# Flood protection gap evidence for public finances and insurance premiums

Mario Bellia, Francesca di Girolamo, Andrea Pagano, Marco Petracco Giudici
European Commission – Joint Research Centre

*Embedding Sustainability in Credit Risk Assessment*

*Banca d'Italia, Venice, 13-14 June 2024*

# Disclaimer

This working paper was finalised in 2023, during the author's time as an employee at the JRC of the European Commission.

The views are those of the author(s) and do not necessarily reflect the official opinion of the European Commission.

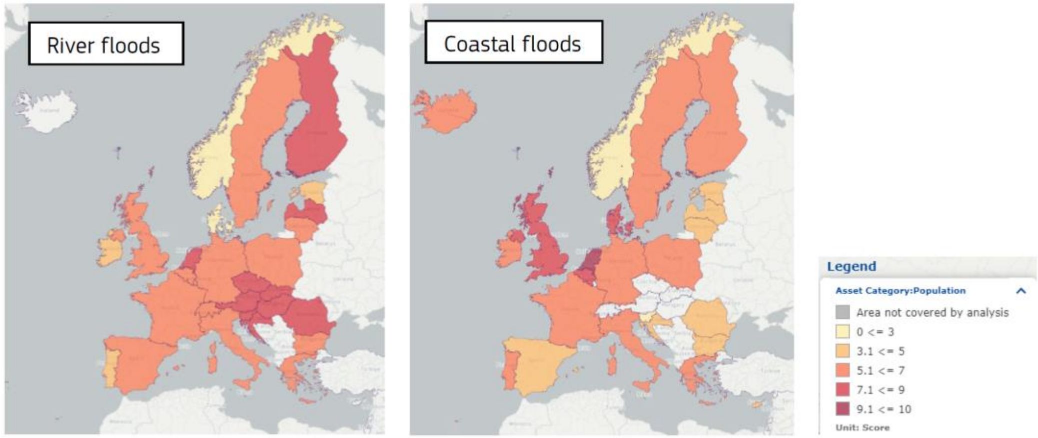
# Research question and data used

We want to estimate:

- The **potential increase in (gross) insurance premiums written** due to an increase of **insurance penetration** for river and coastal floods up to **50%** or **75%** for Member States (MS) that are below these values.
- The **potential reduction in public finance losses from this increase in penetration** at EU level, considering a worst-case situation where insurance is partly ineffective due to defaults in the insurance sector.

To do so, we make use of public data from the JRC Risk Data Hub (as of January 2023) and EIOPA (from 2016Q3 to 2022Q2).

# Distribution of losses from floods (JRC Risk Data Hub)

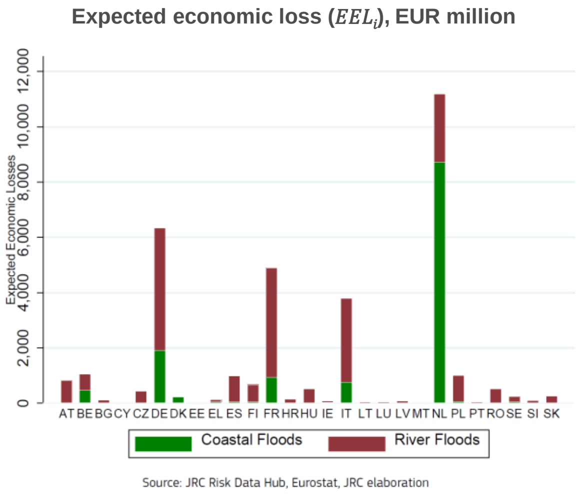



- The JRC Risk Data Hub collects data on disaster losses from historical natural hazards at local, regional, and national levels. The platform also provides georeferenced exposure data for various assets, such as buildings, population, critical services, and the environment, together with a vulnerability indicator.
- Each hazard is covered with a specific grid resolution (100m for river and coastal floods), measuring the population at risk (Exposure of people, or EP).

- To calculate the expected annual human loss (EAHL) over 1 year, the corresponding exposures of people (EP) under different return periods are weighted using the probability of occurrence.

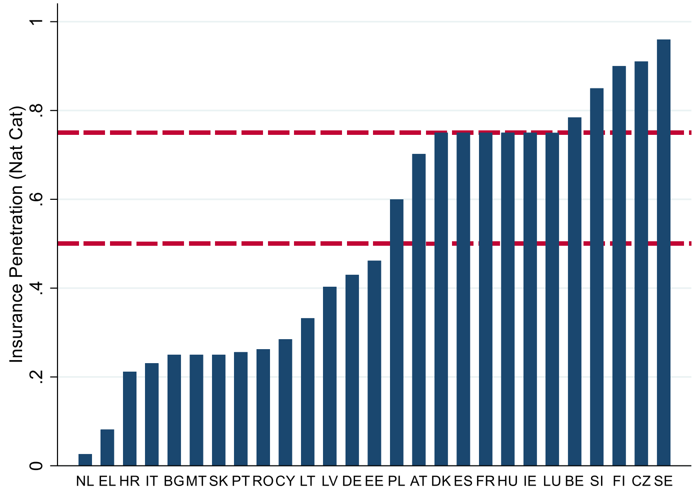
- To calculate the monetary losses due to flood events (EEL), we consider the GDP, the share of population affected over the total population, and the Vulnerability Index ($V_i$) at country level, as follows:

$$EEL_i = GDP_i \times \frac{EAHL_i}{Total\ population_i} \times V_i.$$



# Insurance Penetration and Technical Provisions (EIOPA)

- EIOPA provides data on **Insurance Penetration Rate** for flood “peril”. Values range from 3% (NL) to more than 90% (SE). 14 MS out of 27 are below 50%.16 MS below 75%




- EIOPA provides also data on **Total Technical Provisions** and **Gross Premiums Written for non-life insurance** (a superset including property insurance)

- We make use of expected loss from RDH and EIOPA penetrations data to **estimate expected pure insurance premiums** (EPP) and **expected gross premiums** (EGP) to insure all flood risks and to increase the insurance penetration rate up to 50% ad 75%. One additional euro of EEL should be equal to one euro increase in pure premiums. But…

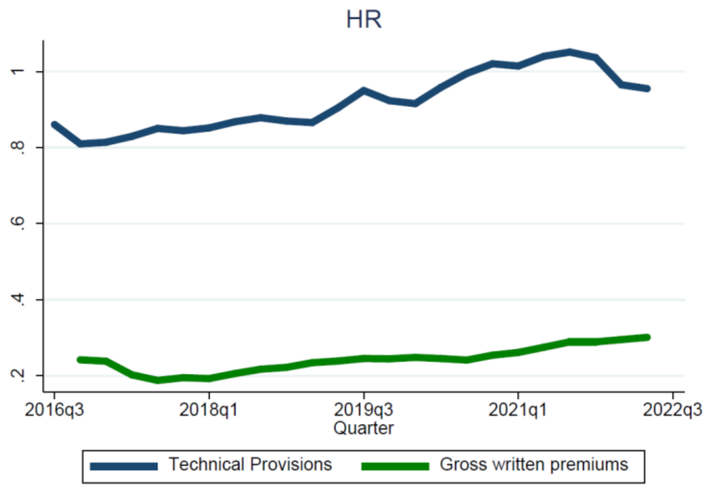
Issues: **1)** insurance margins **2)** potential non-linearities between the increases in expected losses and premiums.

- For **1),** we use the EIOPA data to retrieve an estimation (47.5%, quite stable across years). For **2)** we exploit the cointegration relationship between technical provisions and premiums



European Commission

# The cointegration relationship




- Technical Provisions and Premiums move together (see an example for HR) and are non-stationary. Their relationship can be estimated using a Vector Error Correction Model (VECM), a special case of a VAR(p) model.
- Considering a VAR with p lags:

$$y_t = v + A_1 y_{t-1} + \ldots + A_p y_{t-p} + \varepsilon_t$$

where v is a $K \times 1$ vector of parameters, $A_1$ - $A_p$ are $K \times K$ matrices of parameters, and $\varepsilon_t$ being i.i.d normal over time, with zero mean and covariance matrix Σ. The VAR(p) can be rewritten in a VECM form. Its representation is:

$$\Delta y_t = v + \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-1} + \varepsilon_t$$

where $\Pi = \sum_{i=1}^{p-1} A_j - I_k$ and $\Gamma_i = -\sum_{j=i+1}^{j=p} A_j$.

- In addition, to keep the long term dynamic fixed, we impose that the long-run coefficient for premiums is equal to 1 and the one of technical provision is equal to -1.

# Estimating additional premiums needed to harmonize the insurance penetration

- By calculating the orthogonalized impulse response function (OIRF) of the system, we estimate the response of the premium to a shock, given by the increase in the insurance penetration level.

- Final expected pure premiums written for Member State $i$, $EPP_i$, are obtained multiplying the $EEL_i$ by the value of the orthogonalized impulse response function for Member State $i$, $OIRF_i$ in the last step. $EGP_i$ include also the insurance margin.

- To evaluate the amount of $EGP_i$ that need to be written in order to harmonize the penetration rate at 50% ($EGP_i^{50}$) or 75% ($EGP_i^{75}$) for each Member State *i*:

$$EGP_i^{50} = \max(0.5, IP_{flood\,(i)}) \times \mathrm{EEL_i} \times (1 + \mathrm{OIRF_i}) \times (1 + \mathrm{margin_i})$$

$$EGP_i^{75} = \max(0.75, IP_{flood\,(i)}) \times \mathrm{EEL_i} \times (1 + \mathrm{OIRF_i}) \times (1 + \mathrm{margin_i})$$



European Commission

# Economic losses from insurance defaults

- We do not model single insurance undertaking, but **all insurance companies at individual country level** (or even at the aggregate EU27 level) by making use of a portfolio model of credit risk. The loss rate distribution can be seen as the loss rate on a portfolio of exposures to several insurance undertakings.

- We use the **Vasicek (2002)** model to define the event of default, as occurring when the insurer's asset value falls below a predetermined threshold. **The maximum loss $\boldsymbol{L_i}$** for country $i$ that cannot be exceed in one year with a probability level $\alpha$ is given by:

$$L_i = EAD_i \times LGD \times N\left[\frac{\sqrt{\rho + \delta(1-\rho)}\,N^{-1}(1-\alpha) + N^{-1}(PD)}{\sqrt{1-\ \rho - \delta(1-\rho)}}\right].$$

- Where EAD is exposure at default, or the mass of potential losses to be covered by the insurer, LGD is the loss given default, N is the standard normal distribution, rho is the correlation between the value of different insurers, and PD is the average probability of default of insurers considered in the portfolio.

# Economic losses from insurance defaults

- $EAD_i$ of $TP_i$, our best estimate of liabilities and risk margin and $SRC_i$ as the total amount of funds that an insurer is required to hold to ensure that the company will be able to meet its obligations with a probability of at least 99.5%

$$EAD_i = SCR_i + TP_i$$

- We apply this modelling framework under a situation where flood events happen together with insurance defaults. We do so by considering **uninsured catastrophic losses, besides those stemming from defaults in the insurance sector**

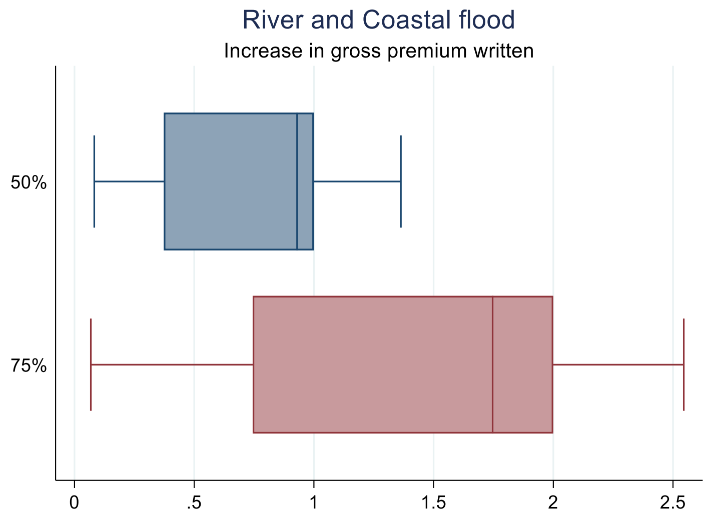
We consider two scenarios:

1. A Baseline scenario where we compare the actual situation versus an harmonized penetration rate of 75% for flood events
2. A severe worst-case scenario that happen in the case of a compound event, in a very rate event that occur one every 200 years (i.e., with a probability of 0.5%), compared with an harmonized 75% penetration rate.

- Final losses on public finances are then computed as **the sum of uninsured losses and losses left over from the insurance sector**.

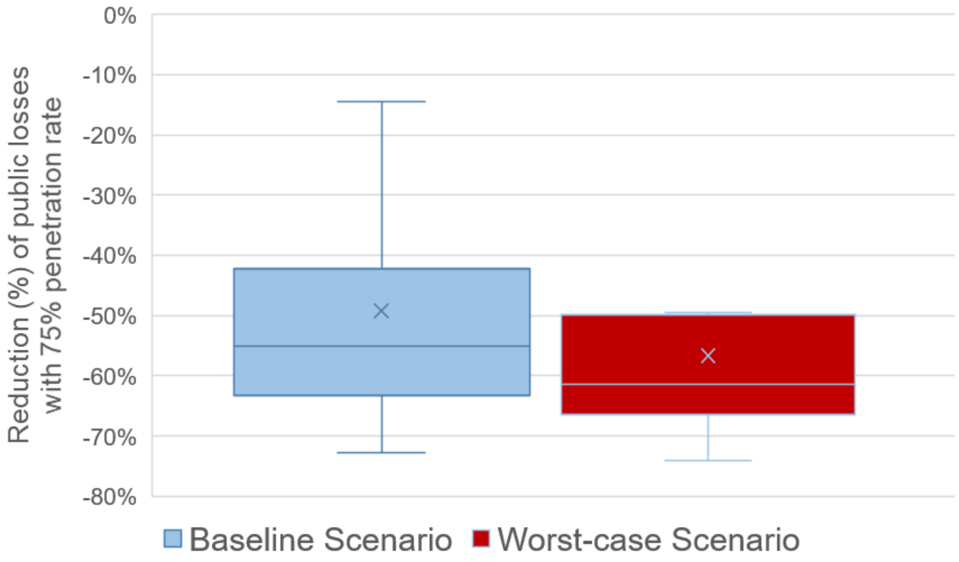
# Results - Additional premiums needed to harmonize the insurance penetration

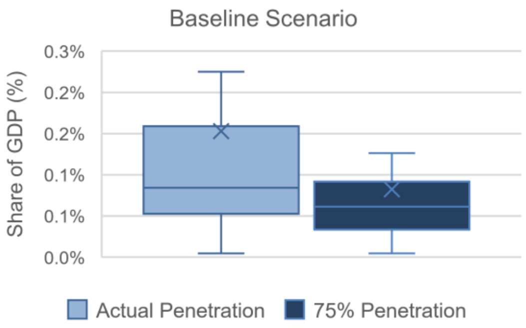
| Member State | $IP_{flood}(i)$ | $EPP_i^{50}$ (EUR Mn) | $EPP_i^{75}$ (EUR Mn) | $EGP_i^{50}$ (EUR Mn) | $EGP_i^{75}$ (EUR Mn) |
|---|---|---|---|---|---|
| AT | 70% | | 618.14 | | 913.43 |
| BG | 25% | 56.83 | 85.24 | 83.98 | 125.97 |
| CY | 28% | 0.55 | 0.83 | 0.82 | 1.22 |
| DE | 43% | 3 177.37 | 4 766.06 | 4 695.27 | 7 042.91 |
| EE | 46% | 6.81 | 10.21 | 10.06 | 15.09 |
| EL | 8% | 62.19 | 93.28 | 91.89 | 137.84 |
| HR | 21% | 70.39 | 105.58 | 104.01 | 156.02 |
| IT | 23% | 1 899.78 | 2 849.66 | 2 807.34 | 4 211.01 |
| LT | 33% | 20.52 | 30.78 | 30.33 | 45.49 |
| LV | 40% | 42.70 | 64.05 | 63.10 | 94.65 |
| MT | 25% | 0.00 | 0.01 | 0.01 | 0.01 |
| NL | 3% | 5 810.21 | 8 715.32 | 8 585.88 | 12 878.82 |
| PL | 60% | | 761.63 | | 1 125.47 |
| PT | 26% | 23.51 | 35.26 | 34.74 | 52.11 |
| RO | 26% | 269.84 | 404.77 | 398.75 | 598.13 |
| SK | 25% | 131.30 | 196.95 | 194.03 | 291.04 |
| | | | | | |
| **Total Premiums** | | 19 943.45 | 25 929.45 | 29 470.87 | 38 316.52 |
| **Total Premiums (excl. NL)** | | 14 133.23 | 17 214.13 | 20 884.99 | 25 437.70 |
| | | | | | |
| **Additional Premiums** | | 7 344.33 | 13 330.33 | **10 852.88** | **19 698.52** |

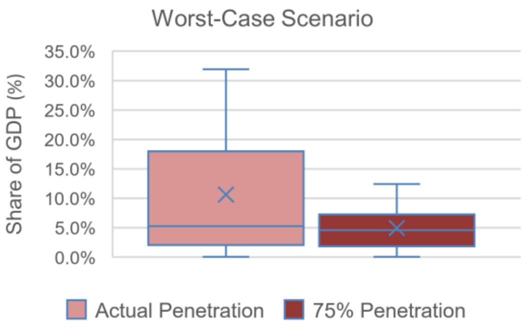



- Harmonise penetration at 50% : EUR 10.8 billion
- Harmonise penetration at 75% : EUR 19.7 billion
- Actual (estimated) premiums from EIOPA for flood events is roughly EUR 10.06 billion (a proxy since for the non-life insurances, multiple risks are bundled). We estimate this amount equal to EUR 12.6 billion
- **Gross Premiums written for flood events should be increased by more than 50% to reach a 50% penetration across the EU** (Assuming all risks are insurable)

# Results - Economic losses on public finances




- **In a baseline (average) scenario, expected losses** from both sources of risk (floods and insurance defaults) **decrease by about 50% when insurance penetration is increased to 75%.**
- In the baseline (average) scenario, the decrease in losses measured in EUR bn is slightly lower than the increase in gross premiums written (as it should be expected).
- **In worst-case scenario,** considering an extreme event (200 years return period), **losses are vastly reduced in the countries with the lower penetration rates**
- Compound disaster worst case scenario shows that increasing IP would have a positive impact even in case of only partly effective insurance in case of natural disaster



European Commission

# Thank you!



**EU Science Hub**
Joint-research-centre.ec.europa.eu

European Commission

# Science for policy

ANTICIPATE

INTEGRATE

IMPACT

## Our purpose

The Joint Research Centre provides independent, evidence-based knowledge and science, supporting EU policies to positively impact society.

European Commission

# JRC sites

Headquarters in **Brussels** and research facilities located in **5 EU Countries:**

Belgium (Geel)

Germany (Karlsruhe)

Italy (Ispra)

The Netherlands (Petten)

Spain (Seville)


European Commission

# Keep in touch

**EU Science Hub**
joint-research-centre.ec.europa.eu

@EU_ScienceHub

EU Science Hub – Joint Research Centre

EU Science, Research and Innovation

EU Science Hub

@eu_science



European Commission