102	37	4	7.891173	7	0.848778	0.07%	0.00%
0.77551	38	4	7.321566	4	0.788805	0.06%	0.00%
0.795918	39	17	6.834355	17	0.823367	0.06%	0.00%
0.816327	40	21	6.704041	18	0.736208	0.06%	0.00%
0.836735	41	21	6.005306	21	0.661111	0.06%	0.00%
0.857143	42	33	5.567697	23	0.590123	0.06%	0.00%

0.877551	43	23	5.212553	20	0.41905	0.06%	0.00%
0.897959	44	20	3.736078	38	0.343215	0.06%	0.00%
0.918367	45	38	3.014161	10	0.316183	0.06%	0.00%
0.938776	46	10	2.526075	34	0.284486	0.05%	0.00%
0.959184	47	10	2.188093	15	0.098201	0.05%	0.00%
0.979592	48	15	-0.01406	49	0.076213	0.05%	0.00%
1	49	49	0.170778	49	0.076213	0.00%	0.00%

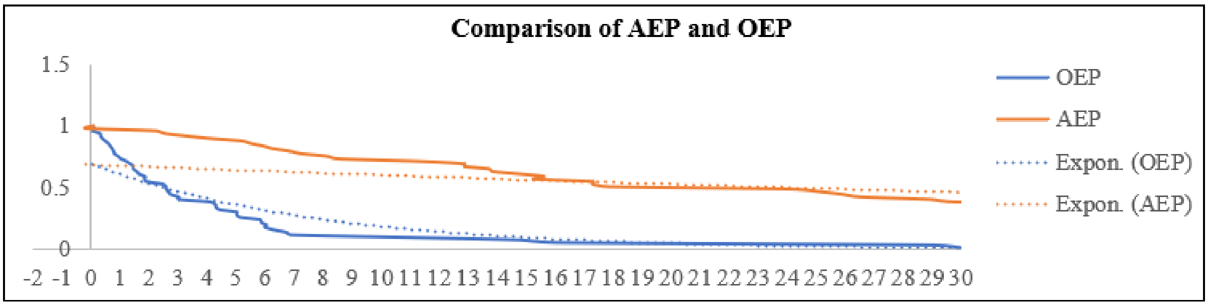
It is evident from above table that severity from both distributions are comparable and it ranges from 20-36% for aggregate loss varying from (62-300 Bn $) in a year exceeds a certain amount of loss.



An exponential trend is included to demonstrate the general behaviour of the function and the loss distributions are consistent with the starting AEPs and the claim count assumptions. Therefore, aggregate based reinsurance structure and reinstatements can easily be formulated



A standard Visualization of the Occurrence and Aggregate EP curves. The AEP is always greater than OEP for a particular loss starting from max. cumulative loss i.e.30 Bn $. Therefore, aggregate based reinsurance structures will be entirely different from the occurrence based structures



Maximum Annual Loss due to Floods:

Probability of Occurance(pi)	Loss (Xi)	Exeedence Probability ((1-(1-p1) (1-p2)……	E[X]=piXi	Probability of non occurance(1-pi)	Non Exeedence Probability ((1-p1)(1-p2)……	Exeedence Probability ((1-(1-p1)(1-p2)……	Return Period (Years)-1/Ep	OEP	Rank	Year	Σi=1 Xi(Max.)-Flood	Probability Mass function(Poisson Distribution)-Probability of exactly one occurance in ten years	Exp(-)10/RP	Probability Mass function(Bionomial Distribution)-Probability of exactly one occurance in ten	μ=1/RP	1-μ	(1-μ)^n-r
0.003	3884137	0.00	0.011	1.00	1.00	0.00	360.0	0.02	1	2014	20.354	**2.70%**	0.97	**2.71%**	0.00	1.00	0.98
0.000		0.00	0.000	1.00	1.00	0.00	360.0	0.04	2	1993	15.194	**2.70%**	0.97	**2.71%**	0.00	1.00	0.98
0.006		0.01	0.000	0.99	0.99	0.01	120.2	0.06	3	2020	13.015	**7.65%**	0.92	**7.72%**	0.01	0.99	0.93
0.006	744722	0.01	0.004	0.99	0.99	0.01	72.3	0.08	4	2019	11.447	**12.04%**	0.87	**12.20%**	0.01	0.99	0.88
0.011	403245	0.02	0.004	0.99	0.98	0.02	40.3	0.10	5	2005	9.276	**19.34%**	0.78	**19.77%**	0.02	0.98	0.80
0.014	1136409	0.04	0.016	0.99	0.96	0.04	26.1	0.13	6	2006	4.921	**26.13%**	0.68	**26.96%**	0.04	0.96	0.70
0.003	804660	0.04	0.002	1.00	0.96	0.04	24.4	0.15	7	2004	4.301	**27.21%**	0.66	**28.13%**	0.04	0.96	0.69
0.006	2122885	0.05	0.012	0.99	0.95	0.05	21.6	0.17	8	2022	4.200	**29.15%**	0.63	**30.23%**	0.05	0.95	0.65
0.011		0.06	0.000	0.99	0.94	0.06	17.6	0.19	9	1975	3.884	**32.22%**	0.57	**33.59%**	0.06	0.94	0.59
0.014	253543	0.07	0.004	0.99	0.93	0.07	14.3	0.21	10	2015	3.556	**34.76%**	0.50	**36.43%**	0.07	0.93	0.52
0.014	2198313	0.08	0.031	0.99	0.92	0.08	12.1	0.23	11	2021	3.456	**36.19%**	0.44	**38.05%**	0.08	0.92	0.46
0.008	1004189	0.09	0.008	0.99	0.91	0.09	11.0	0.25	12	2018	3.339	**36.61%**	0.40	**38.54%**	0.09	0.91	0.43
0.011	1403713	0.10	0.016	0.99	0.90	0.10	9.9	0.27	13	2009	3.320	**36.79%**	0.37	**38.74%**	0.10	0.90	0.38
0.008	2344044	0.11	0.020	0.99	0.89	0.11	9.2	0.29	14	2010	2.884	**36.67%**	0.34	**38.60%**	0.11	0.89	0.36
0.006		0.11	0.000	0.99	0.89	0.11	9.0	0.31	15	2017	2.528	**36.59%**	0.33	**38.51%**	0.11	0.89	0.35
0.011		0.12	0.000	0.99	0.88	0.12	8.1	0.33	16	1988	2.344	**35.95%**	0.29	**37.75%**	0.12	0.88	0.31
0.022	554403	0.14	0.012	0.98	0.86	0.14	7.0	0.35	17	1985	2.198	**34.27%**	0.24	**35.72%**	0.14	0.86	0.25
0.011	644369	0.15	0.007	0.99	0.85	0.15	6.6	0.38	18	2011	2.156	**33.24%**	0.22	**34.47%**	0.15	0.85	0.23
0.014	15194080	0.16	0.211	0.99	0.84	0.16	6.1	0.40	19	1982	2.123	**31.84%**	0.19	**32.74%**	0.16	0.84	0.20
0.006	345519	0.17	0.002	0.99	0.83	0.17	5.9	0.42	20	2016	1.828	**31.26%**	0.19	**32.03%**	0.17	0.83	0.19
0.008	499819	0.18	0.004	0.99	0.82	0.18	5.7	0.44	21	2013	1.711	**30.36%**	0.17	**30.93%**	0.18	0.82	0.18
0.017	361934	0.19	0.006	0.98	0.81	0.19	5.3	0.46	22	2000	1.542	**28.54%**	0.15	**28.67%**	0.19	0.81	0.15
0.017	409857	0.20	0.007	0.98	0.80	0.20	4.9	0.48	23	1987	1.404	**26.71%**	0.13	**26.40%**	0.20	0.80	0.13
0.008	949015	0.21	0.008	0.99	0.79	0.21	4.8	0.50	24	1980	1.136	**25.82%**	0.12	**25.29%**	0.21	0.79	0.12
0.006	953232	0.21	0.005	0.99	0.79	0.21	4.7	0.52	25	1986	1.004	**25.22%**	0.12	**24.56%**	0.21	0.79	0.11
0.017	1542301	0.23	0.026	0.98	0.77	0.23	4.4	0.54	26	1999	0.953	**23.48%**	0.10	**22.41%**	0.23	0.77	0.10
0.025	598187	0.25	0.015	0.98	0.75	0.25	4.1	0.56	27	1998	0.949	**21.01%**	0.09	**19.36%**	0.25	0.75	0.08
0.017	82606	0.26	0.001	0.98	0.74	0.26	3.9	0.58	28	1981	0.805	**19.47%**	0.08	**17.49%**	0.26	0.74	0.07
0.017	268858	0.27	0.004	0.98	0.73	0.27	3.7	0.60	29	1978	0.745	**18.03%**	0.07	**15.76%**	0.27	0.73	0.06
0.017	4301120	0.28	0.072	0.98	0.72	0.28	3.5	0.63	30	1992	0.644	**16.68%**	0.06	**14.15%**	0.28	0.72	0.05
0.047	9276041	0.32	0.438	0.95	0.68	0.32	3.2	0.65	31	2001	0.598	**13.31%**	0.04	**10.25%**	0.32	0.68	0.03
0.047	4921334	0.35	0.232	0.95	0.65	0.35	2.9	0.67	32	1991	0.554	**10.62%**	0.03	**7.31%**	0.35	0.65	0.02
0.044	530921	0.38	0.024	0.96	0.62	0.38	2.6	0.69	33	2007	0.531	**8.62%**	0.02	**5.26%**	0.38	0.62	0.01
0.044	197095	0.41	0.009	0.96	0.59	0.41	2.5	0.71	34	1995	0.500	**7.01%**	0.02	**3.75%**	0.41	0.59	0.01
0.017	3320275	0.42	0.055	0.98	0.58	0.42	2.4	0.73	35	1997	0.410	**6.51%**	0.02	**3.30%**	0.42	0.58	0.01
0.022	2884198	0.43	0.064	0.98	0.57	0.43	2.3	0.75	36	1979	0.403	**5.89%**	0.01	**2.78%**	0.43	0.57	0.01
0.019	2155823	0.44	0.042	0.98	0.56	0.44	2.3	0.77	37	1996	0.362	**5.41%**	0.01	**2.39%**	0.44	0.56	0.01
0.017	311018	0.45	0.005	0.98	0.55	0.45	2.2	0.79	38	1994	0.346	**5.03%**	0.01	**2.10%**	0.45	0.55	0.00
0.014	1711028	0.46	0.024	0.99	0.54	0.46	2.2	0.81	39	2012	0.311	**4.74%**	0.01	**1.88%**	0.46	0.54	0.00
0.019	20354143	0.47	0.396	0.98	0.53	0.47	2.1	0.83	40	2003	0.269	**4.36%**	0.01	**1.61%**	0.47	0.53	0.00
0.028	3556056	0.48	0.099	0.97	0.52	0.48	2.1	0.85	41	1984	0.254	**3.88%**	0.01	**1.29%**	0.48	0.52	0.00
0.022	1827819	0.49	0.041	0.98	0.51	0.49	2.0	0.88	42	2008	0.197	**3.54%**	0.01	**1.08%**	0.49	0.51	0.00
0.025	2527543	0.51	0.063	0.98	0.49	0.51	2.0	0.90	43	2002	0.083	**3.20%**	0.01	**0.88%**	0.51	0.49	0.00
0.025	3339021	0.52	0.083	0.98	0.48	0.52	1.9	0.92	44	1976	0.000	**2.90%**	0.01	**0.72%**	0.52	0.48	0.00
0.000	11447148	0.52	0.000	1.00	0.48	0.52	1.9	0.94	45	1977	0.000	**2.90%**	0.01	**0.72%**	0.52	0.48	0.00
0.014	13015115	0.53	0.181	0.99	0.47	0.53	1.9	0.96	46	1983	0.000	**2.75%**	0.01	**0.64%**	0.53	0.47	0.00
0.025	3456090	0.54	0.086	0.98	0.46	0.54	1.9	0.98	47	1989	0.000	**2.49%**	0.00	**0.52%**	0.54	0.46	0.00
0.008	4200000	0.54	0.035	0.99	0.46	0.54	1.8	1.00	48	1990	0.000	**2.42%**	0.00	**0.49%**	0.54	0.46	0.00

Figure: States of Maximum Cumulative Loss due to Flood ranging (3-20 Bn $) with Exceedance Probability (37%-2%)

Maximum Annual Loss Due to Storm:

Yar	Σi=1 Xi(Max.)-Storm	Probability Mass function (Poisson Distribution)-Probability of exactly one occurance in ten years	Exp(-)10/RP	Probability Mass function (Bionomial Distribution)-Probability of exactly one occurance in ten years, P(X)=1	μ=1/RP	1-μ	(1-μ)^n-r
2020	16871026	**16.01%**	0.823291915	**16.29%**	0.019444444	0.980555556	0.838011236
2014	8653477	**23.75%**	0.718469003	**24.43%**	0.033063272	0.966936728	0.738894633
1990	6479434	**26.17%**	0.680892104	**27.01%**	0.038435142	0.961564858	0.702760341
1999	5253117	**30.86%**	0.595769103	**32.09%**	0.05179021	0.94820979	0.619640671
2021	4752123	**31.58%**	0.5802819	**32.89%**	0.054424126	0.945575874	0.604320666
1996	2799299	**32.86%**	0.550585373	**34.30%**	0.059677325	0.940322675	0.574767468
2018	2498747	**34.78%**	0.4959632	**36.45%**	0.070125355	0.929874645	0.519780106
1977	2407238	**35.46%**	0.470992433	**37.22%**	0.075291325	0.924708675	0.49436121
1982	2260630	**36.51%**	0.414225399	**38.42%**	0.088134501	0.911865499	0.435890152
2019	2071934	**36.70%**	0.393763735	**38.64%**	0.093200421	0.906799579	0.414573741
1983	1736537	**36.78%**	0.374418186	**38.74%**	0.098238196	0.901761804	0.394299769
1976	1371811	**36.59%**	0.330342047	**38.51%**	0.110762666	0.889237334	0.347663576
2015	1319939	**36.10%**	0.299263506	**37.93%**	0.12064308	0.87935692	0.314402991
2016	1219359	**35.95%**	0.292042078	**37.74%**	0.123085738	0.876914262	0.306629686
2013	1124945	**36.59%**	0.330665309	**38.51%**	0.110664857	0.889335143	0.34800789
1975	1087599	**34.52%**	0.246426412	**36.02%**	0.140069186	0.859930814	0.257141162
1998	859966	**34.28%**	0.24060978	**35.73%**	0.142457883	0.857542117	0.2507836
1986	728759	**33.78%**	0.229415604	**35.12%**	0.147222006	0.852777994	0.238519486
2011	488703	**33.25%**	0.218800131	**34.47%**	0.151959661	0.848040339	0.226855127
2009	409237	**32.70%**	0.208730786	**33.80%**	0.156670996	0.843329004	0.215761191
1993	202588	**32.14%**	0.199176966	**33.11%**	0.161356157	0.838643843	0.205209784
1995	92761	**30.97%**	0.181455611	**31.67%**	0.170674422	0.829325578	0.185577594
2003	69999	**30.67%**	0.177323231	**31.31%**	0.172978105	0.827021895	0.18098937
1979	51615	**29.47%**	0.161755011	**29.82%**	0.182167237	0.817832763	0.16367432
2008	33982	**28.55%**	0.151098234	**28.69%**	0.18898251	0.81101749	0.151800074
2002	677	**27.95%**	0.144441366	**27.94%**	0.193488162	0.806511838	0.144376568
1978	0	**0.00%**	0.1350526	**26.81%**	0.200209094	0.799790906	0.133902336
1980	0	**0.00%**	0.123568873	**25.32%**	0.20909566	0.79090434	0.121092049
1981	0	**0.00%**	0.105954708	**22.78%**	0.224474356	0.775525644	0.101476498
1984	0	**0.00%**	0.09720695	**21.39%**	0.233091307	0.766908693	0.091768354
1985	0	**0.00%**	0.089266844	**20.05%**	0.241612515	0.758387485	0.082988979
1987	0	**0.00%**	0.085583927	**19.40%**	0.245825779	0.754174221	0.078930554
1988	0	**0.00%**	0.083809654	**19.08%**	0.247920707	0.752079293	0.076979074
1989	0	**0.00%**	0.082076941	**18.77%**	0.250009816	0.749990184	0.075075842
1991	0	**0.00%**	0.072432765	**16.94%**	0.262509653	0.737490347	0.064536746
1992	0	**0.00%**	0.06275623	**14.97%**	0.276849743	0.723150257	0.054082518
1994	0	**0.00%**	0.059086078	**14.19%**	0.282875995	0.717124005	0.050158939
1997	0	**0.00%**	0.057920722	**13.94%**	0.284868006	0.715131994	0.048918809
2000	0	**0.00%**	0.052444283	**12.72%**	0.294800395	0.705199605	0.043132889
2001	0	**0.00%**	0.047551196	**11.58%**	0.304594834	0.695405166	0.038031304
2004	0	**0.00%**	0.04234736	**10.34%**	0.31618492	0.68381508	0.032692495
2005	0	**0.00%**	0.040001681	**9.76%**	0.321883379	0.678116621	0.03032072
2006	0	**0.00%**	0.036406183	**8.86%**	0.331301665	0.668698335	0.026734507
2007	0	**0.00%**	0.029678241	**7.11%**	0.351734114	0.648265886	0.020219877
2010	0	**0.00%**	0.027122868	**6.43%**	0.360737807	0.639262193	0.017828351
2012	0	**0.00%**	0.025263182	**5.93%**	0.36784072	0.63215928	0.016122733
2017	0	**0.00%**	0.023139663	**5.35%**	0.37662071	0.62337929	0.014215801
2022	0	**0.00%**	0.022352004	**5.14%**	0.380083929	0.619916071	0.013520603

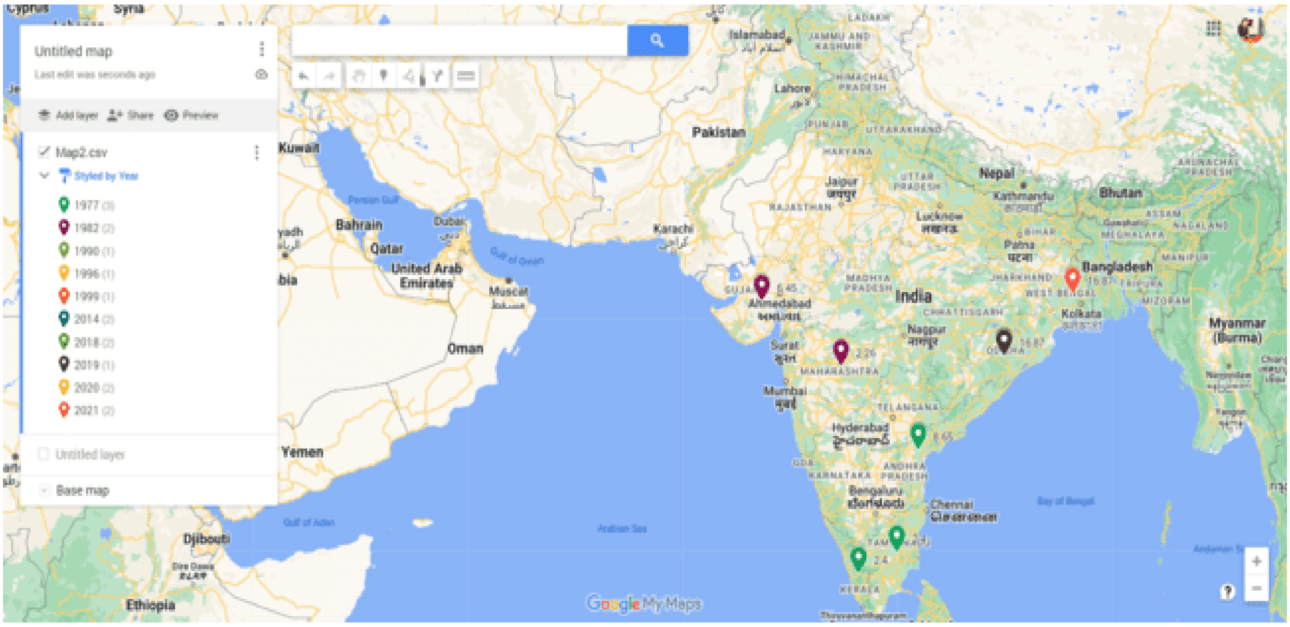


Figure: States of Max. Cumulative Loss due to Storm ranging (>2-16.87 Bn $) with Exceedance Probability (37%-16%)

3. Conclusion

It is concluded from the above probabilistic model that two of the most important notions in Catastrophic Modeling, the Occurance Exceedance Probability(OEP) and Aggregate Exceedance Probability(AEP). In particular, we discussed a connection between the distribution of loss severities and the OEP depending on the distribution of claim counts. This plays a very important role in reinsurance structuring.

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