EXPLANATION PAPER

To: : EIOPA, NBS

From: : Union poistovna, a.s., Slovakia

Date: : August 2016

Subject: : Solvency II: natural catastrophe (earthquake) risk

Purpose

To address the overestimation of the earthquake (also "EQ") catastrophe risk caused by inappropriate calibration by the standard formula.

Scope

The following topics are covered in this document:

- Problem description
- Analysis and arguments
- Comparison with AIR and IF models
- Conclusion

The following documents are considered in this document:

- *The catastrophe task force report on standardised scenarios for the catastrophe risk module in the standard formula*, CEIOPS/EIOPA. This document will be referred as "EIOPA framework".
- *DIRECTIVE 2009/138/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 November 2009 on the taking-up and pursuit of the business of Insurance and Reinsurance (Solvency II)*. This document will be referred as "Solvency II directive"

The following sources were used for interpretations of figures in this document:

- *https://www.cresta.org*
- *http://earthquaketrack.com*

Problem Description

The EIOPA framework was designed as a guideline for the treatment of catastrophe risk under the standard formula. It offers a prescription for the methods to be used in order to calculate the catastrophe risk capital charge, and also a number of country specific inputs:

A. a 1 in 200 year factor or country factor, reflecting the loss to the insurance industry of a country following a 1 in 200 event, as a percentage of the total sum insured. This factor is also a measure of other aspects of the country such as resilience of the buildings (column 2 in Table 1).

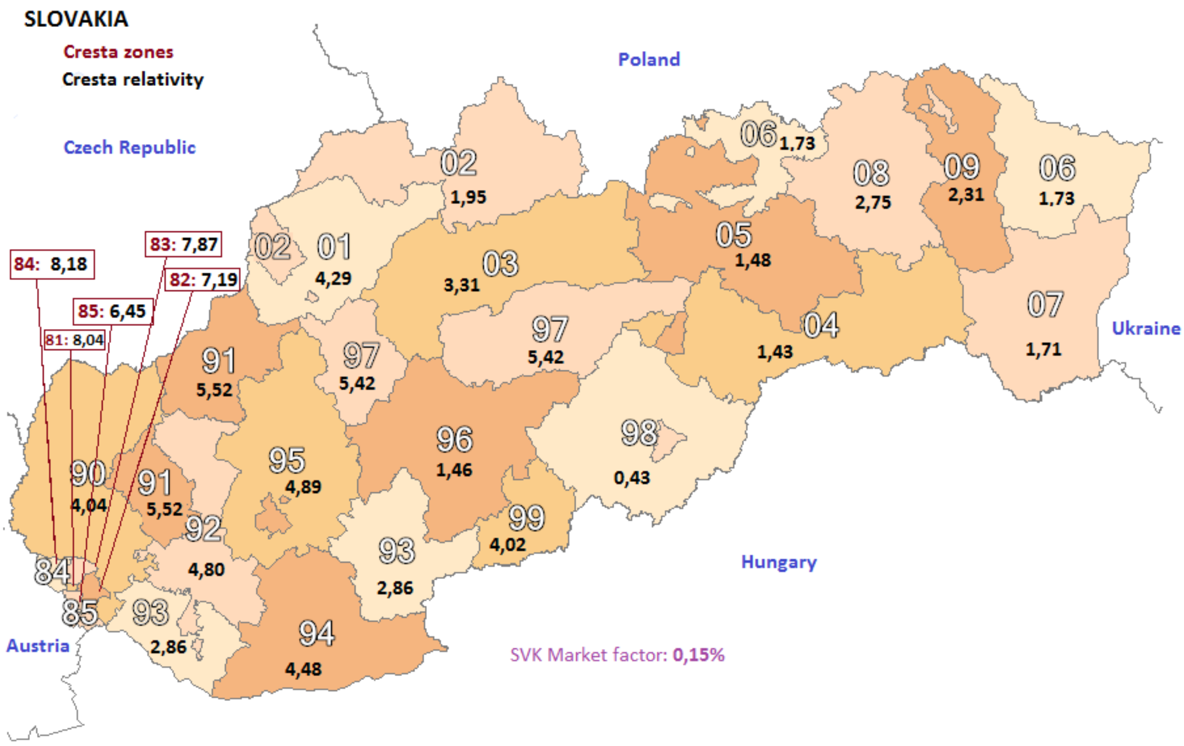
B. a list of Cresta relativities (regional level), representing the level of damage relative to the country factor (see also articles 148 & 149 of the EIOPA framework). Since these measures are relative to the national average, itself reflected by the country factor, we expect the (weighted) average of these relativities to be close to 1. However it is not mentioned anywhere what the weight is.

C. a correlation matrix reflecting the correlations between the regions.

The catastrophe risk charge is to be calculated as follows: for each region within a country the exposure is multiplied by the Cresta relativity (also ”CR”) for that region (by EIOPA framework it is $WTIV_{ZONE}$ - Geographically weighted total insured value by zone). Subsequently we take the sum of all possible combinations of these “weighted exposures”, multiplied with each other and with their respective correlation factor. The capital charge to be held is then the square root of this outcome multiplied by the country factor. For a more detailed explanation of the calculation article 38 of the EIOPA framework can be consulted.

Map below shows the parameters of earthquake risk in Slovakia.

Map 1 – Slovakia: cresta relativity in cresta zones



We see a lot of indications that some of those parameters of earthquake risk in Slovakia are too high or not well calibrated when comparing to other countries. We do not have all official details of models and methods used for a calibration thus we can base our analysis only on sources available. Where definitions of parameters are missing or not clear the explanations from available CEIOPS documents are used.

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Analysis and arguments

We did an exercise (for more details please see the excel file EQ_CAT_Slovakia.xlsx) in which for the countries exposed to earthquake risk, a number of measures are calculated in the table below:

1) The resulting capital charge as a % of the total sum insured. Hereby we used equal exposures for all regions of all countries.
2) The country (market) factor, this is input A of the EIOPA framework
3) The average Cresta relativity, i.e. the average of input B of the EIOPA framework.
4) The capital charge as a percentage of the sum insured (1) divided by the country factor (2) or “Cresta relativity multiplier” of total sum insured (for equal exposure in all cresta zones in a country) as following formulae is valid for each country:

   Gross Cat Risk Charge = Market factor x CR Multiplier x Total sum insured.

5) The number of earthquakes per country out of the 1 000 biggest (magnitude 5,1 and more) earthquakes in Europe (more details in sheet “EQ in Europe”)
6) The number of earthquakes per country out of recent 1 000 (last 3 years, magnitude 2,1 and more) earthquakes in Europe (more details in sheet “EQ in Europe”)

Table 1

Countries with EQ risk	1 Gross Cat Risk Charge %	2 Country Market Factor	3 Average Cresta Relativity	4 Cresta relativity multiplier	5 Biggest 1000 EQ	6 Recent 1000 EQ
Austria	0,07%	0,10%	1,20	0,71	4	3
Belgium	0,03%	0,02%	1,41	1,27	0	2
Bulgaria	0,26%	1,60%	0,34	0,16	6	8
Croatia	0,43%	1,60%	0,64	0,27	6	15
Cyprus	1,93%	2,35%	1,08	0,82	0	0
Czech Republic	0,08%	0,10%	1,51	0,78	1	0
Germany	0,11%	0,10%	1,28	1,12	2	9
France	0,06%	0,06%	1,56	1,06	14	6
Greece	1,47%	1,85%	3,10	0,79	566	478
Hungary	0,06%	0,20%	0,59	0,30	1	2
Italy	0,76%	0,80%	4,19	0,95	79	116
Portugal	0,87%	1,20%	0,98	0,73	7	5
Romania	1,59%	2,50%	0,81	0,64	44	25
Slovenia	0,49%	1,00%	0,88	0,49	5	4
Switzerland	0,27%	0,25%	1,62	1,10	0	3
Slovakia	**0,29%**	**0,15%**	**4,03**	**1,91**	**0**	**0**
Spain	-	-	-	-	20	20
Poland	-	-	-	-	10	3
United Kingdom	-	-	-	-	10	0

One observes that the relative capital charge (1) is 3-4 times higher for Slovakia than for its close neighbours (Austria, Hungary and Czech Republic). Taking into account that Poland is considered to have no earthquake risk at all, this outcome is highly surprising. As Slovakia is not highly exposed to earthquake risk, being located amid other countries with low exposure, we would expect its outcome to be in range with its neighbouring countries. The country factors (2) for these countries are also in line with each other.

Reading of the article 179 of the EIOPA framework: “For Earthquake, risk is mostly connected with the collision of the Eurasian and African tectonic plates. The highest earthquake risk areas are associated with fault systems that pass through Switzerland, Italy and through the south-east European countries towards Greece and Turkey, and towards the western margin of the Eurasian plate, through Portugal.“ would suggest that countries as mentioned in the article would have higher capital charge than Slovakia. However this is not the case. When comparing Slovakia with these countries, some of them have the relative capital charge lower than Slovakia (0,29%): France 0,06%, Bulgaria 0,26%, Switzerland 0,27% or not so higher as we could expect (based on occurrence of EQ - see columns 5 and 6 in Table 1): Croatia 0,43%, Slovenia 0,49%, Italy 0,76%, etc.

We see the reason for the discrepancy in the fact that the average Cresta relativity for Slovakia is very high compared to the results for the neighbours. In our opinion this is not correct and it fundamentally violates the points discussed above, where we assumed that the (weighted) average of the Cresta relativities should be close to 1 (see point B above).

As by article 144 of the EIOPA framework the country factor represents the cost of a 1 in 200 loss to the industry as a whole, expressed as a percentage of sum insured, we expect that this country factor should multiply total insured value after geographical diversification. It is natural to expect that geographical diversification should decrease total sum insured if correct weights are used (i.e. sum of weights = 1). As we do not know what weights were used to derive WTIV (geographically weighted total insured value) for individual countries, we can in order to compare Slovakia with other countries apply only equal weights (average cresta relativity in column 3). We expect the Average Cresta Relativity of Slovakia is even higher than 4,03 when relative exposures by zone are used as weights. This is due to high cresta relativities in areas with highest exposures.

A view from a different angle is offered by “Cresta relativity multiplier” (column 4). In order to calculate the Gross Cat Risk Charge the total insured value of a country is geographically diversified by Cresta Relativity factors and Aggregation Matrix. The ratio between the diversified insured value and total insured value is “Cresta relativity multiplier”. This CR multiplier is 1,91 for Slovakia for equally distributed sum insured by cresta zone. No other country has such high CR multiplier. It usually results around 1 or even below 1 for equal exposure. Distributing the sum insured by real exposure of our company the CR multiplier increases as high as 3,15.

Historical occurrence of earthquake events in European countries also suggests that some of cresta relativity factors are not consistent between countries. Analysis of a list of 1 000 biggest (5) and a list of 1 000 recent (6) earthquakes (with magnitude 2,1 and more) in Europe (http://earthquaketrack.com) confirms there is more countries with several earthquake events comparing to 0 in Slovakia in both cases while the Gross Cat Risk Charge is lower for these countries than for Slovakia. The recent 1 000 events occurred during last 3 year while there were not observed any similar events during last 10 years In Slovakia and only 29 events were observed at all.

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To have more detailed view we compared earthquake events of Slovakia and its neighbouring countries Austria and Hungary. Following table shows number and average magnitude of all EQ events observed in Slovakia and Hungary (with magnitude higher than 2 for both countries) and all events with magnitude higher than 2,5 for Austria[1].

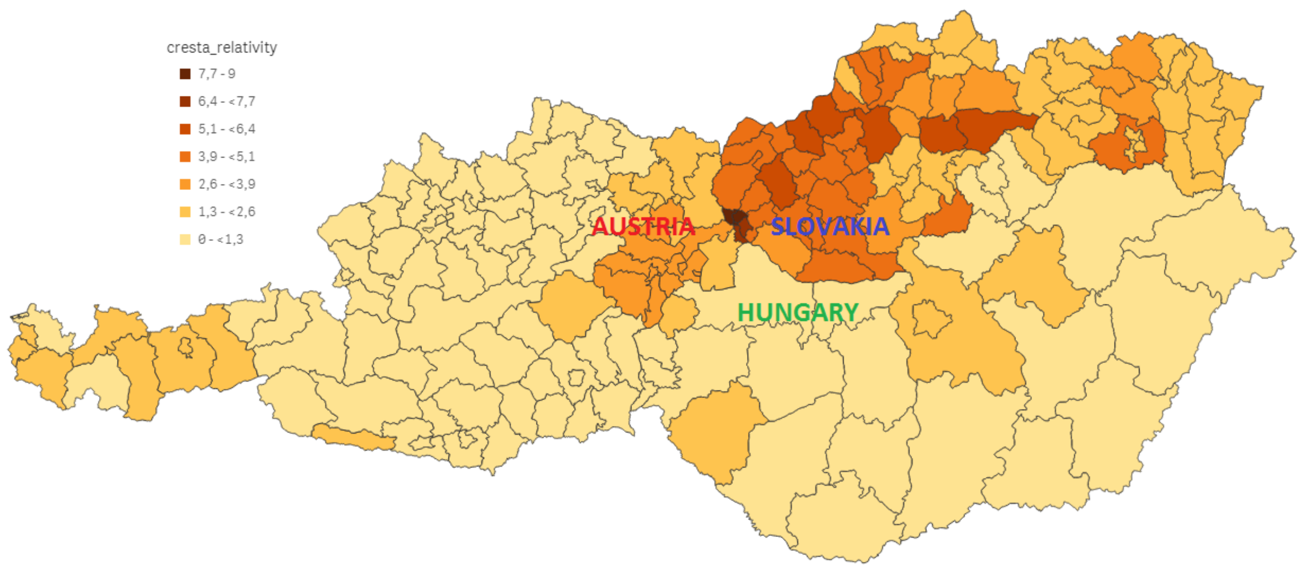
Table 2

Country	All observed EQ[1]		last 37 years		Gross Cat Risk Charge %	Country Market Factor	Average Cresta Relativity	Cresta relativity multiplier
	number	magnitude	number	magnitude				
Austria[1]	432	3,2	414	3,2	0,07%	0,10%	1,20	0,71
Hungary	117	3,3	111	3,2	0,06%	0,20%	0,59	0,30
Slovakia	**29**	**2,9**	**29**	**2,9**	**0,29%**	**0,15%**	**4,03**	**1,91**

Both Austria and Hungary has much lower both Gross Cat Risk Charge percentage (by 4-5 times) and cresta relativity factors (by 3-7 times) but 5 times (Hungary) and 15 times (Austria) higher frequency of EQ events.

For better visualization of cresta relativity factors we include Map 2 and Map 3.

Map 2 – Austria, Slovakia and Hungary: cresta relativity in cresta zones



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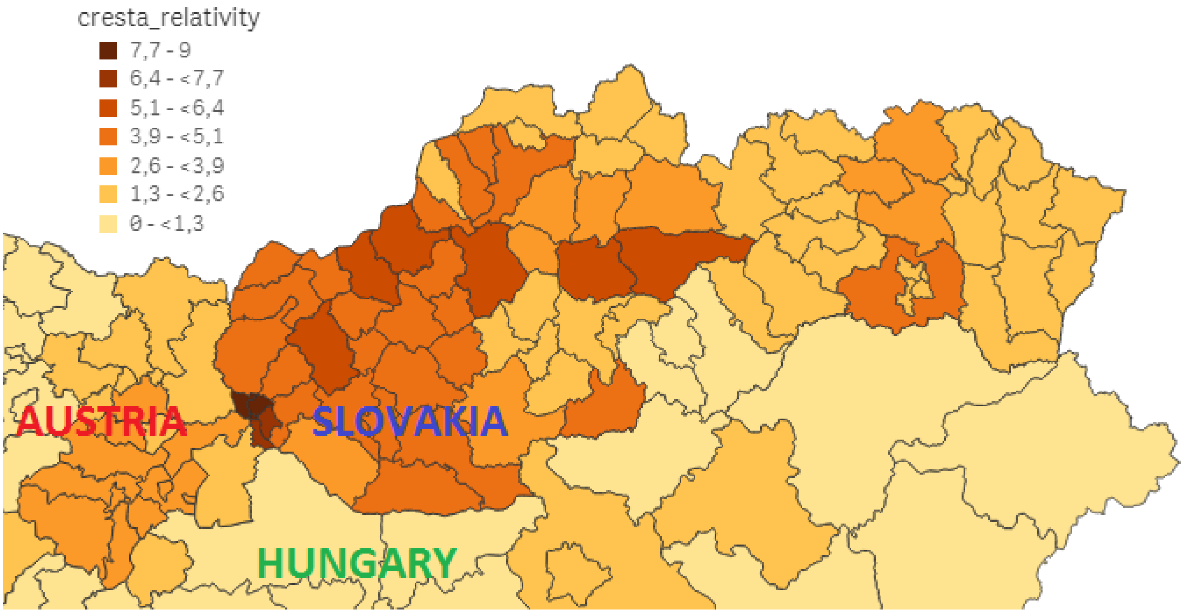
Map 3 – cresta relativity in cresta zones in/near Slovakia



Maps clearly show that CR factors of Slovakia, Austria and Hungary do not correspond with frequencies of observed events and are not consistent between these countries as cresta zones of Slovakia with high factors are neighbouring cresta zones of Austria and Hungary with law CR factors..

For more detail we provide in Table 3, Table 4 and Map 4 comparison and thus mismatch between directly neighbouring cresta zones of Slovakia, Hungary and Austria.

Table 3

Slovakia		**Hungary**		**Gross Cat Risk Charge** (per SI 1 mil. EUR)		**SK / HU ratio**	
Cresta Zone	Cresta Relativity	Cresta Zone	Cresta Relativity	SK zones	HU zones	CR factor	Gross Cat Risk Charge
SVK-85	6,45	Gyor-Sopron	0,38	0,97	0,08	17,1	12,8
SVK-93	2,86	Gyor-Sopron	0,38	0,72	0,08	12,7	9,5
SVK-94	4,48	Komarom	1,00	0,67	0,20	4,5	3,4
SVK-93	2,86	Pest	1,69	0,43	0,34	1,7	1,3
SVK-99	4,02	Nograd	0,53	0,60	0,11	7,6	5,7
SVK-98	0,43	Borsod-Abauj-Zemplen	0,04	0,07	0,01	11,9	9,0
SVK-04	1,43			0,50		39,3	68,2
SVK-07	1,71			0,26		47,0	35,3

Table 4

Slovakia		**Austria**		**Gross Cat Risk Charge** (per SI 1 mil. EUR)		**SK / AT ratio**	
Cresta Zone	Cresta Relativity	Cresta Zone	Cresta Relativity	SK zones	AT zones	CR factor	Gross Cat Risk Charge
SVK-90	4,04	22 – Zistersdorf	2,40	0,61	0,24	1,68	2,52
SVK-84	8,18			1,23		3,41	5,11
SVK-85	6,45	24 - Nickelsdorf	3,40	0,97	0,32	2,02	3,02

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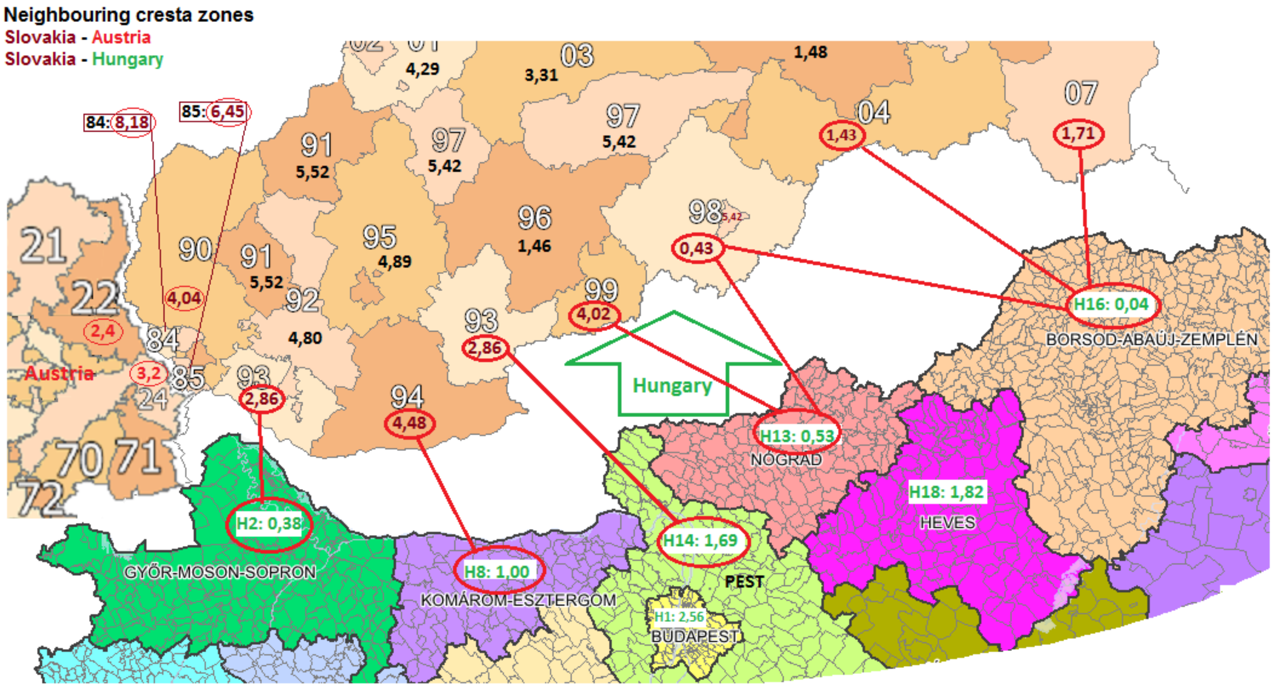
Map 4 – Cresta relativity in neighbouring cresta zones of Austria and Hungary



We can see than not only whole country risk of Slovakia is much higher than in both neighbouring countries but also cresta zones relativities of Slovakia are materially higher than the neighbouring cresta zones of Austria and Hungary which seems unrealistic. The latter is even more strange taking into account that most of the observed EQ activities in recent years in Slovakia had come from events with epicentres in Hungary or Austria as presented in Table 5.

Following table presents all observed EQ events in/near Slovakia:

Table 5

Country	**Number**	**Average years ago**	**Average magnitude**	**Average depth (*km*)**
Austria	47	17,8	3,0	9,9
Hungary	39	17,1	3,0	8,6
Slovakia	29	18,4	2,9	9,9
Poland	22	16,5	3,3	6,5
Czech Republic	4	13,5	2,6	6,3
Ukraine	1	34,0	4,6	14,0
Grand Total	**142**	**17,5**	**3,0**	**8,9**

source: http://earthquaketrack.com/p/slovakia/biggest

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Comparison of SII standard formula with AIR and IF models

Another doubt of standard formula calibration is indicated by the result of alternative earthquake models that Union has access to. Regular part of Union's reinsurance renewal process is assessment of its exposure to earthquake risk. In order to secure objectivity Union observes its earthquake CAT risk exposure using three independent models.

- Aon Benfield AIR Clasic2 v 13.0 model. This methodology is used for reinsurance purposes, i.e. the purchase of excess-of-loss coverage.
- Aon Benfield Impact Forecasting Elements v 5.0. model. This model is used for the purchase of reinsurance as well.
- Standard formula of Solvency II

The comparison of the used models for 30/06/2015 is summarized in the table below:

	Year	Return Period	Total Sum Insured	Gross Cat Risk Charge%	Earthquake Cat Risk Capital Charge
Aon Benfield, AIR Clasic2 v 13.0	2015	200	8.278.830.193	0,13%	**10.639.142**
Aon Benfield, Impact Forecasting Elements v 5.0	2015	200	8.278.830.193	0,22%	**17.799.827**
Solvency II – standard formula	2015	200	8.278.830.193	0,49%	**40.782.786**

Note that these results as well as further details can be also found in sheet “SII Standard Formula” of attached excel (Union_SK_Quake_Loss_Modelling_RW1516_Jun2015).

Comparing the results it is obvious that standard formula is more than twice as high as more prudent IF model and almost four times oppose to AIR model. Assuming higher sophistication of AIR and IF models, Union believes that these are more relevant as indication of risk exposure for earthquake risk. Therefore we believe that standard formula has more prudent calibration than 1 in 200 event. Deviation in calibration might be affected also by the risk distribution among the regions, however we believe that portfolio of Union is not that significantly deviated from market that would explain such extra capital charge.

Conclusion

Despite limited resources we performed our analysis to best we could. Despite there might be more sophisticated approaches to assess EQ risk we believe that indications we have are sound enough to urge necessity of model recalibration. Therefore based on the written above we propose to review the calibration of earthquake risk in SII standard formula, especially the cresta zones relativities.

In the light of detail, information and knowledge that EIOPA or its expert group has, it can occur that some of our understanding, conclusions or interpretations might not be correct. In such case we would appreciate to receive feedback and explanation why our interpretations are not correct.