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May 16

Training on concepts and terminology for analytics related to disaster risk finance and insurance

Block 3. Study case: applied risk metrics to a portfolio of Central American's six countries

José Ángel Villalobos, Darío Bacchini and Barry Maher



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Block 3. Study case: applied risk metrics to a portfolio of Central American's six countries Agenda

15:10 - 16:00

- Seismic Hazard in Central America: CAPRA Output
- Monte Carlo Simulation Output
- Portfolio Analysis
- Key Messages

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Seismic Hazard in Central America CAPRA Output – DRFI Analytics Input





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CAPRA Output

- 13,628 scenarios
 - Frequency per scenario
 - Conditional severity per scenario country



			BELIZE			COSTA RICA		l	EL SALVADOR			GUATEMALA			HONDURAS	5		NICARAGU	JA	
Event	Frequency	A_BEL	B_BEL	EX_BEL	A_CRI	B_CRI EX	CRI	A_ELS	B_ELS	EX_ELS	A_GUA	B_GUA I	X_GUA	A_HON	B_HON	EX_HON	A_NIC	B_NIC	EX_	NIC
CAc1_SF1_M=5.250.00139662	0.00140	2.32	277,039.00	715	0.00	0.00	0	0.00	0.00	0	0.00	589.03	99,017	0.00	0.00	0	0.00	0.	00	0
CAc1_SF1_M=5.750.000527322	0.00053	0.72	37,725.90	715	0.00	0.00	0	0.00	0.00	0	0.00	465.73	99,017	0.00	0.00	0	0.00	0.	00	0
CAc1_SF1_M=6.250.000199101	0.00020	0.37	7,837.43	715	0.00	0.00	0	0.00	0.00	0	0.01	319.79	99,017	0.00	0.00	0	0.00	0.	00	0
CAc1_SF1_M=6.750.0000751744	0.00008	0.24	1,298.70	715	0.00	0.00	0	0.00	0.00	0	0.01	214.02	99,017	0.00	0.00	0	0.00	0.	00	C
CAc1_SF10_M=5.250.00139662	0.00140	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.01	473.04	99,017	0.00	0.00	0	0.00	0.	00	C
CAc1_SF10_M=5.750.000527322	0.00053	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.01	226.42	99,017	0.00	0.00	0	0.00	0.	00	C
CAc1_SF10_M=6.250.000199101	0.00020	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.02	136.56	99,017	0.00	0.00	0	0.00	0.	00	0
CAc1_SF10_M=6.750.0000751744	0.00008	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.04	97.17	99,017	0.00	0.00	0	0.00	0.	00	C
	1																			

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CAPRA Output One scenario: 1

 Event
 Frequency

 CAc1_SF1_M=5.250.00139662
 0.00140



	BELIZE		(COSTA RICA		EL SALVADOR			
A_BEL	B_BEL	EX_BEL	A_CRI	B_CRI	EX_CRI	A_ELS	B_ELS	EX_ELS	
2.32	277,039.00	715	0.00	0.00	0	0.00	0.00	0	
(GUATEMALA		ŀ	HONDURAS		1	NICARAGUA		
A_GUA	B_GUA	EX_GUA	A_HON	B_HON	EX_HON	A_NIC	B_NIC	EX_NIC	
0.00	589.03	99,017	0.00	0.00	0	0.00	0.00	0	

• This scenario can generate losses only in Belize.



CAPRA Output One scenario: 2

 Event
 Free

 CAsp1_SF258_M=7.280.0000767645
 0.4



	BELIZE			COSTA RICA		E	LSALVADOR	
A_BEL	B_BEL	EX_BEL	A_CRI	B_CRI	EX_CRI	A_ELS	B_ELS	EX_ELS
0.14	4.53	95	0.00	0.00	0	0.53	8.80	45,897
	AND							
(GUATEMALA		ŀ	HONDURAS		[NICARAGUA	
A_GUA	B_GUA	EX_GUA	A_HON	B_HON	EX_HON	A_NIC	B_NIC	EX_NIC
0.34	13.63	99,017	0.00	0.00	0	0.41	39.42	46,136
						(3) (3)	1 5 22 34 15 3 34	

• This scenario can generate losses in four countries.



CAPRA Output All Scenarios: again!

There are a total of 13,628 scenarios

- Frequency: 13,628 Poisson distributions ("dice")
- Severity: 81,768 = 13,628 x 6 Beta Distributions ("roulettes")
 - Note that many of them are null

Let's analyze the theoretical Frequency of the scenarios...



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Number of countries affected

Given that a quake has occurred:

- What is the probability that only one country is affected?
- What is the probability that the quake affects two countries?
- And so on...



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Expected Annual Number of earthquakes Per Magnitude

- It is expected that 58 quakes (approx.) of magnitude greater than 5.00 hit Central America per year.
- The expected numbers of quakes per magnitude are as follows:



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Annual Number of Earthquakes

Theoretical probability distribution

The total number of quakes per year follows a Poisson distribution with expected value of 58.22

• Approximately 58 quakes are expected per year... but the realization can vary significantly.



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Monte Carlo Simulation Output





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Simulation output Four Samples: summary

One detailed sample (per scenario):

1. 5,000 Years of Simulations with a total of 285,630 scenarios.

From this sample, it is possible to calculate:

- Countries affected per scenario
- Number of quakes per magnitude
- Annual Number of quakes
- Aggregate Annual Loss
- Maximum Annual Loss

Three grouped samples:

- 2. 10,000 Years of Simulations of grouped annual information.
- **3.** 10,000 Years of Simulations of grouped annual information.
- 4. 20,000 Years of Simulations of grouped annual information.

These samples contains

- Annual Number of quakes
- Aggregate Annual Loss
- Maximum Annual Loss

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Simulation output One detailed sample per scenario



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Simulation output Three grouped annual samples: aggregate losses

	Simulated Sample of 10,000 Years												
				Aggregate Losses									
Year	No_Events	MAX_Events	BELICE	COSTA_RICA	EL_SALVADOR	GUATEMALA	HONDURAS	NICARAGUA	CA_together				
	1 56	2	0.00	61.81	135.81	109.33	17.14	175.77	499.86				
	2 55	2	0.00	12.69	253.94	0.69	86.58	32.13	386.03				
	3 43	2	0.12	130.23	338.13	0.53	28.05	410.20	907.26				
	4 52	1	0.03	930.81	558.83	148.21	52.95	569.64	2,260.47				
9,99	7 53	2	0.02	135.26	299.50	1,489.99	217.16	238.80	2,380.74				
9,99	3 46	1	0.08	89.79	294.09	80.33	47.03	424.06	935.37				
9,99	9 61	2	0.02	133.24	132.08	12.71	99.99	800.85	1,178.88				
10,00	J 46	1	0.01	278.44	1,945.54	381.97	221.39	46.82	2,874.16				

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Simulation output Three grouped annual samples: maximum losses

	Simulated Sample of 10,000 Years											
				Maximum Loss of the year								
Year	No_Events	MAX_Events	BELICE	COSTA_RICA	EL_SALVADOR	GUATEMALA	HONDURAS	NICARAGUA	CA_together			
1	56	2	0.00	32.15	51.12	108.13	9.71	109.17	152.54			
2	55	2	0.00	5.95	233.56	0.23	29.96	20.88	233.70			
3	43	2	0.10	67.17	216.30	0.19	9.73	270.37	282.86			
4	52	1	0.01	770.70	354.64	110.20	21.11	239.23	771.70			
9,997	53	2	0.01	85.34	141.64	1,350.89	193.56	218.85	1,492.53			
9,998	46	1	0.04	75.22	143.29	55.16	12.61	240.52	385.38			
9,999	61	2	0.01	73.65	43.89	9.63	92.47	560.58	561.44			
10,000	46	1	0.01	179.66	1,917.51	322.14	205.98	34.40	2,239.80			

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Number of countries affected Expected vs. Simulated (per scenario)



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Annual Number of earthquakes per magnitude

Expected vs. Simulated (per scenario)



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Annual Number of earthquakes: total

Expected vs. Simulated



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Sample Variability of Risk Metrics

Average Annual Loss & Standard Deviation in Costa Rica

Choose Country:	Costa Rica
-----------------	-------------------

Code: CRI

Exposure: **77,199**

	Agg. Loss from Events	Agg. Loss (Sim 1 - 10k	Agg. Loss (Sim 2 - 10k	Agg. Loss (Sim 3 - 20k
	(5k Years)	Years)	Years)	Years)
AAL	0.73%	0.73%	0.74%	0.73%
Std. Dev.	1.40%	1.42%	1.50%	1.50%
<i>C.V.</i>	193%	195%	203%	207%
Premiu	m Load (% of Std. Dev.):	10.00%		
Premium	0.87%	0.87%	0.89%	0.88%

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Sample Variability of Risk Metrics

Loss at Risk in Costa Rica



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Sample Variability of Risk Metrics

Expected Tail Loss in Costa Rica



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Comparison of Risk Metrics

Metric for extreme events: LaR vs ETL



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Comparison of underlying loss

Maximum vs Aggregate



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Portfolio Analysis





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Risk Metrics per country and for Portfolio AAL & Standard Deviation: million USD

	BELIZE	COSTA RICA	EL SALVADOR	GUATE- MALA	HONDU- RAS	NICARA- GUA	CENTRAL AMERICA	Sum of countries	Pool Benefit
Exposure	1,750	77,199	45,897	99,017	67,933	88,604	380,400	380,400	-
AAL	0.49	562.14	593.21	618.59	137.37	526.66	2,438.46	2,438.46	0.00%
Std. Dev.	3.55	1,184.53	948.36	1,509.23	351.39	1,055.91	2,728.84	5,052.97	-46.00%
Premium (AAL+10% Std.Dev.)	0.84	680.60	688.05	769.51	172.51	632.25	2,711.35	2,943.76	-7.90%

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Insurance Premium per country and for Portfolio Diversification effect



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Correlation Matrix of Annual Aggregate Losses

• Correlations lower than 100% generate the diversification

	Correlation Matrix (estimated from Simulation)												
	BEL	CRI	ELS	GUA	HON	NIC							
BEL	100.0%	0.1%	10.3%	11.7%	-0.8%	0.4%							
CRI	0.1%	100.0%	1.0%	0.1%	-0.8%	10.7%							
ELS	10.3%	1.0%	100.0%	37.4%	0.0%	11.3%							
GUA	11.7%	0.1%	37.4%	100.0%	-0.8%	1.8%							
HON	-0.8%	-0.8%	0.0%	-0.8%	100.0%	-0.9%							
NIC	0.4%	10.7%	11.3%	1.8%	-0.9%	100.0%							

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LaR as a function of exceedance probability (US\$M)



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LaR as a function of exceedance probability (%)



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LaR Curve Risk Layering (hypothetical example)



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Expected Tail Loss Curve (US\$M)



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Expected Tail Loss Curve (%)



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ETL Curve and Reserving

- 99.5% of confidence that *LaR 0.5%* threshold will not be exceeded.
- Given the threshold, the Expected Loss is the *ETL 0.5%*.
- Conservatism
 principle.
- Coherent Risk Metrics.



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Summary of Key messages





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Key Messages

- 1. From deterministic to full probabilistic approach
- 2. Usage of Risk Metrics
 - Quantification of losses
 - Diversification effects
 - Reserving
 - Layering
 - Sovereign DRFI strategies
- 3. Risk-based capital and Reserves:
 - Evolution along with Banking Industry: LaR and ETL
 - Solvency II for Insurance Industry (inspired by Basel II)

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Key Messages

- 4. Uncertainties in Cat Risk Modelling Challenges in Risk Assessment (vs e.g. automobile insurance)
 - Hazard Frequency: Are the (Poisson's) events independent?
 - Vulnerability Functions: Results are very sensitive to them.
 - Exposure: Proxies are usually used (lack of sound databases).
- 6. Risk Metrics based on simulations: how reliable?

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Key Messages

Work in progress!



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