Economics for Disaster Prevention and Preparedness

Financial Risk and Opportunities to Build Resilience in Europe

Funded by the European Union

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STATEMENT FROM EUROPEAN COMMISSION

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The COVID-19 crisis has been an unprecedented challenge for Europe and a major stress test for the resilience of our society, infrastructure, and economy. We have adapted to new constraints posed by the pandemic and turned the lessons learned through this crisis into a strengthened Union Civil Protection Mechanism (UCPM). We have upgraded our European emergency management system so that it can be better equipped for responding to future emergencies and offer concrete and timely EU solidarity to the EU's citizens.

At the same time, the COVID-19 crisis has also emphasised the importance of using the scientific and technical resources we have at our disposal to better anticipate, plan, and prepare for the next crisis. Modelling the impact of future risks is an imperative for making sound decisions when developing the next European civil protection capacities. With robust data and technical advice, we can develop more accurate disaster scenarios and review our preparedness accordingly.

Economics for Disaster Prevention and Preparedness is a concrete example of how a partnership between the European Commission and the World Bank can use data to improve our understanding of risks, produce new tools for communicating them, and, ultimately, make our society more resilient and prosperous. A common emergency management system with a joint capacity to model the impact and prepare for increasingly complex risks: this is European solidarity at its best.

In the challenging socio-economic context that the COVID-19 pandemic has put before us, demonstrating the return on investments of prevention and preparedness measures will be critical. The increasing pressure on national budgets make it an imperative to use resources to generate as many benefits as possible. Investing in making Europe more resilient to disasters and crises provides an opportunity to promote green and sustainable development. Reviewing more than 70 Europe-based examples, this study shows that there is a robust economic case for investing in Europe's resilience. Reducing risks with 'smart' investments stimulates economic activity, promotes innovation, and generates multiple social, environmental, and economic benefits that materialise even when a disaster does not occur. The study also modelled the impact of earthquakes and floods on the economies of EU Member States, analysed the financial instruments available to manage these risks, and found that some disaster scenarios may cause potential funding gaps at national and EU level, including for response assistance.

Physical and financial resilience need, therefore, to be tackled jointly. To do so, we need to continue to invest in human capacity for disaster resilience. The UCPM is well placed to provide access to both knowledge and financing. Our recently created "Knowledge Network" is the shared platform for UCPM Member and Participating States that bridges science and decision-making in disaster risk management. In addition, the financing instruments available under the Prevention and Preparedness Programme of the UCPM can be leveraged to develop strategies and the investments needed for resilience.

Understanding the socio-economic impacts of risks and modelling their future trends will allow us to review our response capacity accordingly, so that we do not prepare for the disaster that just happened, but anticipate future crises while contributing to Europe's social, economic, and environmental well-being. This study is a step in the right direction, providing evidence and examples of how we can become more resilient, together.

STATEMENT FROM WORLD BANK

Natural disasters in Europe, driven by climate change, are increasing in frequency and severity as they impact the lives of millions of people and decrease the value of assets. Between 1980 and 2020, natural disasters affected nearly 50 million people in the European Union and caused economic losses of roughly €12 billion per year on average.[1] This report discusses how the impact from earthquakes and floods can contribute to overall financial and economic instability and offers policy recommendations.

The COVID-19 pandemic demonstrated how vulnerable the world is to large, devastating shocks. As countries think about recovery, they must also confront other complex challenges simultaneously. Climate change is already negatively affecting our ecosystems and biodiversity, much of which is irreversible and will eventually touch all areas of our daily lives. Recently, the World Bank Group's Development Committee emphasized the need to ensure that countries follow a green, resilient, and inclusive development path to recovery from the pandemic.[2] This requires that countries focus on strengthening environmental, socio-economic, and financial resilience as all three aspects are critical to achieving a more sustainable and equitable recovery and making lasting progress toward ending poverty. The readiness of countries to respond to the fiscal, economic, and financial impacts of disasters is critical to remain on track to meet these goals.

New financial instruments are needed that can deliver enough funding quickly in response to the physical damage of disasters, thus helping asset values recover faster, improve the profitability of companies, and strengthen public finances. New monetary and regulatory policies that can accommodate transition risks associated with moving to a net-zero carbon economy can positively affect a wide range of activities, such as borrowing and insurance.

Still, finance alone cannot solve the challenges posed by climate change and disasters. Financial protection is complemented and reinforced by socio-economic and physical resilience. Achieving reductions in greenhouse gas (GHG) emissions through modern engineering should be combined with access to finance for mitigation and adaptation. Regulatory policy measures can help reinforce the green finance agenda in supporting mitigation and preparing for future disasters.

The world recognizes the importance of financial resilience against the risks posed by climate change. Global initiatives, such as international fora, international organizations and development partners, have increased their focus on financial protection to help governments proactively manage risks. Ministries of finance all over the world understand the urgency of developing financial resilience to disaster risk and fostering physical and social resilience.[3] This timely report is an encouraging step forward and we look forward to continuing our strong partnership with the European Commission and EU member states.

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1 European Environment Agency ,2020. Economic damage caused by weather and climate-related extreme events in Europe (1980-2019). Indicator Assessment. Link

2 World Bank. 2021. From COVID-19 Crisis Response to *Resilient Recovery - Saving Lives and Livelihoods while Supporting Green, Resilient and Inclusive Development (GRID). Development Committee.*

3 World Bank, Boosting Financial Resilience to Disaster Shocks: Good Practices and New Frontiers.

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STATEMENT ON COVID-19

The COVID-19 pandemic led to substantial restrictions for travelling, the organization of workshops, and face-to face meetings. Despite these limitations, the World Bank team was able to advance the proposed activities within the agreed time frame due to continuous efforts by all parties to work together remotely and maintain good communication via e-mail, telephone, and video conferences.

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GLOSSARY

adaptation: Adjustments or changes in economic, social, or environmental approaches in response to the effect of present or future climate change.

average annual loss (AAL): The average amount of expected (or potential) loss over a period of many years; calculated as the sum of all modelled or simulated losses that are expected over a period of time, divided by the number of years in that period.

average annual loss ratio (AALR): AAL relative to total replacement cost of the building stock.

contingent liability: A potential payment obligation (or future expenditure) that may be incurred, depending on the outcome of a future event; in the case of disaster risk for governments, the expenditure may be to pay for emergency response or reconstruction in the event of a natural hazard impact. Contingent liabilities can be explicit (underpinned by some form of legal obligation) or implicit (when there is a social expectation that the government will step in as an insurer of last resort).

disaster risk finance (DRF)/financial resilience (preparedness/protection) to disasters: Financial protection that is planned ahead to better manage the cost of disasters, ensure predictable and timely access to much needed resources, and ultimately mitigate long-term fiscal impacts.

disaster risk management (DRM): Processes for designing, implementing, and evaluating strategies, policies, and measures to improve the understanding of disaster risk, foster disaster risk reduction and transfer, and promote continuous improvement in disaster preparedness, response, and recovery practices, with the explicit purpose of increasing human security, well-being, quality of life, and sustainable development. DRM investments are understood as investments in risk identification (risk assessments, etc.), risk reduction (prevention), early warning, emergency and response preparedness, public awareness, financial resilience (various instruments), and resilient recovery.

disaster risk: The combination of the probability of an event and its negative consequences—that is, the likelihood over a specified time period of severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery.

ex ante/pre-arranged risk financing instruments (solutions, mechanisms): In the context of disaster events, instruments (solutions, mechanisms) arranged before the event. Ex ante decisions are decisions made before the event.

ex post risk financing instruments (solutions, mechanisms): In the context of disaster events, instruments (solutions, mechanisms) arranged after the event. Ex post decisions are decisions made after the event.

exposure: The situation of people, infrastructure, housing, production capacities, and other tangible human assets located in hazard-prone areas. Exposure includes the number of people or types of assets in an area. These can be combined with the specific vulnerability and capacity of the exposed elements to any particular hazard to estimate the quantitative risks associated with that hazard in the area of interest.

funding gap: The difference between the available government budget and the probable loss for a given event size (or return period).

hazard: The potential occurrence of a natural or human-induced physical event that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, and environmental resources.

household insurance penetration (in this report): Proportion of households in each country with catastrophe insurance.

losses: Quantifiable damages of disasters that can be translated into monetary terms. A distinction can be made between direct disaster losses, which refer to directly quantifiable losses (number of people killed; damages to buildings, infrastructure, or natural resources) and indirect losses, which refer to indirectly quantifiable losses (declines in output or revenue, impact on well-being, disruptions to flow of goods and services in an economy).

net government liabilities: This report defines net government liabilities as total government liability less national reserves ,contingency funds and the EUSF.

reserve fund (contingency fund): an amount of money set aside to finance - usually - unexpected future needs. May be used interchangeably with contingency fund, however, the latter usually refers to general funds set aside to meet all type of unexpected spending, while reserve funds might be targeted (e.g. dedicated to disasters).

resilience: The ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions.

return period: The estimated time between losses of a certain size occurring. For example, a 1-in-10-year return period refers to losses that are expected to be exceeded once per 10 years—i.e., in any given year there is a 10 percent probability of such losses at least as great as this. The estimates do not mean these disasters will occur only once every 10 (or 20 or 50) years.

total government liabilities: In this report the cost of public assets (e.g. administrative buildings) including public hospitals and schools, emergency response costs and residential losses covered by the government, minus insurance coverage for these assets. That is, *total government liability = (public asset losses + healthcare asset losses + education asset losses) – public asset losses covered by insurance + (residential asset losses – residential asset losses covered by insurance)*government liability for private housing + emergency response cost.*

vulnerability: The characteristics and circumstances of the built environment and communities that make them susceptible to damaging impacts (or human vulnerability). Vulnerability factors include building construction type, socio-economic context, etc.

ABBREVIATIONS

AAL	average annual loss
CAT bond	catastrophe bond
CAT DDO	Catastrophe Deferred Drawdown Option
DRF	disaster risk finance
DRM	disaster risk management
EC	European Commission
EP	exceedance probability
EU	European Union
UCPM	Union Civil Protection Mechanism
EUSF	European Union Solidarity Fund
GDP	gross domestic product
GEM	Global Earthquake Model Foundation
GNI	gross national income
JBA	JBA Risk Management
JRC	Joint Research Centre
MS	Member States
NUTS	Nomenclature of Territorial Units for Statistics
OECD	Organisation for Economic Co-operation and Development
PWT	Penn World Table
SDGs	Sustainable Development Goals

Table 1. EU countries names and abbreviations used in the report

ABBREVIATION	COUNTRY	ABBREVIATION	COUNTRY	ABBREVIATION	COUNTRY
AT	Austria	FI	Finland	NL	Netherlands
BE	Belgium	FR	France	PL	Poland
BG	Bulgaria	HR	Croatia	PT	Portugal
CY	Cyprus	HU	Hungary	RO	Romania
CZ	Czech Republic	IE	Ireland	SE	Sweden
DE	Germany	IT	Italy	SI	Slovenia
DK	Denmark	LT	Lithuania	SK	Slovakia
EE	Estonia	LU	Luxembourg		
EL	Greece	LV	Latvia		
ES	Spain	MT	Malta		

Executive Summary

This report presents an analysis conducted by the World Bank to assess macro-fiscal impacts of earthquakes and floods in European Union (EU) Member States (MS), analyse the financial instruments in place to manage this risk and identify any associated funding gaps. The analysis is underpinned by the outputs of two regionally consistent probabilistic catastrophe risk models, one developed by JBA Risk Management (JBA) for fluvial and surface water flood, and one by the Global Earthquake Model Foundation (GEM) for seismic risk.

The report provides, (i) an indication of future losses for each country; (ii) an indication of each countries funding gap based upon the information available on national and EU level financial instruments; and (iii) options for consideration to strengthen financial resilience at the EU and the national level.

Overall, this report finds that financial instruments to manage disaster risk are limited in most of the countries and at the EU level, despite the devastating impacts disasters pose to welfare, fiscal balance, and more broadly the economy.

Disaster Risks in the EU MS

In the EU, during the period from 1980 to 2020, natural disasters have affected nearly 50 million people and caused on average an economic loss of roughly €12 billion per year;[4] disaster risks are increasing with growing exposure and climate change. Disasters can have a detrimental impact on economies, the fiscal position of governments, and the well-being of the population, especially the most vulnerable. For instance, when insurance coverage is low, disasters can slow down economic growth by an average of 0.6–1% and cause cumulative output loss of two to three times this magnitude (Von Peter, von Dahlen, and Saxena 2012). *Table 2* shows the top-10 countries at risk of earthquakes and floods in the EU according to the outputs from catastrophe risk modelling.

The findings of the catastrophe risk modelling prepared for this report show that the EU countries with the highest earthquake (seismic) risk and flood (fluvial and surface water) risk are Cyprus, Greece, Romania, Slovenia, and Latvia (see *Table 2*). Average annual loss (AAL)[5] relative to the total building stock value exceeds 0.1% in each of the top-10 ranked countries for flood but exceeds this threshold in only four countries for earthquake. This value reflects the long-term average loss per year—extreme events can cause a much greater proportion of the building stock to suffer damage. For example, in Italy, the 1-in-100-year seismic loss would equate to 1.1% of the total building stock value, and would equate to 2.5% for a 1-in-500-year event. Romania, Bulgaria, Austria, Slovenia and Slovakia are in the top-10 ranked countries for both hazards, demonstrating their high risk of both flood and earthquake. In Italy, Romania, and Greece, the regions[6] are estimated to have annual losses between 1% and 3.6% of total building stock value. Residential buildings are estimated to account for, on average, 50% of the AAL for both hazards.

Table 2. Top-10 countries for flood and seismic risk, by AAL as a percentage of exposure

SEISMIC RISK			FLUVIAL AND SURFACE WATER FLOOD RISK		
Rank	Country	AALR	Rank	Country	AALR
1	Cyprus	0.19%	1	Romania	0.14%
2	Greece	0.18%	2	Slovenia	0.13%
3	Romania	0.12%	3	Latvia	0.13%
4	Italy	0.11%	4	Bulgaria	0.13%
5	Bulgaria	0.07%	5	Austria	0.12%
6	Croatia	0.05%	6	Slovakia	0.11%
7	Slovenia	0.04%	7	Germany	0.10%
8	Austria	0.02%	8	Czech Republic	0.10%
9	Portugal	0.02%	9	Hungary	0.10%
10	Slovakia	0.01%	10	Poland	0.10%

Sources: GEM, 2020; JBA, 2021.
Note: AAL = average annual loss; AALR = average annual loss ratio.

4 https://www.eea.europa.eu/data-and-maps/indicators/direct-losses-from-weather-disasters-4/assessment
5 Annual average loss (AAL): The average amount of expected (or potential) loss over a period of many years; calculated as the sum of all modelled or simulated losses that are expected over a period of time, divided by the number of years in that period. Average annual loss ratio (AALR): AAL relative to total replacement cost of the building stock.
6 Regions refer to Nomenclature of Territorial Units for Statistics (NUTS) 3 in EU classifications. In EU classification, NUTS 3 refers to small regions (subnational levels of EU MS). See Eurostat, https://ec.europa.eu/eurostat/web/nuts/background.

Methodology of the Analyses

The macro-fiscal analysis is based on an adaptation of the Solon-Swan economic growth model to evaluate how damages to assets caused by disasters impact gross domestic product (GDP) and government expenditures. To set up the baseline model, i.e., one where no disaster occurs, the analysis uses data for the years 2000–2019 from multiple sources: population and related variables come from the World Development Indicators, model parameters from the Penn World Table, and GDP and related variables from the Eurostat database. The baseline GDP growth model was further calibrated to align with the projected GDP growth rate from the European Commission (EC) (EC, 2020a). It should be noted that the calibration was done to consider the longer-term GDP growth trend (projection over the next 30 years), which might not be reflective of short-term growth rates associated with COVID-19 recovery.

The funding gap analysis provides a tool to help countries build their disaster risk finance (DRF) strategies. There is an increasing need for informed financial decision-making on how much funding to allocate before disasters, how to evaluate risk transfer instruments, or how much to spend on risk reduction (Clarke et al. 2016). Here, the government loss distribution is compared against DRF arrangements for the EU region and a few selected case studies. The funding gap analysis is applied to all the EU MS and four selected case studies: France, Croatia, Romania, and Austria. Each case study includes a disaster profile overview, list of disaster risk financing instruments, discussion of contingent liabilities, and the analysis. In addition, a case study of Albania is presented as part of the funding gap analysis; although not included in the broader macro-fiscal assessment, this case helps to illustrate a recent instance in which the Union Civil Protection Mechanism (UCPM) plays a role in responding to disasters. Analysis for the remaining EU MS can be found in *Annex 7*.

Both the macro-fiscal and funding gap analysis use two scenarios for different levels of liability (i.e. how much out of the total estimated losses the government is expected to cover): (i) a **low- liability scenario** (Scenario A), where the government is expected to reconstruct damaged housing of low-income uninsured households, reconstruct all public assets (with one-third of these assets insured), and to cover the emergency response costs; and (ii) a **high-liability scenario** (Scenario B), where the government is expected to reconstruct damaged housing of all uninsured households, reconstruct all public assets (with no public asset insurance in place), and to cover the emergency response costs.

Disaster Risk Financing

Governments face both an implicit and explicit liability due to disasters, and as a result they tend to shoulder a significant share of disaster response and recovery costs. Explicit liabilities are those that are legislated, such as providing emergency response and support to affected populations, or rebuilding/repairing damaged government-owned public assets. Implicit liabilities are those that are “expected” by municipal authorities and the public, such as providing temporary accommodation if housing is damaged, fixing damaged housing, or repairing municipally owned assets. For example, a number of countries in the EU are explicitly mandated to provide support to disaster-affected households (e.g., the Netherlands), and some might provide it ad hoc after major disasters (e.g., Germany). In other countries, the governments provide support via insurance schemes which in turn offer catastrophe insurance to households (e.g., France or Belgium).

Disaster risk finance is an approach that helps manage the contingent liabilities of governments due to natural disasters and helps increase financial resilience to disasters of governments, households, businesses, and the poor. DRF refers to putting in place pre-arranged financing instruments in a cost-effective manner and linking them to the disbursement channels to ensure timely and sufficient funding to respond, recover, and reconstruct after disasters. It is recognized that while DRF does not explicitly address risk reduction (as these investments are best done through regular budget allocation e.g. operations and maintenance), it can incentivize investment in risk reduction, through insurance for example, by creating the need to keep assets to a quality that is insurable.

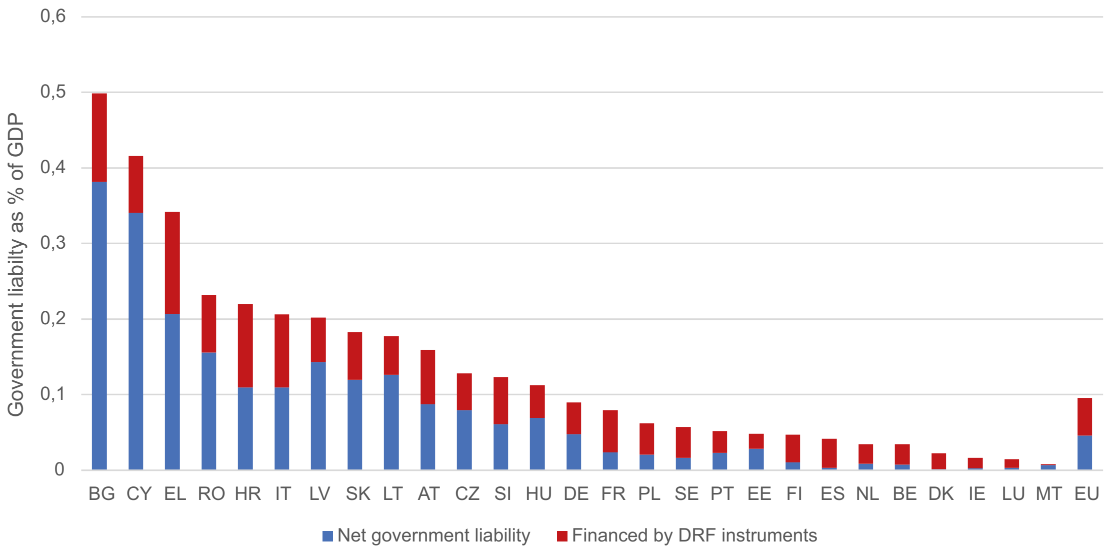
Data on disaster risk financing arrangements in the EU are limited. For example, data on catastrophe insurance for residential property (households) are broadly available but are often outdated, incomplete, and inconsistent across MS. In fact, such data are often provided as a range with sizeable uncertainty. Data on public asset insurance are even more limited, with no comprehensive overview on penetration rates in EU MS available. Data on dedicated reserve funds are often in place, but data on contingency funds, especially the size of these funds, are hard to come by. However, it is recommended that consultations with each MS are conducted to confirm the exact financing arrangements, this will be a necessary requirement to ascertain whether countries hold an optimum amount of finance in reserve for disaster response.

Findings of the Analyses

Currently, DRF across EU MS is limited: penetration rates of insurance for public and residential assets are low, reserve funds are limited, and other types of risk transfer and contingency funding are lacking. Even if low government liabilities are assumed, the average annual cost across EU MS is sizeable (totalling €16.2 billion). It is expected that these liabilities are funded through ad hoc risk financing instruments, such as borrowing, budget reallocation, donor aid, or increased taxation. Lack of comprehensive risk-layering strategies might result in inefficient and ineffective public financial management of disasters in the EU.

Disasters in the EU can have sizeable macro-fiscal impacts, which are projected to increase with climate change. Annual average impact of disasters, in the low-liability scenario and without accounting for DRF instruments, can be as high as 0.38% of GDP, as is the case for Bulgaria. Other countries with high net government liabilities as a percentage of GDP are Cyprus, Greece, Romania, Croatia and Italy (see *Figure 1*). Under the high-government liability scenario, this number rises as high as 1.0% of GDP (Cyprus). Other countries with high government liabilities as percentage of GDP are Bulgaria, Greece, Croatia, Italy and Romania (*Figure 2*).[7]

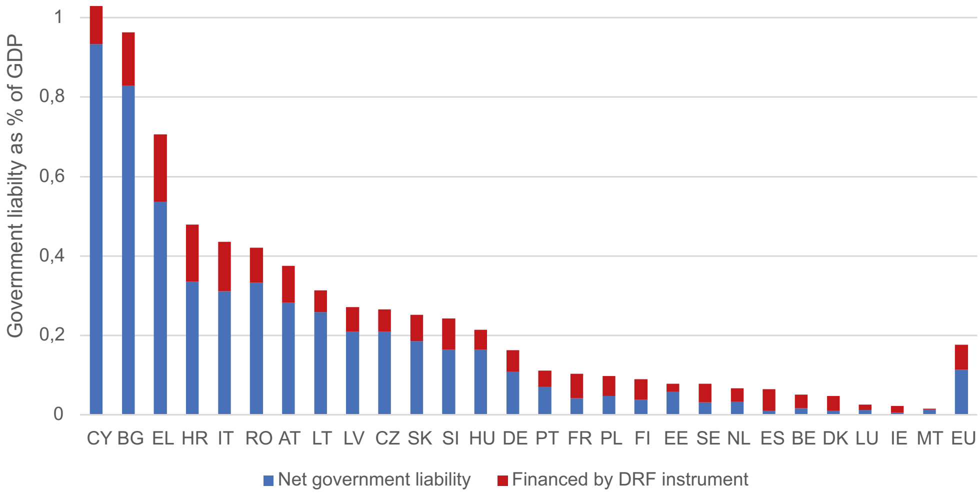
Figure 1. Countries sorted by average total government liabilities relative to GDP: Low government liability scenario



Source: World Bank.

7 In this report, both low government liability and high government liability scenarios were modelled. The low-liability scenario comprises support to low-income households (those that fall beneath the poverty line) that are uninsured; it also includes some public asset insurance. In the high-liability scenario, support is provided to all uninsured households, and no public asset insurance is included.

Figure 2. Countries sorted by average total government liabilities relative to GDP: High government liability scenario



Source: World Bank.

For a major earthquake or flood event, the macro-fiscal impacts can be devastating. For example, for events that occur once every 100 years (or that have a 1% chance of occurring in any given year), fiscal impacts of government liabilities can exceed 7% of GDP for the low government liability scenario and 17% of GDP for the high government liability scenario.

The EU level analysis found that emergency response costs ranged from 40.7% of total government liabilities in the low-liability scenario to 22% of liabilities for the high-liability scenario. This finding highlights the need to implement instruments that can provide finance quickly. The existing EU level instruments take time to disburse, which may delay emergency response. Due consideration should be given to the introduction of a EU level instrument to provide a top-up to national governments to help them finance emergency response. Such an instrument could be embedded within the European Union Solidarity Fund (EUSF).

On average, damage to residential buildings forms over 50% of total loss for both flood and earthquake risk, which points to an urgent need to increase access to and uptake of catastrophe household insurance. For earthquake risk alone, residential building damage may be even higher; in many countries household losses account for over 50% of total loss. The need for insurance is especially clear when looking at the liability generated from public and housing assets, which account for 59.2% of total liabilities in Scenario A (low-liability) and 78% in Scenario B (high-liability).

Based on the assumptions of this report, 35% of liabilities in Scenario A and 64% of liabilities in Scenario B are retained by the government and are expected to be funded through ad hoc risk financing instruments. The number of countries with pre-arranged financing in place is limited, and in fact high insurance penetration helps reduce government contingent liabilities.

The model discovered no difference between fiscal impacts of disasters and the size of reserve and contingency funds of EU MS. It would be fair to assume that countries have invested in strengthening DRF arrangements as a result of the sizeable fiscal impacts they incur. This assumption is not confirmed by this model, however.

DRF can help reduce the level of government liabilities, both in absolute values and as a percentage of GDP. For example, in a high-liability scenario in France, DRF instruments such as catastrophe insurance can help reduce government liabilities for a 1-in-100-year disaster event by €3.6 billion, decreasing the ratio of government liabilities to GDP from almost 0.58% to 0.46%. This finding was also supported by the EU level analysis under this study, which showed that having pre-arranged financing in place and that DRF—such as high insurance penetration for both public and private assets—is critical for reducing government contingent liabilities.

Around 40% of countries lack pre-arranged funding to manage combined emergency response costs for 1-in-10-year flood and earthquake events—that is, for events that occur relatively frequently. It is likely that a part of these costs will be funded through the budgets of civil protection agencies and potentially the UCPM mechanism, but budget reallocation will likely be required to ensure countries have enough money for response. In terms of annual average emergency response costs following earthquakes and floods, most countries have enough in reserves and contingency funds to provide immediate financing. However, only a few countries in the EU have dedicated disaster reserve funds. Funding in general contingency funds might be largely unavailable, especially if a disaster happens towards the end of the fiscal year. The estimated emergency response costs also do not account for other types of disasters that the EU MS might be exposed to (such as landslides and droughts).

The EU level instruments are by design able to cover only a small fraction of response costs from medium to severe events (those that occur once every 10 years or less often). Nevertheless, the analysis finds that there is a 10% probability in any given year that the EU region will experience earthquake or flood events severe enough to produce losses that countries cannot sustain from their national reserves and that will use at least €660 million from the EUSF. For such events, if the EUSF mechanism would need to cover more costs, it would need a "top-up" allocation beyond the assumed limit of €660 million (estimated to be available to cover earthquakes and floods).

The sum of the EUSF, reserve funds and contingency funds available to MS covers on average less than 4% of total government liabilities each year when analysed from a EU perspective (with disasters aggregated for both earthquake and flood and for all EU MS countries). This suggests that there is scope for additional instruments at the EU level and/or a need to incentivize national governments to invest in DRF more seriously.

The EU level funding gap analysis conducted in this study suggests that incentivizing insurance to encourage a higher uptake by households can halve government liabilities to €50 billion for very extreme scenarios and reduce them to €10 billion for smaller events. The magnitude of losses (for earthquake and floods combined) varies between €30 billion for small events to more than €100 billion for severe events (those that occur once in 100 years—that is, have a 1% probability of occurring in any given year).

Options for Consideration

The findings above suggest that there is more that can be done at the national and EU level to ensure financial preparedness for disaster and climate risks. *Table 3* presents some options for consideration, noting that not all of these options need be pursued or implemented at the same time.

Table 3. Summary of options for consideration

REGIONAL OPTIONS	DETAILS	TIME FRAME
1. Strengthen the EUSF. The EUSF has proven an important source of finance to cover a share of disaster damages in EU MS and accession countries, but the funding it can provide covers only a small fraction of needs, by design.	• Strengthen processes and procedures for faster decision-making. • Investigate if the EUSF can support broader disaster resilience considerations, such as building back better (where finance from the EUSF might be eligible for reconstruction of more resilient assets; lack of integration of this principle might result in higher financial costs in the future), in view of limited timeframe for implementation of the EUSF funding (18 months) and potential for coordination of the EUSF aid with other financing sources that target resilience measures (in line with EU Cohesion policy). • Introduce a risk transfer instrument to provide a top-up to the EUSF, and increase the funds available for response for the most rare and severe events.	Medium to long term

	• Investigate financial and policy options to incentivize better financial management of public assets (e.g. through insurance); this could include establishing a risk pool within the EUSF that would allow, e.g., to achieve better diversification of risk, price stabilization and introduction of coherent EU level policies on the subject.	
2. Incentivize the uptake of household and public asset insurance. The study found little information on public asset insurance suggesting that it is largely unavailable. It could be the case that reconstruction and recovery of assets after disas-ters is covered ad hoc through government budgets (i.e., the government—and the EU itself—become the insurer of last resort).	• Undertake an EU-wide review of the availability and scope of different insurance products for catastrophic homeowner and public asset insurance, as well as issues precluding uptake. • Introduce EU-wide regulations and policies that establish minimum coverage requirements for disaster and climate risks.	Short to medium term
3. Introduce risk-informed budgeting at the EU level. The EU funding gap was analysed based upon earthquake and flood risk only. It is likely this gap is much higher.	• Build upon the analysis to understand the level of EU contingent liabilities using an all-hazards approach. • Create incentives to invest in disaster risk finance by introducing a risk-based budgeting approach to ensure that MS understand the risk they face.	Medium term
4. Develop a EU level overarching DRF Strategy. The introduction of coherent and comprehensive EU-wide policy on DRF would benefit the region and help define common priorities and practices. In addition, it can reinforce the existing messaging on what what the EU can finance when countries request assistance. This DRF strategy can be developed to reinforce the application of the 2021 EU Climate Adaptation Strategy.	• Clearly establish and articulate EU level priorities that can be awarded finance from the EU level instruments to delineate what the EU expects countries to cover from national resources. • Improve financial response capacity through greater coordination of EU level resources. • Apply a risk-layering approach, which separates risk into tiers, using different financial instruments to address the needs of these tiers and contributes to a cost-efficient strategy and management of risks	Short term
5. Improve data for DRF. Data and analytics are important to make informed decisions on financial resilience at the EU level. Alongside the recommendation in World Bank (forthcoming (a)) this data should form part of a regional transformation in the availability of open data, information, and knowledge on multi-hazard disaster and climate risks.	• Catastrophe modelling data: Expand the existing regionally consistent catastrophe model to additional hazards and over longer time horizon to improve the accuracy of potential losses faced by the EU. • Data on DRF: For example, collect comprehensive data on penetration of household and public asset insurance; review potential funding gaps to introduce EU level guidelines on addressing these gaps. • Macro-fiscal data: strengthen modelling of government revenues and non-disaster expenditures; modelling of key economic sectors separately to consider how they contribute to the overall productive capacity (using input-output or computable general equilibrium models); and incorporating the effects of government spending on investment rates and capital stock accumulation.	Short to medium term

6. Develop an overarching strategy for "Greening the EU" to build financial resilience. Develop a holistic approach to financial resilience, which should be combined with physical resilience and investment in green and resilient infrastructure that both aligns and can assist with the implementation of the Green Deal.[a]	• Develop a holistic approach towards "Greening the EU" that comprises measures to strengthen financial and physical resilience and promotes green investments for sustainable and green growth.	Short term

NATIONAL OPTIONS	DETAILS	TIME FRAME
7. Develop national DRF strategies. These should be aligned to complement the EU level DRF strategy.	• Establish priorities to finance in the aftermath of a disaster. • Identify additional financial instruments to help manage this risk. • Apply a risk-layering approach.	Short term
8. Develop a structured financing approach. Understanding how much financing is needed and for what purpose is key to understanding how to structure financial response capacity.	• Quantify contingent liabilities from natural disasters (implicit and explicit). • Identify instruments to help manage this risk that will release finance when needed most. • Ensure these instruments are aligned in a cost-effective manner.	Medium to long term
9. Ensure availability of pre-arranged funding to cover immediate liquidity needs following disasters and crises. The COVID-19 pandemic demonstrated how timely action leads to better outcomes.	• Clearly define limits of contingency reserves for immediate response. • Create dedicated national disaster reserve funds with clear disbursement rules and procedures.	Medium term
10. Increase penetration of catastrophe insurance for households. If not done at the EU level, national governments should consider options for increasing catastrophe household insurance.	• Introduce minimum policy and coverage standards for catastrophe insurance for households.	Medium to long term

a. European Commission, "A European Green Deal," https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en.

The findings of the report should be interpreted with caution: the work is the result of theoretical models and involved making some key assumptions—hence any changes to these assumptions will impact the results. The analysis marks a first attempt to look at the economic impacts of disasters across the EU, and like any analysis has some limitations. Future analysis to strengthen the findings of the report could consider (i) longer historical time series data for projections and a broader set of disasters, (ii) enhanced modelling of government revenues and non-disaster expenditures; (iii) modelling of key economic sectors separately to consider how they contribute to the overall productive capacity (using input-output or computable general equilibrium models); and (iv) incorporating the effects of government spending on investment rates and capital stock accumulation.

ABOUT THIS REPORT

This report forms part of the World Bank's technical assistance project undertaken with the European Commission's Directorate-General for European Civil Protection and Humanitarian Aid Operations (DG ECHO) and financed under the Union Civil Protection Mechanism (UCPM) Annual Work Programme 2020. This report is the output produced under Component 2, "an analysis of the fiscal and economic impact of disasters in the EU MS", with the aim of identifying potential opportunities to increase financial resilience to disaster risk.

1. Introduction

In the European Union (EU), during the period from 1980 to 2020, natural disasters have affected nearly 50 million people and caused on average an economic loss of roughly €6.67 billion per year.[8] With climate change, along with growing populations and assets, disaster risk may increase. Disasters can slow down economic growth and reduce government revenue by, for instance, destroying private and public assets (buildings and infrastructure), affecting businesses, and causing supply chain breakdowns. These impacts are especially an issue for disasters that occur in areas with low insurance coverage, where they can slow down economic growth by an average of 0.6–1% and cause cumulative output loss of two to three times this magnitude (Von Peter, von Dahlen, and Saxena 2012). Disasters can induce poverty, especially in economically vulnerable areas, by pushing people back into poverty or trapping them in it. With increased spending from the public budgets, disaster can lead to budget volatility and impact a country's fiscal position. They can also lead to budget cuts, reducing the planned spending for development projects.

Strengthening disaster resilience helps mitigate the impacts of disasters. Disaster resilience comprises physical, social, and financial resilience, which complement each other. It includes both structural measures, such as physical constructions and enhanced engineering technology, and nonstructural measures, such as early warnings and business continuity planning (World Bank 2019). Financial resilience—referred to in this report as disaster risk financing (DRF)—is an approach that helps governments manage their contingent liabilities due to disasters and increases the financial resilience to disasters of governments, households, businesses, and the poor. DRF means putting in place pre-arranged financing instruments in a cost-effective manner and linking them to disbursement channels to ensure timely and sufficient funding to respond, recover, and reconstruct after disasters. It does not cover investments in risk reduction that can be more effectively managed through regular budget allocations and operational budgets but can reinforce and provide incentives to invest in risk reduction and preparedness. For more information on the return of investments in risk reduction please see World Bank (forthcoming (a)).

Adequate legal and policy frameworks are important for promoting disaster resilience and mitigating impacts of climate change. Global agreements such as the 2015 Paris Agreement, Sustainable Development Goals (SDGs), and Sendai Framework for Disaster Risk Reduction 2015–2030 provide frameworks and guidelines for both areas. EU level policies and frameworks include the 2021 EU Climate Adaptation Strategy (that builds upon the 2013 EU Adaptation Strategy), the EU Floods Directive (Directive 2007/60/EC), and the European Green Deal, among others. The European Green Deal (2019), for instance, aims to achieve the United Nations' 2030 Agenda for Sustainable Development and the SDGs in the EU. The focus of the Green Deal is to address the challenges of a changing climate and environmental degradation by mobilizing the private sector for green investments, promoting green finance, and greening national budgets (EC 2019). As of March 2021, the European Union has also enacted 37 climate laws and six climate policies, in addition to over 500 country-level laws and policies.[9] These laws aim to achieve some of the 30 EU climate targets that address different aspects of climate challenges.[10]

Among these frameworks in the EU, only a few address disaster risk finance. Reviewing the Climate Change Laws of the World database[11], this report identified six such laws for the EU and these are complemented by EU-level strategic frameworks (*Table 4*). Among these, the 2020 Sustainability Bond Framework in Luxembourg is the only one providing comprehensive guidance for climate and disaster risk financing. This study did not identify

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8 Data are from EM-DAT: The OFDA/CRED International Disaster Database, Université catholique de Louvain, Brussels, Belgium, and were converted to euros from US dollars. See Prevention Web, "Europe - Disaster Statistics," https://www.preventionweb.net/english/countries/statistics/index_region.php?rid=3.
9 Climate Change Laws of the World database, Grantham Research Institute, London School of Economics, https://climate-laws.org/geographies/european-union/climate_targets.
10 See ibid for a list of EU climate targets.
11 Ibid.

in Europe any DRF strategies that define a comprehensive approach to post-disaster risk financing and articulate how to combine different risk transfer instruments in a cost-effective manner. However, some of the existing policies and laws cover specific risk transfer instruments. For example, Austria's Disaster Fund Act 1996 established a national disaster reserve fund that can cover both ex ante risk management and post-disaster needs.

Table 4. Legislation and key policies related to climate and disaster risk finance

TITLE	COUNTRY	YEAR OF ENACTMENT
Green Deal	EU	2019
EU Climate Adaptation Strategy	EU	2021
Fourth Supplementary Budget	Finland	2020
Sustainability Bond Framework	Luxembourg	2020
Climate Settlement, Innst. 390 S (2011–2012)	Norway	2012
Decree on the Use of the Climate Change Fund in 2017–18	Slovenia	2016
Royal Decree 658/2019 on Environmental Subsidies	Spain	2019
Development Policy Loan with Catastrophe Deferred Drawdown Option	Romania	2018

Source: Climate Change Laws of the World database*, Grantham Research Institute, London School of Economics,* https://climate-laws.org/geographies/european-union/climate_targets.

Strengthening regulatory frameworks for disaster and climate resilience is important; these could be developed to reinforce the existing EU strategic frameworks, including the 2021 EU Climate Adaptation Strategy. Climate change, among its other impacts, increases the frequency and severity of natural disasters such as floods, leading to greater costs for disaster response and recovery. Climate change adaptation and disaster risk management are mutually reinforcing, as the strategic implementation of climate policies can mitigate disaster impacts and improve adaptation. Eskander and Fankhauser (2020) found that integrating disaster risk financing into the legislative framework can catalyse faster and more systematic recovery after disasters. Strategic frameworks for climate mitigation, such as the Green Deal are already in place and there is an opportunity to address financial resilience to climate hazards as part of the green agenda (an example is in *Box 1*). In 2021, the EU enacted the new Climate Adaptation Strategy that defines strategic approach of the EU to climate adaptation and includes recommendations on strengthening disaster risk finance.

The ongoing COVID-19 pandemic offers an opportunity to further efforts that integrate disaster and climate resilience into public policies and thus ensure that countries can build back better. For example, the 2020 Fourth Supplementary Budget in Finland, which consists of a €5.5 billion stimulus package to combat the adverse economic effects of the COVID-19 pandemic, also includes measures to create green jobs and foster a low-carbon future. In addition, this package includes measures to support public transport services, walking and cycling, and ecosystems preservation and restoration. Introducing such combined measures across the EU Member States (MS) can reduce disaster impacts and ensure better preparedness to future disasters. Opportunities to promote resilient recovery following COVID-19 - including financial preparedness to growing disaster risks - is reinforced within the 2021 EU Climate Adaptation Strategy.

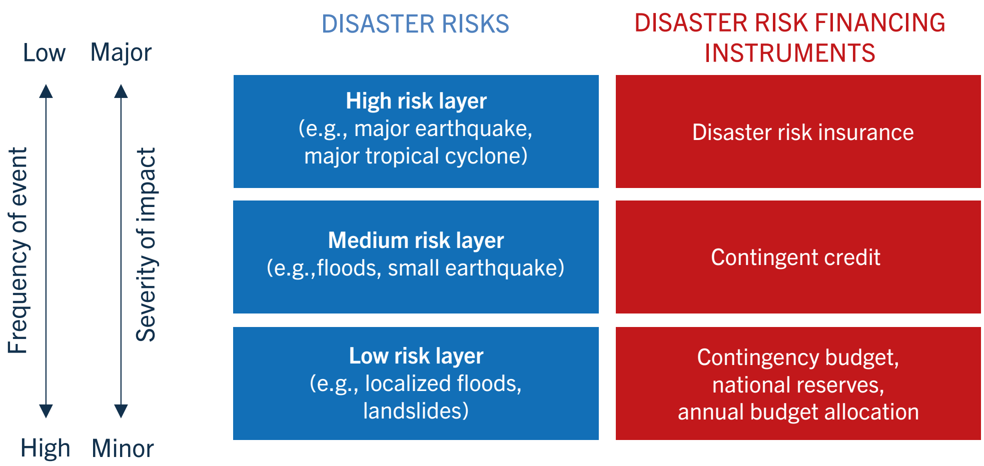
Box 1. Greening finance in the EU

Capital market instruments offer an opportunity for greater climate resilience. For example, Luxembourg issued a series of bonds (green, social, and sustainability bonds) to support climate-responsible investments in the capital market. Proceeds from the bonds issued through this framework can be used to (re)finance eligible expenditure in the following green and social categories: construction of green buildings; energy transition; development of low-carbon transport; environmental protection; water and wastewater management; climate financing and research and development (R&D); access to essential services (health, education, and social inclusion); affordable housing; and job creation.

Because governments have both an implicit and explicit liability to respond to disasters, they tend to carry a significant share of the financial burden to fund disaster response and recovery. Explicit liabilities are those that are legislated, such as the need to provide emergency response and support to affected populations or rebuild/fix damaged central government–owned public assets. Implicit liabilities are not defined by law but there is the expectation that the government will finance these loses, for example, losses from not defined by law but there is the expectation that the government will finance these loses, for example, losses from state owned enterprisesstate owned enterprises and the public (e.g. the provision of temporary accommodation). For example, a number of countries in the EU are explicitly mandated to provide support to disaster-affected households (e.g., the Netherlands), and some might provide support ad hoc after major disasters (e.g., Germany). In other countries, the government provides support via insurance schemes, which in turn offers catastrophe insurance to households (e.g., France or Belgium).

Timely access to pre-arranged funding after disasters improves the speed and quality of a government's public financial management of natural disasters, and it hastens the human and economic recovery. Without pre-arranged risk financing solutions, use of public funds can be inefficient, while response and recovery can be unnecessarily slow. The World Bank DRF framework considers a three-tiered approach for the development of a strategy to cover the residual disaster risk that cannot be reduced through measures such as flood protection, seismic strengthening of buildings, etc. These layers align to the basic principles of sound public financial management, such as the efficient allocation of resources, access to sufficient resources, and macroeconomic stabilization. The first layer, retention, relates to countries' development of an internal layer of protection against disasters to prevent the diversion of funds (*Figure 3*), such as a reserve fund that is financed annually in a government budget. The second layer considers access to rapid and predictable contingent financing e.g., Romania's Catastrophe Deferred Drawdown Option, CAT DDO. The third layer involves transferring risk to the market via insurance, catastrophe bonds, etc. The approach highlights the need to combine financial instruments to develop cost-effective financial protection—e.g., leveraging contingency funds and national reserves as a first layer and combining these with more expensive and perhaps complex instruments to manage more severe yet less frequent risks.

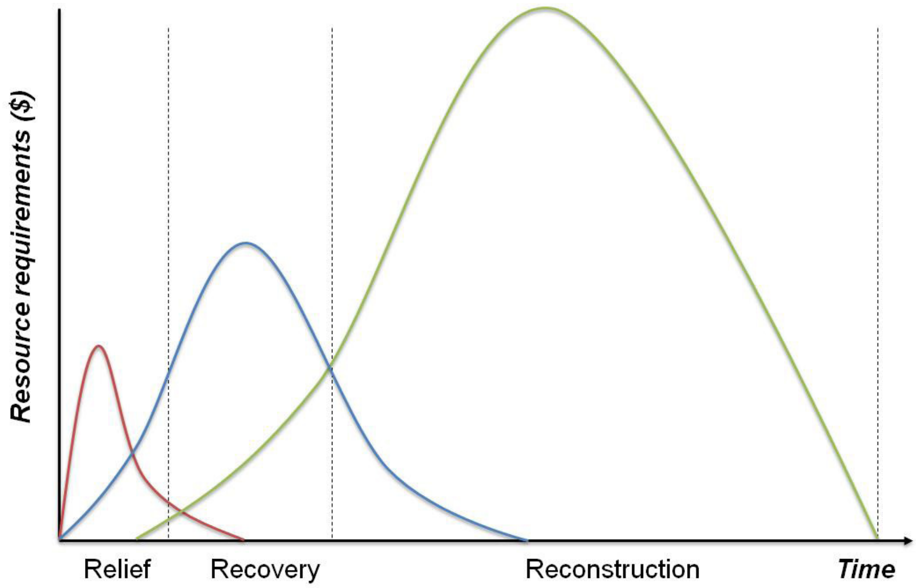
Figure 3. Three-tiered disaster risk financing strategy



Source: Ghesquiere and Mahul 2010.

There is also a time dimension to DRF relating to the post-disaster funding needs and the various phases of relief, recovery, and reconstruction. Some financing instruments can and must be activated rapidly. Others may take longer to activate but can generate substantial funding; see *Figure 4*. A disaster risk financing strategy needs to reflect both time and cost dimensions, ensuring that the volume of funding available at different stages in the response efforts matches actual needs in a cost-efficient manner.

Figure 4. Funding requirements for post-disaster phases and their duration



Source: Ghesquiere and Mahul 2010.

The analysis conducted for this report utilized an application of the Solow-Swan macroeconomic model with data on the risk profile for disasters in 27 EU MS. The aggregated analysis provides a demonstration of the EU level impacts. This report analyses the fiscal and economic impacts of disasters caused by floods and earthquakes in the 27 EU MS,[12] along with the anticipated changes of this risk through the year 2050. Floods and earthquakes were selected because these disasters have the greatest potential for substantial impact—as demonstrated by their prevalence in EU Solidarity Fund (EUSF) applications—and because regionally consistent data were available for these hazards. The report also discusses a select number of recent disasters.

The analysis reviews mechanisms that are currently used to manage the financial impacts of disasters at the national and EU levels, such as insurance for private and public assets, reserve funds, etc., and also reviews the potential funding gap—the difference between the available budget and the probable loss for a given event size (or return period). The report proposes potential measures that could be considered by the EU MS and the European Commission (EC) to reduce national and EU level contingent liabilities due to floods and earthquakes, but that would also be relevant to all major disasters (e.g., widespread drought or wildfires, pandemics, etc).

It is important to note that this analysis does not review the social transfers and specific budget spending on social assistance in detail. The COVID-19 pandemic highlighted the important role of social transfers, used by most governments to support vulnerable households, in both developed countries and developing countries. The recently completed *Public Expenditure Review: Disaster Response and Rehabilitation in the Philippines* (World Bank 2020b) further highlights social assistance as the second biggest spending category following disasters. It is therefore possible that there are dedicated budget allocations available for this type of spending. This is a recognized gap in this study, and one that will be explored for Romania and Bulgaria in a forthcoming World Bank analytical study and technical assistance, using a framework that could easily be scaled EU-wide.

12 Please note that it was not possible to attain homogenous data to meet the needs of the macro-fiscal modelling and catastrophe risk modelling beyond the 27 MS, and the analysis is therefore limited to these.

2. Current Disaster Risk Financing Instruments

This section reviews different financing instruments available in the EU MS to manage disaster costs. It also provides a basis for the modelling of macro-fiscal impacts and funding gap analysis presented in this report. The review focuses on national-level disaster risk financing instruments (as opposed to subnational) and the EU level disaster risk financing mechanism (the EU Solidarity Fund). The Union Civil Protection Mechanism (UCPM), which can provide in-kind assistance and support emergency response in the EU MS (and across the world), is discussed using the example of Albania's response to an earthquake in 2019.

While other sources of funds may be available to EU MS at the EU and national levels, it was not pos-sible to find information on them, or the information was too limited to be used in the analysis. Consequently, the estimates of financial coverage in the report are viewed as conservative estimates based on the information available at the time of writing. For example, public asset insurance penetration may be higher than expected in some countries. Lack of data on public asset insurance and more generally on the financial protection of public assets is a concern because governments are stewards of public assets and are responsible for their effective management, going forward efforts should be made to address this issue.

Moreover, some local governments may have their own sources of funding (such as contingency funds); this is the case in Austria, where local and national governments share response and reconstruction costs equally (Hanger et al 2018; Unterberger et al. 2019). In Croatia, according to the Law on the Reconstruction of Earthquake-Damaged Buildings in the Zagreb Area, cost-sharing arrangements provided that central government will cover 60% of reconstruction costs, local government - 20%, and building owners (excluding those of limited means) - 20% (AXCO, 2021).

National Level Instruments

RESERVE FUNDS

Reserve funds can help governments meet their post-disaster financing needs and improve the speed of disbursement to the intended beneficiaries while strengthening overall fiscal stability. Setting aside an adequate amount of budget annually to meet post-disaster needs can help mitigate disaster impacts and reduce the need for budget reallocation in the event of an emergency, in turn lessening the negative impact of budget reallocations on economic development. The availability of rapid liquidity (or the lack of it) may have implications for timeliness of disaster response and immediate recovery.

While it is generally assumed that most of the EU MS have some form of a contingency budget or "rainy day fund", only four EU MS (Austria, France, Hungary and Italy) have a dedicated disaster reserve fund. Moreover, only 10 EU MS were found to have general contingency funds that explicitly cover disaster relief. *Table 5* describes some reserve and contingency funds identified across the EU MS, and additional examples are highlighted in *Annex 2*.

Table 5. Examples of disaster reserve funds and contingency funds in EU MS

NAME	PURPOSE	COUNTRY
Dedicated disaster funds		
National disaster reserve fund (*Katastrophen-fonds*)	Established with the Disaster Fund Act of 1996, the fund can cover both ex ante risk management and post-disaster needs. The fund can be used to finance large-scale protection infrastructure (ex ante risk management), but also serves to compensate the affected population. It covers damage from flood, avalanche, earthquake, landslide, hurricane, and hail. In addition to this fund, ministries and agencies in Austria seem to be able to use their reserves at their own discretion for different purposes, including post-disaster financing.	Austria
Fonds de prévention des risques naturels majeurs (Fonds Barnier)	The fund can cover emergency housing or temporary rehousing and relocation, prevention measures, information measures, and research activities (the local governments are the beneficiaries).[a]	France
General contingency funds		
Interagency Commission for Relief and Recovery to the Council of Ministers	The Commission is allocated with regular budget that is aimed at covering exceptional and unanticipated costs that may occur from disasters (natural or man-made) or other events such as the mass migration of refugees.	Bulgaria
Budgetary reserve	Article 56 of the Budget Act provides for the establishment of a budgetary reserve covering expenditures for natural disasters, epidemics, environmental mishaps, or extraordinary events and other unforeseen purposes. Use of the reserve funds is by the Sabor (the Croatian Parliament). Its amount cannot exceed 0.5% of budget revenues (including taxes but excluding receipts such as user charges and fees).	Croatia
Fondul de rezervă budgetară	The fund was set up by Lege 500/2002 to cover disaster costs as well as other contingencies. In 2020, this fund was topped up through the CAT DDO to support early action after the COVID-19 pandemic.	Romania
Ad hoc reserve funds		
Funds established after disasters	Several post-disaster ad hoc reserve funds have been established. For instance, Germany has set up (i) Sonderfonds Aufbauhilfe, amount €7.1 billion, to cover damages from the 2002 flood; and (ii) Aufbauhilfegesetz, amount €8 billion, to cover damages from the June 2013 flood. In France, ad hoc emergency relief funds are usually set up by the Ministry of Interior to provide immediate disaster relief to affected individuals, with compensation capped at €300 per adult and €100 per child. These funds are excluded from the analysis.	E.g., Germany, France
Subnational disaster reserve funds		
Funds to cover disaster costs at the local level	In some countries, like in Belgium, the national disaster reserve fund was abolished and instead replaced with funds at the subnational level. In Germany, disaster risk reduction and management are the responsibility of the *Landers*. In Slovakia, self-governing regions can also establish crisis funds to finance potential damage, even if the obligation to do so does not exist. These funds are excluded from the analysis.	E.g., Belgium, Germany, Slovakia

Sources: OECD 2015, 2016, 2018; Steger 2010 (Austria); French Ministry of Ecology 2019 (France); Republic of Bulgaria 2018 (Bulgaria); Kraan et al. 2006 (Croatia); România Consiliul Fiscal 2019 (Romania); Merz et al. 2014 (Germany); DRIVER Slovakia 2015 (Slovakia).

a. Other special purpose reserve funds covering disaster relief expenditures are available in France, but were not considered for the purpose of the analysis. The Fonds national de gestion des risques en agriculture covers agricultural producers for uninsurable crop lost due to natural hazards or disease outbreak, and (ii) the Fonds de secours outre-mer covers the reconstruction of uninsured private assets and uninsurable subnational assets, as well as immediate disaster relief in overseas territories (purchase of basic necessities). See OECD and World Bank (2019).

There is also a considerable variation in the level of funds set aside in reserve funds. For instance, France has €131 million in dedicated disaster reserve funds and Austria has €438 million. The report was not always able to locate information on the size of funding allocated yearly to the contingency funds. There are some sizeable contingency funds in place, such as in Ireland (over €1.5 billion) and Romania (over €1 billion), but it is unlikely that these funds are meant to be spent entirely on disaster response and recovery.

CONTINGENT LINES OF CREDIT

Contingent credit arrangements offer rapid liquidity that is disbursed following an event of a pre-agreed magnitude or based on a pre-agreed trigger (e.g., declaration of a national emergency situation). Contingent credits can be fungible or conditional by design. As with other sources of credit, the amount available will depend on the development status of the country and the debt-servicing ratio. The advantage of contingent credit is its rapidity and its capacity to cover a financing gap between a reserve fund and more expensive or longer-disbursing sources of funds (such as insurance).

Contingent credit can be offered by the private sector or development institutions. For example, the World Bank CAT DDO provides a line of credit to countries upon successful completion of some policy actions that are agreed in advance. The release of the finance is contingent upon a disaster event happening and sequential national declaration of disaster/statement of emergency. For example, Romania had a CAT DDO of €400 million and chose to draw down upon the funding in two tranches during the COVID-19 pandemic. The first tranche was triggered in early February 2020, prior to any reported COVID-19 cases in Romania, to enable the procurement of critical medical and personal protective equipment and strengthen the country's response capacity. In March 2020, as the pandemic spread, the second €200 million was triggered to provide additional budgetary allocations to the Government Reserve Fund. This reserve fund supported the Ministry of Health in covering health services for people infected with COVID-19, as well as costs for quarantined people (food, accommodation, medical needs) and coverage of additional medical leave. Similarly, Serbia withdrew the equivalent of US$20 million from its CAT DDO to finance COVID-19 operations. In each case, the World Bank approval for withdrawal was made within 48 hours.

EU Level Instruments

This section describes EU level instruments which in this instance refers to funding from outside of the national budget but from within the EU.

EU SOLIDARITY FUND

Established in 2002 with revisions in 2014 and 2020, the European Union Solidarity Fund is an instrument that provides financial assistance to emergency and recovery operations in MS (and accession countries).[13] The aid can be spent on the four predefined types of interventions (Article 3 of the Solidarity Fund Regulation[14]):

- Restoring the working order of infrastructure and plants in the fields of energy, water and wastewater, telecommunications, transport, health, and education
- Providing temporary accommodation and funding rescue services to meet the needs of the population concerned
- Securing preventive infrastructure and measures of protection of cultural heritage
- Cleaning up disaster-stricken areas, including natural zones, in line with, where appropriate, eco-system-based approaches, as well as immediate restoration of affected natural zones to avoid immediate effects from soil erosion

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13 Council Regulation (EC) No 2012/2002 of 11 November 2002 establishing the European Union Solidarity Fund (OJ L 311, 14.11.2002, p. 3), https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02002R2012-20140628&from=EN.
14 Ibid.

Between 2002 and 2020, the EUSF mobilized a total of almost €6.5 billion for interventions in 96 disaster events in 23 MS and 1 accession country. Italy is by far the biggest beneficiary of the fund, having received more than €3 billion in that period predominantly for earthquake damage, followed by Germany, which received over €1 billion for flood, and Croatia, which received € 683.7 million after a major earthquake in 2020 (with a total of €706 million provided to Croatia from the EUSF). In that period, flooding was by far the most frequently occurring disaster affecting European countries, followed by storm; but proportionally payouts for earthquake were the largest. From 2002 to the end of 2020, 142 applications were made to the EUSF; 96 were successful, 43 were rejected, and three were withdrawn[15] (see *Annex 3* on funding provided by the EUSF versus total disaster damages).

TIMING

On average the application process for the EUSF takes 8–10 weeks (EC 2018), including the preparation of damage reports, while actual disbursement takes an average of 56 weeks (although advances can be provided before the full grant is disbursed).

ELIGIBILITY

To be eligible for support from the Solidarity Fund, the disaster should exceed the following thresholds:

- Minimum impact of a major disaster: over €3 billion in 2011 prices, or more than 0.6% of its gross national income (GNI) (different for public health emergencies)[16]
- Minimum impact of a regional disaster: direct damage in excess of 1.5% of that region's gross domestic product (GDP) (note that regional disasters are not considered in the analysis)

RECENT MODIFICATIONS

In 2020, the new multi-annual financial framework for the period 2021–2027[17] introduced some changes in the EUSF's mechanism:

- **Merging of the EUSF's budget with Emergency Aid Reserve.** Both instruments are in demand, and there is fungibility in case of increasing demand on either of the funds. Both instruments were allocated with a total of €1.2 billion in 2020, with the following limitations: 25% of the total should be reserved until October 1 each year to cover unexpected costs; out of the remaining 75%, each fund is allocated with 50% of funding, with a possibility to tap into the other fund. This leaves €478 million in the EUSF readily available (current prices) and an additional €318 million that becomes available on October 1. The total amount is replenished annually. Unspent funds could also roll out to the next year to provide advances.
- **Budget treatment to facilitate faster activation.** The provided budget was entered in the general budget of the EU as a provision. This means that budget amendments are no longer needed except in case of carry-over and frontloading—a change that is expected to increase the speed at which the mechanism is activated.
- **Front-loading and carry-over.** In addition, while there is a maximum annual ceiling on the EUSF, there is an option of front-loading, whereby current-year disasters can be funded from the future-year budget of the EUSF if they exceed the EUSF ceiling. Front-loading is possible for the EUSF up to a maximum of €400 million in the year of occurrence of a disaster. Any portion of the annual amount not used in year n may be used up to year n+1 as a carry-over.
- **Increased advances**. The percentage of advance payments has also been increased, from 10% to 25%.

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15 EUSF data on disaster aid provided: https://cohesiondata.ec.europa.eu/stories/s/An-overview-of-the-EU-Solidarity-Fund-2002-2019/qpif-qzyn
16 The thresholds used for the analysis in this report are as provided for 2020 on the EUSF website, https://ec.europa.eu/regional_policy/sources/thefunds/doc/solidarity/thresholds.pdf. Whenever €3 billion is exceeded, the €3 billion threshold applies.
17 Official Journal of the European Union, "Council Regulation (EU, Euratom) 2020/2093 of 17 December 2020 laying down the multiannual financial framework for the years 2021 to 2027," https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.LI.2020.433.01.0011.01.ENG&toc=OJ%3AL%3A2020%3A433I%3ATOC.

In addition, in 2020, the EUSF coverage was expanded to health emergencies to address the ongoing COVID-19 pandemic (EC 2020). Major health emergencies are now added as a separate field of intervention for the EUSF, covered from the same budget as disasters. The basis for calculating support towards the pandemic has changed to a proportion of public expenditure on most essential emergency operations. The threshold for mobilizing the assistance for major health emergencies is lower than for other disasters by half (i.e., €1.5 billion or 0.3% of GNI). At the same time, the EUSF can also finance, in relation to health emergencies, such measures as prevention, monitoring, or control of the spread of diseases, combating of severe risks to public health, or mitigation of their impact on public health. While the analysis in this report does not explicitly account for COVID-19 impact, these changes might result in lower funding available to disasters.

BENEFITS AND LIMITATIONS

The EUSF meets it objective to provide a limited amount of finance to MS following a disaster. Because of its wide coverage of multiple countries, and the fact that disasters rarely affect more than one country (except in few cases over the EUSF's history), it can flexibly balance the demand for financial aid with the available funding. Having such an EU level mechanism in place provides improved financial capacity to the MS.

Yet, the amount of funding available to the EUSF may be insufficient in the case of major disasters, such as catastrophic earthquakes or disasters that affect multiple countries at once (even when considering that the mechanisms aims to only cover a small share of disaster costs). The question on the funding is reviewed below in *Chapter 5* . The EUSF also depends fully on the EU budget and there are no risk transfer mechanisms linked to it. As such, major events might require frontloading and additional budget allocations, which might come in late.

It is also important to note that the EUSF does not finance compensation to the population or reconstruction of private housing or assets. However, it can finance public spending on these items (e.g., if public money is being used to restore private schools, then the EUSF can be used for covering this public expenditure).

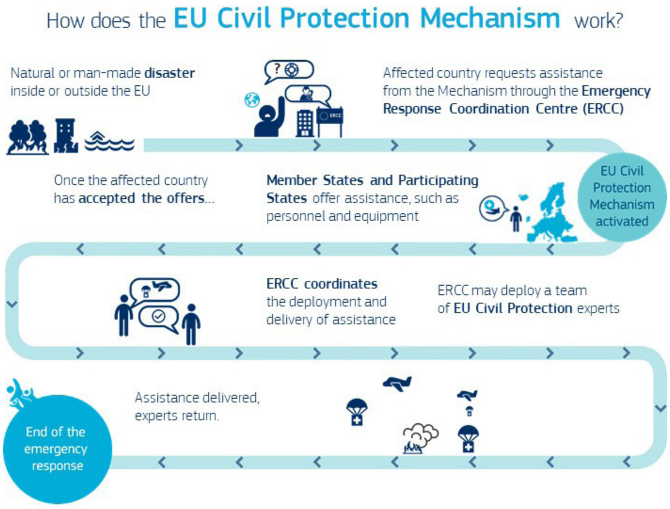
UNION CIVIL PROTECTION MECHANISM

The UCPM can provide rapid assistance to EU MS after disasters (mobilizing support within a few days after a disaster strikes). The UCPM includes a number of mechanisms to support affected countries, such as pre-positioning of response goods, financing of transportation costs, deployment of expert and specialized teams after disasters, provision of grants, etc. On average, in the period 2016–2020, about €1.5 million was used solely for financing of transportation costs in EU MS.[18]

From 2010 to 2019, the UCPM provided co-financing for emergency response in the amount of €6.1 million on average every year. However, 2020 saw the number of grants more than triple, and co-financing requests were 13.5 times higher than the past average. In 2020, around 16.5% of the total UCPM budget was dedicated to response to crisis within the EU, including assistance with measures to address the COVID-19 pandemic.

18 According to UCPM data as of February 2021.

Figure 5. How the UCPM works



Source: European Commission, *"Union Civil Protection Mechanism,"* https://ec.europa.eu/echo/what/civil-protection/mechanism_en.

Risk Transfer Instruments

Risk transfer solutions help in mobilizing private sector capital (which often exceeds available public funds) and can be structured in various ways—for example, as (i) sovereign insurance or capital market instruments (protecting government budgets); (ii) public asset insurance; or (iii) property insurance for households.

SOVEREIGN INSURANCE OR CAPITAL MARKET INSTRUMENTS

The risk of disaster losses can be transferred to the private insurance market (or to capital markets in the case of catastrophe bonds) via sovereign insurance—i.e., insurance where a government is the policyholder. Together with budget reserves and contingent credit, sovereign risk transfers can be a key part of a comprehensive DRF strategy.[19]

Sovereign insurance can be structured in different ways, as indemnity-based, modelled loss–based, parametric index, and parametric products. Indemnity-based products require extensive loss assessment and adjustment before a payout can be confirmed, but have the advantage that payout is closely tied to the loss that occurs, so that basis risk[20] is minimal. Typical household insurance, for example, follows an indemnity approach. A modelled loss–based product relies on the assessment of loss using an agreed independent risk model, with a payout occurring if a modelled loss threshold is exceeded. A parametric index is a simplified version of this that uses formulae to estimate loss from an event that has occurred. Parametric products pay out when an event occurs that meets a pre-agreed definition (in terms of type, location, and hazard intensity threshold). Thus they typically offer faster payouts than other types of sovereign insurance but are also subject to the greatest basis risk.

Governments can also transfer their disaster risk through capital market instruments. For example, a catastrophe (CAT) bond is a risk transfer capital market instrument that allows the issuer to raise funds in case of a natural disaster and does not count against a country's debt ceiling. A high-yield debt instrument, a CAT bond pays out only if a specific event such as an earthquake or a flood occurs. If the insured event occurs and triggers the payment to the bond issuer, then the principal will be used to cover a part of the losses. Investors who are ready to take this kind of risk target CAT bonds because they offer attractive interest rates that are usually higher than other fixed-income securities. In addition, because losses on CAT bonds are not correlated with those of other capital market instruments, they offer portfolio diversification for large investors.

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19 World Bank, "Sovereign Catastrophe Risk Pools: A Brief for Policy Makers," http://documents1.worldbank.org/curated/en/603121502870773583/pdf/118676-WP-v1-PUBLIC.pdf.

20 Basis risk is the level of potential risk that exists when a calculated loss of a model or insurance index differs from the actual incurred loss. Any mismatch between the two will result in a discrepancy in the payout received. This could mean either that a payout is higher than the actual loss incurred (positive basis risk) or that the payout is lower than the actual loss (negative basis risk).

This report did not identify sovereign insurance or widespread use of capital market instruments to transfer disaster risks in the EU MS, however, several countries have worked together to establish a public-private partnership reinsurer. In 2009, the governments of Albania, North Macedonia, and Serbia established jointly a regional reinsurer—Europa Re—through the World Bank South East Europe Catastrophe Risk Insurance Facility (SEE CRIF) project. A licensed Swiss-based specialty reinsurance company, Europa Re aims to increase reinsurance capac-ity and strengthen the offering of catastrophe insurance in the region thereby supporting the uptake of catastrophe insurance. Europa Re has also designed catastrophe insurance products for such perils as earthquake, flood, and drought, and has offered them for sale on the local market (households, small and medium enterprises and municipalities) as voluntary insurance policies. Despite availability of these high-quality products, however, disaster insurance penetration in the three countries involved has remained low.

PUBLIC ASSET INSURANCE

Public assets are assets and infrastructure owned or managed by the government; they can include networks and facilities providing services in such areas as transport, energy, telecommunications, water, and social infrastructure. Disasters can cause damage and disruption across different public assets. For example, damage to power generation and distribution and transport infrastructure alone costs about US$18 billion a year in low- and middle-income countries.[21] Disruptions and damage to public assets and infrastructure cause broader macro-fiscal, economic, and social impacts. Altogether, disruptions caused by natural hazards and by poor maintenance cost households and firms at least US$390 billion a year in low- and middle-income countries around the world.[22] Because these assets often have key functions in an economy, they require rapid restoration after disasters to enable communities and livelihoods to recover as effectively as possible, while mitigating the economic losses.

Data on penetration of public asset insurance in Europe are limited. Bräuninger et. al. (2011) mentions that only one-third of private and public assets in the EU are insured against floods and drought (with public assets generally uninsured). Bulgaria has a legal requirement for municipalities to buy insurance for their assets (excluding against floods in high-flood-risk areas), but the extent to which this law has been implemented is unclear.

Public asset insurance, as part of a comprehensive disaster management strategy, can help avoid budget shocks by transferring the risk to the private insurance sector. It can provide benefits by pooling multiple assets into an insurance scheme, thereby diversifying the risk and reducing the premium cost per asset. Insurance cover for public assets may be voluntary or compulsory, and products may be indemnity-based (payout determined by the assessed losses), parametric (payout based on the occurrence or severity and location of a hazard event), or a hybrid; each has its own benefits and challenges (IDF 2019). Financial management of public assets can be complemented by risk retention instruments. Mexico's FONDEN (Natural Disaster Fund), for instance, provides funding of over US$1.5 billion in annual cost of public infrastructure reconstruction following disasters, but is structured to encourage asset owners to obtain insurance and introduce risk reduction measures (see further details about FONDEN in *Annex 13*).

HOUSEHOLD INSURANCE

Catastrophe insurance for households can be offered in different ways. Globally, much household insurance against disasters is offered by private sector insurers, but the number of public or private-public schemes is growing. Catastrophe insurance (usually referred to as "natural catastrophe" or "NatCat" cover) is offered as a stand-alone product, as part of a general property damage policy, or as an extension to such a policy. It can also be either compulsory or voluntary (or voluntary with some elements of obligation, e.g., through mortgage contracts). Depending on the country, flood, storm, or earthquake cover (or some combination of these) is commonly provided as standard in a household policy (EU JRC 2012), and payout is usually on an indemnity basis, requiring assessment and adjustment of losses after an event.

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21 World Bank, "An Overview of Financial Protection of Public Assets: Introduction to SEADRIF Knowledge Series," draft working paper for SEADRIF webinar, https://www.financialprotectionforum.org/sites/default/files/SEADRIF%20factsheets%20overview.pdf.
22 Ibid.

Some examples of catastrophe insurance for households in Europe include the following:

- **Stand-alone mandatory catastrophe insurance**:
  - In Romania, catastrophe insurance is mandatory. It is implemented by private insurers who formed an association, the Natural Disaster Insurance Pool (PAID). The insurance is offered with two fixed sets of premium rates/coverage that differ for urban and rural areas. Beyond this policy, households can purchase multi-peril top-up property insurance cover from private insurers with market-based premiums (OECD 2018). However, despite the mandatory nature of the policy, penetration is about 20% due to lack of trust in the instrument, limited enforcement of the "mandatory" aspect (which requires municipalities to fine those not in compliance), and lack of public awareness.
- **Compulsory extension to property damage policy:**
  - In France, a compulsory extension applies to a general fire or property damage policy with a fixed 0.12% rate that is estimated based on the policy size; the insurance is administered by private insurance companies. Insurers may choose to maintain the full disaster exposure covered or access government reinsurance offered through a state-owned reinsurer (Caisse Centrale de Réassurance), which offers a stop-loss reinsurance cover (limited to 50% of exposure) guaranteed by the government (OECD 2016).
  - In Spain, a compulsory extension applies to voluntary property, life, and personal accident policies offered by the Consorcio de Compensación de Seguros (CCS). The cover is sold by private insurance companies, which can access reinsurance from the CCS. Solvency of the CCS is guaranteed by the government (OECD 2016).
  - In Belgium, earthquake insurance is a mandatory extension to fire policy. The government supports the provision of catastrophe insurance by guaranteeing up to €280 million (€700 million for earthquakes) per insurer and event if the damage per insurer and event exceeds a maximum of €3 million plus 0.35 times the premium income.[23]
- **Private sector cover**: In the remaining countries, there seem to be no specific arrangements for household insurance. However, there are some country-specific regulations:
  - In Denmark, storm flooding is excluded from insurance cover; damages from such events are covered through a compensation scheme, the Danish Storm Council (Stormradet);[24]
  - In Hungary, the Wesselenyi Miklos Ar-es Belvizvedelmi, set up by Law LVIII of 2003, covers individuals with real property located in areas prone to flooding who cannot obtain insurance for flooding. In order to receive compensation, an individual must contribute to the scheme. In return, compensation will be provided on an indemnity basis (OECD 2015).
  - In the Netherlands, uninsured properties can receive ad hoc compensations through a pre-established scheme, the Wet Tegemoetkoming Schade bij Rampen en Zware Ongevallen. Uninsurable losses from natural and technological accidents can be partly covered by the government up to a maximum of €450 million (OECD 2016).

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23 Insurance Europe, NatCat Chart—Property Insurance," https://www.insuranceeurope.eu/sites/default/files/assets/NatCartChart-Belgium-privatelines.pdf; OECD 2015; Bruggeman and Faure 2018.
24 AXCO: Country Reports: Denmark, 2020.

The number of households covered by catastrophe insurance in EU MS varies, from practically no households covered to almost every household covered. In France, Finland, Slovakia, Sweden, and Ireland, most households are covered against both earthquake and flood perils. In some countries exposed to both earthquake and flood risk, there is a notable difference in the uptake of policies against the respective perils. For example, in Hungary it seems that no households are covered against floods, but almost 70% have earthquake cover; in Latvia, only 20% of households are covered against earthquakes, while 95% are covered against floods (see <u>*Figure 6*</u> and <u>*Figure 7*</u> below for penetration of catastrophe insurance; more details are in <u>*Annex 4*</u>.

Figure 6. Proportion of households covered by earthquake insurance in EU MS

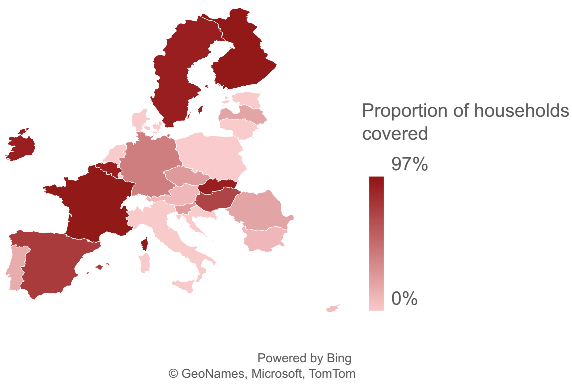
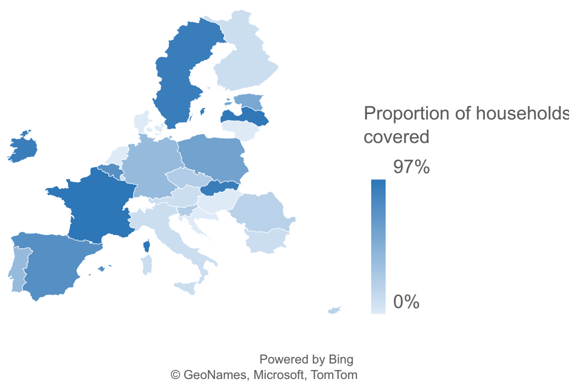


Figure 7. Proportion of households covered by flood insurance in EU MS



Sources: AXCO Non-life insurance market reports: *Country report, 2020s; OECD 2015, 2016, 2018; EU JRC 2012.*
Note: There are some limitations to the above data, which are in some cases outdated. In addition, when the range of households covered was provided, the upper limit was selected, so the penetration might be overstated.

If a major disaster occurs in countries with low insurance penetration, households might appeal for government help. Both the macro-fiscal analysis (<u>*Chapter 4*</u>) and the funding gap analysis (<u>*Chapter 5*</u>) test the results of eventually providing assistance.

3. Catastrophe Risk Modelling

Two regionally consistent probabilistic disaster risk models were used as inputs to the macro-fiscal and funding gap analysis: the JBA Risk Management (JBA) model for fluvial and surface water flood, and the Global Earthquake Model Foundation (GEM) model for seismic risk. The models provide risk estimates for each EU Member State and all MS combined, using a common building asset data set comprising residential, commercial, industrial, health care, and education buildings. These models and organisations were selected for use in the analysis after a review of available data and models for the EU, conducted in the inception phase of this analysis. A summary of the methods is given in the next sections, with more details provided in the respective technical reports of GEM (2020 and JBA Risk Management (2021).[25] In addition to estimating risk in 2020, the study projected loss estimates to 2030, 2040, and 2050, incorporating projected changes to the building stock for earthquake and flood, as well as the impact of climate change on the frequency and severity of fluvial flood. Beyond estimating economic loss, the analysis estimates flood-affected population and fatalities due to earthquakes (see *Annex 14*).

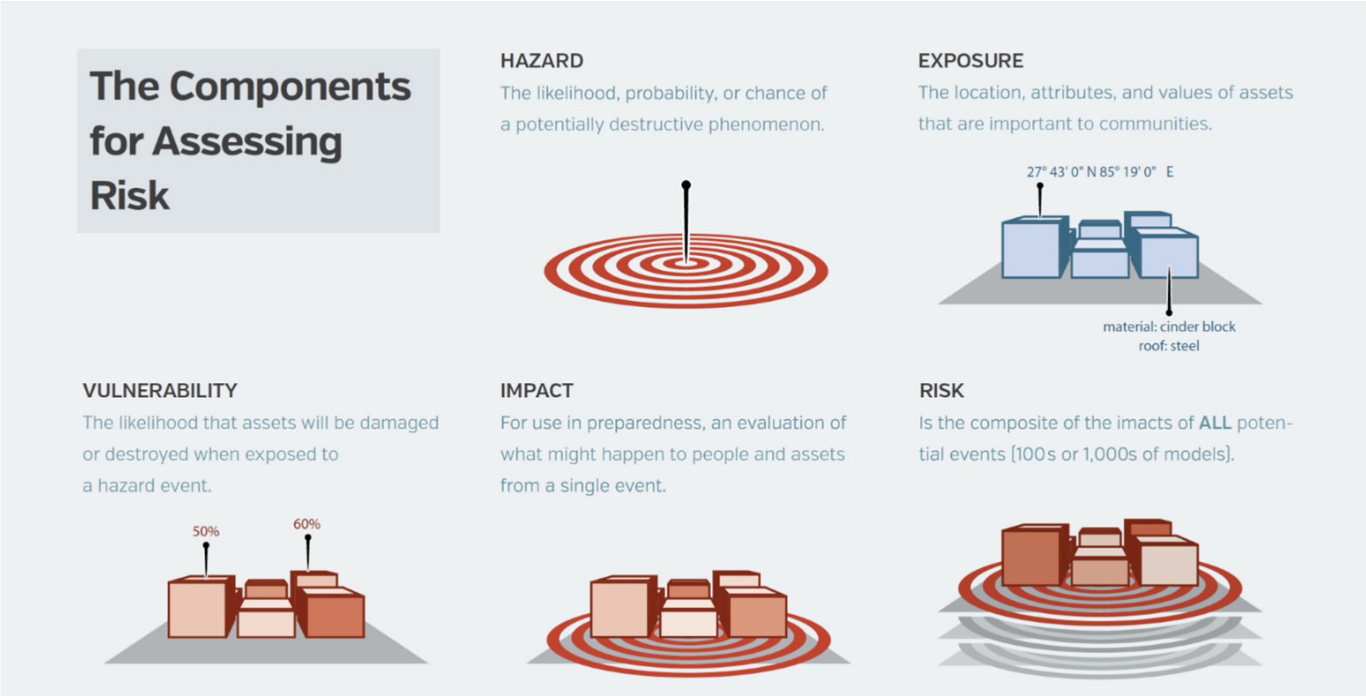
The EU risk profile is of course much broader than flood and earthquake meaning that future losses will likely exceed the estimates in this report it is there-fore recommended that the catastrophe modelling is expanded to include additional perils. Data from the CRED EM-DAT disaster event database show that storm is the dominant hazard in Northern and Western Europe (contributing 50% of all disasters in each region), followed by flood (25% in each) and extreme temperatures (13–14%). In Eastern Europe floods dominate (42%) followed by extreme temperature (21%) and storm (18%). Floods also dominate in Southern Europe (37%), followed by storm (15%), extreme temperature (14%), earthquake (13%), and wildfire (13%).[26] Various flood risk analyses exist for Europe that describe the impact on transport infrastructure; for example, van Ginkel et al. (2020) estimates €250 million of damage to roads per year, and Bubeck et al. (2019) estimates €581 million to rail annually. Other analyses use a land cover and GDP approach to estimate fluvial flood risk or coastal flood risk, such as Vousdoukis et al. (2018). These analyses use existing fluvial flood return-period hazard maps to compute AAL, but do not provide event-by-event losses or break down the risk by built asset type, as is desired for this analysis. Various sources of modelled European wind risk estimates exist via the insurance industry, but the data availability was deemed insufficient for this analysis. An open model of wind risk exists, but it provides only annual estimated wind damages from simulating 40 years of historical storm damage (Koks and Haer 2020), and it does not provide an event-based perspective on asset loss, as required here. Existing wildfire, extreme temperature, and drought risk estimates are also derived from different methodologies and do not yet provide the event-based asset losses required for the subsequent analyses. To maintain focus on an event-based modelling approach and internal coherence in the economic modelling and risk estimation methodology applied, we have limited the inclusion of perils to earthquake and flood.

Overview of Disaster Risk Analysis

Disaster risk analysis—or "catastrophe modelling" in the insurance sector—uses the concept of risk as a product of hazard, exposure, and vulnerability, as defined in *Figure 8*. Disaster risk models estimate economic loss by assessing the intersection of different types of assets with the spatial distribution of hazard intensity and its associated annual frequency. Vulnerability relationships convert the hazard intensity at a given asset type into an expected damage ratio or probability of sustaining a certain level of damage. Each type of asset has a different vulnerability relationship that depends on its structural characteristics, including construction type, age, and height. These factors, among others, govern the potential for damage given a certain level of force on the structure or water level. When the damage level has been estimated, the cost to repair or replace the asset can be estimated, if the total replacement cost is known.

25 These will be provided separately.
26 EM-DAT: The OFDA/CRED International Disaster Database, Université catholique de Louvain, Brussels, Belgium, http://emdat.be.

Figure 8. The components for assessing risk



Source: GFDRR 2014.

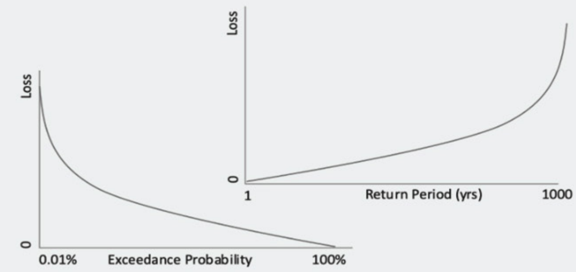
Subsequently, the estimated cost per building in a portfolio or defined area is aggregated to produce a total estimated loss for each event. The estimated loss and annual frequency of each event is generated for many physically plausible events in thousands of simulated years—enabling the estimation of frequent small losses and rarer extreme events, including those not experienced or observed in recorded history. The outputs of the analysis are provided as loss exceedance curves and derived metrics, including AAL and return period loss (see Box 2).

Box 2. Explaining loss exceedance curves, AAL, and return period loss

Annual Average Loss (AAL): The mean loss expected in any given year. It is the average of all losses estimated over a long simulation period

Return Period Loss: The probable maximum loss expected to occur for a given return period, or with the equivalent annual frequency. For example, a 100-year return period loss of $100mn means that to the maximum loss is expected to be exceed $100mn *at least once* in a 100-year period, or there is a 1% chance in a given year of a loss exceeding $100mn. The annual frequency is the inverse of the return period, such that the 250-year RP has an annual frequency of 0.4% and 50-year RP equates to 2% annual frequency. Return period is also known as recurrence interval.

Exceedance Probability (EP) curve: The above statistics are derived from the EP, or loss exceedance curve. The EP curve is generated from the frequency and loss of each simulated event.



Source: World Bank.

EXPOSURE DATA

The same exposure data were applied in the analysis of both seismic and flood risk. A number of available exposure data sources were considered, including gridded population data, settlement layers, and building stock estimates. The final selection was determined by the need to have data developed using a consistent methodology across EU Member States, and by the need for the data to contain structural attributes (for assessing the vulnerability of buildings to flood depth and seismic ground motion) and building replacement cost (for estimating loss). A summary of the data is given below with simulated replacement cost in *Table 6*; further detail is provided in the project technical report (GEM 2020).

RESIDENTIAL, COMMERCIAL, AND INDUSTRIAL DATA

The SERA exposure model (Crowley et al. 2020a) was selected as the most suitable source of residential, commercial, and industrial data. It covers all EU Member States with the attributes required for risk analysis: spatial distribution, number of buildings, estimates of building occupants, estimates of replacement costs, and categorization of building classes, each linked to a vulnerability function. Data were applied in this study at approximately 1 km resolution; to achieve this, the residential and commercial data were resampled from first administration level (as provided in SERA) using WorldPop gridded population data. Industrial data were developed in SERA at this higher resolution (Sousa, Silva, and Bazzurro 2017).

EDUCATION AND HEALTH CARE BUILDINGS

No regionally consistent data with the necessary attributes for risk analysis were available for education and health care buildings. Several sources of information were combined to generate data on hospitals and clinics: national total number of facilities and number of beds to estimate number of occupants—based on national information from the Organisation for Economic Co-operation and Development (OECD) and Eurostat—were coupled with average unit costs. The location of some facilities was known from OpenStreetMap (OSM), while the remaining number of facilities in each country was distributed proportional to population within NUTS3 boundaries (from Eurostat)[27]. For schools and universities, national databases or the World Bank Global Program for Safer Schools (GPSS) data[28] were used to obtain national total building counts. OpenStreetMap geolocated facilities were mapped at their location, and remaining facilities per country were distributed proportional to NUTS3 population, as in the health care data approach. Cost of facilities and number of occupants were derived from the Global Program for Safer Schools data.

Table 6. Simulated total replacement cost of buildings for each MS in 2020 (billion €)

MS	COMMERCIAL	EDUCATION	HEALTH CARE	INDUSTRIAL	RESIDENTIAL	TOTAL
AT	335	41	40	150	729	1,295
BE	259	43	33	307	477	1,119
BG	44	5	31	97	168	345
CY	17	7	1	33	58	116
CZ	150	30	16	218	361	775
DE	1,877	557	307	850	3,903	7,494
DK	279	57	8	213	417	974
EE	16	5	2	33	46	102

27 The Nomenclature of territorial units for statistics (NUTS) is a geographical nomenclature subdividing the EU into regions at three different levels (NUTS 1, 2 and 3 respectively, moving from larger to smaller territorial units). Above NUTS 1, there is the 'national' level of the Member States.
28 GPSS Global Library of School Infrastructure (GLOSI), https://gpss.worldbank.org/en/GLOSI

EL	82	44	19	81	391	617
ES	357	193	52	442	2,300	3,344
FI	87	44	14	163	217	525
FR	1,095	525	150	1,186	3,433	6,389
HR	29	5	8	22	124	188
HU	60	19	20	69	165	333
IE	196	32	9	62	323	622
IT	580	249	76	1,314	3,382	5,601
LT	66	6	7	93	76	248
LU	29	8	1	12	30	80
LV	25	9	4	32	58	128
MT	7	2	1	11	14	35
NL	388	212	25	513	1,214	2,352
PL	235	54	77	212	423	1,001
PT	111	18	12	92	513	746
RO	31	22	41	78	257	429
SE	383	73	17	394	1,088	1,955
SI	16	11	2	18	45	92
SK	50	9	12	140	190	401

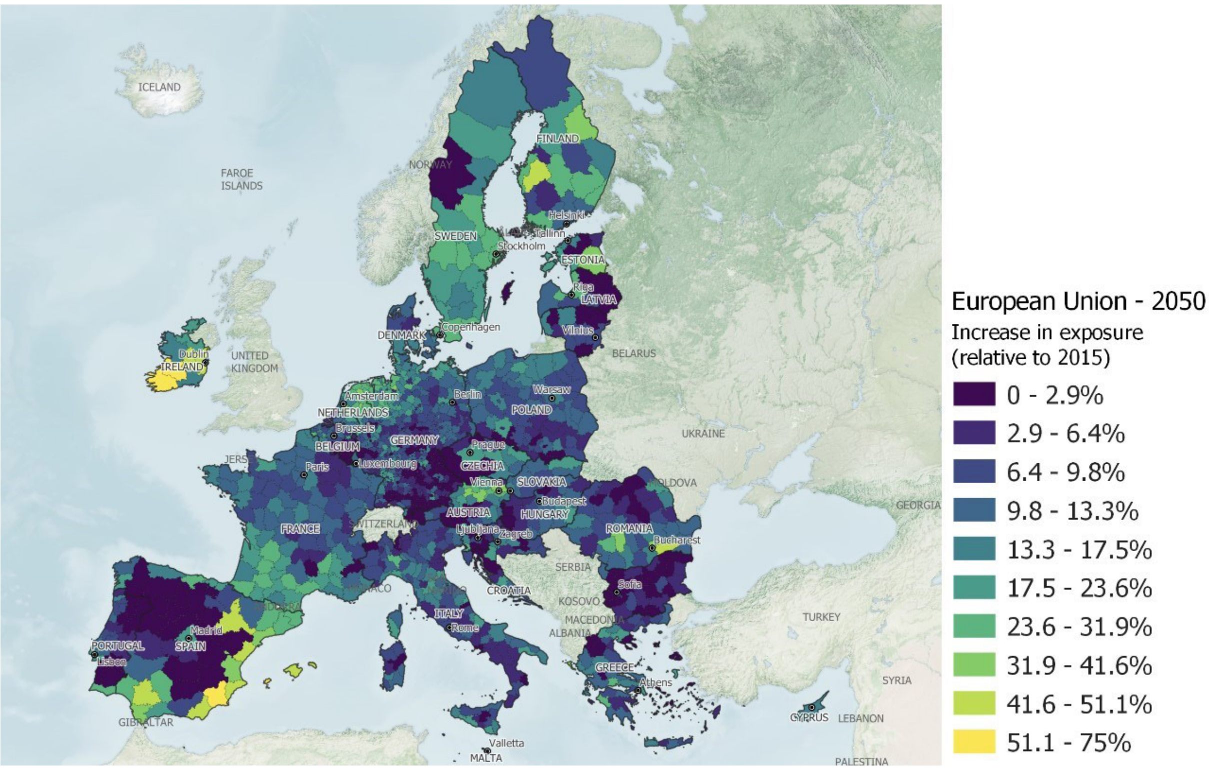
Source: GEM 2020.
Note: The exposure values are applied to simulation of current risk (earthquake and flood) and are the baseline for future projections in this analysis.

EXPOSURE PROJECTIONS

Exposure was projected to 2030, 2040, and 2050 by adjusting the number of occupants, buildings, and capital stock present in the 2020 baseline data. Built-up area was projected based on OECD (2014) GDP projections, applying a correlation between Global Human Settlement Layer (GHSL) data from the European Commission Joint Research Centre (JRC) (Pesaresi et al. 2013) and World Bank GDP estimates (World Bank 2020c), adjusted by -3.5% to account for impacts on GDP of the COVID-19 crisis. Population was estimated using existing population projections (Eurostat 2020). Location of future assets used a geographical weighted regression approach, which estimates the probability of future development in each km^2, given the following factors: density and proximity to towns, terrain slope and elevation, density and proximity to roads, proximity to cities, and density of civic amenities.

The total capital stock value and building stock at each decade were derived by increasing the 2020 baseline values proportionally to the increase of built-up area soil. The new values were distributed to building classification assuming the proportion of building stock is unchanged from 2020. The future vulnerability of buildings was adjusted for areas where high-code buildings are present in 2020, to enact the assumption that all new buildings would be built to current seismic codes. *Figure 9* shows the increase in building replacement for the modelled assets using this methodology; further details are presented in GEM (2020).

Figure 9. Increase in replacement cost (all modelled asset classes) relative to 2015 value at NUTS3 level



Source: GEM 2020.

SEISMIC HAZARD

For seismic hazard, the analysis used the Seismic Hazard Harmonization in Europe (SHARE) or European Seismic Hazard Model (ESHM13) data (Giardini et al. 2014; Woessner et al. 2015). This is a probabilistic time-independent seismic hazard model covering all EU Member States. It was completed in 2013 and developed with seismic institutions and experts throughout Europe, building on national seismic hazard mapping initiatives. It comprised the latest earthquake catalogues, seismic faults and tectonic data, seismic source models, and ground motion models. An updated European hazard model from the SERA project was in development at the time of analysis and not available for application.

SEISMIC RISK ANALYSIS

The seismic risk analysis applied the exposure and hazard data described above, with GEM's Global Vulnerability Model (Martins and Silva 2020) to assess building damage. The risk analysis was conducted in the OpenQuake engine[29] and produced direct losses due to damage and fatalities using event-based Monte Carlo simulations. A stochastic event set represented the seismicity of the region within a given time interval; each event in the event set represented an individual synthetic rupture scenario from a modelled source and its ground motion field. Logic trees were used to account for epistemic uncertainty in source characterization and ground motion model choice for different tectonic regions. Ten thousand event sets were applied for each of 100 logic tree branch samples, each sample having a one-year time period to determine AAL and loss distributions.

For each event, the seismic hazard intensity (from the ground motion field) was obtained at the location of assets; using the available vulnerability models for each exposure class, a loss ratio was sampled (for each metric—economic loss and fatality). The corresponding asset replacement cost or number of occupants was multiplied by that ratio to obtain the resulting economic loss or number of fatalities at that asset for that event. These values were then aggregated across all simulated events to produce the exceedance probability (EP) curve, AAL, and return period losses (see *Box 2* for definitions).

29 The OpenQuake Platform, by the GEM Foundation, is a web-based interactive platform in which to access, manipulate, share and add data, and explore models and tools for integrated assessment of earthquake risk. https://platform.openquake.org/

VULNERABILITY

Existing vulnerability relationships for residential, commercial, and industrial buildings were augmented to provide an assessment of fatalities. In the GEM Global Vulnerability Model, the seismic fragility (the probability of exceeding a damage state—i.e., slight, moderate, extensive, and complete) of each building class is estimated by testing the response of a structure to seismic forces. The response of a structure depends on its structural and dynamic properties. Seismic vulnerability is then obtained by applying a damage-to-loss model for economic loss (Yepes-Estrada et al. 2017) and fatality ratios for each damage state.

The vulnerability functions for education and health care buildings were derived from an average of selected residential and commercial exposure in each country, weighted by exposed value to reflect the expected construction attributes of education and health care building stock. Schools' vulnerability was based on the complete residential and commercial building stock; for clinics, only commercial classes were used, and for universities and hospitals, commercial building classes were used but restricted to classes with good seismic performance.

FLOOD HAZARD

Estimation of fluvial (river) and pluvial (surface water) flood hazard uses JBA's Global Flood Event Set, which is a catalogue of inland flood events describing the intensity of events at point locations. An event is generated by simulation of rainfall, routing of water through a physically based hydrological rainfall-runoff model, prediction in ungauged basins, and then identification of distinct events. The models are calibrated using historical data from river gauges and re-analysis data (Climate Forecast System Reanalysis) of precipitation and temperature. The approach captures plausible events more extreme than those observed in the historical records and includes the effect of antecedent catchment conditions. Because the approach is regionally calibrated, events can still be defined in locations not served by gauges—i.e., where there is an absence of historical flow data; however, Europe has good distribution of flow gauges that provided historical data for the event set.

Event extent and intensity are compiled into 30 m flood maps, generated by hydraulic modelling to estimate likelihood and extent of flood inundation from river flow volumes estimated in the previous step. JBA's Global Flood Map provides a consistent source of undefended river and surface water flood extents and depths for six return periods (20, 50, 100, 200, 500, and 1,500 years). Flooding from rivers with a catchment area over 500 km^2 is captured in the fluvial data; flooding from smaller rivers and locations where rainfall pools in topographic depressions is captured in the pluvial data. A defended version of fluvial flood is generated by defining areas that benefit from permanent physical barriers (not demountable defences). The defended area is considered to be fully protected for events of lower return period than the defence's standard of protection (i.e., no flooding occurs, provided there is no flooding from adjacent undefended areas). Flooding is reduced for events expected to overtop the defence (those with a longer return period than the standard of protection). Location and standard of protection are developed using published official information, arial imagery, and engineering reports. Further information is provided in the technical report (JBA Risk Management 2021).

FLOOD HAZARD UNDER FUTURE CLIMATE CONDITIONS

The future climate analysis uses the mid-century time horizon (2050s) and the moderate RCP4.5 scenario, a realistic future climate change scenario in which some adjustments to social and economic behaviour result in a reduction in carbon emissions with significant economic impact. The analysis uses extreme river flows from a study undertaken by the European Commission to investigate the impacts of different climate pathway scenarios on projected river flows (Mentaschi et al. 2020). For technical details of how this analysis has been incorporated into the current analysis, see JBA Risk Management (2021).

FLOOD RISK ANALYSIS

The proprietary JBA FLY model was applied, combining (i) the hazard modelling above with (ii) exposure data provided by GEM and used for the seismic risk analysis and (iii) vulnerability curves described below. Ten thousand years of flood events were simulated to estimate economic loss and population affected per event. Exceedance probability curves and summary statistics were generated on the basis of these event losses.

APPLICATION OF EXPOSURE DATA

For the flood risk analysis, some refinements to the exposure data were applied to ensure the scale of data was suitable for the localized nature of flood hazard. Data received from GEM were aggregated to the ADMIN 1 level before being disaggregated according to population distribution (using WorldPop data). Exposure data for flooding are thus distributed to a finer resolution than in the seismic risk modelling. A limitation of this necessary process was that education and health care assets with a known location were also distributed on the basis of the population.

VULNERABILITY

This analysis uses JBA's default regional European residential vulnerability curve for all residential exposure. The function is based on the assumption that most buildings are two storeys tall with few taller than 10 storeys; cellars are a feature of some buildings; construction materials are mainly brick and reinforced; and the build quality is very good. This approach was developed using JBA functions from Australia, Canada, China, Sierra Leone, Thailand, the UK, the US, and Vietnam, and with information from Huizinga, Moel, and Szewczyk (2017). In the absence of information to match the commercial and industrial building classifications provided with more European-focused curves, a global default vulnerability curve for commercial and industrial exposure is used. All functions assume no flooding occurs until depth exceeds 0.2 m, to account for height of floors above ground. Construction attributes and number of storeys could not be considered in the risk analysis without developing bespoke vulnerability relationships.

Health care and education vulnerability curves were developed specifically for this project, as none existed for the JBA Global Flood Model. A literature review found six existing vulnerability curves for school and five for clinics or hospitals (FHRC 2005; Nofal and van de Lindt 2020; Martínez-Gomariz et al. 2020). For each asset class the average of the curves was taken at discrete depths and converted to a stepped function as required by the model.

Key Findings

The outputs of the risk models provide a view of seismic and flood risk on a regionally consistent basis and using common exposure data for each hazard analysis.

SEISMIC

- The most at-risk countries based on average annual loss relative to exposure value (total replacement cost from residential, commercial, industrial, education, and health care buildings) are given in *Table 7*.
- Romania is listed in the top three for both flood risk (ranked first) and seismic risk (ranked third). Slovenia, Bulgaria, Austria, and Slovakia also appear in the top 10 for both hazards.
- All countries in the top 10 have average annual loss ratio of over 0.1% for flood risk, whereas this threshold is exceeded by only four countries for seismic risk.
- Italy has by far the most seismic risk in terms of absolute average annual losses (€6 billion), followed by Greece (€1.1 billion) (*Figure 11*).
- Residential building stock tends to be the main source of losses from earthquakes, accounting for 50% or more in many countries (*Figure 11*).
- Variations in AAL ratios at a subnational level are available in the technical report (GEM 2020); Italy, Greece, and Romania also have the highest values, with substantial proportions of their NUTS3 units estimated to have annual losses between 1% and 3.6% of total building stock value.

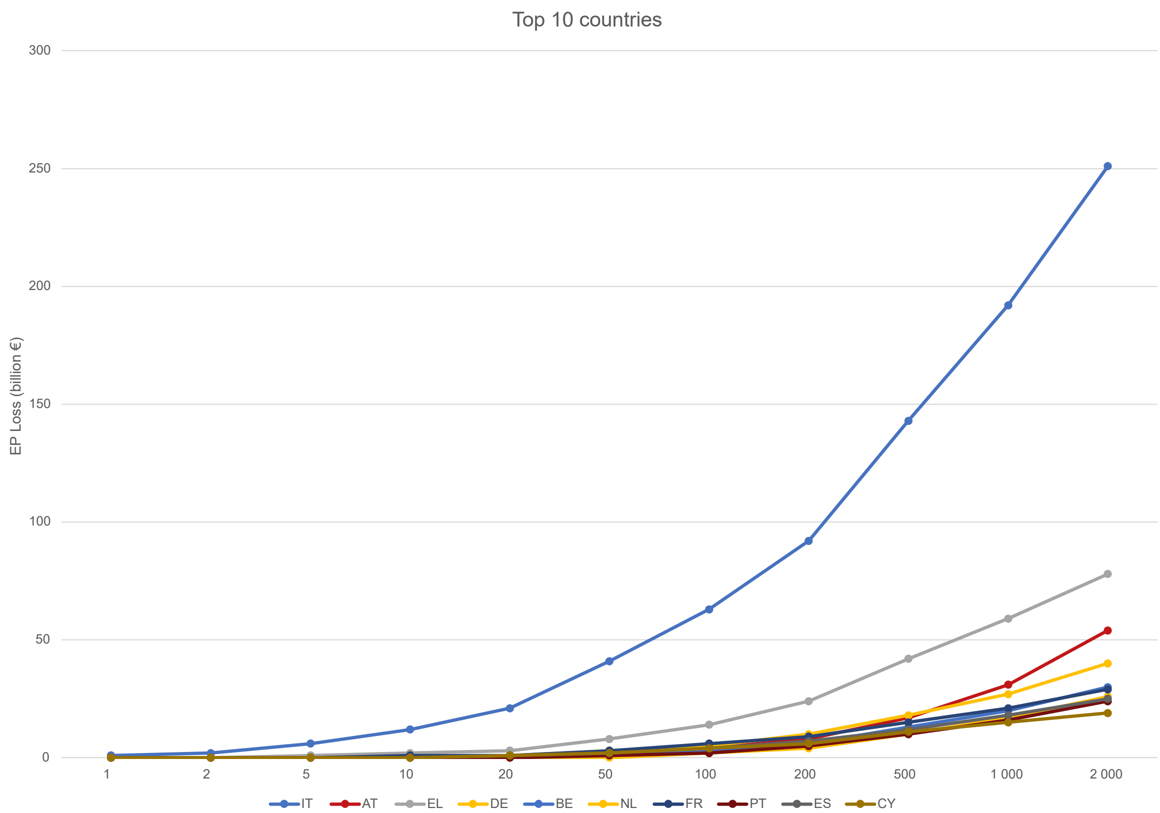
Table 7. Top-10 countries for flood and seismic risk, by AAL as a percentage of exposure

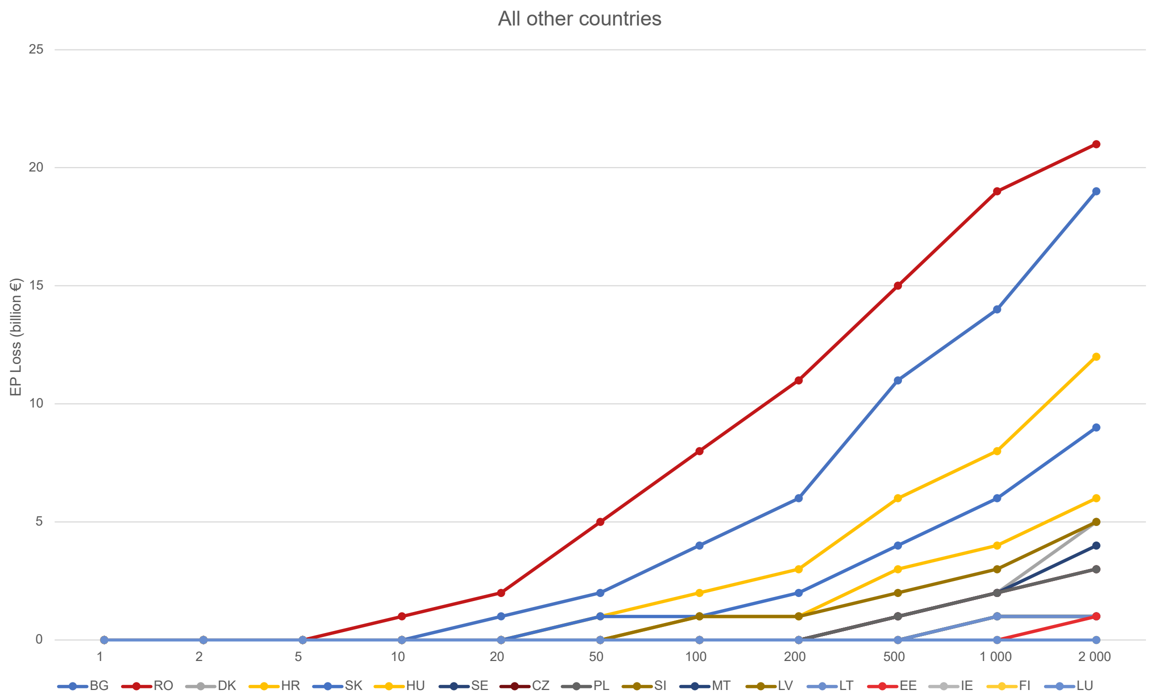
SEISMIC RISK		
Rank	**Country**	**AAL ratio**
1	Cyprus	0.19%
2	Greece	0.18%
3	Romania	0.12%
4	Italy	0.11%
5	Bulgaria	0.07%
6	Croatia	0.05%
7	Slovenia	0.04%
8	Austria	0.02%
9	Portugal	0.02%
10	Slovakia	0.01%

FLUVIAL AND SURFACE WATER FLOOD RISK		
Rank	**Country**	**AAL ratio**
1	Romania	0.14%
2	Slovenia	0.13%
3	Latvia	0.13%
4	Bulgaria	0.13%
5	Austria	0.12%
6	Slovakia	0.11%
7	Germany	0.10%
8	Czech Republic	0.10%
9	Hungary	0.10%
10	Poland	0.10%

Sources: GEM 2020; *JBA 2021.*
Note: AAL = average annual loss.

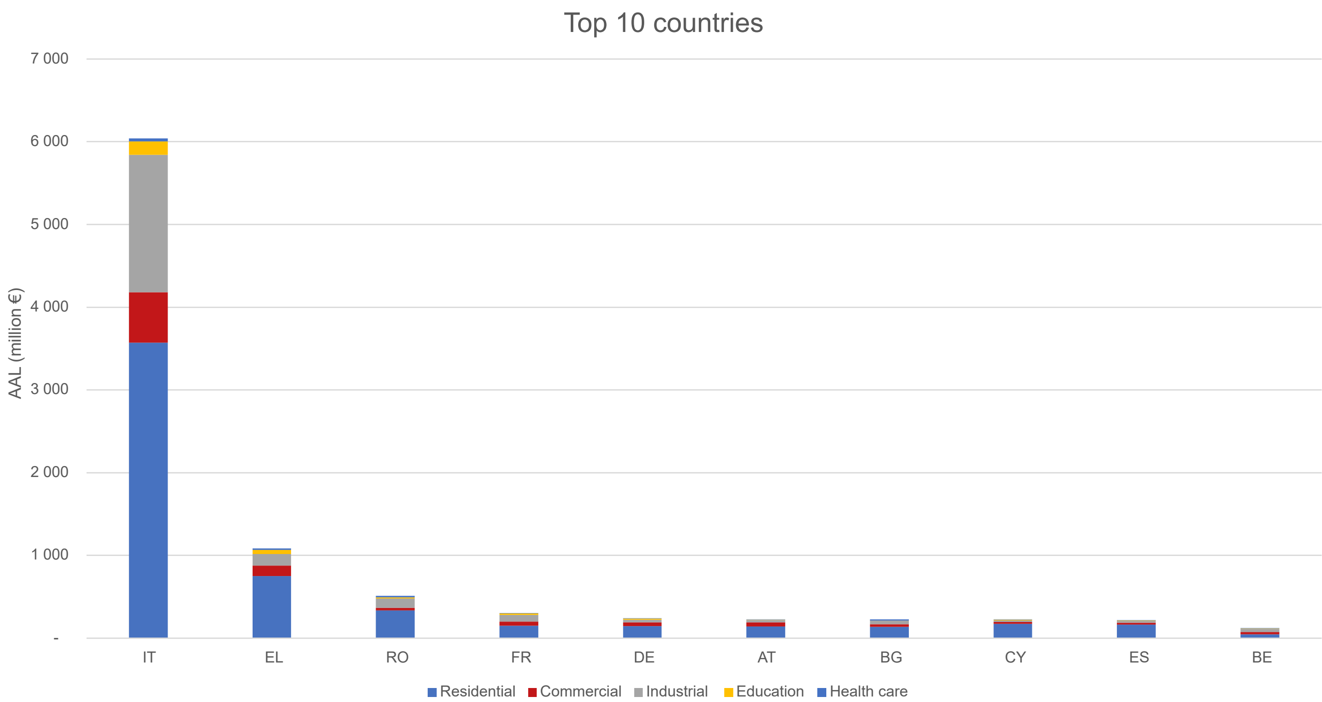
Figure 10. EP curves for earthquake, showing return period losses for each EU Member State. The countries loss ranked in the top 10 by 500-year return period are shown in the top figure, other countries in the bottom figure

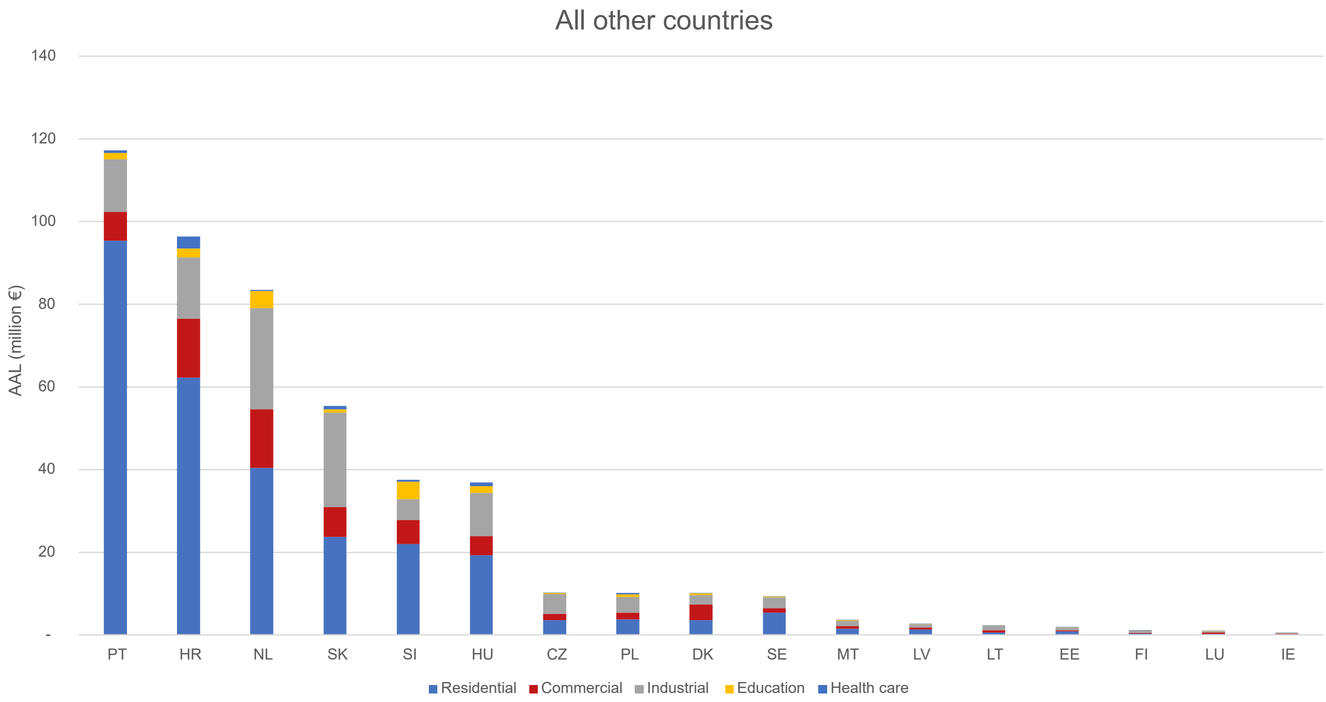




Source: GEM 2020.
Note: EP = exceedance probability.

Figure 11. Average annual seismic losses by sector for baseline risk analysis of EU Member States. The countries ranked in the top 10 by AAL are shown in the top figure, other countries in the bottom figure





Source: GEM 2020.

- *Figure 10* shows the variation in Member State seismic EP curves. The figure makes clear the potential for large losses from extreme events and indicates the frequency of events that drive the AAL. For instance, Italy and Romania have a steep EP curve, with losses exceeding a billion Euros from just a five-year return period, whereas in Greece similar levels of loss are seen from the 50-year return period and in Austria from the 200-year return period onwards.
- As AAL reduces, Member States tend to have a steep EP curve that shows little to no loss below a 50-year return period *Figure 10*, with losses arising almost entirely from events with return periods of over 200 years, and even then with absolute loss limited to hundreds of millions of euros.

FLOOD

- The highest absolute AAL due to fluvial and surface water flood is in Germany (€7.9 billion), France (€5.4 billion), and Italy (€2.0 billion) (*Table 8*), while Romania, Slovenia, and Latvia have the highest risk relative to the replacement cost of building stock included in this analysis.
- The countries most at risk of surface water flood (and therefore seeing the largest drops in AAL when considering fluvial flood only) are Malta (100% of loss due to surface water flood), the Netherlands (50%), Luxembourg (28%), and Belgium (22%). Conversely, only 1–2% of flood AAL is due to surface water flood in Bulgaria, Romania, Lithuania, and the Czech Republic (*Table 8*).
- All countries except for Cyprus show an increase in AAL between 2020 and 2050. Both Ireland and Sweden experience a 50% increase in AAL from 2020 to 2050, the largest increase in the EU; several countries experience a 20-30% increase (see *Table 8*).

Table 8. AAL, surface water component of AAL, and change from 2020 to 2050 for flood risk

COUNTRY	2020 AAL: FLUVIAL AND SURFACE WATER (€ MILLION)	SURFACE WATER COMPONENT OF 2020 AAL	CHANGE IN AAL 2020-2050 (FLUVIAL ONLY)
Germany	7,853	10%	25%
France	5,362	8%	21%
Italy	1,972	17%	14%
Austria	1,527	4%	24%
Spain	1,327	7%	25%
Sweden	1,047	13%	50%
Poland	949	5%	31%
Czech Republic	799	2%	30%
Netherlands	798	50%	38%
Romania	616	2%	11%
Belgium	514	22%	16%
Slovakia	440	3%	25%
Bulgaria	429	1%	16%
Hungary	333	4%	16%
Finland	280	11%	24%
Denmark	233	13%	9%
Greece	209	7%	15%
Lithuania	187	2%	30%
Latvia	168	7%	12%
Ireland	154	3%	50%
Croatia	147	5%	19%
Slovenia	123	4%	18%
Portugal	83	6%	18%
Estonia	46	14%	15%
Luxembourg	29	28%	22%
Cyprus	13	10%	-9%
Malta (SW only)	2	100%	n/a (SW only)

Source: JBA 2021.
Note: AAL = average annual loss; SW = surface water.

- Residential buildings contribute over 65% of AAL in Italy, Spain, and Portugal, but just 35% in Poland and Lithuania; the average contribution of residential buildings across all countries is 50%. The relative contribution to total AAL is shown in *Figure 12*.
- Poland, Romania, Hungary, and Finland have the highest absolute contribution from public buildings (education and health care) at around 32–38% of total AAL in each country.
- *Figure 13* shows the EP curves for each country. Beyond the 1-in-200-year return period, most countries have little further increase in the estimated loss. Substantial increases in loss at higher return periods are however seen for Bulgaria, Belgium, Slovakia, Hungary, Latvia, and Croatia.
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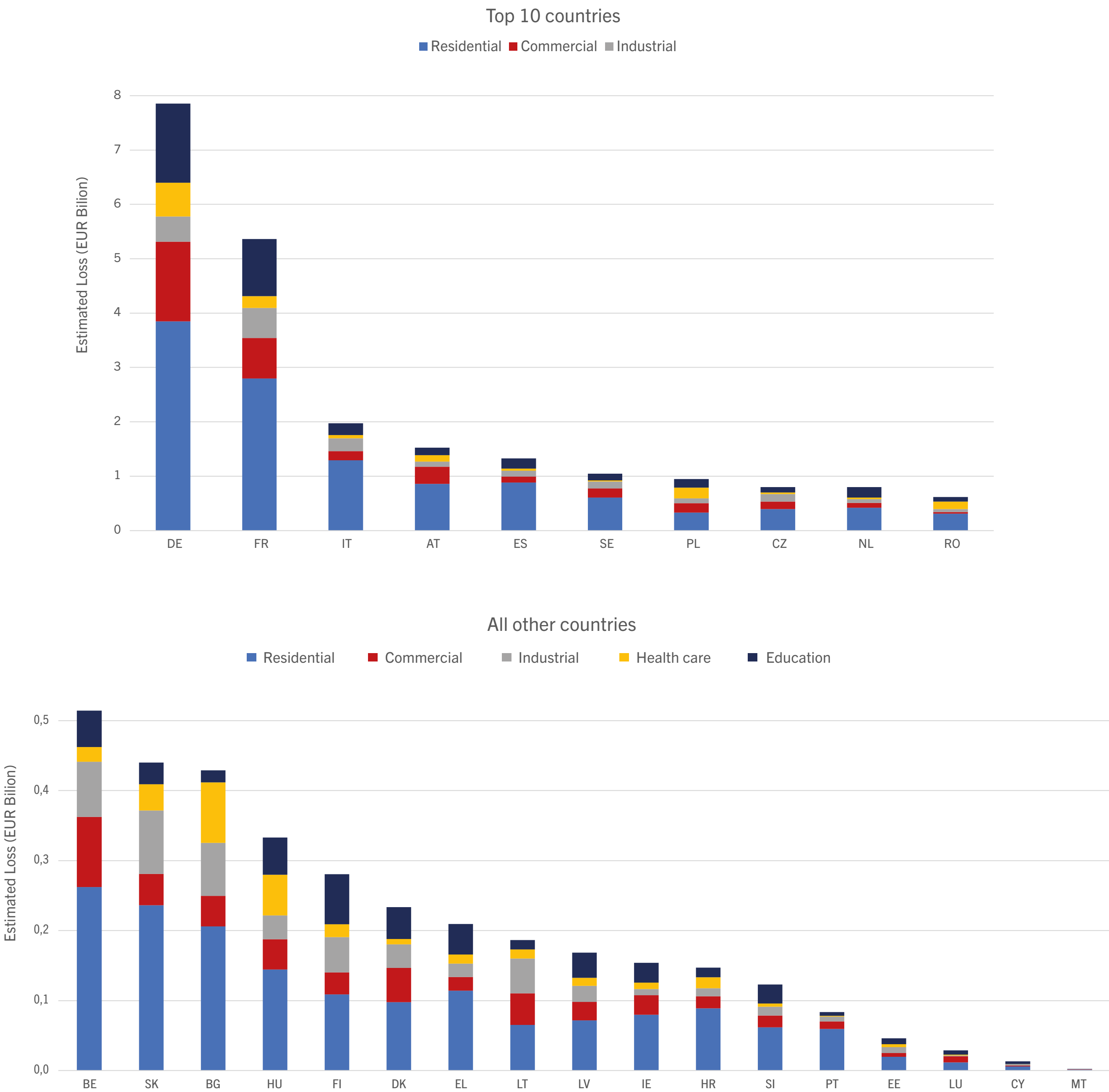
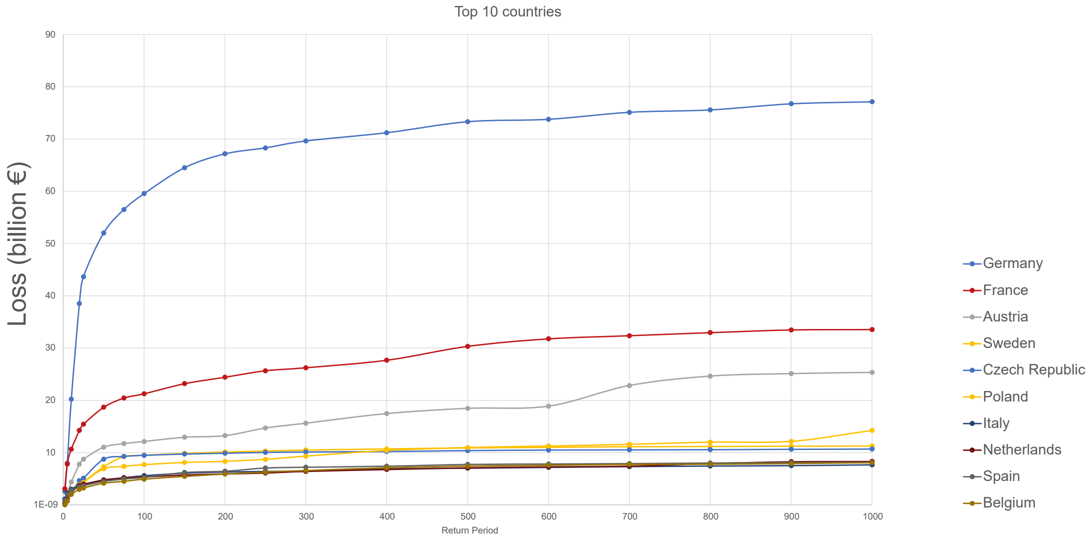
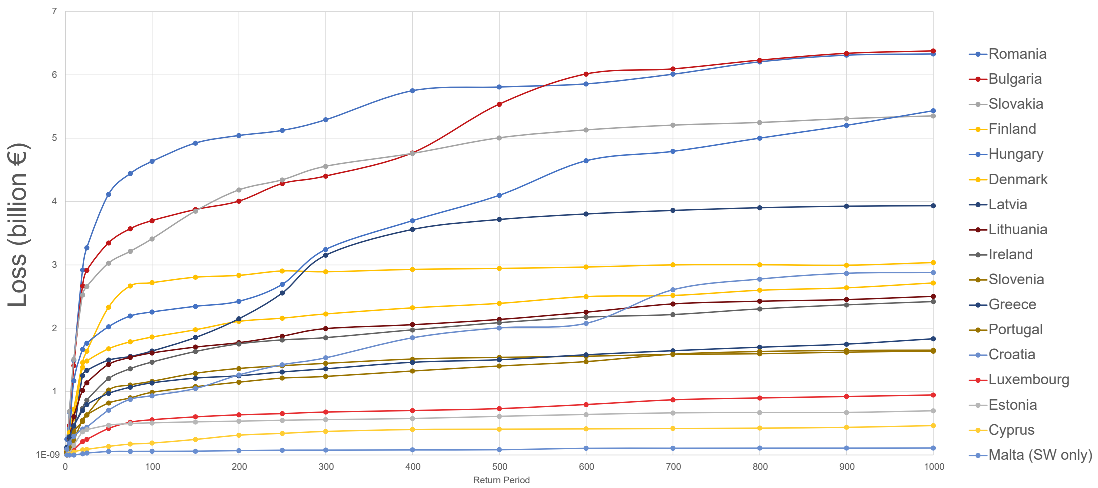
Figure 12. Breakdown of average annual flood losses by sector: Top-10 countries (above) and all other countries (below)



Source: JBA 2021.
Note: AAL = Average annual loss.

Figure 13. National fluvial and surface water flood occurrence EP (OEP) curves for all sectors combined. Top-10 countries (above) and all other countries (below), ranked by 100-year return period loss





Source: JBA 2021.
Note: SW = surface water.

Validation of Results

SEISMIC

The hazard model was validated to the extent possible in the ESRM-13 project; according to Woessner et al. (2015), "rigorous statistical validation of shaking hazard estimates is not possible to date", and "it is impossible to test for maximum magnitude". However, components such as the source model earthquake rates were tested.

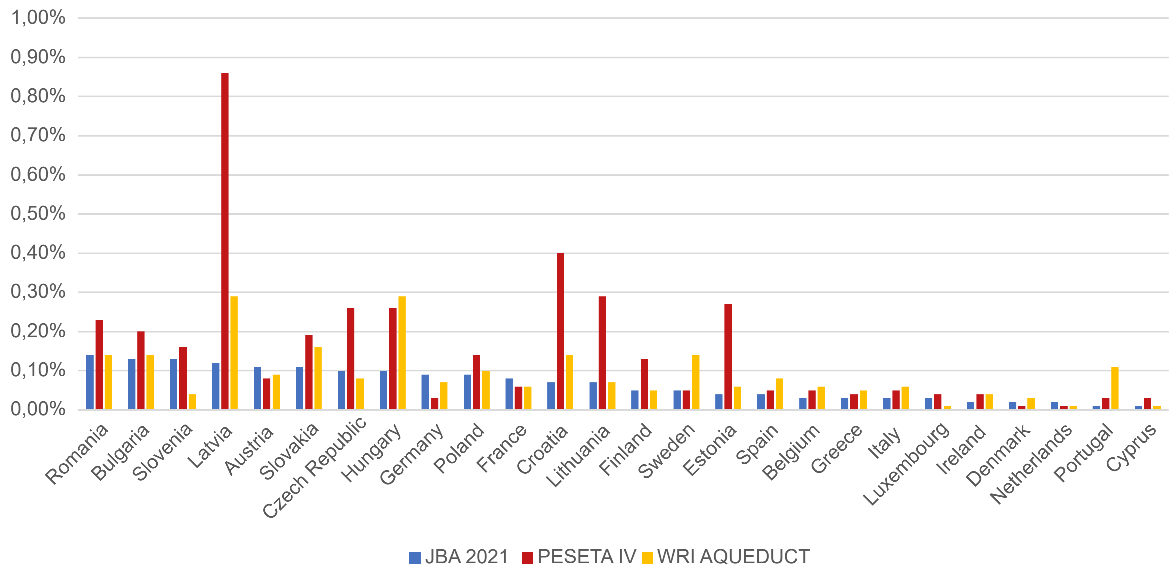
The exposure and vulnerability components of the seismic model have been validated in the course of its development under the ESRM20 project (Crowley et al. 2020b). Sanity checks of relative exposure values and comparison against census data or publicly available GDP estimates were performed. Checks of relative vulnerability between construction types and comparison against existing sources of vulnerability information were used to validate the vulnerability relationships. Comparison between this and other seismic models for the region have not been conducted for this study due to lack of access to comparable models. However, to check the validity of risk estimates in ESRM20, AAL ratios across building classes and cities have been compared, as have simulated and observed losses for over 20 past events in Europe. The comparisons show reasonable alignment. For more details on this testing, see Crowley et al. (2020b).

FLOOD

On an EU-wide scale, the annual average risk estimated by GEM and JBA exceeds insurance industry estimates of loss for 1980–2017. According to AON Impact Forecasting and Munich Re, during this period earthquake caused €86–140 billion of loss (AAL €2.4–3.8 billion) and flood caused €160–217 billion (AAL €4.3-5.9 billion). This compares to €9.7 billion in seismic AAL and €25.6 billion in fluvial and surface water flood AAL. To carry out a comparison with PESETA IV river flood AAL estimates, the surface water component is removed, giving an estimated EU-wide AAL of €23.0 billion, compared to just €7.8 billion from PESETA IV. However, the basis of exposure used to develop these estimates differs greatly: it is a combination of land use and GDP per capita in PESETA IV, but replacement cost on distributed building stock from five sectors in this analysis. For example, public buildings contribute only €5.9 billion of the total in this analysis.

Generally, a comparison of fluvial flood AAL ratios (relative to GDP in PESETA IV, urban asset value in WRI AQUEDUCT, and building stock replacement cost in this analysis) shows reasonable agreement in many countries (*Figure 14*), though notable differences compared to PESETA IV are shown for Czech Republic, Croatia, Lithuania, Finland and Estonia. There are also notable differences between JBA and WRI in Sweden and Portugal, while JBA shows much lower losses than both models for Latvia and Hungary.

Figure 14. Comparison of fluvial flood AAL ratios under JBA, PESETA IV, and AQUEDUCT modelling



Source: World Bank *calculations based on JBA (2021), PESETA IV (Vousdoukas et al., 2020), and WRI AQUEDUCT (WRI 2020) data.*
Note: AAL = average annual loss; AALR = average annual loss ratio; SW = surface water.

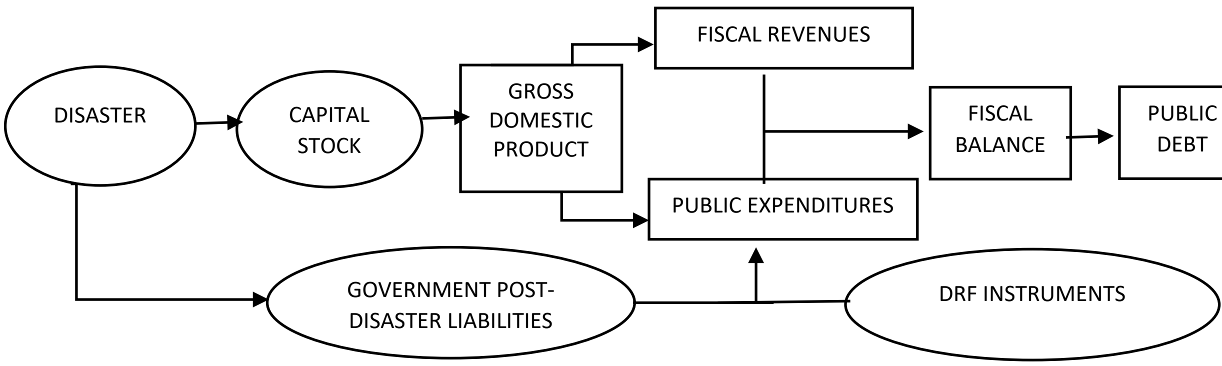
4. Structure of the Macro-economic Model

The model assesses the potential impact of disasters in the main macro-fiscal indicators and provides reference information for decision-making to implement policy measures that strengthen the resilience of public finances against earthquakes and floods.

To assess the impact of natural disasters on macro-economic and fiscal variables such as GDP, fiscal revenues, public expenditure, pubic debt, and the overall fiscal balance, a standard Solow-Swan economic growth model is used.

The logical chain describing the impact of disasters is illustrated in *Figure 15* below.

Figure 15. Impact of a severe event on the real and fiscal sectors of the economy



Source: World Bank.

The transmission of the impact on the real and fiscal sectors of the economy has been divided into three blocks:

1. The first block contains exogenous information about the disaster shock or impact on the stock or balance of capital. It serves as input for the growth model. At this stage, damage and loss due to fluvial floods and earthquakes are modelled in the residential, industrial, commercial, and public (including health and education) sectors, and the losses are translated to reduction in capital stock.
2. The second block translates the impact on the balance of capital stock into the real sector of the economy, where the main variable of interest is the effect on GDP and economic growth. In this block, a Solow-Swan type economic growth model is used with a Cobb-Douglas function, which includes the capital stock or balance as one of its determinants.
3. Finally, the third block corresponds to the fiscal sector. It translates the impact on the real sector to fiscal variables such as fiscal revenues, public spending, and thus fiscal deficit and public debt, in the following manner:
    - First, a disaster shock reduces the accumulation of capital, shrinking the economic output.
    - Second, the shock worsens the government's fiscal position in two ways: the shock reduces the revenue base, as the deterioration in economic activity negatively impacts tax collection; and at the same time it increases public expenditure, as the government responds to meet emergency and reconstruction needs.

Disaster Shock

In order to represent the uncertainty associated with disaster event occurrence, 1,000 realizations of potential earthquake and flood events are modelled over the next 30 years for each of the EU MS. The damage and loss that occur as a result of these events consider the population and building stock evolution and climate change over the next 30 years (see Chapter 3 on catastrophe modelling). The damage and loss in the residential, industrial, commercial, health, education, and public sectors contribute to the reduction of capital stock, which in turn affects the country's GDP.

GDP Growth Model

The model considers the damage shock in the stock of capital using a Solow-Swan long-term economic growth model (World Bank 2018) with a Cobb-Douglas production function to capture the disaster impact in the real sector of the economy.

The first step to assess the macro-fiscal impacts of severe events is to establish the growth model, where GDP (Y_t) is modelled based on capital stock (K_t), human capital per worker ($h_t L_t$), and a technological efficiency parameter that measures productivity (A):

$$Y_t = A_t \, K_t^{1-\beta} \, (h_t L_t)$$

Parameters β and $1-\beta$ represent the elasticity of capital and labour, respectively.
The complete model consists of three main building blocks:

- Production function: $Y_t = A_t \, K_t^{1-\beta} \, (h_t L_t)$
- Accumulation of capital: $K_{t+1} = (1-\delta_t) K_t + I_t$
- Demography and labour market: $y_t = \frac{Y_t}{N_t} \frac{L_t}{W_t} \frac{W_t}{N_t} \; A_t k_1^{1-\beta} h_t^{\beta} \rho_t \omega_t$

In the above equations, the following notations are used:

Y_t - GDP

y_t - GDP/capita

A_t - Total factor productivity

N_t - Total population

W_t - Working-age population

K_t - Capital stock

L_t - Number of workers

I_t - Gross investment

ρ_t - Participation ratio

ω_t - Ratio of working-age population to total population

h_t - Human capital per worker

δ_t- Depreciation rate

β - Participation of human capital in GDP

$1-\beta$ - Participation of labour in GDP

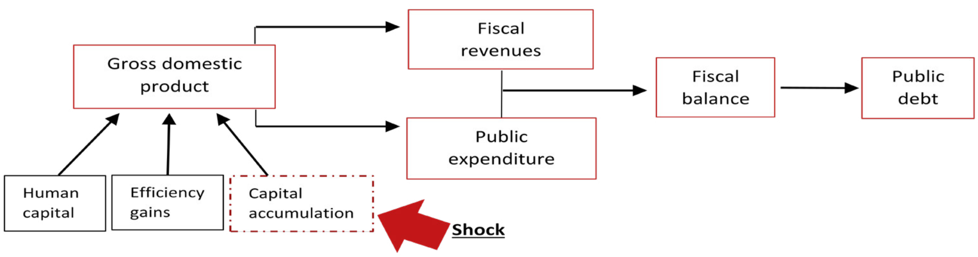
In line with the empirical evidence, the model assumes that the shock or impact on the capital stock is not fully translated in lower growth. The destroyed productive capital will depend on the characteristics of the type of event. For example: a drought event tends to have a greater impact on production of agricultural goods than on productive infrastructure. In contrast, a seismic event tends to affect the productive infrastructure to a greater extent. In this model, we assume that asset losses translate to a 75% reduction in capital stock, where resilient adaptation strategies can be used to sustain productivity.

The model incorporates the shock on the capital stock in the following manner: if the catastrophic event occurs at time t, then the impact on capital stock will be $K_{t+1} = d\,[(1-\delta_t)\,K_t + I_t]$ where $d \in [0,1]$ is the proportion of shock transmitted to the capital stock, and the capital stock is rebuilt according to the investment rate (I_t).

Fiscal Sector Model

The government is responsible for the implementation of public policies through the provision of public goods and services, as well as transfer income, supported mainly by mandatory tax collection. Accordingly, the government carries out its fiscal policy through two main instruments: public expenditure and fiscal revenues (see *Figure 16*). Public expenditure represents (i) non-financial public expenditure, Gt, such as spending on salaries, pensions, acquisition of goods and services, and public investment; and (ii) financial expenditure, $i_t D_{t-1}$,the spending on interest payments from previously incurred liabilities.

Figure 16. Potential fiscal impacts of disaster shocks



Source: World Bank.

To finance its operations, the government primarily relies on fiscal revenues (Rt), which in turn can be disaggregated into tax revenues and non-tax revenues such as royalties. If fiscal revenues are not sufficient to cover public expenditure, the government incurs a fiscal deficit, which, in the absence of financial assets or other instruments, may be financed by an increase of public debt (for example, through loans or debt instruments such as treasury bills or bonds).

Figure 17. Structure of fiscal accounts

Source: World Bank.

The model makes it possible to assess the impact of the disaster shock on public finances through its potential impact on the fiscal accounts. For this purpose, we rely on the government flow budget constraint, which is a mathematical representation of government operations where the difference between fiscal revenues and public expenditure (financial and non-financial) determines fiscal deficit and the change in public debt (see *Figure 17*).

A disaster event has possible implications for both tax revenues and public spending. In particular, the effects of disaster are transmitted to the fiscal accounts in two ways: first, disasters could generate lower tax revenues as the deterioration of economic activity (decrease in GDP) impacts tax collection; and second, disasters demand additional public expenditure spawned by response and reconstruction costs and additional funds required to boost economic activity. Thus, severe disaster events usually increase the fiscal deficit, which in countries that lack DRF instruments could lead to an increase in the debt-to-GDP ratio.

The effects on fiscal revenues (R_t) and public non-financial expenditure (G_t), which may reflect changes in the primary balance, reflect deviations of the fiscal balance and the level of public debt (D_t), where i_t is the average interest rate for debt payment:

$$G_t + i_t D_{t-1} - R_t = D_t - D_{t-1}$$

The expenditures (Gt) are comprised of non-disaster-related expenditures and government liabilities, which include emergency response costs, public asset reconstruction, and any household post-disaster assistance net of any DRF instruments. Finally, the increase in public debt is calculated according to the formula below:

$$D_t = (1 + i_t)D_{t-1} -(G_t\text{-}R_t)$$

To reflect the impact of the disaster shock on fiscal revenues, we use the implicit elasticity of fiscal revenues to GDP for each corresponding country. A similar approach is taken to estimate non-disaster-related expenditures. In estimating the public debt, we assume that the revenues cannot surpass expenditures by more than 1%. To estimate the elasticity of expenditures and revenues to GDP, an ordinary least squares (OLS) model was used, considering for each country the historical data on real government expenditures, real government fiscal revenues, and real GDP.

Effect of Disaster Risk Finance Instruments on the Fiscal Sector Model

To understand how pre-arranged DRF instruments impact fiscal outcomes, the model includes the following variables for 27 EU MS:

- Government liabilities
- Reserve and contingency funds
- Residential insurance penetration (expressed as the proportion of the total households covered) and limits of cover
- Poverty levels
- Proportion of emergency response cost to total disaster cost

EU MS use a different combinations of risk financing instruments to address their differing levels of risk, and some assumptions and limitations of this model for including these instruments are presented below.

Government liabilities include all the post-disaster costs that are expected to be covered through the public budget. They comprise support to the affected households, reconstruction of public assets, and emergency response costs. Total government liabilities are the costs of government-covered residential and public asset losses and emergency response costs net of insurance, but they do not consider the effect of reserve and contingency funds. Net government liabilities refer to the same as above, except they consider the effect of reserve and contingency funds, thus resulting in lower liabilities. Due to the lack of a comprehensive data set on DRF (particularly the lack of data on public asset insurance), the model reviews two potential scenarios:

- A **low- liability scenario** (Scenario A), where the government is expected to reconstruct damaged housing of low-income uninsured households[30], reconstruct all public assets (with one-third of these assets insured), and to cover the emergency response costs,
- A **high-liability scenario** (Scenario B), where the government is expected to reconstruct damaged housing of all uninsured households[31], reconstruct all public assets (with no public asset insurance in place), and to cover the emergency response costs.

Under both scenarios, commercial and industrial losses are entirely excluded from the government liabilities, which might not be the case in practice (governments do often support businesses following major disasters). For example, in Luxembourg, the government can help companies that suffered prejudice arising from natural disasters, according to Law of 9 August 2018, On an Aid Scheme for Small and Medium-Sized Enterprises.[32] However, this is rarely an explicit liability of the government, and the size of the government's role in private sector recovery is often determined ad hoc.

DISASTER RISK FINANCING INSTRUMENTS IN THE MACRO-FISCAL MODEL

Reserve funds contribute to reducing macro-fiscal impacts of disasters by providing rapid funding and reducing the need for budget reallocation or borrowing. The model reduces the total loss of each event in country by the amount of its reserve fund. This analysis accounted for reserve funds that (i) explicitly cover disaster costs; (ii) indicate support towards disasters among their key objectives but might aim to cover other types of unexpected costs; and (iii) cover general contingency needs (assumed available for all the EU MS). There are a few key caveats, however:

- **Treatment of general contingency funds**. The analysis comprises general contingency funds that do not include disasters as their key funding scope. However, (i) data were generally unavailable on the amounts of these funds, so their average size was assumed at 0.5% of total 2019 revenues; and (ii) given these funds can be used for other contingencies, assuming their full availability for disasters might be an overstatement (however, the model still assumes their full availability).
- **Treatment of ad hoc reserve funds and local funds.** Ad hoc funds are not included in the analysis; only pre-arranged funds are included. Local-level reserve funds are also not considered, although they may play an important role in post-disaster financing, especially in countries with more responsibilities allocated to the subnational level (e.g., Germany). However, because the study focuses on losses at the national level, these funds are excluded from the estimates.
- **Treatment of particular cases of reserve funds.** Some reserve funds cover an explicit post-disaster scope, such as compensations, and some can also be used for broader disaster risk management financing, such as preventive activities. Given the challenges in identifying a part of financing aimed at response and recovery as opposed to other activities, and given the lack of access to funds' standard operating procedures (which would allow full assessment of their scope), the reserve funds are assumed to be fully available.
- **Further refining due to some outdated data and lack of legal/policy supporting documents.** Some data used are outdated and supporting legal or policy documents are not always publicly available. Moreover, the amount of funding available is not always derived from budget documents (such as annual budget laws), as these do not always explicitly include contingency or reserve funds. In view of this limitation, further refining for this analysis is important.

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30 based on Eurostat at risk of poverty rates

31 often the case after the most destructive disasters, e.g., earthquakes

32 Luxembourg Government, "Funding and Aid," https://guichet.public.lu/fr/entreprises/financement-aides/regime-pme/aides-generales-pme/aide-dommages-calamites-naturelles.html.

The EUSF is integrated into the model through its capacity to reduce macro-fiscal impacts. The EUSF is used to finance public spending on disasters, assumed as government liabilities in the model. The model considers minimum national disaster loss thresholds (provided in *Annex 9*) as "activation" points and estimates how often disasters at national level exceed this threshold. Once the aforementioned threshold is breached, the model assumes a certain share of the government liabilities is covered with aid from the EUSF, up to an annual cap of €660 million for floods and earthquakes among all EU MS, estimated on the basis of historical share of EUSF used for these two disasters[33]. The share of government liabilities that will be covered using EUSF aid is calculated based on the analysis of previous flood and earthquake disasters for the period 2002–2020 ; it is assumed that 15% of the total government liabilities from a qualifying disaster event are requested to be covered by the EUSF.

In the model, if the annual EUSF amount is not sufficient to cover all events that meet the EUSF funding criteria, the disbursements for a given year across all MS will be scaled proportionally: *(country's EUSF request) x (total EUSF annual fund) / (sum of all countries' EUSF requests).* This assumption is necessary, because the model does not have enough information on which events will be funded and which will be rejected without introducing bias.

Contingent credit arrangements have not been identified in the reviewed EU MS, except for the World Bank CAT DDO in Romania. Because there is an uncertainty in these findings and some contingency credit arrangements might be available, CAT DDOs were not factored into the macro-fiscal analysis (but were included in the funding gap analysis; see the Romania case study in *Chapter 5*).

Data on **public asset insurance** penetration in Europe are limited. Bräuninger et. al. (2011) mentions that only one-third of private and public assets in the EU are insured against flood and drought (with public assets generally uninsured). The above-mentioned study provides a basis for two assumptions in the model: the low-liability scenario assumes 33% of public asset losses are covered by insurance, and the high-liability scenario assumes no assets are covered. The model assumes that the government will cover reconstruction of all the uninsured public assets.

Data on **household insurance** is more widely available; there are multiple sources of data on penetration of private property insurance against catastrophes (measured as the number of households insured). Where data sources provided ranges of households insured, the study selected the upper limits, but aimed to rely mostly on the following data sources, listed in the order of priority: country's financial supervision authority reports, AXCO market studies, data from international organizations (such as OECD and EC EUROPA reports), and secondary data sources (such as university research and publications). The model assumes that catastrophe insurance for households reduces the losses (although it considers separately what share of total losses will be borne by the insurance sector).

Emergency response costs are those costs incurred by the responders (in this case the government) immediately after a disaster occurs; they are associated with immediate relief activities, debris removal, etc. For the purpose of both the macro-fiscal model and the funding gap analysis, we consider that emergency response costs in the model are added on top of total asset losses, as a percentage of the total ground-up losses to residential dwellings, commercial and industrial establishments, public buildings, schools, and hospitals. Various studies offer different shares of the size of emergency response costs if compared to total disaster damage or total asset losses. This study uses previous emergency cost estimates prepared by AIR Worldwide and based on disasters in Central America, and then adjusts these for the European context, to ensure they are not underestimated. The final percentage used for this study differs by peril; it is 20% for earthquake and 15% for flood. The percentages are considered the same for all MS.

See *Annex 8* for technical details on how DRF instruments are integrated in the model.

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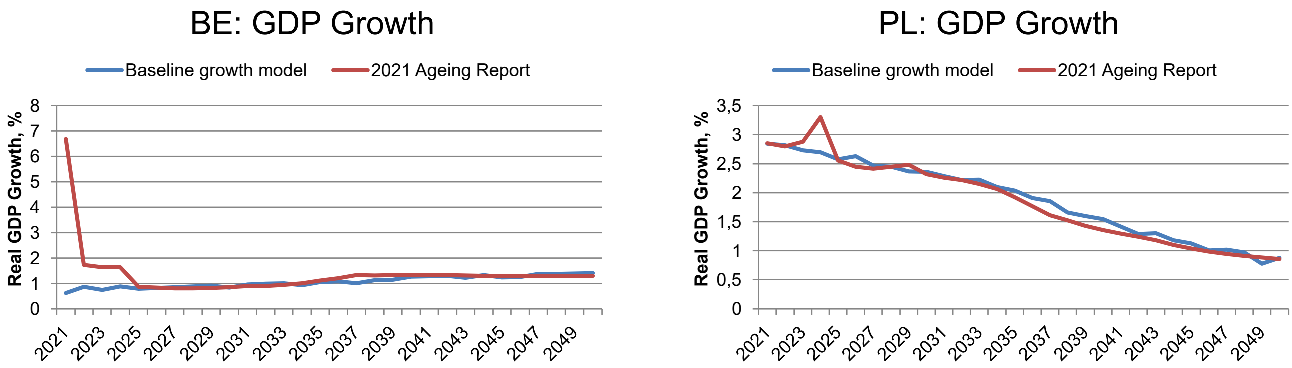
33 The cap is estimated from the historical analysis which shows that approximately 87% of all payments made were for earthquake and flood and then allocates and annual share to only EQ and FL, following the following formula = ((€1.200 million * 75%)/2) + (€1.200 million * 25%) and adjusted to inflation = €761 million * 87% = € 662 million (rounded to €660 million for the purpose of the analysis).

Macro-Fiscal Inputs to the Model

For the macro-fiscal analysis, we adopt a neoclassical Solow-Swan framework to identify the effects of disaster on macroeconomic variables such as GDP. To set up the baseline model, i.e., one where no disaster occurs, we use data for the years 2000–2019 from multiple sources: population and related variables come from the World Development Indicators, model parameters come from the Penn World Table (PWT), and GDP and related variables come from the Eurostat database.[34] *Table 9* below lists the variables. All monetary values are expressed in millions of euros. The baseline GDP growth model was further calibrated to align with the projected GDP growth rate from the EC 2021 Ageing Report (*Figure 18* reports two examples of calibration, for Belgium and Poland). It should be noted that the calibration was done to consider the longer-term GDP growth trend (projection over the next 30 years), which might not be reflective of short-term growth rates associated with COVID-19 recovery.

Figure 18. GDP growth calibration for Belgium (left) and Poland (right) under baseline scenario (i.e., no disaster impacts) based on 2021 Ageing Report



Source: World Bank analysis based on Eurostat data and EC 2021 Ageing Report

Projections of *"population"* and *"ratio_pop_wa"* variables for 50 years (2020–2069) come directly from the projections reported in the Eurostat database. We also use GDP projections from the 2021 Ageing Report.

Table 9. Variables

VARIABLE NAME	VARIABLE DESCRIPTION	DATA SOURCE
Population	Total population of a country	WDI
ratio_pop_wa	Percentage of population aged 15–64 years	WDI
part_rate_wa	Labour force participation rate, total: labour force participation as the percentage of total population aged 15–64 years (modelled ILO estimate)	WDI
GDP_defl	GDP deflator index (implicit deflator), with base year 2010 = €100	Eurostat
rev_n_baseline	General government revenues, million €, nominal	Eurostat
expend_n_baseline	General government total expenditure, million €, nominal	Eurostat

34 World Development Indicators Database, https://databank.worldbank.org/source/world-development-indicators; Penn World Table, https://www.rug.nl/ggdc/productivity/pwt/related-research; Eurostat, https://ec.europa.eu/eurostat/data/database.

GDP_r	Real GDP, million € chained to a year	Eurostat
GDP_n	Nominal GDP, million €	Eurostat

Sources: World Development Indicators Database, https://databank.worldbank.org/source/world-development-indicators; *Eurostat,* https://ec.europa.eu/eurostat/data/database.
Note: ILO = International Labour Organization; WDI = World Development Indicators.

The autoregressive integrated moving average (ARIMA) method was used for forecasting the variables (except for GDP) for the future years 2020–2069. For this purpose, we first determine the levels of autoregressive (AR), integration (q), and moving-average (MA) components, and then set up the projection models accordingly for each country separately. In addition, two GDP variables, "*GDP_r*" and "*GDP_n*" are determined within the model for the years 2020–2069.

Calculating the effects of disaster requires parameterizing the contributions of labour, capital, and human capital in GDP, among others. Parameters are available only for the years 2012–2017. Therefore, we take the average of the reported annual values of respective parameters over 2012–2017 (see *Table 10*).

First, we use production elasticity of labour from the PWT database, where it is directly reported as "*labsh*". The rate of depreciation ("*delta*") and the ratio of investment to GDP ("*csh_i*") also come from the same source. We then use the initial values (i.e., 2019 values) of the capital-to-GDP ratio and gross debt. Of these, initial (2019) capital-to-GDP ratio is calculated as the ratio of real per capita capital (i.e., "*rnna*") and real per capita GDP (i.e., "*rgdpna*") from the PWT database. The initial (2019) gross debt comes from the Eurostat database.

The PWT database reports the level of human capital (i.e., "hc"), which we use to calculate the human capital growth rate as $\frac{hc_t - hc_{t-1}}{hc_{t-1}}$, where *t* denotes time.
Similarly, we use the total factor productivity (i.e., *"rtfpna"*) reported in the PWT database to calculate its growth rate. Finally, exchange rates from local currency to euros come from the Eurostat database.

Table 10. Parameters

VARIABLE	DESCRIPTION	SOURCE
beta	Production elasticity of labour	PWT
delta	Rate of depreciation	PWT
invest_2_GDP	Ratio of investment to GDP	PWT
k_2_GDP_i	Initial (2019) capital-to-GDP ratio	PWT
pub_debt_n_i	Initial (2019) gross debt	Eurostat
g_h_t	Human capital growth rate	PWT
g_tfp	Total factor productivity growth rate	PWT
exch_2_EUR	Exchange rate from local currency to €	Eurostat

Sources: Eurostat, https://ec.europa.eu/eurostat/data/database; *PWT,* https://www.rug.nl/ggdc/productivity/pwt/?lang=en.
Note: Parameters are averaged over 2012–2017.

Limitations and Opportunities for Future Model Enhancement

Results are to be interpreted considering the limitations of the model. Limitations are related to the specific model, even though this model allows building on simplicity to understand the impact of disasters. The model accuracy may also be affected by the length of the time series (30 years of projections using 20 years of historical data) and the fact that the years are not homogenous, especially due to the COVID-19 pandemic.

It is important to highlight that the model has several assumptions, related to both the real sector and the fiscal sector of the economy. In the case of the real sector, the assumption is the **impact on the stock of productive capital**. The impact of a disaster on the productive capital and productive capacity of the country is heterogeneous (for example, damages to some sectors will have a greater impact on productive capacity than will damages in others; and large businesses can continue production despite damages, whereas smaller businesses can be shut down by minor damages). In that sense, the percentage of the negative shock of the disaster that results in damage to productive capital and productive capacity can vary significantly and affect the results obtained in the model. One way to mitigate this is to model key economic sectors separately and consider how they contribute to the overall productive capacity using input-output or computable general equilibrium models.

The model also assumes that only 75% of asset losses translate to a reduction in capital stock. The impact of this assumption on the GDP loss is relatively large; assuming that 100% of the losses translate to capital stock reduction results in 33% increase in EU average annual GDP loss. Therefore, it is proposed that this assumption is investigated further in future model development

The Cobb-Douglas production function has several drawbacks in terms of reflecting changes in output due to a sudden capital stock change. The function is relatively non-sensitive i.e. the impact of a substantial absolute capital loss may be re-flected in a very low output loss, depending on the initial capital stock and the parameters of the production function. While this can be representative of a non-disaster time where capital accumulation or depreciation are relatively slow, the output tends to be more impacted following a sudden destruction of capital when more productive capital is damaged. There can also be a capital stock threshold below which the production takes significantly longer to recover. For future developments of the model, a minimum capital threshold can be considered, below which production is significantly affected.

In the current model, destroyed capital stock affects the GDP by decreasing the productivity of the most recent or "marginal" capital investments. Hallegatte et al. (2016) argue the destroyed capital in-cludes both marginal (new) capital and inframarginal (old) capital, where the productivity of the older capital is typically higher. One recommendation for future model development is to incorporate an adaptation of the Cobb-Douglas production function proposed by Burns et al. (2021) that uses the av-erage productivity of capital, thereby implicitly assuming that the destroyed capital includes a random selection of both high and low productivity capital. Using this technique, the GDP impacts of a disaster will be significantly larger.

The other assumption that is sensitive to the results of the model is based on the r**esponse of public spending to the disaster shock (expansive policy of public spending)**. Depending on the external conditions, the macro-fiscal strength, and intrinsic characteristics of the country, the fiscal policy response through an expansion of spending can also be heterogeneous, both in magnitude and temporality. Currently the model does not consider how government spending impacts the overall capital investment rate.

Another important limitation of the model is related to the ability to correctly estimate the **impact of natural disasters on public debt**. The impact of natural disasters on expenditures can be described more accurately than the impact on revenues; this situation negatively impacts the accuracy of the estimation for the fiscal balance, ultimately increasing the forecasting error for the public debt.

One limitation of the current model is the limited opportunity cost of disaster-related expenditures and impact on the overall capital investment. In the current model increased government expenditures associated with disasters are financed through disaster risk financing instruments or increase in public debt. While the additional public debt results in higher interest payments, the current model does not necessarily reflect the full extent of opportunity cost of disaster expenditures, in particular their impact on the GDP and the capital stock. It is recommended that in future iterations of the model, government disaster spending is linked to a decrease in productive capital investments. This will result in longer lasting disaster impacts on the GDP, and in turn government revenues.

Other future model development considerations may include:

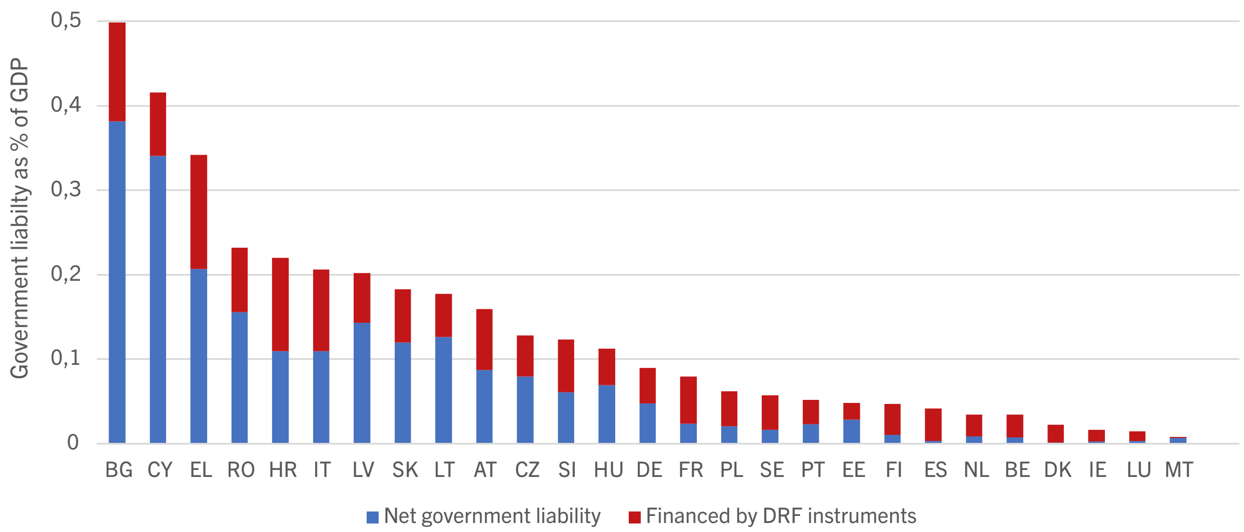
- Quantification of impacts associated with higher government debt, such as crowding out of private sector investment via higher interest rates.
- The impact of disaster funding speed and availability and on the recovery process, i.e., if sufficient funds are unavailable to repair damages in a timely fashion, recovery would be delayed and long-term economic impacts increased.

Results of Macro-Fiscal Analysis

To assess the macro-fiscal impact of disasters in EU MS, two above-mentioned scenarios were considered**.** Taking into account the existing risk financing arrangements, the analysis finds that several countries experience significant fiscal impacts.

In Scenario A (low government liability), in terms of total government liabilities, the annual average impact can be as high as 0.54% of GDP (Bulgaria). Other countries with high values of net government liabilities as a percentage of GDP include Cyprus, Greece, Romania, Croatia, Italy, and Slovenia (see *Figure 19*).

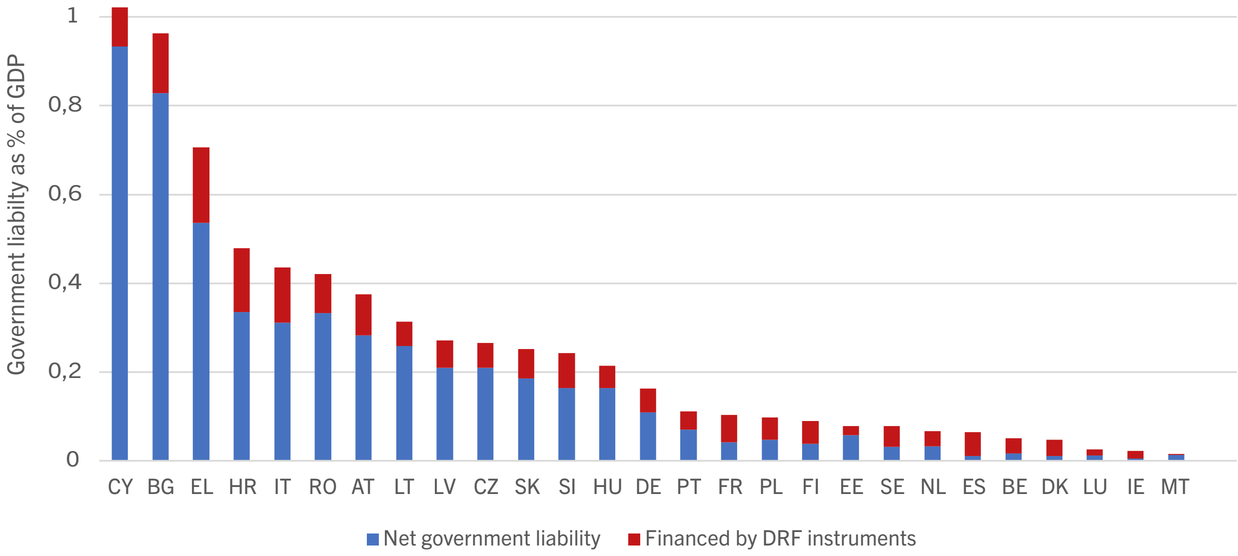
Figure 19. Countries sorted by average total government liabilities relative to GDP: Low government liability scenario



Source: World Bank.

In Scenario B, high government liabilities, in terms of total government liabilities, the annual average impact can be as high as 1.0% of GDP (Cyprus). Other countries with high values of total government liabilities as a percentage of GDP include Bulgaria, Greece, Romania, Croatia, and Italy (see *Figure 20*).

Figure 20. Countries sorted by average total government liabilities relative to GDP: High government liability scenario

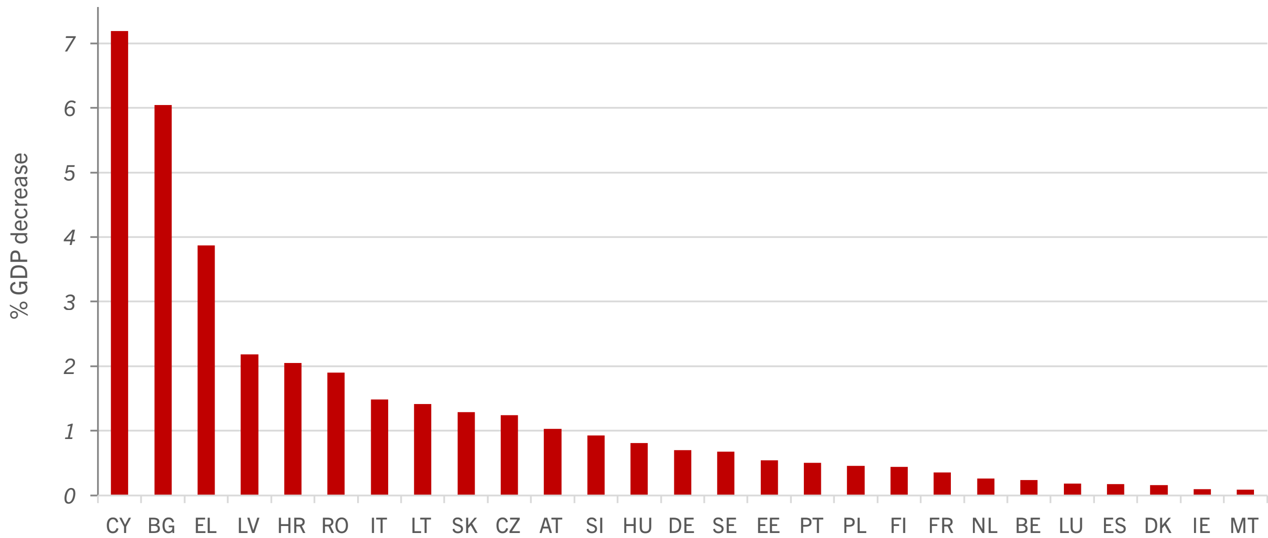


Source: World Bank.

Among the most affected countries, none have dedicated disaster reserve funds, although it is assumed that these countries have contingency funds available. Catastrophe insurance penetration for households differs across these countries, with the highest share of households insured in Slovenia (25% for both flood and earthquake insurance) and almost no households insured in Croatia (see details in section on risk transfer instruments in Chapter 2).

The countries with an average GDP decrease higher than 0.5% (to greater than 2% of decrease in GDP) are Cyprus, Bulgaria, Greece, Latvia, Croatia, and Romania (see *Figure 21*), in terms of overall annual average impact of disasters on GDP, i.e., the percentage difference in GDP projections with and without considering the impact of disasters.

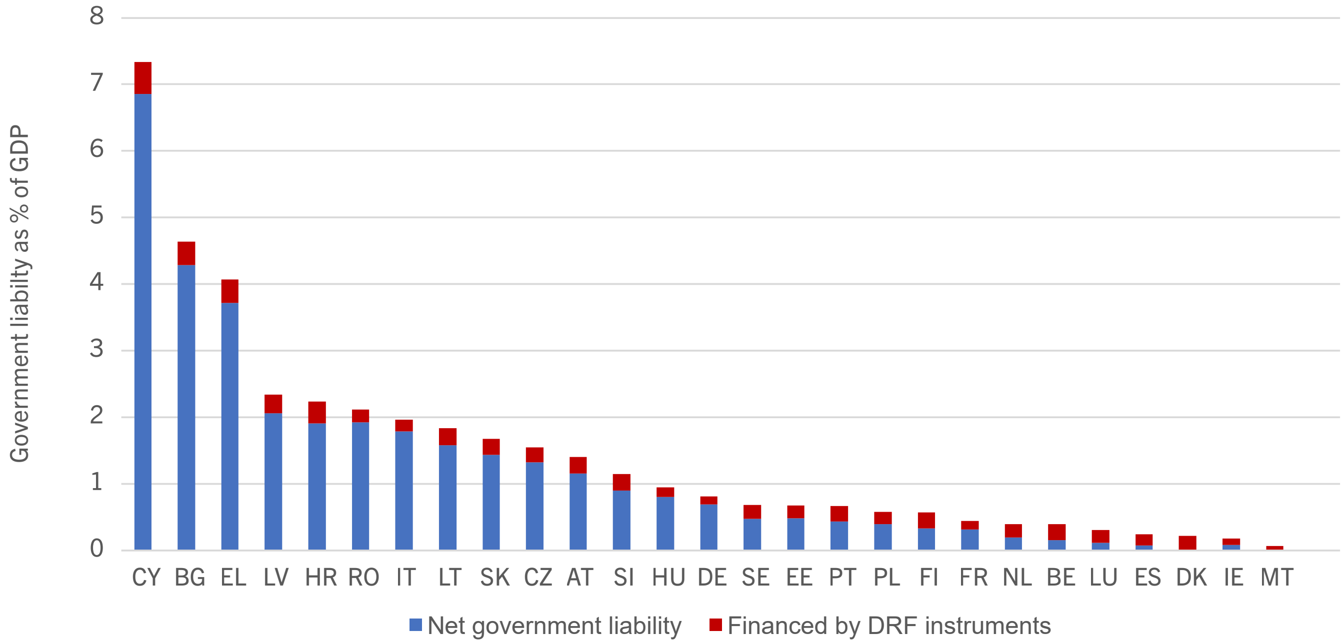
Figure 21. Countries sorted by average percentage GDP decrease from the baseline scenario due to disasters



Source: World Bank.

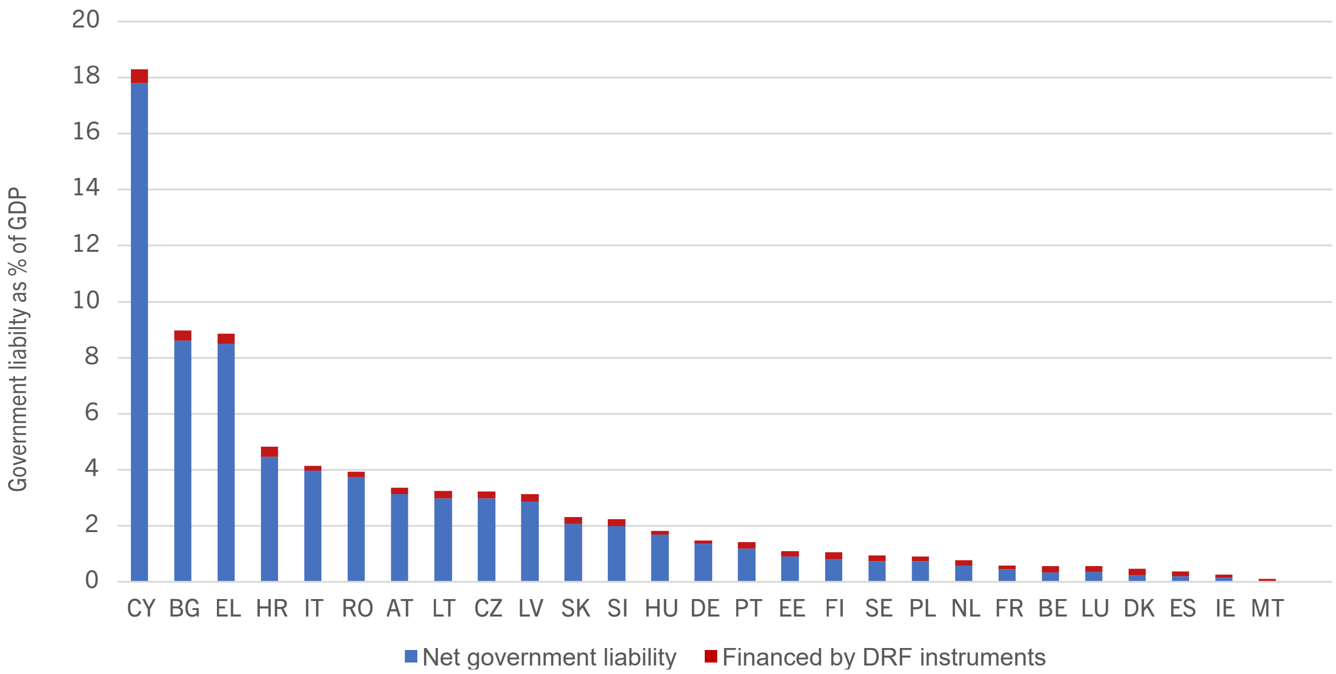
For major earthquake or flood, such as a 1-in-100-year event, fiscal impacts of government liabilities can exceed 7% of GDP for the low government liability scenario (see *Figure 22*) and 18% for the high government liability scenario (see *Figure 23*), as is the case for Cyprus.

Figure 22. Countries sorted by impact of government liabilities as a percentage of GDP for 1-in-100-year loss from earthquakes and floods (combined): Low government liability scenario



Source: World Bank.

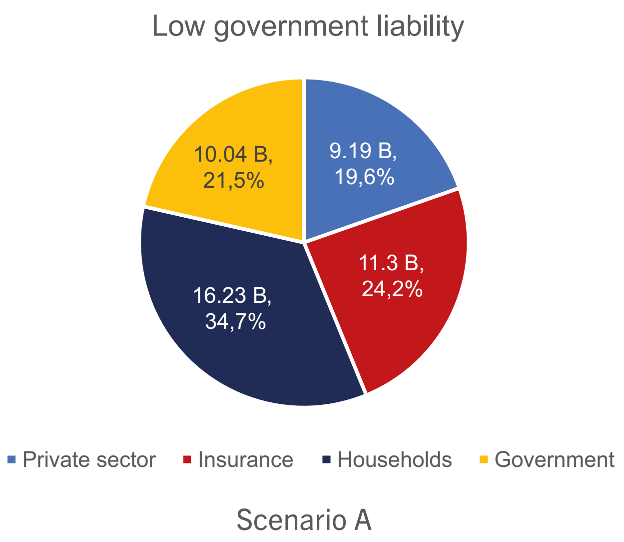
Figure 23. Countries sorted by impact of government liabilities as a percentage of GDP for a 1-in-100-year loss from earthquakes and floods (combined): High government liability scenario

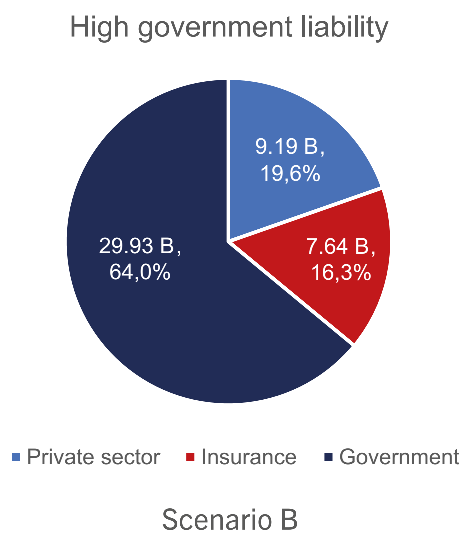


Source: World Bank.

On average in the EU, about 35% of liabilities in Scenario A and 64% of liabilities in Scenario B are retained by the government and are expected to be funded through ad hoc risk financing instruments, such as borrowing, budget reallocation, donor aid, or increased taxation (see *Figure 24*). Only a few countries have pre-arranged financing in place, and in fact high insurance penetration helps reduce government contingent liabilities.

Figure 24. Distribution of sector liabilities across EU MS for average annual loss: Low-liability scenario (left) vs. high-liability scenario (right)

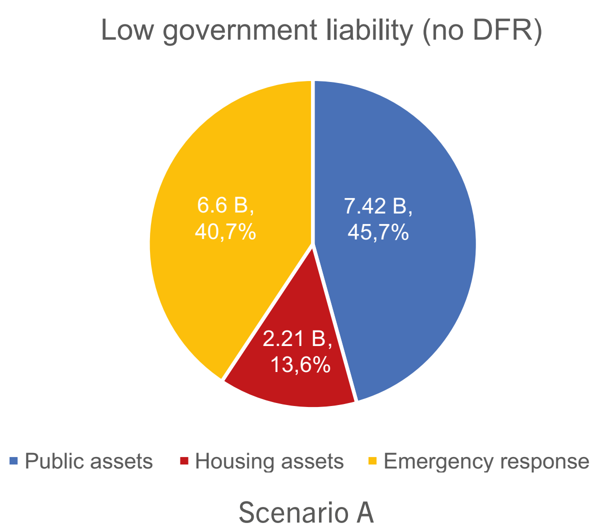


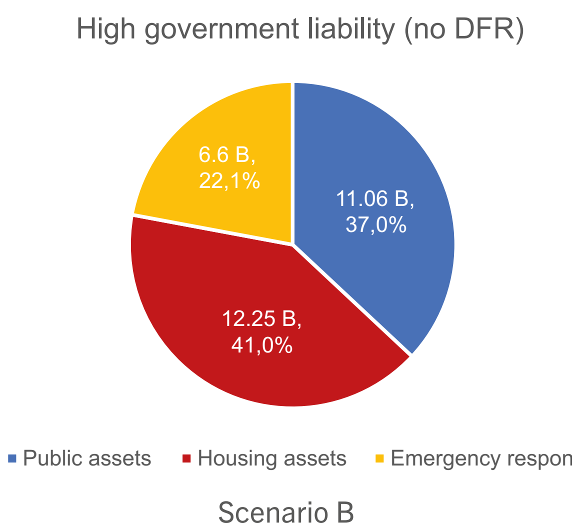


Source: World Bank.

In Scenario B, most of the liabilities are due to asset losses for private households, followed by public asset losses and emergency response costs. In Scenario A, most of the liabilities are due to asset losses for public assets, followed by emergency response costs and private households' losses.

Figure 25. Distribution of liabilities in overall government liabilities: Low-liability scenario (left) vs. high-liability scenario (right)





Source: World Bank.

At the EU MS level, the emergency response costs form 40.7% of total government liabilities in Scenario A, whereas in Scenario B, emergency response represents 22% of total liabilities. The liability generated from public and housing assets accounts for 59.2% and 78% of total liabilities in scenarios A and B, respectively (see *Figure 25*).

Macro-Fiscal Impacts and DRF Arrangements

The model discovered no difference between fiscal impacts of disasters and the size of EU MS reserve and contingency funds. It would be fair to assume that countries have invested in strengthening DRF arrangements as a result of the sizeable fiscal impacts they incur. This assumption is not confirmed by this model, however.

Figure 26. Net government liability as a percentage of GDP

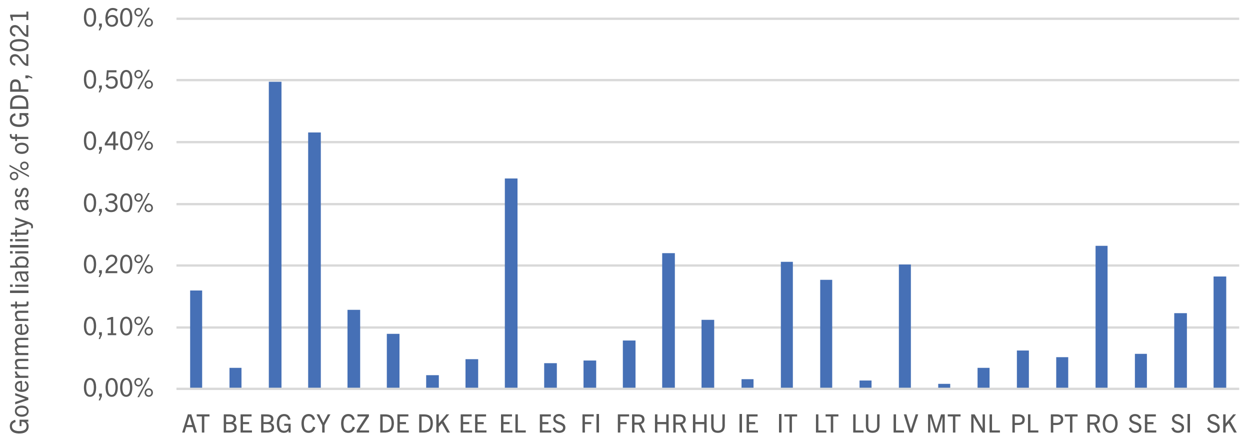
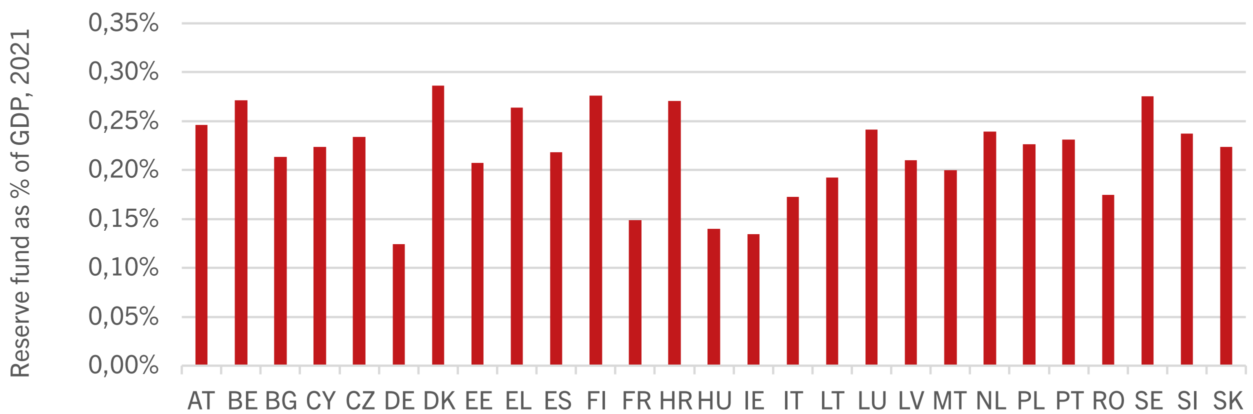


Figure 27. Reserve fund as a percentage of GDP



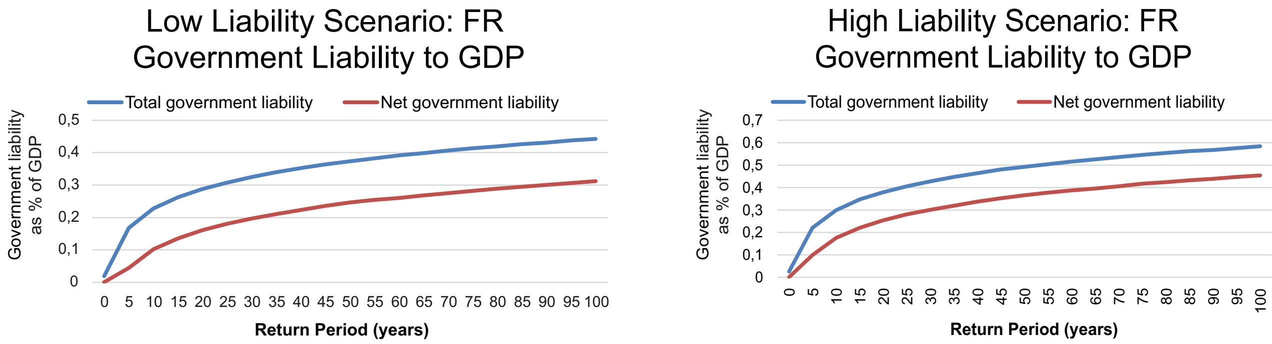
Source: World Bank.

As seen in *Figure 26* and *Figure 27*, there is no correlation between the level of the reserve fund as a percentage of GDP and the level of net government liabilities as a percentage of GDP.[35]

The model finds that DRF instruments (such as public asset insurance and reserve funds) help reduce government liabilities and subsequent macro-fiscal impacts of disasters from earthquakes and floods, both in absolute values and as a percentage of GDP (*Figure 28*). In the high-liability scenario for France, DRF instruments can help reduce the 100-year return period government liabilities by €3.6 billion, in turn reducing the ratio of government liabilities to GDP from almost 0.58% to 0.45%.

35 The correlation coefficient is not statistically significant.

Figure 28. Government liabilities as a share of GDP over various return periods in France: Low-liability scenario (right) vs. high-liability scenario (left)



Scenario A

Scenario B

Source: World Bank.

Approximately 40% of countries lack the pre-arranged funding needed to manage 1-in-10-year (i.e., relatively frequent) combined flood and earthquake emergency response costs. It is likely that a part of these costs will be funded through budgets of civil protection agencies and potentially the UCPM, but budget cuts might be required to ensure that countries have enough money for response. Moreover, the existing EU level instruments take time to disburse, which could delay emergency response, while the financing available under instruments like the EUSF might be insufficient (and top-up funding might be required, as described in *Chapter 5* on the funding gap analysis).

In terms of annual average emergency response costs following earthquakes and floods, most countries have enough in reserves and contingency funds to provide immediate financing (*Table 11* shows the emergency response costs in low liabilities scenario). However, only few EU countries have dedicated disaster reserve funds; general contingency funds might be largely unavailable, especially if a disaster happens towards the end of the fiscal year. The estimated emergency response costs also do not account for other types of disasters that the EU MS might be exposed to (such as landslides and droughts).

Table 11. Emergency response costs in low liabilities scenario against available reserve and contingency

COUNTRY	AVERAGE EMERGENCY RESPONSE COST (MILLION €)	EMERGENCY RESPONSE COST (MILLION €), 10-YEAR RETURN PERIOD	RESERVE AND CONTINGENCY FUNDS TOTAL SIZE (MILLION €)[A]
AT	330.84	1052.08	926
BE	95.65	326.57	1,191
BG	127.82	412.68	94
CY	56.41	108.52	45
CZ	161.14	492.50	464
DE	1331.13	4155.90	4,022
DK	35.26	106.79	828
EE	7.47	28.06	447
EL	299.88	563.71	447
ES	295.16	770.25	2,434
FI	47.05	146.80	626

FR	964.10	2647.99	3,321
HR	49.09	107.03	128
HU	72.72	274.27	316
IE	32.63	101.86	437
IT	1724.25	3769.24	2,768
LT	39.67	150.17	85
LU	4.34	6.74	142
LV	29.86	80.96	60
MT	0.84	0.00	25
NL	105.00	357.87	1,771
PL	163.16	528.70	1,092
PT	54.99	129.41	455
RO	252.67	686.66	354
SE	192.14	660.83	1,181
SI	30.95	89.22	106
SK	97.28	360.31	195

Source: World Bank.
Note: The analysis shown in this table is carried out in more detail in the next chapter.
a. Contingency funds are estimated as 0.5% of revenues.

In some countries, especially higher-income countries, post-disaster costs may be absorbed through budget cuts, in which case the economic impact will transform from the impact on fiscal space into budget cuts and subsequent opportunity cost. Opportunity cost is defined as the loss of other alternatives when one alternative is chosen. In the context of disasters and associated budget cuts, it means the losses associated with forgoing certain budgeted expenditures, in order to reallocate the funds for disaster response or recovery. There is a global evidence gap on how significant such opportunity cost can be after disasters and it likely needs to be assessed on a case by case basis. However, there is a broader understanding that it can affect long-term growth, poverty reduction and equity. Therefore, subsequent impacts of the above described costs might take a different form across the MS.

5. Funding Gap Analysis

This section of the analysis seeks to demonstrate the proportion of the future losses from earthquakes and floods that existing financial instruments held by EU MS can cover, and what proportion remains to be financed (that is, the funding gap). Analysing the funding gap provides a tool to help countries build their DRF strategies**.** There is an increasing need for informed financial decision-making on how much funding to allocate before disasters, how to evaluate risk transfer instruments, and how much to spend on risk reduction (Clarke et al. 2016).

The funding gap analysis is applied to the region (all EU Member States) and in four selected case studies: France, Croatia, Romania, and Austria. Each case study includes a disaster profile overview, list of disaster risk financing instruments, discussion of contingent liabilities, and the analysis. In addition, a case study of Albania is presented below; although not included in the broader macro-fiscal assessment, this case helps illustrate a recent instance in which the UCPM played a role in responding to disasters. Analysis for the remaining EU MS can be found in *Annex 7*.

This study has not found a connection between the availability of reserve funds and the amount of funding provided through the EUSF mechanism. Availability of domestic reserves seems not to affect whether countries apply for EUSF funds or how much finance they apply for. However, in countries like Romania or the Czech Republic, there is a good alignment between the maximum level of national resources available to pay for disasters and the activation point (disaster threshold) of the EUSF mechanism for the same countries.

The case studies demonstrate how combining different risk financing instruments can affect the amount of finance available for disaster losses (e.g., using assumptions of high versus low residential insurance penetration) and how the amount of finance required differs across countries. Three strategies were developed to facilitate the analysis and are shown in The EUSF assumptions are shown in *Table 12*.

Table 12. Assumptions on the maximum amount provided by EUSF for earthquake and floods under three DRF strategies[36]

STRATEGY	ACTIVATION LEVEL (ATTACHMENT POINT)*	PERCENTAGE OF LOSSES COVERED	MAXIMUM ALLOCATION FROM EUSF FOR RESPONSE
Base	Standard, as defined in the EUSF guidelines	4–5% of total asset losses on average, based on the historical analysis of previous disasters when EUSF support was used	€660 million for floods and earthquakes
Strategy B	Standard, as defined in the EUSF guidelines	7–8.5% of total asset losses on average (70% more than the average shown by the historical analysis of previous disasters when EUSF support was used)	€1,100 million for floods and earthquakes
Strategy C	Lower activation point: 0.5% of GNI	4–5% of total asset losses on average, based on the historical analysis of previous disasters when EUSF support was used	€660 million for floods and earthquakes

**See Annex 9 for attachment points by MS*
Note: EUSF = European Union Solidarity Fund: GNI = gross national income.

36 In the table presenting the set of 3 strategies, 2 of them are hypothetical (Strategy B and Strategy C) only used in the funding gap analysis to test whether a different activation level or a higher coverage of the EUSF would make a significant difference in covering the financing gap that countries experience in the aftermath of a disaster. The "Base Strategy" is the one closest to the reality, and it is based on observed historical allocations from the EUSF fund for the period 2002-2020.

Incorporating the assumptions made on the EUSF outlined above, the treatment of reserve funds under the three strategies is as follows:

Base Strategy	Strategy B	Strategy C
reserves at EU level considered as 1% of the sum of all national reserves (rounded to the nearest 10 million),	reserves at EU level considered as 1% of the sum of all national reserves (rounded to the nearest 10 million),	reserves at EU level considered as 5% of the sum of all national reserves.

These strategies are underpinned by a series of assumptions at both the national level (described in *Annex 5*) and the EU level (described in *Annex 6*).

The analysis assumes that the resulting funding gap will be covered by (i) budget reallocation, (ii) debt, or (iii) donor assistance. Due to data limitations, the analysis does not review alternative DRF strategies that include sovereign risk transfer.

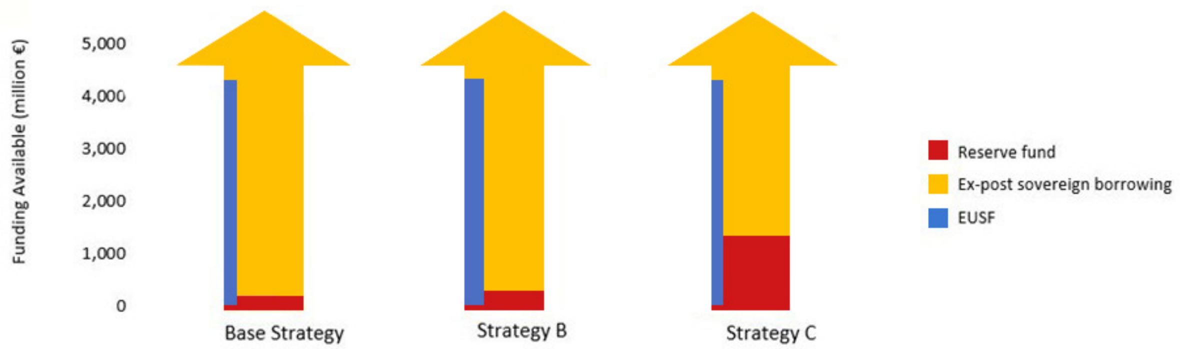
Given the importance of the UCPM in supporting emergency response, one challenge was to compute the amount of funding provided per country (as this is mostly in-kind assistance). The analysis looks at how the UCPM helped in emergency response after recent disasters in Croatia and Albania only through the funding gap case studies.

Risk estimates were derived for both the EU and national level analysis using the JBA and GEM models (see Chapter 3 on catastrophe modelling) in the form of event loss tables. These tables provide a loss for each simulated event from which the exceedance probability curve—the curve describing the probability of exceeding an event of a given severity in any year—is derived. Using the sector level event information provided by GEM and JBA, the losses were aggregated by simulated year to produce year loss tables. In addition, national-level loss tables were aggregated to proxy a regional loss table, which enables analysis based on the probability of exceeding expected loss across the EU MS.

Results of the EU Level Analysis

Three disaster risk financing strategies (*Table 12*) were compared. The analysis found that in all cases, there is a significant funding gap at EU level and a high reliance on national reserves to cover the disaster costs (*Figure 29*). The EUSF mechanism should be seen in this case as only a supplement for national strategies, one providing punctual aid in extreme situations.

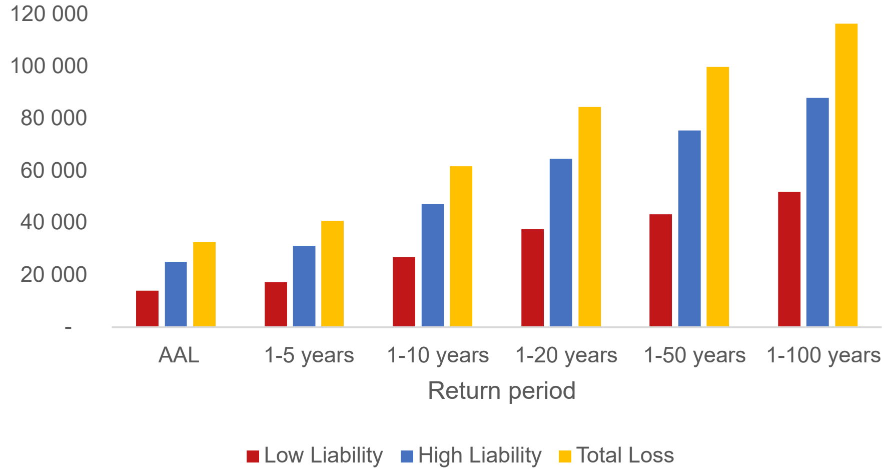
Figure 29. Comparison of three EU level disaster risk financing strategies



Source: World Bank.
Note: EUSF = European Union Solidarity Fund.

Incentivizing insurance to encourage a higher uptake by households can halve government liabilities to €50 billion for very extreme hazard events, and reduce government liabilities to €10 billion for smaller events (see *Figure 30*)**.** The magnitude of losses (earthquake and floods aggregated) varies between €30 billion for small events to more than €100 billion for severe events (those that occur once in 100 years—that is, have a 1% probability of occurring in any given year).

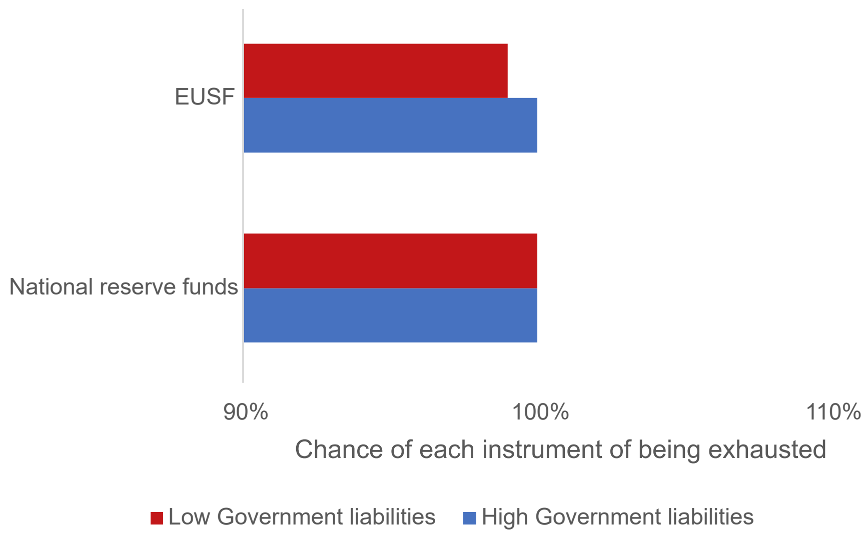
Figure 30. The expected magnitude of total loss and government liabilities at different return periods (million €) at EU level



Source: JBA, *GEM stochastic models.*
Note: AAL = average annual loss.

Even for low government liabilities, the EUSF mechanism will not be enough to cover the needs of response to medium-severe events (rarer than once in 10 years). This finding implies that there is a approx. 10% probability in any given year that the EUSF mechanism will need to be topped up with funds beyond a limit of €660 million to cover earthquakes and floods (see *Figure 31* below). The figure shows for each DRF instrument in how many instances, from all the modelled events dataset, the funds available in that instrument have been used entirely to cover the cost of a disaster.

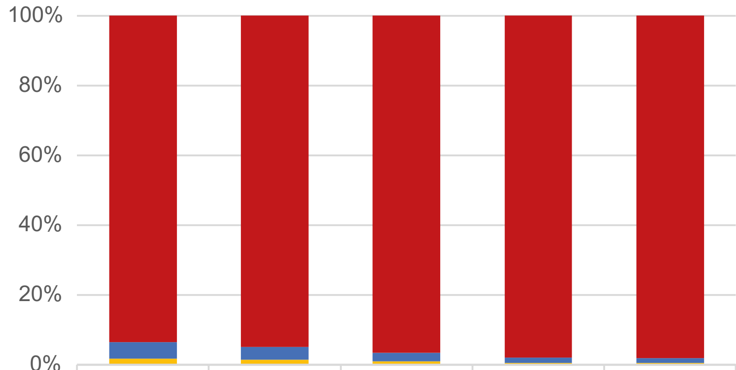
Figure 31. Chances of each instrument being fully drawn in any given year at low and high government liability at EU level



Source: World Bank.
Note: EUSF = European Union Solidary Fund.

The sum of the EUSF, reserve funds and contingency funds available to MS covers, on average, less than 4% of total government liabilities each year when analysed from a EU perspective (with disasters aggregated for both earthquake and flood and for all EU MS countries). This suggests that there is scope for additional instruments at the EU level and/or a need to incentivize national governments to invest in DRF more seriously (see *Figure 32* below).

Figure 32. The breakdown of instrument use to fund different magnitudes of low government liability for all EU MS under Base Strategy, by return period (million €) at EU level



	Average annual loss	1-5 y	1-10 y	1-50 y	1-100 y
Funding gap	13 125	16 643	25 928	42 890	49 643
EUSF	660	660	660	660	660
Reserve Fund	240	240	240	240	240

Source: World Bank.
Note: EUSF = European Union Solidary Fund.

National Case Studies

FRANCE

DISASTER PROFILE

The MunichRe NatCat database[37] estimates €67.5 billion of losses and almost 23,500 fatalities since 1980 in France due to climatological and hydro-meteorological events; 50% of those losses were insured. Seismic risk analysis conducted under this World Bank project that this report is part of estimates an annual average of 34 fatalities in France, and AAL of €302 million, with risk concentrated in the southeast and southwest regions close to the Alps and Pyrenees. AAL due to flood damage to private and public buildings is estimated at €5.4 billion (0.24% of GDP); flood causes about 80% of all disaster damages (Pottier et al. 2005). France experiences strong European windstorms from the west, resulting in damaging winds and storm surge. For example, storm Xynthia in 2010 caused damage to flood defences along 200 km of the Atlantic coastline, flooding 50,000 ha of land and resulting in 47 fatalities due to strong wind and floods (Kolen, Slomp, and Jonkman 2013). Windstorms are estimated to cause an average of €682 million of damages annually, with approximately 2 million people exposed to this hazard (Spinoni et al. 2020). Coastal flood alone results in annual expected damage of €200 million (Vousdoukas et al. 2020). EM-DAT records 11 wildfire events for France totalling about €8.5 million in damages, seven avalanches causing similar levels of damage, and similar numbers of drought (though just four droughts caused combined damage of almost €1.4 billion), cold waves, and heatwaves (seven of which caused €3.7 billion in damages).

37 https://www.munichre.com/en/solutions/for-industry-clients/natcatservice.html

DISASTER RISK FINANCING ARRANGEMENTS AND GOVERNMENT CONTINGENT LIABILITIES

Table 13 below provides an overview of the findings on DRF arrangements for France and on contingent liabilities; these are the basis for the funding gap analysis.

Table 13. DRF arrangements and contingent liabilities considered in modelling for France

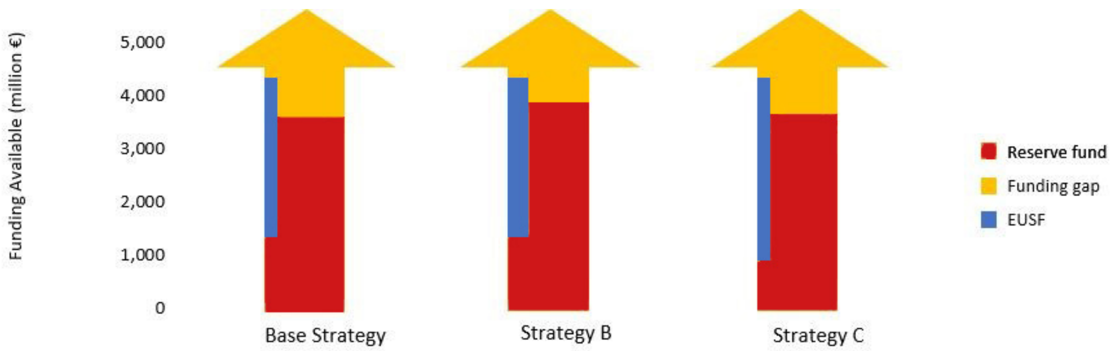
DRF INSTRUMENT	LOW GOVERNMENT CONTINGENT LIABILITY SCENARIO	HIGH GOVERNMENT CONTINGENT LIABILITY SCENARIO
Pre-arranged funding: disaster reserve funds and contingent funds	€3,320.77 million	€3,320.77 million
Household insurance and government liabilities	97% of all household losses are covered. Government is expected to compensate, among the remaining households, only the share of low-income households—13.4% (based on Eurostat income poverty statistics).	97% of all household losses are covered. Government is expected to compensate 100% of the losses of the remaining uninsured households.
Public asset insurance and government liabilities	Government is expected to cover reconstruction of all uninsured public assets; 33% of asset losses are covered through insurance in line with the general study assumptions.	Government is expected to cover reconstruction of all uninsured public assets. No assets are covered by insurance in line with the general study assumptions
Commercial and industrial losses	Government is not expected to cover these losses.	Government is not expected to cover these losses.
Contingent credit line	Not available	Not available

Sources: French Ministry of Ecology 2019*; French Senate 2017; OECD 2015, 2016, 2018; Eurostat at risk of poverty rates.*

France has the highest catastrophe insurance penetration rate across all of Europe, which helps transfer much of the risk to the private sector and serves to reduce government liabilities. That is not to say that the government does not maintain some of the cost; rather the state reinsurer covers up to 50% of the liabilities taken by the private insurers. This cost is not factored into the analysis.

The DRF strategy in France is underpinned by significant disaster reserves, estimated at more than €3 billion. This suggests that the country can self-finance disaster response to small events and request EU level aid only for infrequent severe events. The three strategies in *Figure 33* below assume that the government has available only two types of sovereign DRF instruments: national reserves and the support from the EUSF (that can activate at higher or lower levels of severity). The remaining unfunded disaster costs can be funded by instruments such as budget reallocations, sovereign risk transfer solutions, contingent credit lines, or ex post sovereign borrowing. However, these instruments are not discussed for the purpose of this analysis.

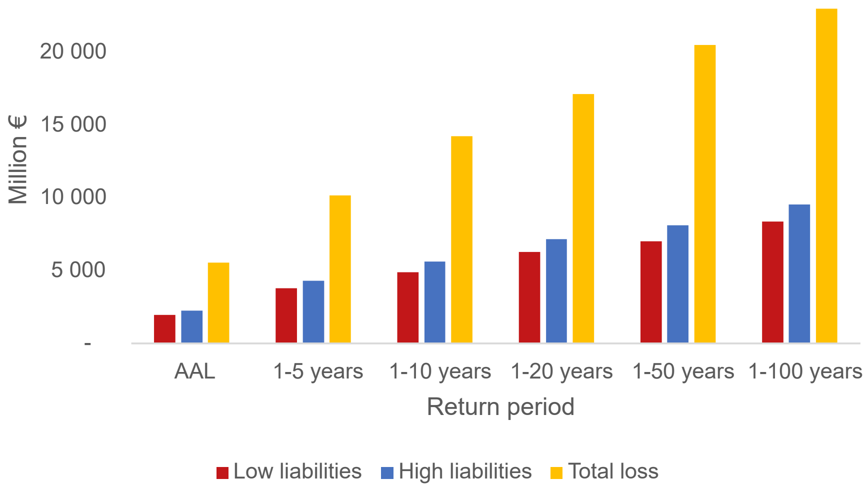
Figure 33. Comparison of three disaster risk financing strategies in France



Source: World Bank.
Note: EUSF = European Union Solidary Fund.

The high penetration (~97%) of catastrophe coverage attached to household insurance helps keep the government liabilities below 50% of total loss, even in extreme events. The difference between high liabilities and low liabilities comes in this case from the absence of public asset insurance, but this type of insurance has a much lower impact than private household insurance, so high and low government liabilities do not differ too much (see *Figure 34* below).

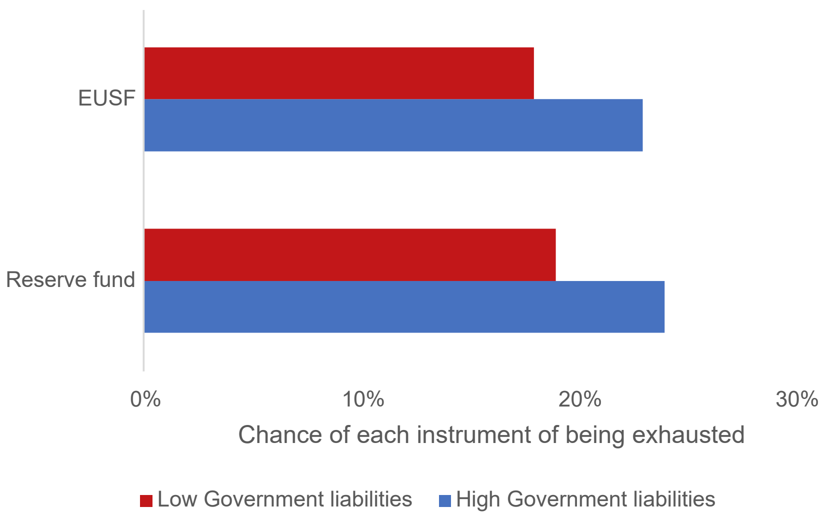
Figure 34. The expected magnitude of total loss and government liabilities at different return periods in France (million €)



Source: JBA, *GEM stochastic models.*

Given the high level of insurance penetration in France, the use of the EUSF aid up to its maximum value allowed per year (€660 million) could occur for more than 20% of events (see *Figure 35*). *Figure 35* shows the funds from each DRF instrument that have been used to cover the cost of a disasters from all the modelled events in the dataset. In the case of France, the difference between high and low government liabilities is not significant (as described above), and the levels of utilization of reserves and EUSF aid do not differ too much between different scenarios of government liabilities. However, given the high asset values, the potential of depleting the national reserves (€3.2 billion) is greater (between 20% and 25%) than in the other case study countries.

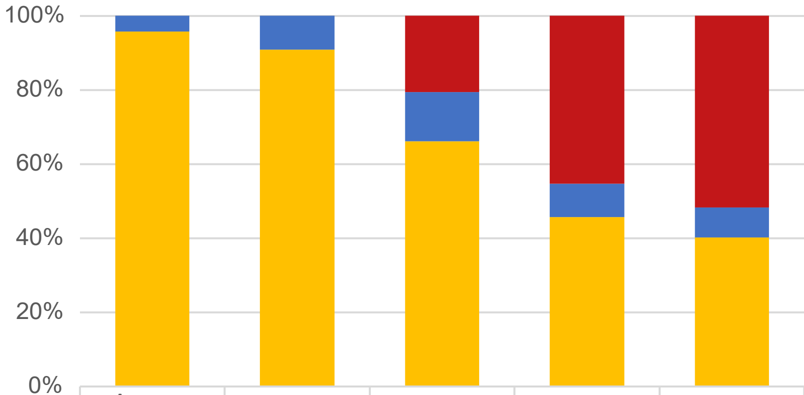
Figure 35. Chances of each instrument being fully drawn in any given year at low or high government liability: France



Source: World Bank.
Note: EUSF = European Union Solidary Fund.

Given the high level of the reserve fund, which covers more frequent, less severe disasters, a lower activation level of the EUSF fund for France would not make any difference (*Figure 36* below). The types of disasters whose costs the government is unable to cover with national reserves are the more severe ones, which also have significant liabilities (€7–10 billion); for these, different mechanisms, including sovereign risk transfer, could be more appropriate than the EUSF.

Figure 36. The breakdown of instrument use to fund different magnitudes of low government liability in France under Base Strategy, by return period (million €)



	Average annual loss	1-5 year	1-10 year	1-50 year	1-100 year
Funding gap	-	-	1 033	3 299	4 275
EUSF	84	324	660	660	660
Reserve fund	1 874	3 238	3 321	3 321	3 321

Source: World Bank.
Note: EUSF = European Union Solidary Fund.

CROATIA

DISASTER PROFILE

The MunichRe NatCat database[38] estimates €3.2 billion of losses (only 2% of those insured) and 722 fatalities since 1980 in Croatia due to climatological and hydro-meteorological events. Seismic analysis in this project estimates an annual average of 24 fatalities in Croatia due to earthquake, and AAL of €96 million from building stock (around 60% from residential building damage). Three earthquakes occurred in the 1960s of M5.6–6.2, with only eight fatalities in total, and in March 2020 a M_W5.5 earthquake in central Croatia caused €11.3 billion of damage and loss.[39] AAL due to flood damage to private and public buildings is estimated in this project at €147 million (0.29% of GDP), similar to the 0.40% of GDP estimated by JRC (Dottori et al. 2020). Two convective storms recorded in EM-DAT caused a combined total of €137 million in damage, while just two heatwaves resulted in 828 deaths. Annual expected windstorm damage is estimated at €29 million by JRC.

DISASTER RISK FINANCING ARRANGEMENTS

Table 14 below provides an overview of the findings on DRF arrangements for Croatia and a discussion of contingent liabilities; these are the basis for the funding gap analysis.

38 https://www.munichre.com/en/solutions/for-industry-clients/natcatservice.html
39 The damage and loss figure does not include the December 2020 earthquake. Details on the March 2020 event are in Government of the Republic of Croatia (2020).

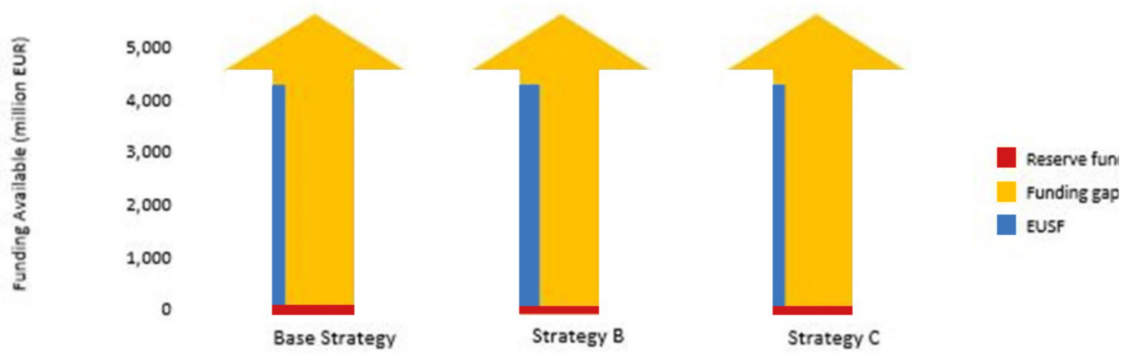
Table 14. DRF arrangements and contingent liabilities considered in modelling for Croatia

DRF INSTRUMENT	LOW GOVERNMENT CONTINGENT LIABILITY SCENARIO	HIGH GOVERNMENT CONTINGENT LIABILITY SCENARIO
Pre-arranged funding: disaster reserve funds and contingent funds	€128.13 million	€128.13 million
Household insurance and government liabilities	Approximately 7.15% of households are covered against earthquakes and no households are covered against floods. Government is expected to compensate, among the remaining households, only the share of low-income households—19.3% (based on Eurostat income poverty statistics)	Approximately 7.15% of households are covered against earthquakes and no households are covered against floods. Government is expected to compensate all losses of households.
Public asset insurance and government liabilities	Government is expected to cover reconstruction of all uninsured public assets; 33% of asset losses are covered through insurance in line with the general study assumptions.	Government is expected to cover reconstruction of all uninsured assets. No assets are covered in line with the general study assumptions.
Commercial and industrial losses	Government is not expected to cover these losses.	Government is not expected to cover these losses.
Contingent credit line	Not available	Not available

Sources: AXCO 2021, *OECD 2015, 2016, 2018; CROATIA EARTHQUAKE Rapid Damage and Needs Assessment 2020, Croatia Budget Law 2015; IMF 2004; Kraan et al. 2006; Eurostat at risk of poverty rates.*

Croatia has a very low reserve fund to cover disasters and thus relies heavily on the EUSF for aid. At the same time, the activation point of the EUSF aligns well with the amount of funding available from the estimated national reserve, ensuring that there is no gap in funding small events. The three strategies in *Figure 37* below assume that the government has available only two types of DRF instruments: national reserves and the support from the EUSF (that can activate at higher or lower levels of severity). The remaining unfunded disaster costs can be funded by instruments such as budget reallocations, sovereign risk transfer solutions, contingent credit lines, or ex post sovereign borrowing. However, these instruments are not discussed for the purpose of this analysis.

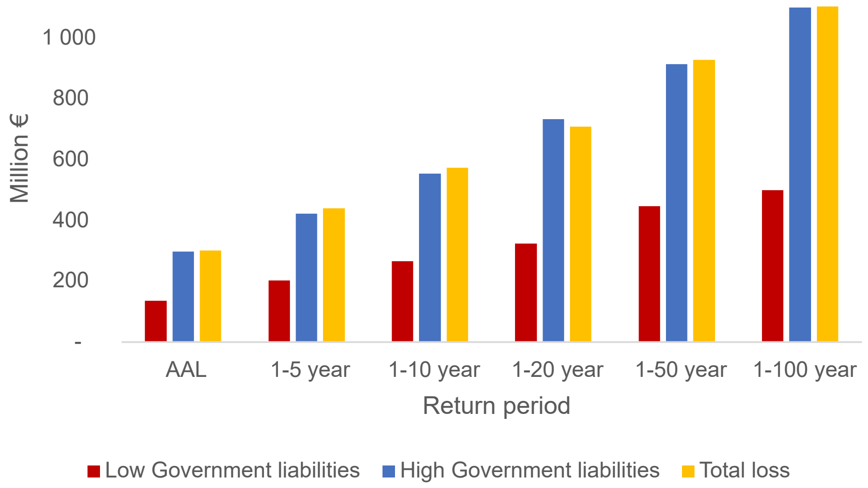
Figure 37. Comparison of three disaster risk financing strategies in Croatia



Source: World Bank.
Note: EUSF = European Union Solidary Fund.

With a very low penetration rate, the government liabilities in Croatia are highly influenced by the share that the government decides to cover from the loss of the residential sector. If the government decides to cover all the reconstruction costs of the residential sector (high liability scenario), then the government's exposure to disaster costs can equal the total disaster loss for medium and severe events (see *Figure 38* below).

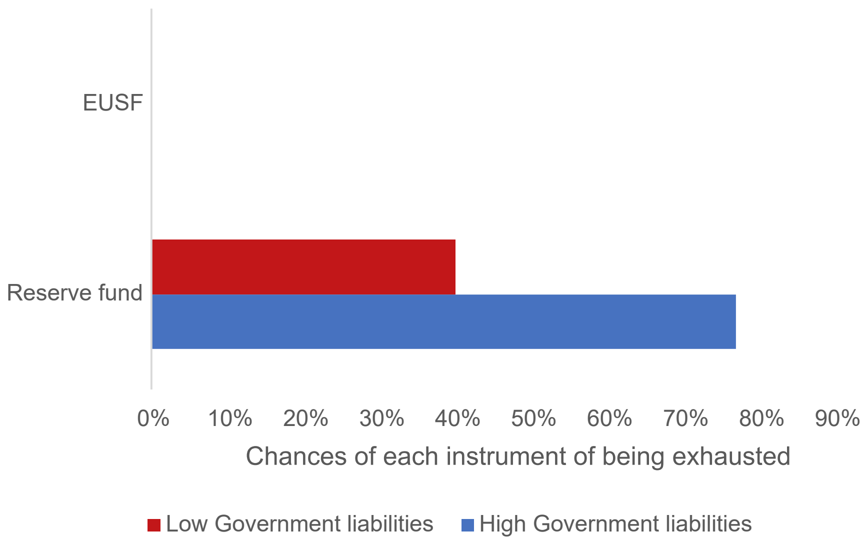
Figure 38. The expected magnitude of total loss and government liabilities at different return periods in Croatia (million €)



Source: World Bank.

The only instrument with the possibility of being fully used is the reserve fund. None of the modelled events shows a chance of using the EUSF to its maximum cap of €660 million (see *Figure 39*). A loss similar in magnitude to the 2020 earthquake (€11 billion; €684 million aid from EUSF) is considered to have a probability of less than once in 10,000 years. *Figure 39* shows the funds from each DRF instrument that have been used to cover the cost of a disasters from all the modelled events in the dataset.

Figure 39. Chances of each instrument being fully drawn in any given year at low and high government liability: Croatia

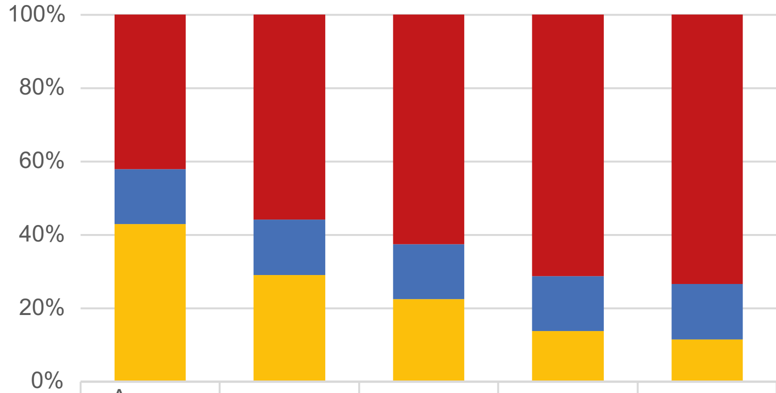


Source: World Bank.
Note: EUSF = European Union Solidary Fund.

In any given year, Croatia could experience a funding gap that exceeds its reserve fund suggesting that even for small events the reserve fund is insufficient. This may reflect the fact that the country has a low national disaster reserve relative to its exposure to catastrophic events and depends on the EUSF mechanism or donor support.

The government could investigate the option to increase the penetration rate of catastrophe insurance for households or of public asset insurance. In this case, the government liabilities could be decreased, and the funding gap could be managed better (see the comparison of Croatia's use of DRF instruments for high and low government liability scenarios in *Figure 40* and *Figure 41*, respectively).

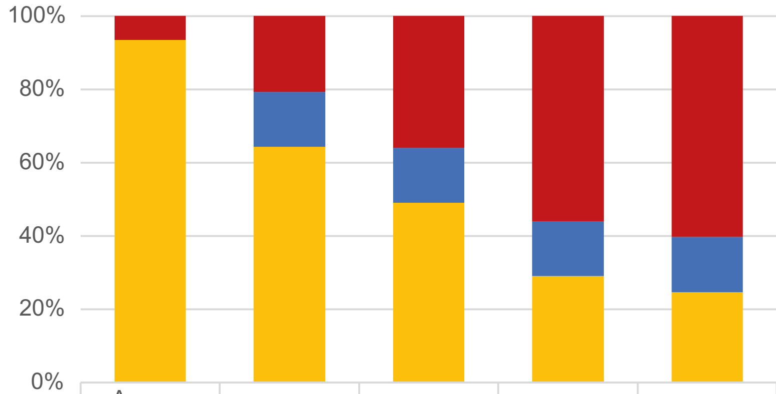
Figure 40. The breakdown of instrument use to fund different magnitudes of high government liability in Croatia under Base Strategy, by return period (million €)



	Average annual loss	1-5 year	1-10 year	1-50 year	1-100 year
Funding gap	125	246	357	663	815
EUSF	45	66	86	140	166
Reserve fund	128	128	128	128	128

Source: World Bank.
Note: EUSF = European Union Solidary Fund.

Figure 41. The breakdown of instrument use to fund different magnitudes of low government liability in Croatia under Base Strategy, by return period (million €)



	Average annual loss	1-5 year	1-10 year	1-50 year	1-100 year
Funding gap	9	41	94	247	313
EUSF	-	30	39	66	78
Reserve fund	128	128	128	128	128

Source: World Bank.
Note: EUSF = European Union Solidary Fund.

ROMANIA

DISASTER PROFILE

The MunichRe NatCat database[40] estimates €12 billion of losses (99% of those not insured) and almost 1,322 fatalities since 1980 in Romania due to climatological and hydro-meteorological events. Seismic analysis under this World Bank project that this report is part of estimates that Romania has the third highest annual seismic risk of all EU MS, with AAL of €512 million, the majority of which arises from damage to residential buildings. There is an estimated annual average risk to life of 275 fatalities in Romania. Seismic risk is concentrated in the east of the country, including Bucharest, Bacau, and Prahova. Major earthquakes occurred in 1940 (M7.3, 1,000 fatalities) 1977 (M7.5, 1,641 fatalities), and 1990 (M6.7, 14 fatalities).[41] AAL due to flood damage to private and public buildings is estimated in this project at €585 million (0.28% of GDP), similar to the 0.23% of GDP estimated by JRC (Dottori et al. 2020). EM-DAT records for Romania 36 river floods with a combined total of 403 deaths, 368,000 people affected, and €2.6 billion of total damages. Extreme temperature events are the next most commonly recorded event, with 11 cold waves and eight heatwaves recorded. Annual expected windstorm damage is estimated at €83 million by JRC, and over 660,000 people in Romania are exposed to windstorm hazard.

DISASTER RISK FINANCING ARRANGEMENTS

Table 15 below provides an overview of the findings on DRF arrangements for Romania and a discussion of contingent liabilities; these are the basis for the funding gap analysis.

Table 15. DRF arrangements and contingent liabilities considered in modelling for Romania

DRF INSTRUMENT	LOW GOVERNMENT CONTINGENT LIABILITY SCENARIO	HIGH GOVERNMENT CONTINGENT LIABILITY SCENARIO
Pre-arranged funding: disaster reserve funds and contingent funds	€354.18 million	€354.18 million
Household insurance and government liabilities	Estimated 20% of households are covered with catastrophe insurance. Government is expected to compensate, among the remaining households, only the share of low-income households—23.5% (based on Eurostat income poverty statistics)	Estimated 20% of households are covered with catastrophe insurance. Government is expected to compensate 100% of the losses of the remaining uninsured households.
Public asset insurance and government liabilities	Government is expected to cover the reconstruction cost of all uninsured public assets; 33% of asset losses are covered through insurance in line with the general study assumptions.	Government is expected to cover all reconstruction costs of public assets. No assets are covered in line with the general study assumptions.
Commercial and industrial losses	Government is not expected to cover these losses.	Government is not expected to cover these losses.
Contingent credit line	€400 million CAT DDO that was entirely used to cover the COVID-19 health emergency	€400 million CAT DDO that was entirely used to cover the COVID-19 health emergency)

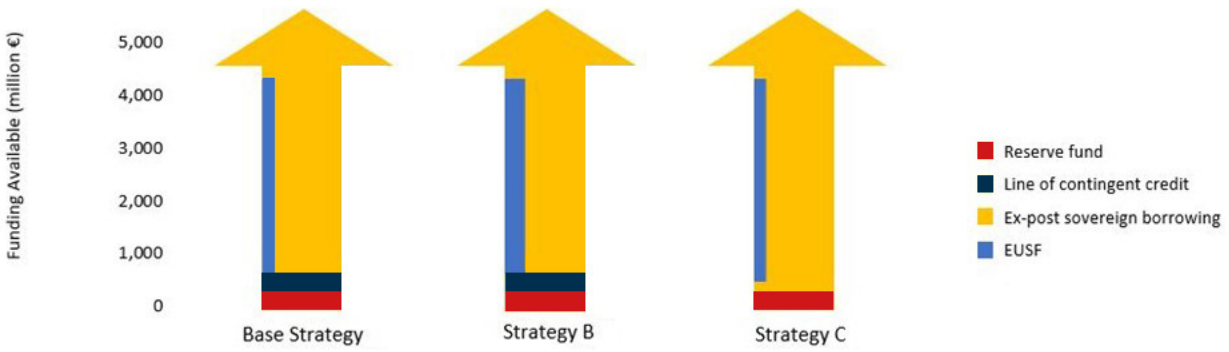
Source: OECD 2015, 2016, 2018*; Romania fiscal council report 2019; GFDRR 2008; Romania Ministry of Health 2020; Eurostat at risk of poverty rates.*

40 https://www.munichre.com/en/solutions/for-industry-clients/natcatservice.html
41 Values are from GEM (2019).

Compared to the other countries, Romania had an additional DRF instrument available, a line of contingent credit provided by the World Bank. This contingent credit supplemented the national disaster reserves and is layered between the reserves and the activation point of the EUSF mechanism. The contingent credit line was drawn down entirely to respond to the COVID-19 pandemic.

In the absence of the line of contingent credit, Romania has a gap between the moment its national reserves are depleted and the moment the EUSF mechanism can be activated. For the purpose of this analysis, we have simulated a strategy where the line of contingent credit is not renewed (Strategy C in *Figure 42*).

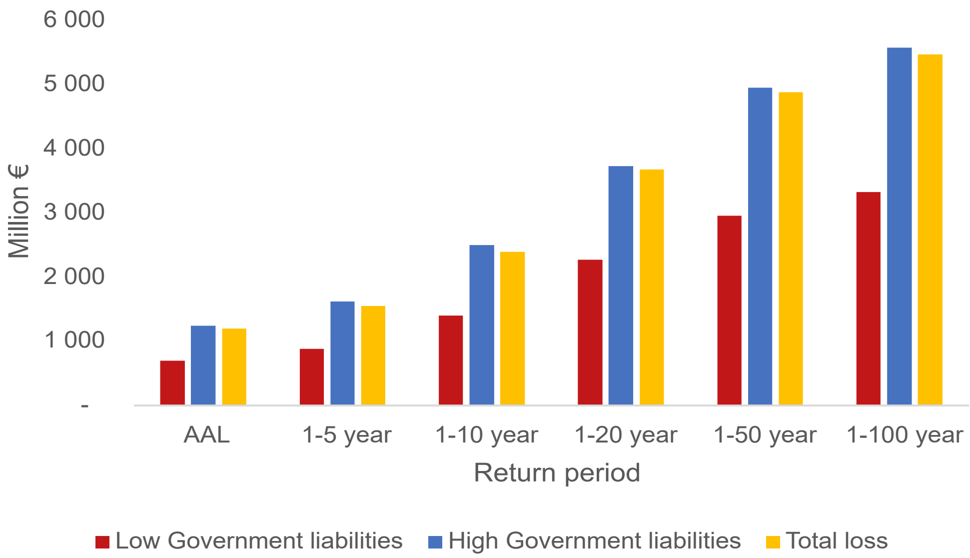
Figure 42. Comparison of three disaster risk financing strategies in Romania



Source: World Bank.
Note: EUSF = European Union Solidary Fund.

The effect of the mandatory catastrophe insurance scheme that the government put in place is obvious when comparing the levels of low and high government liabilities. At the same time, given the penetration rate of the catastrophe insurance is still not sufficient (only 20% to date), the choice of which households to support in case of a disaster (only the poor or all uninsured) has a strong impact on government liabilities (see *Figure 43* below).

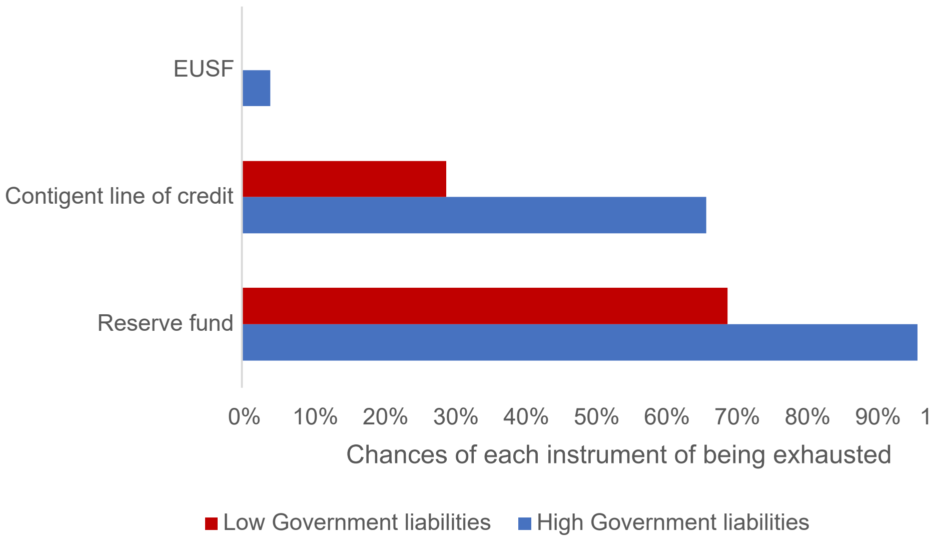
Figure 43. The expected magnitude of total loss and government liabilities at different return periods in Romania (million €)



Source: World Bank.

Both the reserve fund and the contingent credit line are expected to be fully used in most cases, but since they are layered very closely together, there is much less reliance on the EUSF mechanism than in other countries; it is used only when the government decides to cover the majority of the uninsured households. If the government decides to cover only the poor impacted households (low liability), then there is no risk of reaching the maximum payout of €660 million from the EUSF (see *Figure 44* below). *Figure 44* the funds from each DRF instrument that have been used to cover the cost of a disasters from all the modelled events in the dataset.

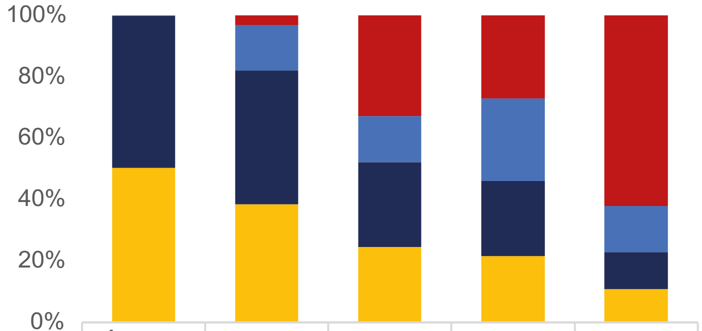
Figure 44. The chances of each instrument being fully drawn in any given year at low and high government liability: Romania



Source: World Bank.
Note: EUSF = European Union Solidary Fund.

If insurance penetration remains low and there is pressure for the government to cover all uninsured households in case of a disaster, then, in any given year, Romania could experience a funding gap that exceeds its reserve fund (Figure 46). However, given that Romania's reserve fund + Contingent credit line amount is very closely aligned with the activation point of the EUSF aid, one option is to cover a larger share of disaster costs with support from the EUSF, but only for medium-severe events. The EUSF mechanism is useful for medium to severe events (between 1-in-5-year and 1-in-50-year return periods) if there is a contingent credit line in place together with the national disaster funds. This suggests that the government should consider increasing its national reserve while attempting to increase the household catastrophe insurance penetration rate (see *Figure 45* and *Figure 46* below).

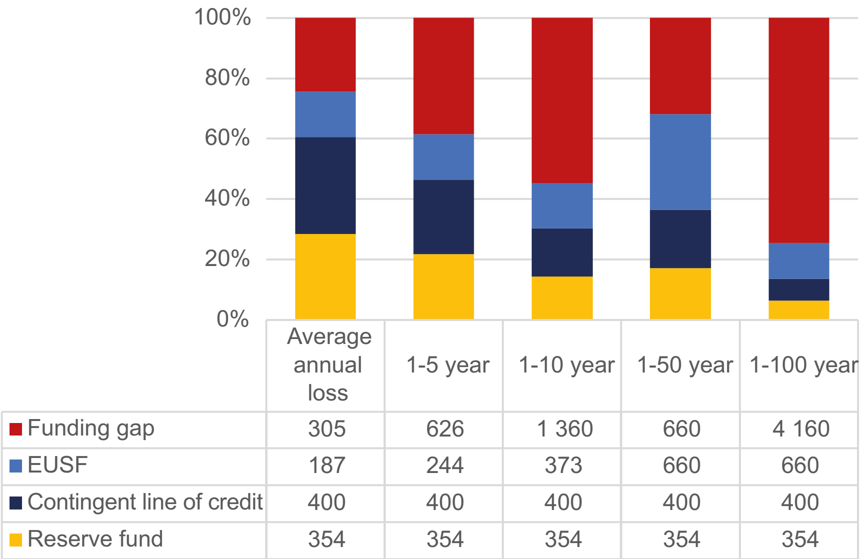
Figure 45. The breakdown of instrument use to fund different magnitudes of low government liability in Romania under Base Strategy, by return period (million €)



	Average annual loss	1-5 year	1-10 year	1-50 year	1-100 year
Funding gap	-	27	474	443	2 056
EUSF	0	138	217	443	496
Contingent line of credit	348	400	400	400	400
Reserve fund	354	354	354	354	354

Source: World Bank.
Note: EUSF = European Union Solidary Fund.

Figure 46. The breakdown of instrument use to fund different magnitudes of high government liability in Romania under Base Strategy, by return period (million €)



Source: World Bank.
Note: EUSF = European Union Solidary Fund.

AUSTRIA

DISASTER PROFILE

The MunichRe NatCat database[42] estimates €15.4 billion of losses and 601 fatalities since 1980 in Austria due to climatological and hydro-meteorological events, with 33% of those losses insured. Seismic analysis in this project estimates an annual average of 29 fatalities in Austria and AAL of €229 million. For flood, Austria is estimated to have an AAL of €1.4 billion for damage to public and private buildings, equivalent to 0.4% of GDP (JBA 2021, World Bank estimates). Austria is also susceptible to heatwaves (351 deaths in three recorded events) and to cold waves, avalanches (just four events caused 105 deaths and €35 million in damages), and convective storms (10 recorded events averaged €45 million in damage and three deaths each). Annual expected windstorm damage in Austria is estimated at €116 million by JRC (Spinoni et al. 2020), with 278,000 people exposed to windstorm hazard.

DISASTER RISK FINANCING ARRANGEMENTS

Table 16 below provides an overview of the findings on DRF arrangements for Austria and a discussion of contingent liabilities; these are the basis for the funding gap analysis.

Table 16. DRF arrangements and contingent liabilities considered in modelling for Austria

DRF INSTRUMENT	LOW GOVERNMENT CONTINGENT LIABILITY SCENARIO	HIGH GOVERNMENT CONTINGENT LIABILITY SCENARIO
Pre-arranged funding: disaster reserve funds and contingent funds	€925.71 million	€925.71 million
Household insurance and government liabilities	Estimated 10% of households are covered with catastrophe insurance. Government is expected to compensate, among the remaining households, only the share of low-income households—14.3% (based on Eurostat income poverty statistics)	Estimated 10% of households are covered with catastrophe insurance. Government is expected to compensate losses of the remaining uninsured households.

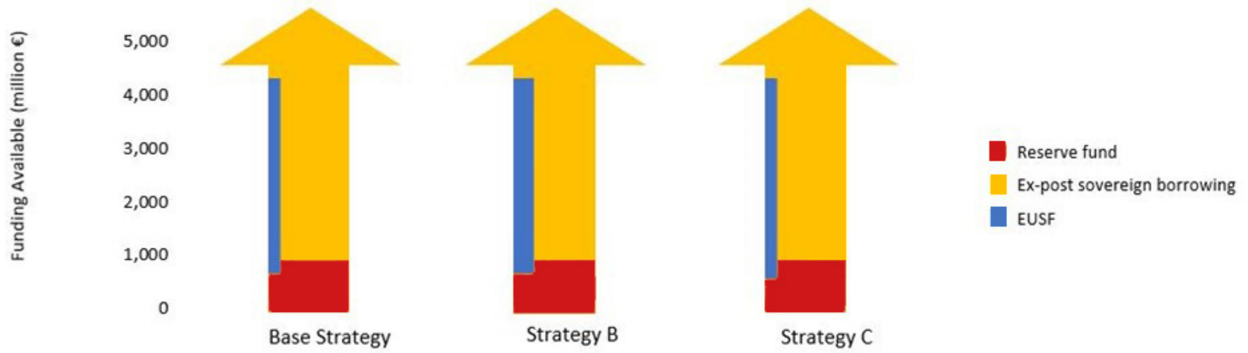
42 https://www.munichre.com/en/solutions/for-industry-clients/natcatservice.html

Public asset insurance and government liabilities	Government is expected to cover reconstruction costs of all uninsured public assets; 33% of asset losses are covered through insurance in line with the general study assumptions.	Government is expected to cover all reconstruction costs of uninsured public assets. No assets are covered in line with the general study assumptions.
Commercial and industrial losses	Government is not expected to cover these losses.	Government is not expected to cover these losses.
Contingent credit line	Not available	Not available

Sources: OECD 2015, 2016, 2018; *Austrian Ministry of Finance website; Austrian Federal Law 2021; Shinko et al. 2016; Hanger et al. 2018 Eurostat at risk of poverty rates.*

The three strategies assume that the government has available only two types of sovereign DRF instruments: national reserves and the support from the EUSF (that can activate at higher or lower levels of severity) (see *Figure 47* below). The remaining unfunded disaster costs can be funded by instruments such as budget reallocations, sovereign risk transfer solutions, contingent credit lines, or ex post sovereign borrowing. However, these instruments are not discussed for the purpose of this analysis.

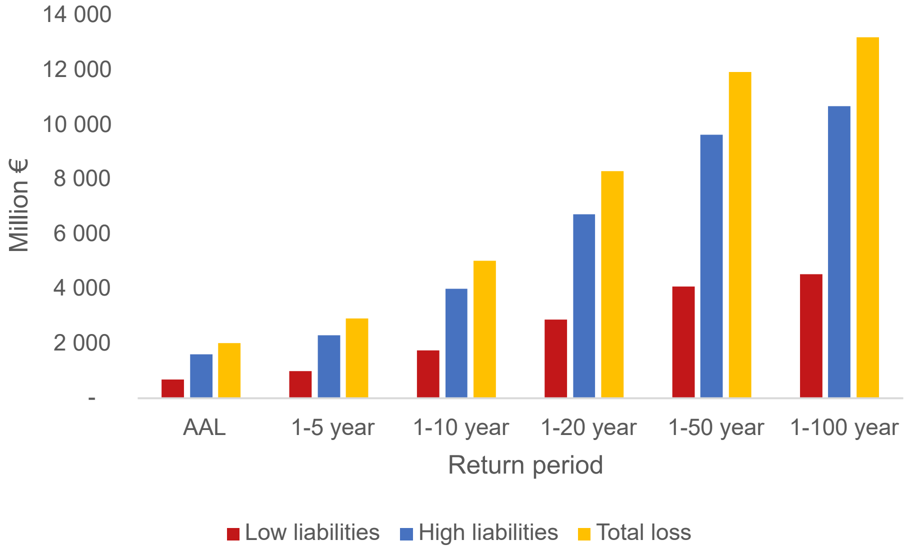
Figure 47. Comparison of three disaster risk financing strategies in Austria



Source: World Bank.
Note: EUSF = European Union Solidary Fund.

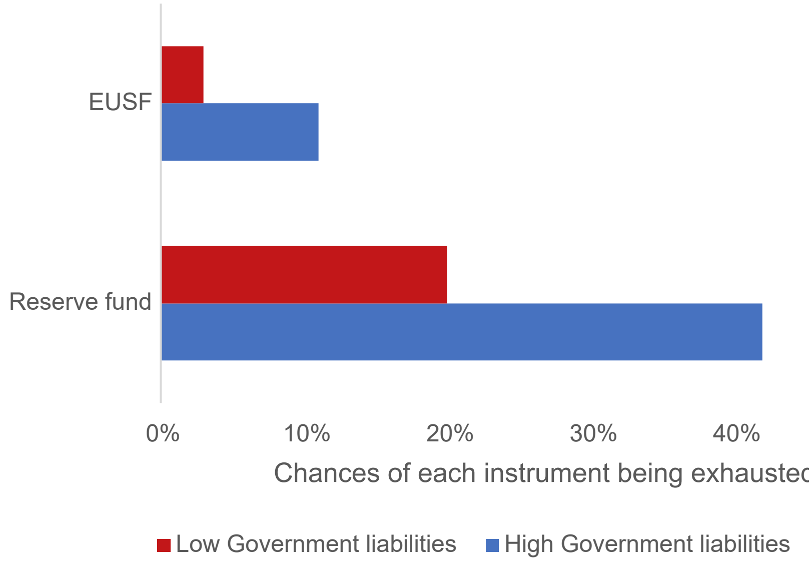
For the high government liability scenario, where there is no insurance of public assets and a greater reliance on government to cover reconstruction of residential assets, the government liability is very close to the total loss (see *Figure 48* below). In this case, the chances of using up the full reserve and the EUSF aid are substantially increased to 40% for the former and 8% for the latter (see *Figure 49* below). *Figure 49* shows the funds from each DRF instrument that have been used to cover the cost of a disasters from all the modelled events in the dataset.

Figure 48. The expected magnitude of total loss and government liabilities at different return periods (million €) in Austria



Source: World Bank.
Note: EUSF = European Union Solidary Fund.

Figure 49. Chances of each instrument being fully drawn in any given year at low and high government liability: Austria



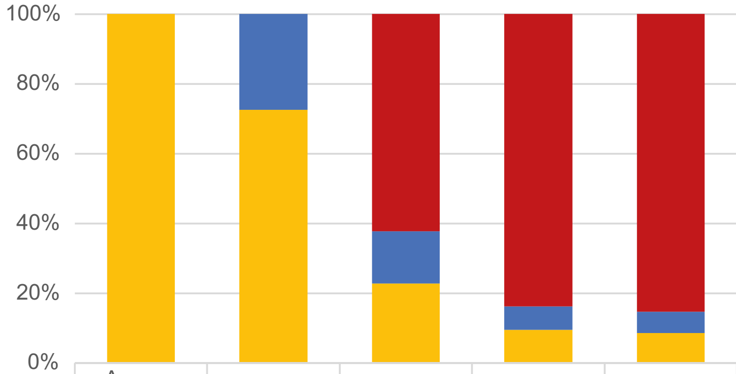
Source: World Bank.
Note: EUSF = European Union Solidary Fund.

The EUSF activation point as a percentage of GNI is well aligned to the level of the reserve available at national level, so decreasing it to 0.5% of GNI (Strategy C) would not produce significant positive impacts, except in the case of very low severity events (up to 1-in-10-year return periods).

However, increasing the share of loss that the EUSF is covering (Strategy B) has a more significant impact in reducing the funding gap that the government might experience (up to €300 million for a 1-in-50-year event).

Given that Austria's reserve fund is very closely aligned with the activation point of the EUSF aid, one option is to cover a larger share of disaster costs with support from the EUSF, but only for medium-severe events. For very severe events (1-in-100 years and above), the government would need to prepare a strategy of response that includes other DRF instruments, such as risk transfer solutions. At the same time, the government could introduce a risk transfer solution that would lower its exposure to all events, such as promoting private household insurance with a catastrophe cover or public asset insurance (see *Figure 50* and *Figure 51* below).

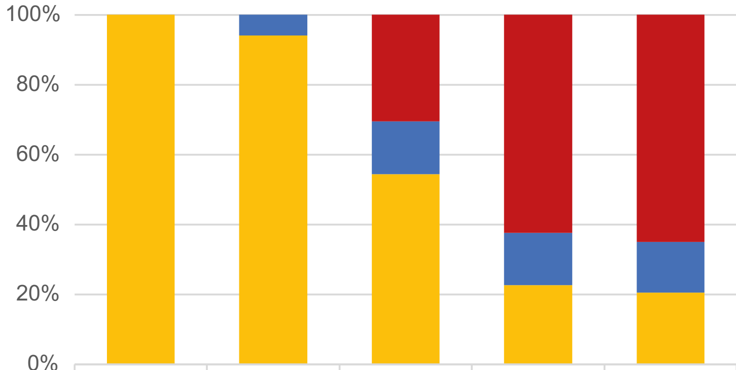
Figure 50. The breakdown of instrument use to fund different magnitudes of high government liability for Base Strategy in Austria, by return period (million €)



	Average annual loss	1-5 year	1-10 year	1-50 year	1-100 year
Funding gap	-	-	2 527	8 157	9 168
EUSF	-	349	609	660	660
Reserve fund	926	926	926	926	926

Source: World Bank.
Note: EUSF = European Union Solidary Fund.

Figure 51. The breakdown of instrument use to fund different magnitudes of low government liability for Base Strategy in Austria, by return period (million €)



	Average annual loss	1-5 year	1-10 year	1-50 year	1-100 year
Funding gap	-	-	519	2 558	2 944
EUSF	-	59	255	615	660
Reserve fund	682	926	926	926	926

Source: World Bank.
Note: EUSF = European Union Solidary Fund.

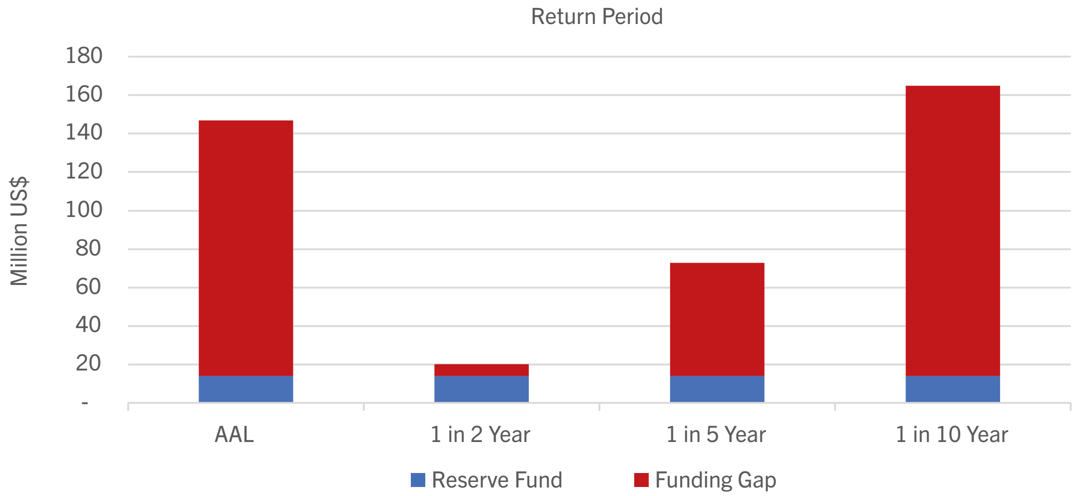
ALBANIA: LEVERAGING UCPM

UCPM is exposed to a variety of natural hazards, in particular flooding and earthquakes. Over the period 1995–2015, an average of 30,000 people were affected annually by natural disasters, and more than 95% of Albanian municipalities were affected by at least one disaster. In 2019, Albania was hit by a severe earthquake that affected over 200,000 people in 11 municipalities, including Tirana and Durrës, and caused damages equal to 6.4% of 2018 GDP and losses equal to an additional 1.1% (Government of Albania et al. 2020).

The global risk modelling firm AIR Worldwide estimates the average future damages from earthquakes and flooding in Albania to be €125 million per year, with a catastrophic event—for example, a 1-in-100-year earthquake—causing damages of over €1.7 billion (*Figure 52***.** Major earthquakes are in general infrequent but can result in high levels of damage (such as the 2019 earthquake); they are estimated to cause on average almost €84 million in damage per year. In contrast, floods are more localized and more frequent, causing an estimated average damage of about €41 million per year.

Albania has few pre-arranged risk financing instruments and relies on budget reallocation, borrowing ex post, and donor aid. Albania has had a consistently large catastrophe insurance protection gap, one that is not narrowing for households or farmers.[43] The funding gap after disasters could exceed on average €111 million per year, and the government of Albania will likely resort to borrowing, budget reallocation, and requesting donor aid after even moderate disasters (World Bank 2020a).

Figure 52. Funding gap across return periods in Albania, assuming Reserve Fund at US 14 million (or around €12 million) and damages from the combined risk of earthquakes and flooding



Sources: AIR Worldwide and World Bank staff estimates.
Note: The model output from AIR Worldwide is based on industry data, which include commercial and residential assets and exclude public assets (an assumption for public asset losses was made in this analysis). For public assets alone, the damages would be lower. Hence, the funding gap should be interpreted with caveats, as not all of the above losses are likely to be the government's contingent liabilities.

As an EU accession country, Albania can request support from the EUSF, and it has access to the UCPM. While the EUSF was not available to the country following the 2019 earthquake, Albania received sizeable support from the UCPM, with the first response mobilized the day of the earthquake. (The UCPM was activated for both the 2019 earthquake as well as earlier for a smaller earthquake that occurred the same year). The UCPM facilitates support from other member and participating states (21 countries) in a timely and coordinated way, with many resources being pre-positioned. In Albania, according to the World Bank (forthcoming (a)), mobilization of the UCPM saved lives and demonstrated that getting people back to work and providing certainty on the status of damaged buildings outweighs the costs of training and deploying personnel through the UCPM, even without considering co-benefits to private individuals. It is likely that the presence of such a mechanism makes it possible to cover immediate disaster response needs more effectively, although the support the UCPM can offer is limited to in-kind assistance, co-financing of transport costs, damage assessment, and specialist support.

43 This report identified no information or data on public asset insurance, such as insurance of critical infrastructure, schools, hospitals, or government administration buildings.

6. Key Findings

Currently, DRF arrangements, policies, and strategies across EU MS are limited: insurance penetration rates for public and residential assets are low, reserve funds are in place in only a few countries, and no sovereign insurance or capital market instruments have been identified. Even if low government liabilities are assumed, the **average annual cost of disasters across EU MS is sizeable, totalling €16.2 billion**. It is expected that these liabilities are funded through ad hoc risk financing instruments, such as borrowing, budget reallocation, donor aid, or increased taxation. The lack of comprehensive risk-layering strategies might result in inefficient and ineffective public financial management of disasters in the EU.

Disasters in the EU can have sizeable macro-fiscal impacts, which are projected to increase with climate change. Annual average impact of disasters, in the low-liability scenario and without accounting for DRF instruments, can be as high as 0.38% of GDP, as is the case for Bulgaria. Other countries with high net government liabilities as a percentage of GDP are Cyprus, Greece, Romania, Croatia and Italy (see *Figure 1*). Under the high-government liability scenario, this number rises as high as 1.0% of GDP (Cyprus). Other countries with high government liabilities as percentage of GDP are Bulgaria, Greece, Croatia, Italy and Romania.

For a major earthquake or flood event, such as an event occurring once every 100 years (or having a 1% chance of occurring in any given year), fiscal impacts of government liabilities can exceed 7% of GDP under the low government liability scenario (Scenario A) and 17% of GDP under the high government liability scenario (Scenario B).

At the EU MS level, emergency response costs form 40.7% of total government liabilities in Scenario A, whereas in Scenario B, emergency response represents 22% of total liabilities. Under the low-liability scenario, it is assumed that the government provides support for the reconstruction of housing for uninsured households whose income falls below the poverty line, and that one-third of public assets are covered by insurance. However, under the high-liability scenario, the government is responsible for reconstruction of housing for all uninsured households, and there is no public asset insurance.

On average, damage to residential buildings forms over 50% of total loss for both flood and earthquake risk, which points to an urgent need to increase access to and uptake of catastrophe household insurance. For earthquake risk alone, residential building damage may be even higher; in many countries household losses account for over 50% of total loss. The need for insurance is especially clear when looking at the liability generated from public and housing assets, which account for 59.3% of total liabilities in Scenario A and 78% in Scenario B.

On average in the EU, about 35% of liabilities in Scenario A and 64% of liabilities in Scenario B are retained by the government and are expected to be funded through ad hoc risk financing instruments. The number of countries with pre-arranged financing in place is limited, and in fact high insurance penetration helps reduce government contingent liabilities.

The model discovered no correlation between fiscal impacts of disasters and the size of EU MS reserve and contingency funds. This suggests that EU MS do not allocate their funding to reserves and contingency funds using risk informed budgeting. However, it would be fair to assume that countries have invested in strengthen-ing DRF arrangements as a result of the sizeable fiscal impacts they incur. This assumption is not confirmed by this model, however.

DRF arrangements can help reduce the level of government liabilities, both in absolute values and as a percentage of GDP. For example, in a high-liability scenario in France, DRF instruments such as catastrophe insurance can help reduce government liabilities for a 1-in-100-year disaster event by €3.6 billion, and can decrease the ratio of government liabilities to GDP from almost 0.58% to 0.46%. This finding was also supported by the EU level analysis, which showed that few countries have pre-arranged financing in place, and that high insurance penetration for both public and private assets is critical to reducing government contingent liabilities.

Around 40% of countries lack pre-arranged funding to manage combined emergency response costs for 1-in-10-year flood and earthquake events—that is, for events that occur relatively frequently. It is likely that a part of these costs will be funded through budgets of civil protection agencies and potentially the UCPM, but budget cuts might be required to ensure that countries have enough money for response. In terms of annual average emergency response costs following earthquakes and floods, most countries have enough in reserves and contingency funds to provide immediate financing. However, few EU countries have dedicated disaster reserve funds; hence this funding might be largely unavailable when needed, especially if a disaster happens towards the end of the fiscal year. The estimated emergency response costs also do not account for other types of disasters that the EU MS might be exposed to (such as landslides and droughts).

The EU level funding gap analysis conducted in this study suggests that incentivizing insurance to encourage a higher uptake by households can halve government liabilities to €50 billion for very extreme scenarios and reduce them to €10 billion for smaller events. The magnitude of losses (earthquake and floods aggregated) varies between €30 billion for small events to more than €100 billion for severe events (those that occur once in 100 years—that is, have a 1% probability of occurring in any given year).

The EU level instruments, by design, are able to cover only a small fraction of response costs arising from medium to severe events (those that occur once every 10 years or less often). This implies that there is a 10% probability in any given year that the EUSF mechanism will need to be topped up with funds beyond the assumed limit of €660 million to cover earthquakes and floods.

The sum of the EUSF and the reserve funds covers less than 4% of average annual government liabilities when analysed from a EU level perspective (disasters aggregated for both earthquake and flood and for all EU MS countries). This suggests that there is scope for additional instruments at the EU level and/or a need to incentivize national governments to invest in DRF more seriously.

The EU risk profile is broader than flood and earthquake suggesting that future losses will likely exceed the estimates in this report it is therefore recommended that the catastrophe modelling is expanded to include additional perils. The outputs of the risk models used provide a view of seismic and flood risk on a regionally consistent basis and using common exposure data for each hazard analysis, as a result the analysis was limited the inclusion of perils to earthquake and flood. Future analysis should seek to expand this work to incorporate additional hazards.

Finance alone cannot solve the challenges posed by climate change and needs the support of other policy levers to drive change; investments aimed at achieving and integrating multiple objectives make technical, financial, and social sense. Achieving reductions in GHG emissions through energy efficiency savings in buildings typically does, and rightly should, require a complementary structural strengthening to ensure that buildings constructed prior to modern codes—most of the European built environment—are resilient to snow, wind, and seismic loading. As highlighted in a World Bank (forthcoming (a)) report, there is opportunity to ensure simultaneous improvements in fire safety, modernization, and functionality and ensure access for people with disabilities. Integration of these objectives saves money, reduces disruption, and is more sustainable over the short and long terms. The forthcoming study also highlights the need to accompany early warning systems with public preparedness, readiness for action, and enhanced coordination to achieve the highest return on investment.

There is a strong case to green the EU, given that financial resilience and physical resilience complement and reinforce each other; financial resilience includes actions to both address the growing climate risks and prevent the creation of new ones through climate risk finance. The adaptation principles developed by the World Bank (Hallegatte, Rentschler, and Rozenberg 2020), for instance, suggest that climate risk finance should be implemented across all priority areas for climate change adaptation and resilience policy. See *Annex 12* for more information.

Options for Consideration

The findings above suggest that more can be done at the national and EU level to promote DRF solutions and close funding gaps. Presented below are some options for consideration; note that not all need to be pursued or implemented at the same time.

At the EU level:

1. **Strengthen the EUSF.** The EUSF has proven an important source of finance for disaster damages in EU MS and accession countries. Though the funding it can provide covers only a small fraction of needs, it might still be insufficient. Recognizing the opportunity costs of holding funds in reserve, the following could be considered:

    - *Strengthen processes and procedures for faster decision-making.* This step could include the introduction of some objective metrics on disaster risk that can trigger the release of a small amount of finance when an event of a pre-agreed magnitude occurs.

    - *Investigate if the EUSF can support broader disaster resilience considerations,* such as building back better (where finance from the EUSF might be eligible for reconstruction of more resilient assets; lack of integration of this principle might result in higher financial costs in the future), in view of limited timeframe for implementation of the EUSF funding (18 months) and potential for coordination of the EUSF aid with other financing sources that target resilience measures (in line with EU Cohesion policy).

    - *Investigate financial and policy options to incentivize better financial management of public assets (e.g. through insurance).* The analysis within the report suggests that this warrants serious consideration, given the impact public asset insurance can have in reducing government liabilities. This option could include establishing a risk pool within the EUSF that would allow, e.g., to achieve better diversification of risk and significant economies of scale, price stabilization and introduction of coherent EU level policies on the subject. A feasibility study should be conducted to further develop this idea.

    - *Introduce a risk transfer instrument.* A parametric risk transfer instrument—e.g., a catastrophe bond—could be introduced to secure private capital when needed. This approach would recognize the significant opportunity cost of holding reserves at the EU level and instead structure an additional instrument to release finance into the EUSF when severe events occur. A good example of this approach is Mexico's National Disaster Fund, FONDEN; see *Annex 13*.

2. **Incentivize the uptake of household and public asset insurance.** This could be done through the introduction of EU-wide regulations and policies that establish minimum coverage requirements, though due attention would need to be paid to the regulatory aspects, in particular the solvency framework that would be required to underpin a large uptake in insurance. This study found that information on public asset insurance is largely unavailable and it is possible that public asset insurance, especially for infrastructure, is largely unavailable. It is likely the case that reconstruction and recovery of assets after disasters is covered ad hoc through government budgets or that some damage is not addressed. This is a particular concern as governments are stewards of public assets and are responsible for their effective management. It is important for the MS to strengthen the dialogue on public asset insurance, exploring solutions with insurance and capital markets.

3. **Introduce risk-informed budgeting.** An EU level funding gap was identified based upon earthquake and flood risk only. It is likely this gap is much higher. This analysis should be expanded to understand the level of EU contingent liabilities based on an all-hazards approach. This would help develop quantified estimates of risk that could be applied to a risk-based budgeting framework; this would in turn create incentives to invest in DRF by introducing a risk based budgeting approach to ensure that MS know and understand the risk they face.

4. **Develop an EU level overarching DRF strategy**. The introduction of a coherent and comprehensive EU-wide policy on DRF would benefit the region by defining common priorities and practices and identifying the level of loss it can cover via its EU level instruments. Having simple and clear messaging at the EU level could incentivize investments in disaster risk management, including disaster risk finance, at the national level. This DRF strategy can be developed to reinforce the application of the 2021 EU Climate Adaptation Strategy.
5. **Improve data on DRF.** To inform decision-making on DRF at the EU level, it is important to have reliable data and an-alytics. This would serve to strengthen the recommendation in World Bank (forthcoming (a)) as this data would then form part of a regional transformation in the availability of open data, information, and knowledge on multi-hazard disaster and climate risks. This study has high-lighted a series of gaps including:

    - *Catastrophe modelling data:* the average loss from natural disasters is likely an under-estimate as only earthquake and flood analysis were conducted using regionally con-sistent catastrophe risk models. Future analysis should the regionally consistent catas-trophe risk modelling work to additional hazards and over longer time horizon to im-prove the accuracy of potential losses faced by the EU.
    - *Data on DRF:* data on DRF are limited and there is no comprehensive understanding of how the EU MS manage disaster costs. To address this gap, comprehensive data on penetration of household and public asset insurance could be collected to illuminate how much risk is retained versus transferred in the EU. With these data, it would be possible to develop an informed approach or guidelines on addressing the potential funding gaps.
    - *Macro-fiscal data:* to address the limitations of the macro-fiscal modelling in this study, the EU could consider strengthening modelling of government revenues and non-disaster expenditures; model key economic sectors separately to consider how they contribute to the overall productive capacity (using input-output or computable gen-eral equilibrium models); and incorporating the effects of government spending on in-vestment rates and capital stock accumulation.
6. **Develop an overarching strategy for integrating resilience investments as part of "greening the EU"**. The analysis in this report highlights the need to build financial resilience to natural disasters. However, as demonstrated in a World Bank report on *Retrospective Analysis of the Costs and Benefits of Selected Disaster Risk Management Investments* (forthcoming (a)), financial resilience needs to be complemented by investment in green and resilient infrastructure. A holistic approach should be developed to foster physical and financial resilience to disaster risk; see *Adaptation Principles: A Guide for Designing Strategies for Climate Change Adaptation and Resilience* (Hallegatte, Rentschler, and Rozenberg 2020). The Component 3 report, *Report on the Feasibility of a Technical Assistance Facility for Leveraging Investments in DRM for Participating States,* highlighted the challenges of securing resources for mitigation, adaptation, and response to large-scale events. Developing a combined approach and "greening the EU" would send a clear message that this is a priority for the Commission and that they are willing to dedicate resources to a holistic approach and make it a reality.

At the EU MS level:

7. **To complement the EU level DRF strategy, consider the introduction of comprehensive national DRF strategies to ensure financial preparedness to disasters.** The first step would include determining national priorities in strengthening disaster risk financing (such as focusing on households, the poorest members of society, government budget, etc.).

8. **Develop a structured financing approach to fund disaster response.** Understanding how much financing is needed and for what purpose is key to understanding how to structure a country's financial response capacity. There are many instruments that might be explored, such as capital market instruments (including at the local government level, such as municipal bonds), catastrophe insurance, dedicated off-budget reserve funds, and contingent credit, but each instrument will have its own cost and instruments should therefore be carefully combined. Using a risk-layering approach that combines instruments to address natural disasters and crises of different severities and frequencies, and to meet different post-disaster needs as they arise, promotes a cost-effective approach.

9. **Ensure availability of pre-arranged funding to cover immediate liquidity needs following disasters and crises.** The COVID-19 pandemic demonstrated how timely action leads to better outcomes (Cook and Skalon 2020). Ensuring that funding is available to support such timely response is as important as having contingency plans in place. For example, funding could be ensured though improved management of existing contingency funds or introduction of national disaster response funds, but governance, disbursement, and procedures of these funds must be clearly defined.

10. **Increase penetration of household insurance.** If catastrophe insurance is not increased at the EU level, national governments should consider options for increasing catastrophe household insurance. This could be done, for instance, through public-private partnerships. A good example of this approach is the Turkish Catastrophe Insurance Pool, which saw the introduction of mandatory earthquake insurance after the Marmara earthquake (see *Annex 11*) or the Earthquake Commission in New Zealand and private schemes such as PAID in Romania. However, each country has it unique set of circumstances each will face different complexities when introducing household insurance (i.e. making insurance mandatory may not be feasible for all countries). At the same time, in some countries, a political decision may be made on providing different ways of supporting households after disasters, such as through public compensation. Reinforcing sustainability, predictability and transparency of the latter schemes is equally important. Therefore, a decision on how to increase penetration of household insurance will be context specific.

7. Annexes

Annex 1. Reserve Funds of the EU MS in million EURO

Table 17. Reserve and contingency funds in the EU MS, including the estimated contingency funds

	Existing data (mil EUR)			Estimates (mil EUR)				
country_code	2019 revenues	Contingency funds	Disaster reserve funds	Contingency fund (lower bound)	Contingency fund (upper bound)	Total gov retention mechanism (Lower bound)	Total gov retention mechanism (upper bound)	Amount used (mil EUR)
AT	195,101		438.0	488	976	926	1,413	**925.71**
BE	238,268			596	1,191	596	1,191	**1,191.34**
BG	23,292	35.0		58	116	58	116	**116.46**
CY	9,047			23	45	23	45	**45.24**
CZ	92,763			232	464	232	464	**463.82**
DE	1,608,567			4,021	8,043	4,022	8,044	**4,022.42**
DK	165,616			414	828	414	828	**828.08**
EE	10,849		433.8	27	54	461	488	**460.96**
EL	89,480			224	447	224	447	**447.40**
ES	486,754			1,217	2,434	1,217	2,434	**2,433.77**
FI	125,239			313	626	313	626	**626.20**
FR	1,275,708		131.5	3,189	6,379	3,321	6,510	**3,320.77**
HR	25,626			64	128	64	128	**128.13**
HU	63,288			158	316	158	316	**316.44**
IE	87,453	1,527.0		219	437	219	437	**437.26**
IT	841,441		687.6	2,104	4,207	2,791	4,895	**2,791.21**
LT	17,024			43	85	43	85	**85.12**
LU	28,456			71	142	71	142	**142.28**
LV	11,790		30.5	29	59	60	89	**59.95**
MT	5,045			13	25	13	25	**25.23**
NL	354,279			886	1,771	886	1,771	**1,771.40**
PL	218,417			546	1,092	546	1,092	**1,092.08**
PT	91,008			228	455	228	455	**455.04**
RO	70,836	1,061.8		177	354	177	354	**354.18**
SE	236,269			591	1,181	591	1,181	**1,181.35**
SI	21,228			53	106	53	106	**106.14**
SK	39,085			98	195	98	195	**195.42**

Annex 2.
Examples of Disaster Reserve Funds and Contingencies Funds in the EU

Table 18. Different types of reserve and contingency funds in the EU MS

NAME	PURPOSE	COUNTRY
Dedicated disaster funds		
National disaster reserve fund (*Katastrophenfonds*)	Established with the Disaster Fund Act of 1996, the fund can cover both ex-ante risk management and post-disaster needs. The fund can be used to finance large-scale protection infrastructure (ex-ante risk management), but also serves to compensate the affected population. The fund can cover damages from flood, avalanche, earthquake, landslide, hurricane and hail.[44] In addition to this fund, ministries and agencies in Austria seem to be able to use their reserves (savings or additional revenues) at their own discretion for different purposes, including post-disaster financing.[45]	Austria
National Recovery Fund	Managed by the Ministry of Finance, the fund can support municipalities in case disaster damages to public infrastructure exceed their own budgets. However, the amount of funding available annually is challenging to estimate.[46]	Finland
Fonds de prévention des risques naturels majeurs ('Fonds Barnier')	The fund can cover emergency housing or temporary rehousing and relocation, prevention measures, information measures and research activities (the local governments are the beneficiaries).[47,48]	France
General contingency funds		
Interagency Commission for Relief and Recovery to the Council of Ministers	The Commission is allocated with regular budget that is aimed at covering exceptional and unanticipated costs that may occur from disasters (natural or man-made) or other events such as the mass migration of refugees.[49]	Bulgaria

44 OECD 2015, 2016 and 2018.
45 Gerhard Steger, Austria's Budget Reform: How to Create Consensus for a Decisive Change of Fiscal Rules. OECD: Journal on Budgeting. Volume 2010/1
46 DRIVER Finland 2015.
47 French Ministry of Ecology Report 2019.
48 Other special purpose reserve funds covering disaster relief expenditures are available in France, but were not considered for the purpose of the analysis; (i) the *Fonds national de gestion des risques en agriculture* covers agricultural producers for uninsurable crop lost due to natural hazards or disease outbreak, and (ii) the *Fonds de secours outre-mer* covers the reconstruction of uninsured private assets, uninsurable subnational assets, and for immediate disaster relief in overseas territories (purchase of basic necessities). OECD 2019, Fiscal Resilience to Natural Disasters
49 Bulgaria Assessment of DRM sector 2018.

Budgetary reserve	Article 56 of the Budget Act provides for the establishment of a budgetary reserve covering expenditures which emerged during the alleviation of the consequences of natural disasters, epidemics, environmental mishaps or extraordinary events and other unforeseen purposes for which no funding has been secured in the budget, or for purposes for which it is ascertained during the course of the year that insufficient funds were established for them because they were impossible to foresee during budget planning. Although the government can use the reserve discretionally, it has to report use of the reserve to the Sabor (the Croatian Parliament).Its amount cannot exceed 0.5% of budget revenues (including taxes but excluding receipts such as user charges and fees).[50]	Croatia
General contingency funds	Two general contingency funds are available: (i) a budgetary allocation for emergency and immediate measures, based on Regulatory Acts No. 239/2000 Sb. and No.240/2000 Sb, that can cover rescue and health protection of affected population and (ii) a budgetary allocation for property reconstruction and revitalization (State Aid for Territorial Restoration), based on Acts No. 12/200 Sb and No.186/2002 Sb. that can cover reconstruction of destroyed property in the form of interest-free loans to municipalities, firms and households.[51]	Czech Republic
Stabilization Reserve Fund	The fund can be used in case of “resolution or prevention of an emergency situation, a state of emergency, a state of war or other extraordinary situation or a crisis with material effect”. Unexpected costs of small-scale emergencies are covered by the government liquidity reserve.[52]	Estonia
Force Majeure Fund	**The fund** can cover reconstruction of government owned assets destroyed by natural disasters.[53]	Hungary
Rainy Day Fund	**The fund was** set up by National Surplus Bill 2018, and managed by the National Treasury Management Agency (NTMA) on behalf of the Ministry of Finance, aims to mitigate severe economic shocks, in excess of the normal fluctuations of the economic cycle.	Ireland
Fondo per le emergenze nazionali	The fund was set up by art. 5.5-quinquies Legge 225/1992 to cover “situations of national emergencies”. The fund can for instance finance relief and assistance to the population, restoration of public services and network infrastructure, needs and damages assessments, fiscal exonerations for victims and temporary suspensions of repayments of real estate loans on destroyed or damaged buildings, etc.[54]	Italy
Fiscal Safety Reserve	The fund was set up by the Civil Protection and Disaster Management Law and can cover fiscal risks with funding of maximum 0.1% of GDP.[55]	Latvia
Stabilization Reserve Fund	The fund can cover state budget expenditures in case of “exceptional circumstances”.[56]	Lithuania

50 Budgeting in Croatia 2006.
51 World Bank 2011, Financial and Fiscal Instruments for Catastrophe Risk Management Addressing Losses From Flood Hazards In Central Europe (Poland, Czech Republic, Hungary And Slovakia)
52 Estonian Ministry of Finance website.
53 World Bank 2011, Financial and Fiscal Instruments for Catastrophe Risk Management Addressing Losses From Flood Hazards In Central Europe (Poland, Czech Republic, Hungary And Slovakia)
54 PROMETEIA 2019.
55 Civil Protection and Disaster Management Law
56 OECD 2012, Budgeting in Lithuania

Annual reserve for prevention and recovery	It can cover disaster risk prevention activities such as flood protection works, as well as liquidation of property damages caused by natural disasters through financial assistance to local governments for housing or infrastructure reconstruction, and post-disaster assistance to individuals.[57]	Poland
Fundo de Apoio Municipal and the Emergency Bank Account	The *Fundo de Apoio Municipal* financial can cover recovery of the municipalities in financial state of imbalance through the implementation of municipal adjustment programmes. This includes loans to municipalities to finance reconstruction of infrastructure and equipment damaged as a result of disasters. The Emergency Bank Account can support individual citizens affected by certain disasters.[58]	Portugal
Fondul de rezervă budgetară	The fund was set up by Lege 500/2002 to cover disaster costs, as well as other contingencies.[59]	Romania
Special budget reserve	The reserve can cover general contingencies and disaster relief programmes.[60]	Slovenia
Ad hoc reserve funds		
Funds established after disasters	Following disasters, several ad hoc reserve funds were established, for instance in Germany: (i) *Sonderfonds Aufbauhilfe*, amount € 7.1 billion, was set up to cover damages from the 2002 flood; (ii) *Aufbauhilfegesetz*, amount € 8 billion, was set up to cover damages from the June 2013 flood.[61] In France, ad hoc emergency relief funds are usually set up by the Ministry of Interior to provide immediate disaster relief (purchase of basic necessities, e.g. food, clothing, accommodation) to the affected individuals with compensations. capped at €300 per affected adults and €100 per affected child. These funds are excluded from the analysis.	E.g. in Germany, France
Subnational disaster reserve funds		
Funds to cover disasters costs at the local level	In some countries, like in Belgium, the national disaster reserve fund was abolished and instead replaced with funds at the subnational level. In Germany, disaster risk reduction and disaster risk management is under the responsibility of the *Landers*. In Slovakia, self-governing regions can also establish crisis funds to finance a potential damage, even if the obligation to do so does not exist[62]. These funds are excluded from the analysis.	E.g. in Belgium, Germany, Slovakia

57 Act on Crisis Management of 26 April 2007.
58 EC. EUROPA 2019 and Fundo de Apoio Municipal website, https://www.fundodeapoiomunicipal.gov.pt/o-fam.
59 România Consiliul Fiscal 2019
60 Final account of the budget of the Republic of Slovenia for 2019
61 MERZ, ELMER, KUNZ et al. 2014.
62 DRIVER Slovakia 2015.

Annex 3.
Funding from the EUSF and Disaster Damages over 2002 - 2020

Table 19. Funding from the EUSF over 2002 – 2020 vs total damages of the disasters after which the EUSF aid was provided

COUNTRIES	SUM OF EUSF AID (2002-2020)	SUM OF TOTAL DIRECT DAMAGE OF DISASTERS FOR WHICH THE EUSF WAS REQUESTED
Austria	178,940,000	4,694,000,000
Bulgaria	41,500,000	1,182,000,000
Croatia	706,527,523	12,374,586,387
Cyprus	14,900,000	346,000,000
Czech Republic	160,900,000	3,579,000,000
Estonia	1,300,000	48,000,000
France	252,600,000	9,527,000,000
Germany	1,002,900,000	23,263,000,000
Greece	122,800,000	3,436,400,000
Hungary	37,600,000	1,238,000,000
Ireland	13,000,000	521,000,000
Italy	2,792,900,000	58,739,300,000
Latvia	27,200,000	573,500,000
Lithuania	17,300,000	423,000,000
Malta	960,000	30,000,000
Poland	124,971,280	3,767,851,202
Portugal	142,612,697	4,251,508,000
Romania	127,200,000	4,360,700,000
Serbia	60,200,000	1,105,000,000
Slovakia	26,100,000	764,000,000
Slovenia	48,300,000	1,273,000,000
Spain	90,943,358	3,730,734,308
Sweden	81,700,000	2,297,000,000
UK	222,600,000	7,024,000,000
Grand Total	6,295,954,858	148,548,579,897

Annex 4.
Insurance penetration in the EU MS

Table 20. Proportion of households covered by insurance in the EU MS

	PROPORTION OF HOUSEHOLDS COVERED	
COUNTRY	EARTHQUAKE	FLOOD
DK	0%	0%
HR	0%	0%
LT	0%	0%
MT	0%	0%
NL	0%	0%
LU	0%	10%
EE	0%	55%
PL	1%	60%
IT	7%	10%
CY	7%	20%
AT	10%	10%
BG	10%	10%
EL	15%	10%
PT	16%	40%
RO	20%	20%
LV	20%	95%
CZ	25%	25%
SI	25%	25%
DE	40%	40%
HU	70%	0%
ES	75%	75%
BE	90%	75%
IE	90%	90%
SE	90%	90%
SK	90%	90%
FI	95%	10%
FR	97%	97%

Sources: AXCO; OECD 2015, 2016 and 2018; EU JRC 2012.

Note: There are some caveats to the above data, including that it is, in some cases, outdated. When the range of households covered was provided, the upper limit was selected, so the penetration might be overstated.

Annex 5.
Assumptions of the National Funding Gap Analysis

GOVERNMENT LIABILITIES:

The contingent liabilities of the government from natural disasters are estimated using the following:

- **Emergency response cost:** it is assumed that such costs represent 15% of total government liabilities for floods and 20% of total government liabilities for earthquakes.
- **Public asset reconstruction**: it is assumed that the government is 100% liable for the costs of reconstruction of uninsured public assets.
- **Support to households**: represented by reducing the residential losses by the proportion of households with insurance cover. Two scenarios are analysed; (i) "high" - government is liable for 100% of residential loss of uninsured households; or, (ii) "low" - support is provided to those households whose household income is below the poverty line.

FINANCIAL INSTRUMENTS:

To understand the funding gap in EU MS the analysis considers the following financial instruments:

- **National reserve funds**: maximum of 0.5% of national revenues in 2019 to serve as a proxy for general contingencies fund (including any dedicated national disaster reserves).
- **Household insurance penetration**: Proportion of households in each country with catastrophe insurance.
- **The EUSF:** Given the complexity of the EUSF the level of loss required to activate the EUSF (0.6% of GNI or a max level of disaster loss) is analysed to understand; (i) where the activation point is relative to the national reserves; and, (ii) if lowering the activation level allows for an improved risk layering of instruments for less severe but frequent events.

  Second, EUSF financing is capped due to the split between the EUSF aid and the Emergency Aid of the EU. Through the funding gap analysis, we are trying to ascertain whether or not increasing the share of the EUSF beyond the total €1.2 billion available at EU level for response could result in an improved financial resilience for more extreme events.

  For all scenarios a provision of €100 million for "other disasters", those that are not earthquake and flood related, was made and hence the maximum amount that could be covered for EQ and floods is presented in the *Table 21*

Table 21. Maximum amount that could be provided by the EUSF for earthquake and floods

SCENARIO	ACTIVATION LEVEL ("ATTACHMENT POINT"	PERCENT LOSSES COVERED.	MAXIMUM AMOUNT COVERED.
BASE	Standard, as defined in the EUSF guidelines.	4%-5% of total asset losses on average, as shown by the historical analysis of previous disasters when EUSF support was used.	€660 million for floods and earthquakes
Strategy B	Standard, as defined in the EUSF guidelines.	70% more than the average shown by the historical analysis of previous disasters when EUSF support was used, to use all the €1.2 billion fund	€1,100 million for floods and earthquakes
Strategy C	Lower activation point, of 0.5% of GNI	4%-5% of total asset losses on average, as shown by the historical analysis of previous disasters when EUSF support was used.	€660 million for floods and earthquakes

Annex 6.
Assumptions of the EU Level Funding Gap Analysis

On top of the assumptions already presented in *Annex 5* above, some more simplifying assumptions were needed to be able to run an all MS analysis.

GOVERNMENT LIABILITIES:

Total government liabilities are reduced by 33% to represent public assets covered by insurance; and, (ii) the government could be liable to cover the reconstruction of uninsured households of either 100% (high government liability) or 20% (low government liability).

NATIONAL RESERVES:

Here it is assumed that each country will have a national contingency fund and/or a dedicated disaster reserve to respond to disasters, and that for the EU level analysis it is assumed that the EU will benefit from a country's national DRF instruments. The national funds are aggregated according to two strategies; (i) 1% of the sum of all EU MS estimated national contingency funds; and, (ii) 5% of the sum of all EU MS estimated national contingency funds.

EUSF:

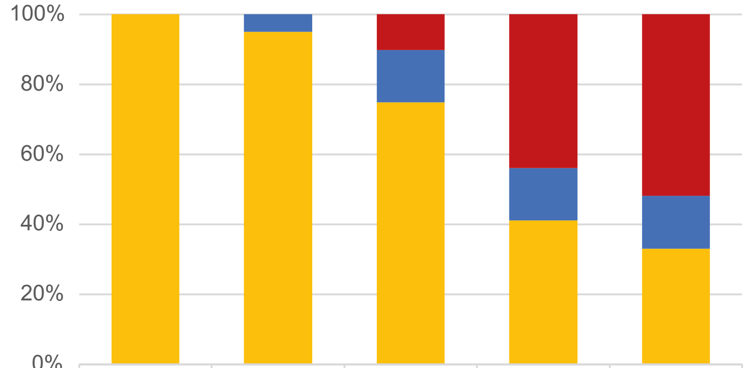
For the EU level analysis it is assumed that the EUSF is the main DRF instrument available for response and that it activates for disasters above pre-defined thresholds of loss and can cover up losses to a maximum annual level, see *Table 21*. As per the national level a provision of €100 million for "other disasters" was made.

It is important to highlight that the analysis was constrained by the low number of EQ events and that the long tail of high severity EQ risk means that at any point a moderately-severe EQ can deplete the total of €761 million in the EUSF. This is however a limitation of the model, as we will not be able to dynamically account for the coexistence of FL and EQ at the EU level, but only country by country. It is thus critical that the EU maintains the flexibility to allocate funds between the EUSF and Emergency Aid Reserve, up to the total of €1.2 billion, in extreme situations.

Annex 7.
Summary of Utilization of DRF Instruments EU MS

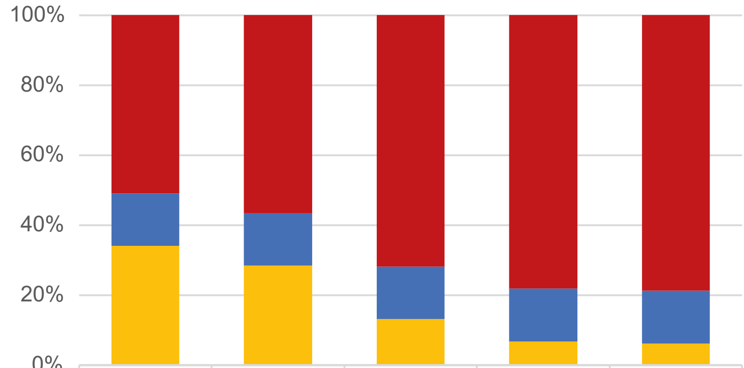
This annex contains the breakdown of utilization of DRF instruments (national reserves, EUSF) to cover low government liabilities (total government liabilities after the effect of household catastrophic insurance and public asset insurance) for each EU MS, except for the 4 case study countries already discussed in detail in the report.

Belgium: The breakdown of instrument use to fund different magnitudes of low government liability by return period (million €)



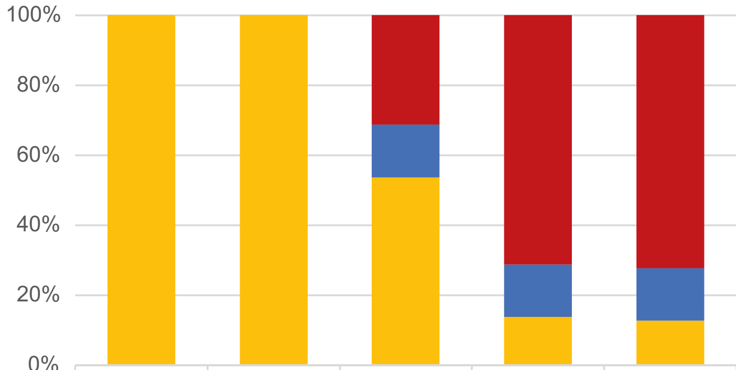
	Average annual loss	1-5 year	1-10 year	1-50 year	1-100 year
Funding gap	-	-	160	1 276	1 869
EUSF	-	56	239	435	540
Reserve fund	749	1 066	1 191	1 191	1 191

Bulgaria: The breakdown of instrument use to fund different magnitudes of low government liability by return period (million €)



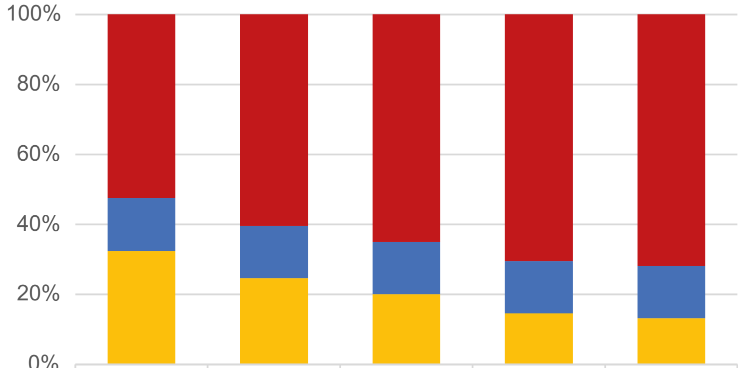
	Average annual loss	1-5 year	1-10 year	1-50 year	1-100 year
Funding gap	174	232	638	1 340	1 478
EUSF	51	62	133	257	281
Reserve fund	116	116	116	116	116

Czech Republic: The breakdown of instrument use to fund different magnitudes of low government liability by return period (million €)



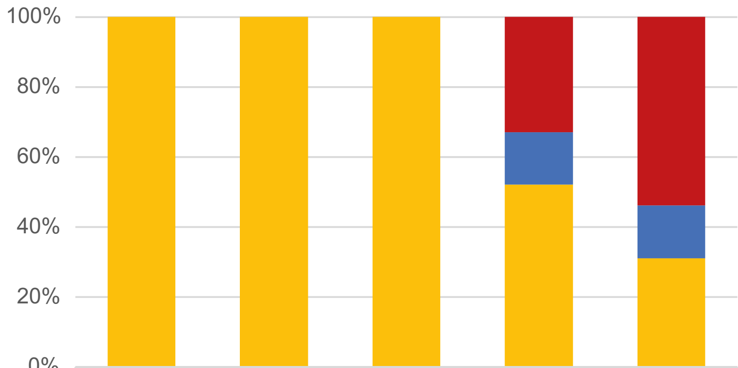
	Average annual loss	1-5 year	1-10 year	1-50 year	1-100 year
Funding gap	-	-	270	2 399	2 640
EUSF	-	-	130	505	548
Reserve fund	348	442	464	464	464

Cyprus: The breakdown of instrument use to fund different magnitudes of low government liability by return period (million €)



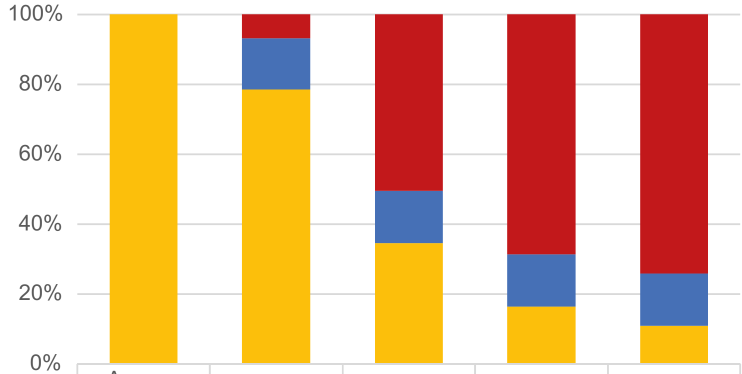
	Average annual loss	1-5 year	1-10 year	1-50 year	1-100 year
Funding gap	73	111	147	220	246
EUSF	21	28	34	47	51
Reserve fund	45	45	45	45	45

Denmark: The breakdown of instrument use to fund different magnitudes of low government liability by return period (million €)



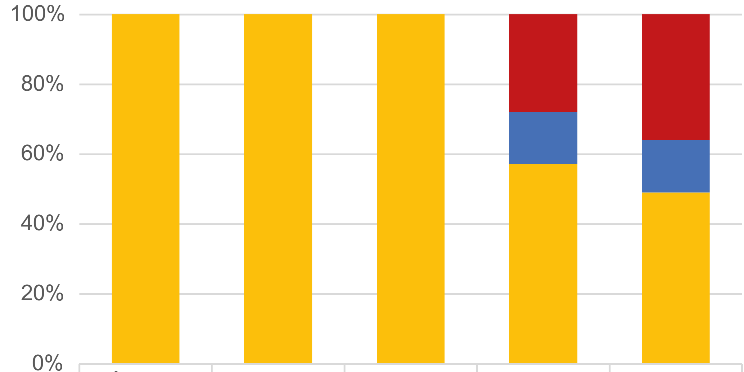
	Average annual loss	1-5 year	1-10 year	1-50 year	1-100 year
Funding gap	-	-	-	522	1 437
EUSF	-	-	-	238	400
Reserve fund	234	283	607	828	828

Estonia: The breakdown of instrument use to fund different magnitudes of low government liability by return period (million €)



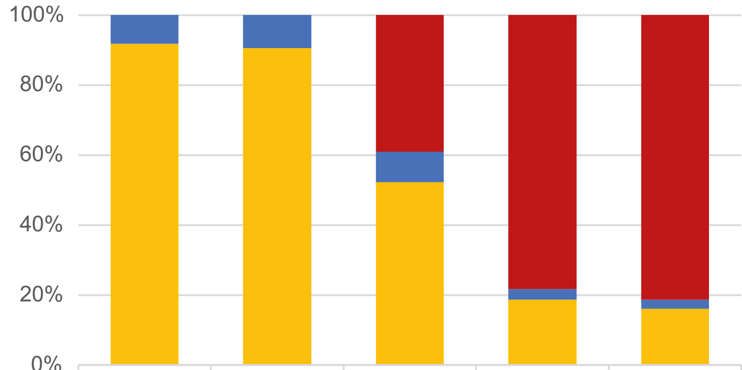
	Average annual loss	1-5 year	1-10 year	1-50 year	1-100 year
Funding gap	-	5	80	228	371
EUSF	-	10	24	50	75
Reserve fund	50	54	54	54	54

Finland: The breakdown of instrument use to fund different magnitudes of low government liability by return period (million €)



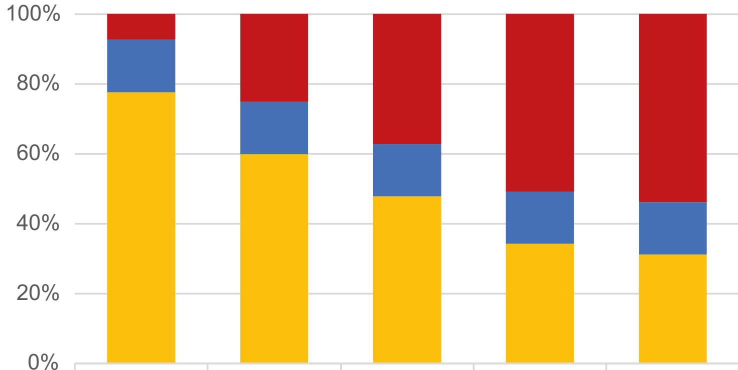
	Average annual loss	1-5 year	1-10 year	1-50 year	1-100 year
Funding gap	-	-	-	305	458
EUSF	-	-	-	164	191
Reserve fund	135	205	382	626	626

Germany: The breakdown of instrument use to fund different magnitudes of low government liability by return period (million €)



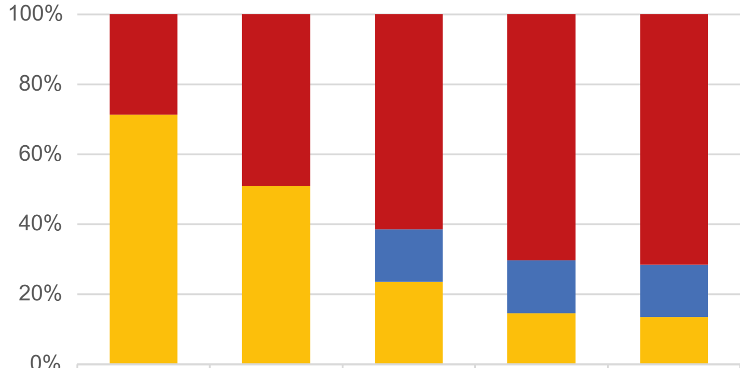
	Average annual loss	1-5 year	1-10 year	1-50 year	1-100 year
Funding gap	-	-	3 004	16 952	20 421
EUSF	251	346	660	660	660
Reserve fund	2 823	3 360	4 022	4 022	4 022

Greece: The breakdown of instrument use to fund different magnitudes of low government liability by return period (million €)



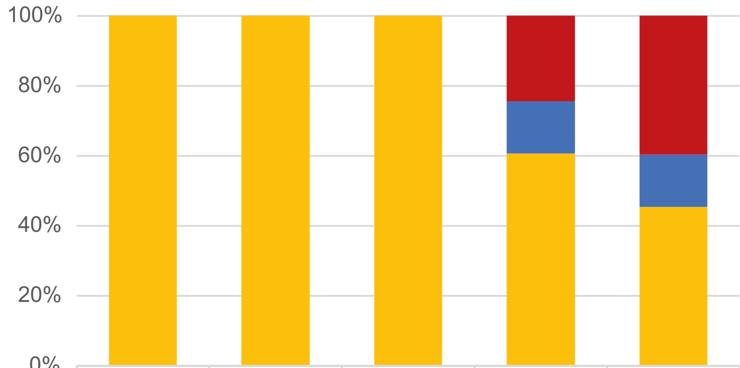
	Average annual loss	1-5 year	1-10 year	1-50 year	1-100 year
Funding gap	42	188	349	664	773
EUSF	86	112	140	196	215
Reserve fund	447	447	447	447	447

Hungary: The breakdown of instrument use to fund different magnitudes of low government liability by return period (million €)



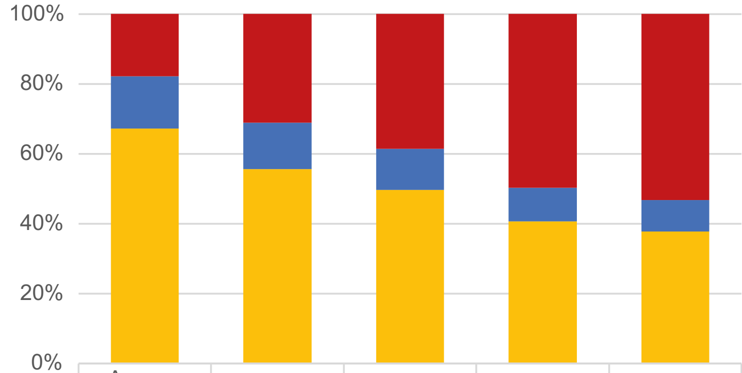
	Average annual loss	1-5 year	1-10 year	1-50 year	1-100 year
Funding gap	70	169	457	845	936
EUSF	-	-	111	180	196
Reserve fund	175	175	175	175	175

Ireland: The breakdown of instrument use to fund different magnitudes of low government liability by return period (million €)



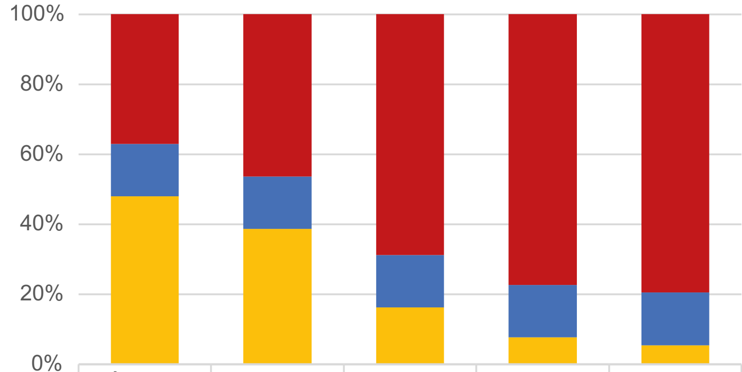
	Average annual loss	1-5 year	1-10 year	1-50 year	1-100 year
Funding gap	-	-	-	176	382
EUSF	-	-	-	108	145
Reserve fund	69	80	168	437	437

Italy: The breakdown of instrument use to fund different magnitudes of low government liability by return period (million €)



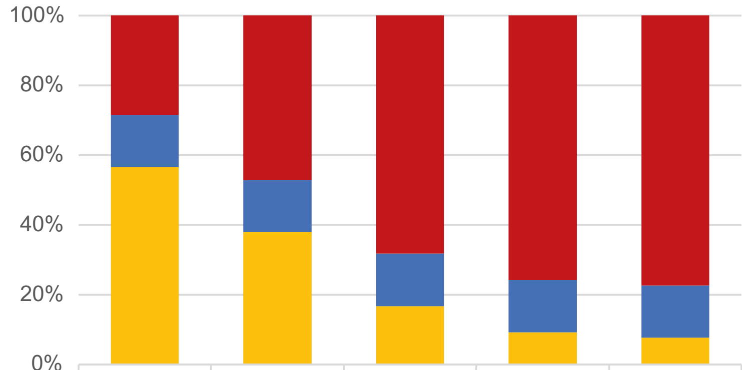
	Average annual loss	1-5 year	1-10 year	1-50 year	1-100 year
Funding gap	741	1 561	2 174	3 410	3 933
EUSF	623	660	660	660	660
Reserve fund	2 791	2 791	2 791	2 791	2 791

Latvia: The breakdown of instrument use to fund different magnitudes of low government liability by return period (million €)



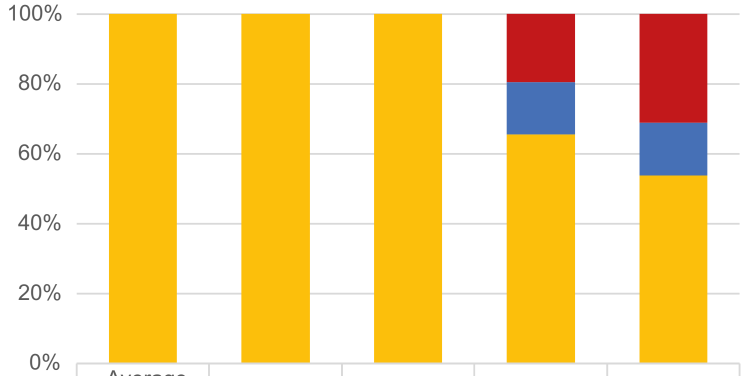
	Average annual loss	1-5 year	1-10 year	1-50 year	1-100 year
Funding gap	46	72	254	604	878
EUSF	19	23	55	117	165
Reserve fund	60	60	60	60	60

Lithuania: The breakdown of instrument use to fund different magnitudes of low government liability by return period (million €)



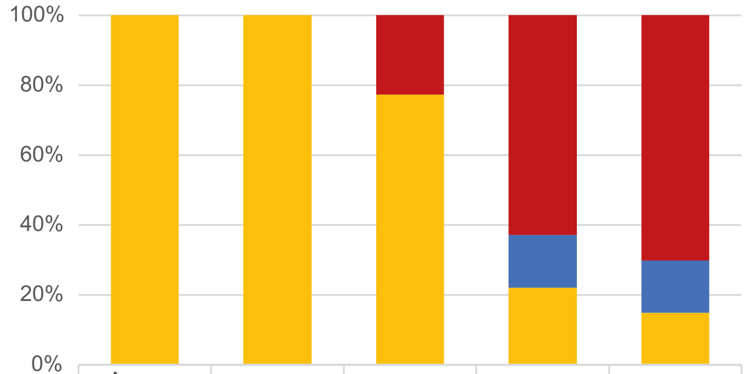
	Average annual loss	1-5 year	1-10 year	1-50 year	1-100 year
Funding gap	43	106	347	705	857
EUSF	23	34	76	139	166
Reserve fund	85	85	85	85	85

Luxembourg: The breakdown of instrument use to fund different magnitudes of low government liability by return period (million €)



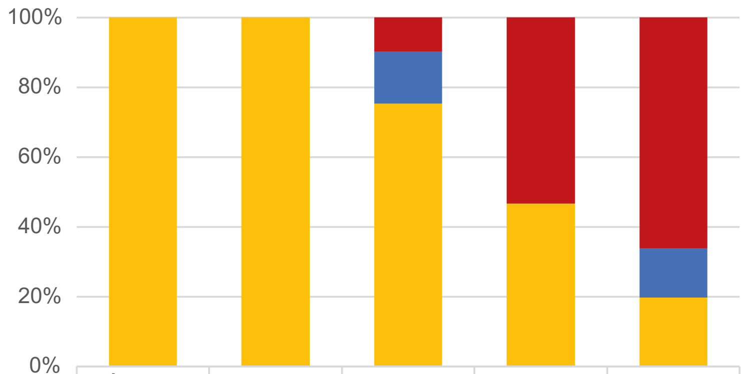
	Average annual loss	1-5 year	1-10 year	1-50 year	1-100 year
Funding gap	-	-	-	42	82
EUSF	-	-	-	33	40
Reserve fund	23	22	56	142	142

Malta: The breakdown of instrument use to fund different magnitudes of low government liability by return period (million €)



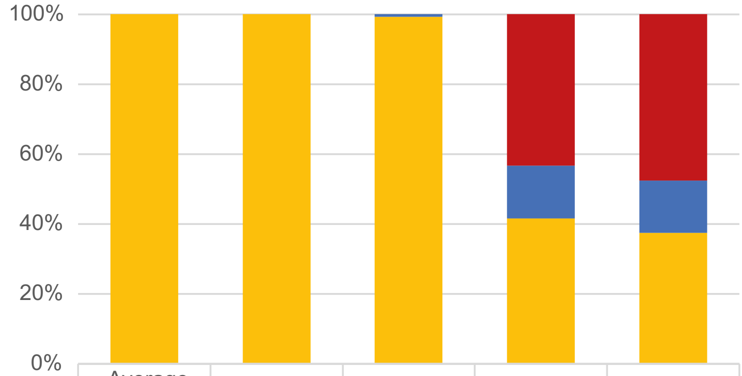
	Average annual loss	1-5 year	1-10 year	1-50 year	1-100 year
Funding gap	-	-	7	72	120
EUSF	-	-	-	17	26
Reserve fund	15	16	25	25	25

Netherlands: The breakdown of instrument use to fund different magnitudes of low government liability by return period (million €)



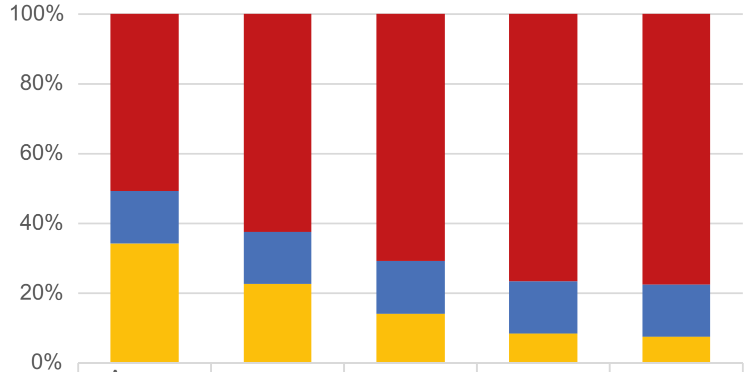
	Average annual loss	1-5 year	1-10 year	1-50 year	1-100 year
Funding gap	-	-	229	2 021	3 102
EUSF	-	-	353	6	660
Reserve fund	921	1 450	1 771	1 771	921

Poland: The breakdown of instrument use to fund different magnitudes of low government liability by return period (million €)



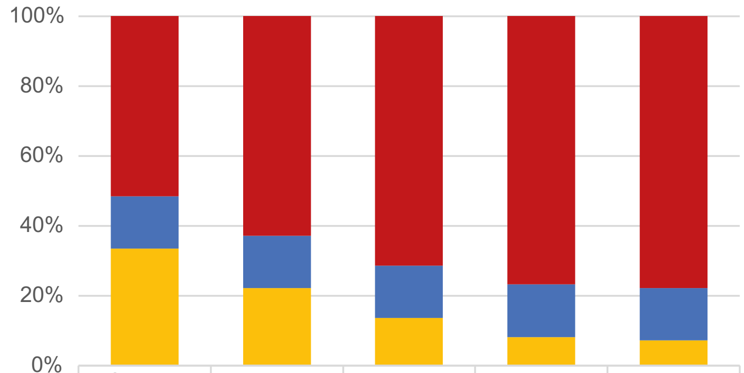
	Average annual loss	1-5 year	1-10 year	1-50 year	1-100 year
Funding gap	-	-	-	1 138	1 391
EUSF	-	-	6	393	438
Reserve fund	397	632	1 037	1 092	1 092

Portugal: The breakdown of instrument use to fund different magnitudes of low government liability by return period (million €)



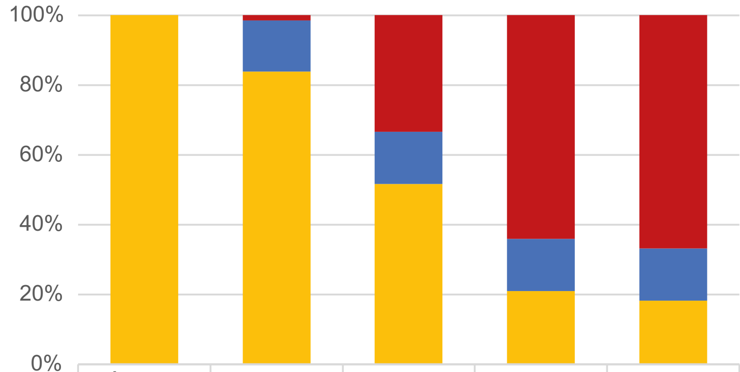
	Average annual loss	1-5 year	1-10 year	1-50 year	1-100 year
Funding gap	157	293	533	960	1 108
EUSF	46	70	113	188	214
Reserve fund	106	106	106	106	106

Slovakia: The breakdown of instrument use to fund different magnitudes of low government liability by return period (million €)



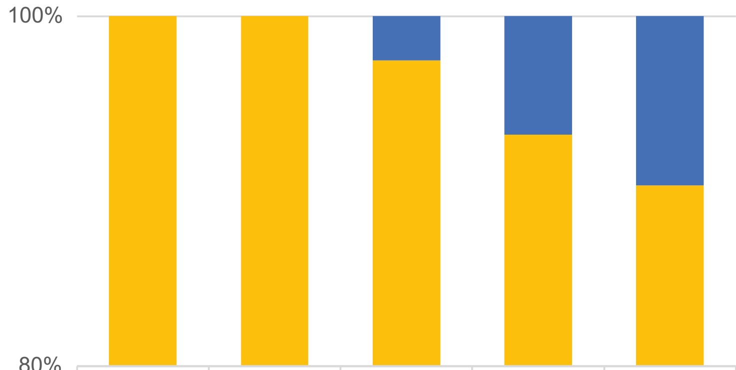
	Average annual loss	1-5 year	1-10 year	1-50 year	1-100 year
Funding gap	164	301	554	997	1 158
EUSF	48	72	117	195	223
Reserve fund	106	106	106	106	106

Slovenia: The breakdown of instrument use to fund different magnitudes of low government liability by return period (million €)



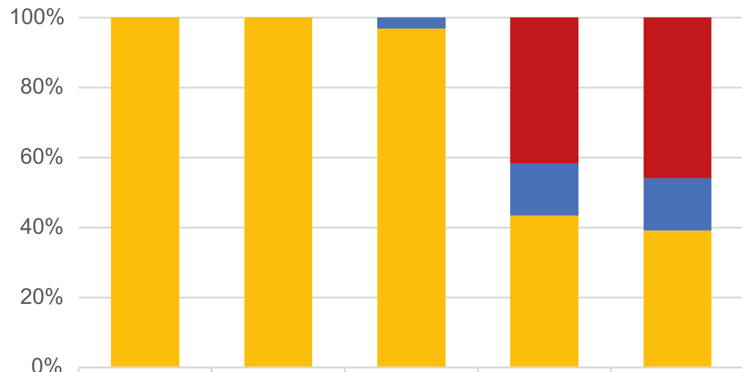
	Average annual loss	1-5 year	1-10 year	1-50 year	1-100 year
Funding gap	-	2	68	325	391
EUSF	-	19	31	76	88
Reserve fund	98	106	106	106	106

Spain: The breakdown of instrument use to fund different magnitudes of low government liability by return period (million €)



	Average annual loss	1-5 year	1-10 year	1-50 year	1-100 year
Funding gap	-	-	-	-	-
EUSF	-	-	40	161	261
Reserve fund	636	1 048	1 525	2 210	2 434

Sweden: The breakdown of instrument use to fund different magnitudes of low government liability by return period (million €)



	Average annual loss	1-5 year	1-10 year	1-50 year	1-100 year
Funding gap	-	-	-	1 134	1 386
EUSF	-	-	32	409	453
Reserve fund	377	569	997	1 181	1 181

Annex 8.
Integration of Disaster Risk Finance Arrangements in the Macro-Fiscal Model

In our model, the impact of the catastrophic event on the government expenditures considers the factors detailed in the table below.

Table 22. Factors influencing government expenditures in case of a natural disaster.

NR.	VARIABLE DESCRIPTION	ACRONYM
1	Percent of commercial losses that the government is liable for	COMM_LIAB
2	Ratio of emergency response cost to direct asset losses	EMR_2_LOSS
3	Percent of emergency response costs that the government is liable for	EMR_LIAB
4	Percent of industrial losses that the government is liable for	IND_LIAB
5	Percent of losses in commercial sector covered by insurance	INS_COM_COVER
6	Percent of losses in industrial sector covered by insurance	INS_IND_COVER
7	Percent of losses in public sector covered by insurance	INS_PUB_COVER
8	Maximum payout per dwelling for residential insurance	INS_RES_MAX
9	Penetration rate of residential insurance	INS_RES_PEN
10	Number of dwellings in the country	N_DW
11	Ratio of publicly owned assets to total value of assets	PUB_ASSET_RATIO
12	Percent of government asset losses that the government is liable for	PUB_LIAB
13	Percent of private households losses that the government is liable for	RES_LIAB
14	Amount of reserve fund in million € (not including solidarity fund) to be spend on emergency response on recovery	RESERVE_FUND
15	European Union Solidarity Fund payout	SF_PAYOUT

Based on the Catastrophe Risk modelling results, the following variables are used as inputs in the fiscal part of our macro-model:

Losses by sector:

- LOSS_IND_R – industrial losses
- LOSS_COM_R – commercial sector losses
- LOSS_RES_R – residential sector losses
- LOSS_HLT_R – health sector losses
- LOSS_EDU_R – educational sector losses

To estimate the expenditures under the shock scenario, the following steps are taken:

Determine the insurance industry liabilities, by country and type of hazard:

Insurance liability for private sector:
*INS_LOSS_PS_R= LOSS_IND_R*INS_IND_COVER+LOSS_COM_R*INS_COM_COVER*

Insurance liability for households:
*INS_LOSS_RES_R= LOSS_RES_R*INS_RES_PEN*

Insurance liability for insurance:
INS_LOSS_RES_R= MIN (LIMIT_INS_RES, INS_LOSS_RES_R),

*where LIMIT_INS_RES= = INS_RES_MAX/1E6*LOSS_RES_R*RATIO_NDW_2_RES*LOSS_RES_R.*

Insurance liability for public sector:
*INS_LOSS_PUB_R= (LOSS_PUB_R+LOSS_EDU_R+LOSS_HLT_R)*INS_PUB_COVER*

Determine the government liabilities, by country and type of hazard:

Government liabilities for private sector:
GOVT_LIAB_PS_R=LOSS_IND_R(1-INS_IND_COVER)*IND_LIAB+LOSS_COM_R*(1-INS_COM_COVER)*COMM_LIAB*

Government liabilities for residential sector:
*GOVT_LIAB_RES_R = (LOSS_RES_R-INS_LOSS_RES_R)*RES_LIAB*

Government liabilities for public sector:
*GOVT_LIAB_PUB_R = (LOSS_PUB_R+LOSS_EDU_R+LOSS_HLT_R-INS_LOSS_PUB_R)*PUB_LIAB+ INTER_COST_R*EMR_LIAB*

Total Government liabilities:
GOVT_LIAB_TOT_R = GOVT_LIAB_PS_R+GOVT_LIAB_RES_R +GOVT_LIAB_PUB_R

The impact of the catastrophic event on the expenditures can be defined as follows, taking into account the European Union Solidarity Fund and the reserve fund in a particular country:

GOVT_LIAB_NET_R = MAX (0, GOVT_LIAB_TOT_R-SF_PAYOUT_PER_COUNTRY-RESERVE_FUND)

If we assume that the recovery period is *n* years, then the additional annual government expenditures due to natural disaster can be express by the following formula:

$$EXPEND\_LOSS\_R = \frac{\sum GOVT\_LIAB\_NET\_R}{n}.$$

Under the shock scenario, induced by the natural disaster, the government expenditures are calculated using the estimated expenditures under the baseline scenario, plus the additional expenditures due to disaster:

$$G_t^{shock} = G_t^{baseline} + EXPEND\_LOSS\_R_t.$$

Annex 9.
Thresholds for the EUSF by Country

Below are the thresholds for mobilization of the EUSF in 2019 used for the macro-fiscal model.

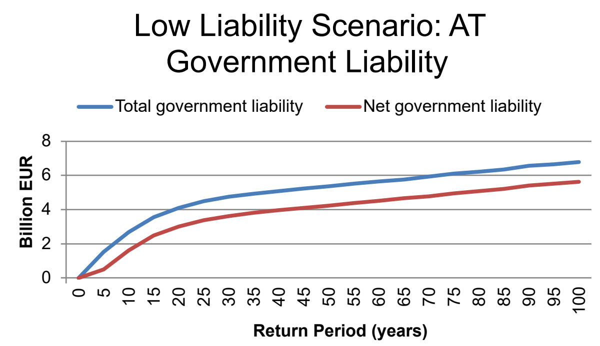
Table 23. EUSF thresholds per country

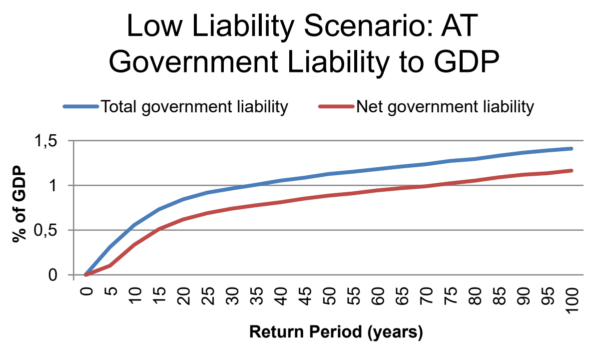
COUNTRY CODE	GNI 2018 (MILLION €)	0.6% OF GNI (MILLION €)	MAJOR DISASTER THRESHOLD 2020 (MILLION €)	MAJOR DISASTER THRESHOLD 2019 (MILLION €)	MAJOR DISASTER T HRESHOLD 2019 (€)
AT	384 653	2 307.918	2 307.918	2214	2,213,502,000
BE	462 774	2 776.644	2 776.644	2666	2,666,094,000
BG	56 570	339	339	314	314,046,000
CY	20 388	122	122	114	114,222,000
CZ	196 199	1 177.194	1 177.194	1079	1,079,232,000
DE	3 437 908	20 627.448	3 585.278*	3515	3,514,978,000
DK	305 366	1 832.196	1 832.196	1770	1,769,964,000
EE	25 549	153	153	139	138,888,000
EL	183 740	1 102.440	1 102.440	1086	1,086,066,000
ES	1 204 894	7 229.364	3 585.278*	3515	3,514,978,000
FI	235 241	1 411.446	1 411.446	1359	1,358,922,000
FR	2 406 070	14 436.420	3 585.278*	3515	3,514,978,000
HR	50 546	303	303	289	288,612,000
HU	128 421	771	771	715	714,576,000
IE	254 307	1 525.842	1 525.842	1405	1,405,326,000
IT	1 784 620	10 707.720	3 585.278*	3515	3,514,978,000
LT	43 811	263	263	243	243,006,000
LU	38 256	230	230	235	235,194,000
LV	28 649	172	172	161	161,076,000
MT	11 355	68	68	62	62,358,000
NL	781 718	4 690.308	3 585.278*	3515	3,514,978,000
PL	476 858	2 861.148	2 861.730	2640	2,639,730,000
PT	199 411	1 196.466	1 196.466	1142	1,142,184,000
RO	198 675	1 192.050	1 101.966	1102	1,101,966,000
SE	478 524	2 871.144	2 871.144	2892	2,891,772,000
SK	88 303	530	530	499	498,984,000
SI	45 034	270	270	253	253,332,000
UK	2 386 586	14 319.408	3 585.278*	3515	3,514,978,000
ME	4 718	28	28	26	26,304,000
TR	743 610	4 461.660	3 585.278*	3515	3,514,978,000
RS	40 642	244	244	220	219,732,000

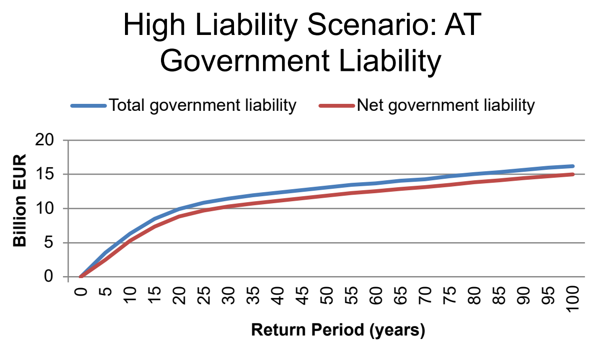
*Note: *The threshold of €3 billion in 2011 prices applies (in 2019, €3,317.75 million)*
Source: https://ec.europa.eu/regional_policy/sources/thefunds/doc/thresholds_2019.pdf *and the World Bank staff estimates*

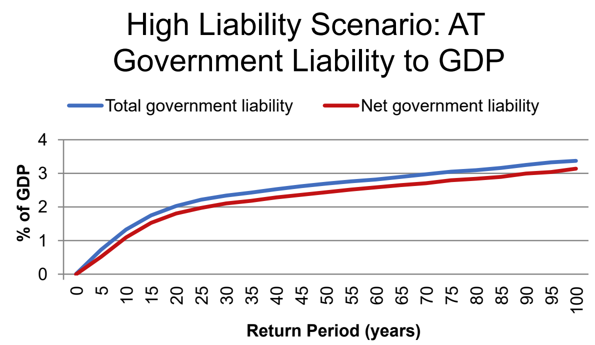
Annex 10.
Results of Macro-Fiscal Modelling

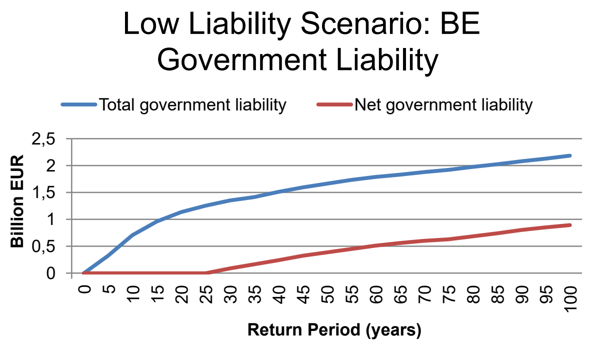
IMPACT OF DRF INSTRUMENTS ON GOVERNMENT LIABILITIES AT DIFFERENT RETURN PERIODS

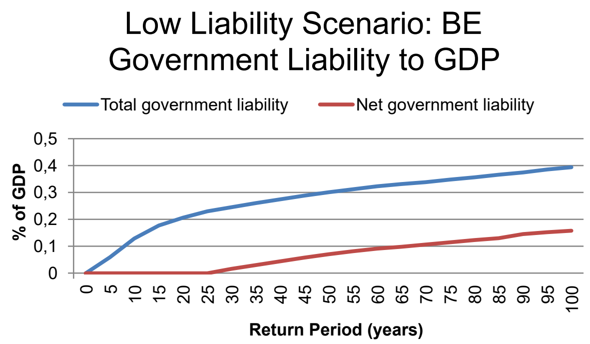


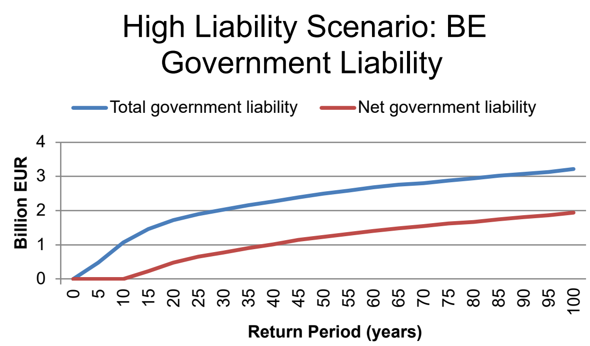


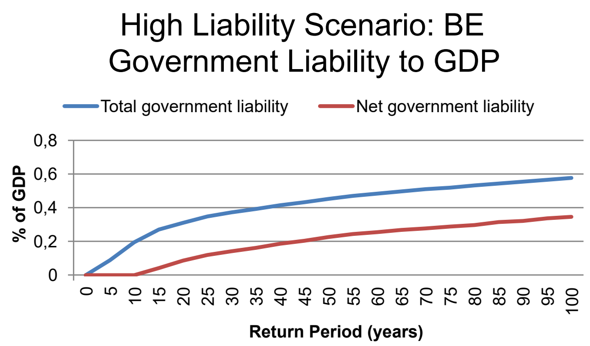


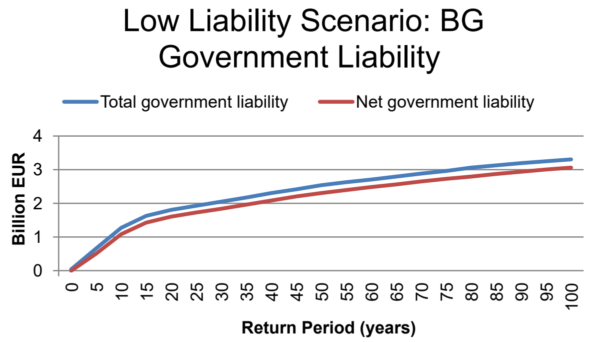


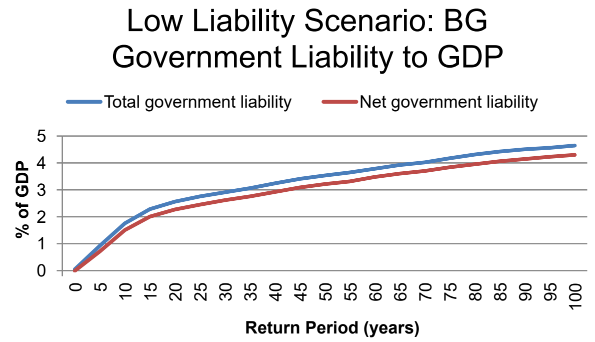


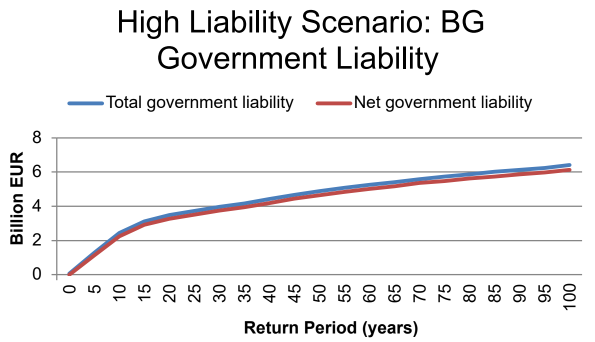


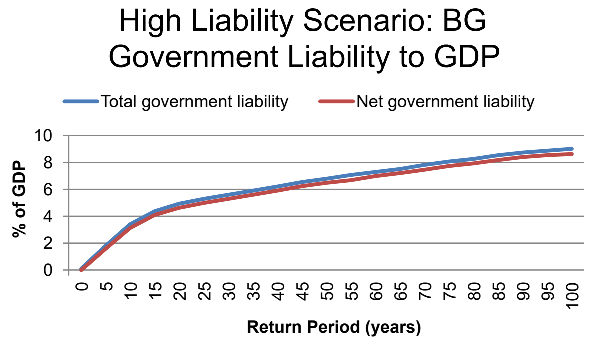


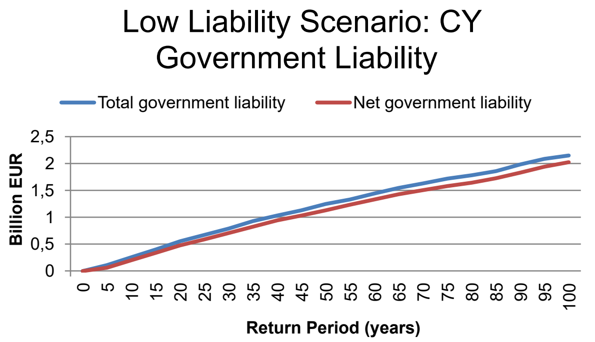


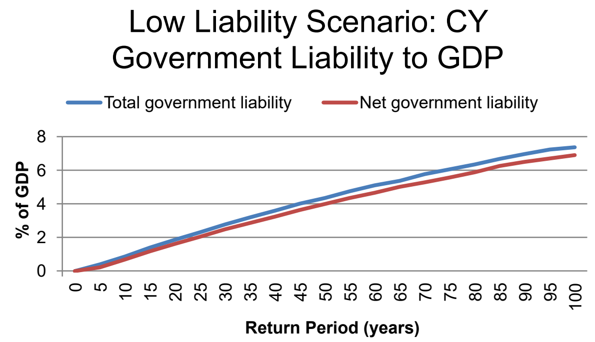

Low Liability Scenario: BG
Government Liability
Total government liability
Net government liability
Billion EUR
Return Period (years)

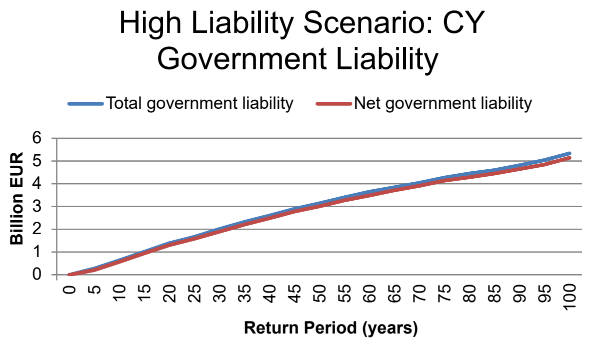

Low Liability Scenario: BG
Government Liability to GDP
Total government liability
Net government liability
% of GDP
Return Period (years)

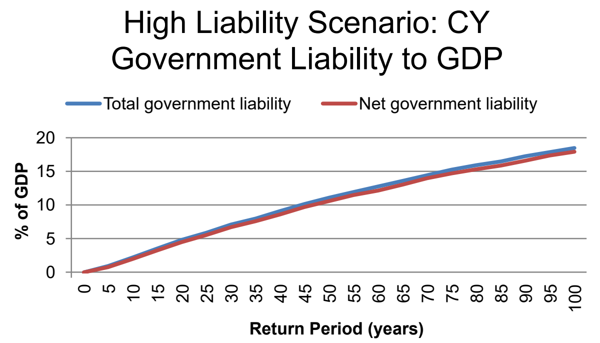

High Liability Scenario: BG
Government Liability
Total government liability
Net government liability
Billion EUR
Return Period (years)

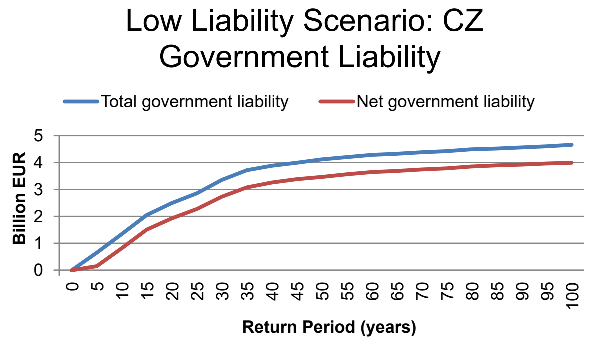

High Liability Scenario: BG
Government Liability to GDP
Total government liability
Net government liability
% of GDP
Return Period (years)

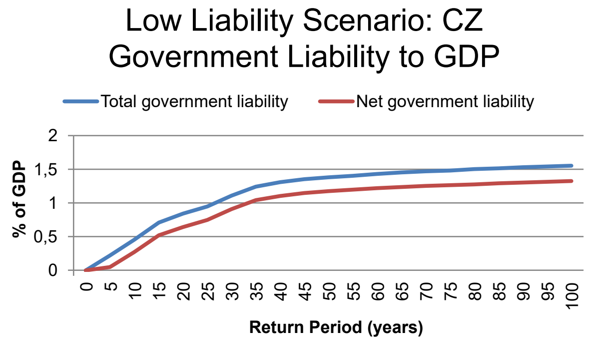

Low Liability Scenario: CY
Government Liability
Total government liability
Net government liability
Billion EUR
Return Period (years)

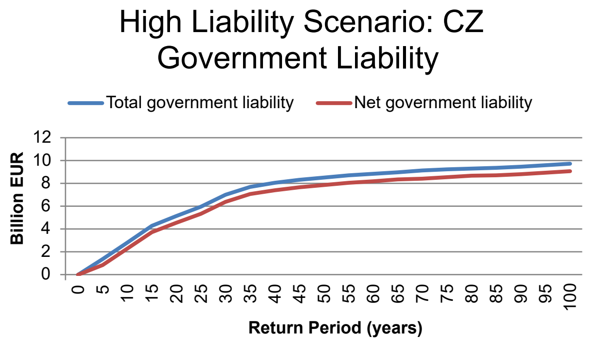

Low Liability Scenario: CY
Government Liability to GDP
Total government liability
Net government liability
% of GDP
Return Period (years)

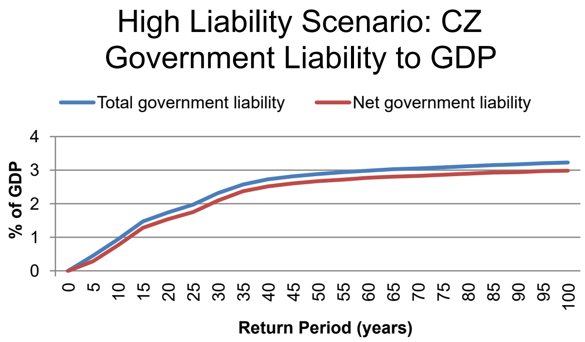

High Liability Scenario: CY
Government Liability
Total government liability
Net government liability
Billion EUR
Return Period (years)

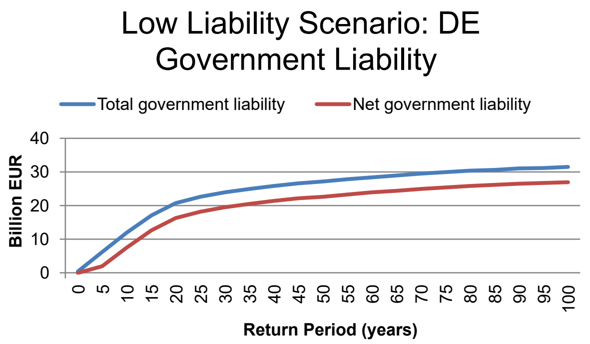

High Liability Scenario: CY
Government Liability to GDP
Total government liability
Net government liability
% of GDP
Return Period (years)

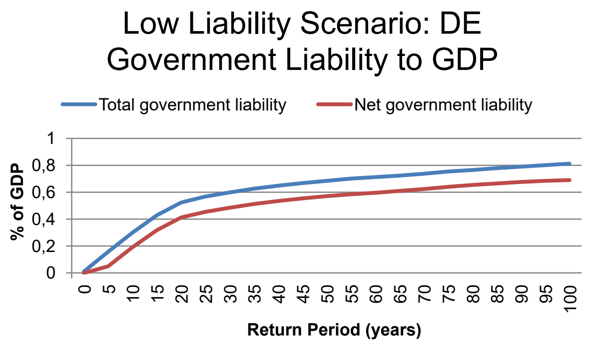

Low Liability Scenario: CZ Government Liability
Total government liability
Net government liability
Billion EUR
Return Period (years)

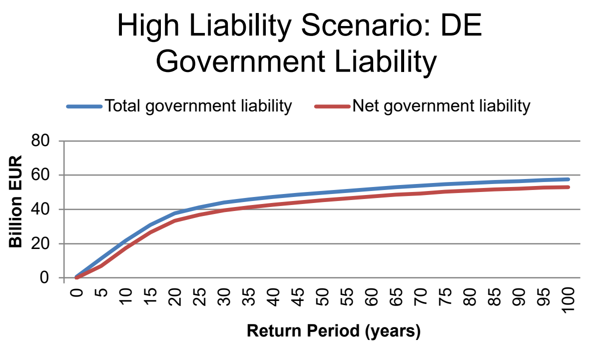

Low Liability Scenario: CZ Government Liability to GDP
Total government liability
Net government liability
% of GDP
Return Period (years)

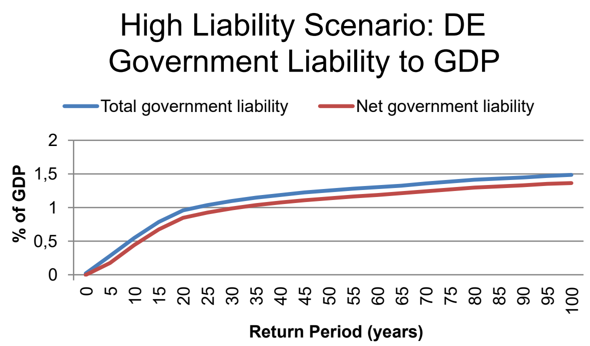

High Liability Scenario: CZ Government Liability
Total government liability
Net government liability
Billion EUR
Return Period (years)

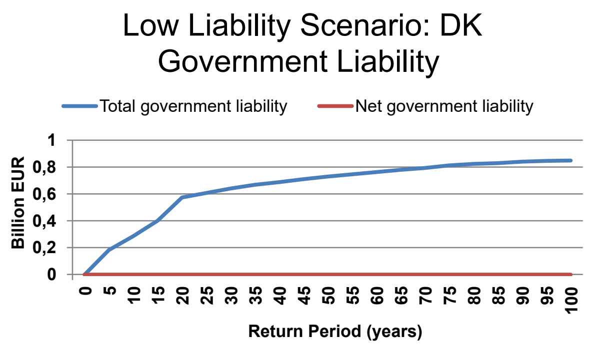

High Liability Scenario: CZ Government Liability to GDP
Total government liability
Net government liability
% of GDP
Return Period (years)

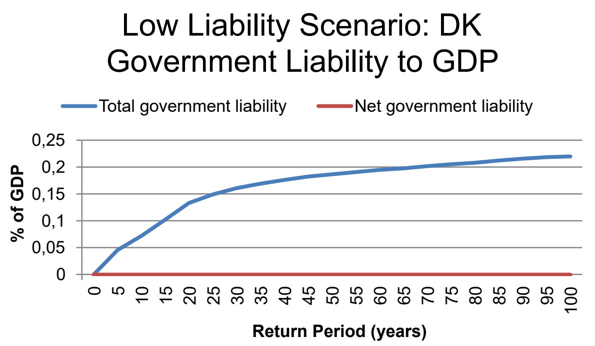

Low Liability Scenario: DE Government Liability
Total government liability
Net government liability
Billion EUR
Return Period (years)

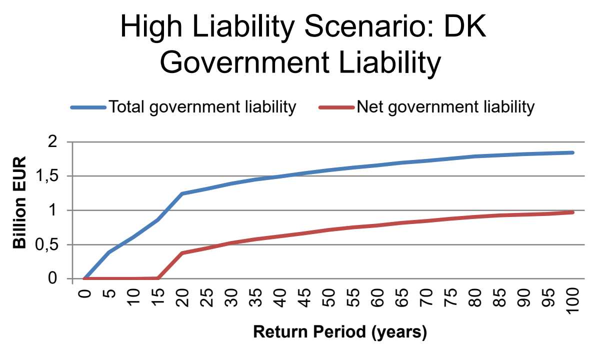

Low Liability Scenario: DE Government Liability to GDP
Total government liability
Net government liability
% of GDP
Return Period (years)

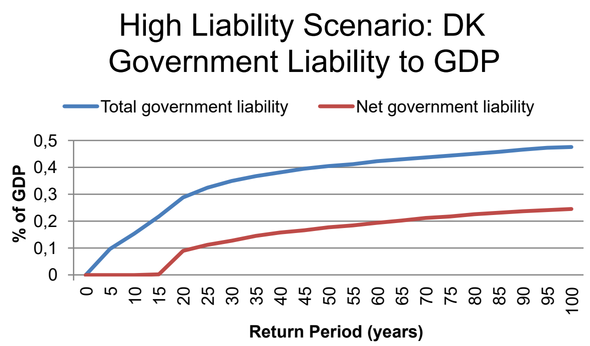

High Liability Scenario: DE Government Liability
Total government liability
Net government liability
Billion EUR
Return Period (years)

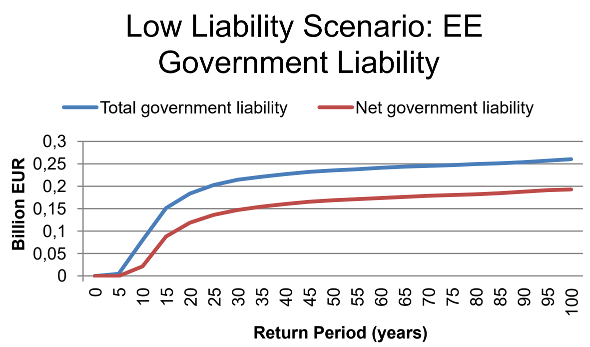

High Liability Scenario: DE Government Liability to GDP
Total government liability
Net government liability
% of GDP
Return Period (years)

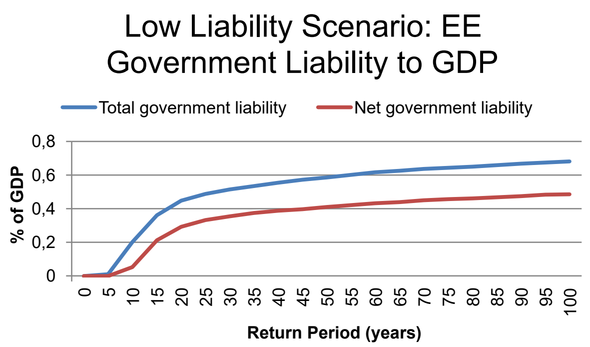

Low Liability Scenario: DK
Government Liability
Total government liability
Net government liability
Billion EUR
Return Period (years)

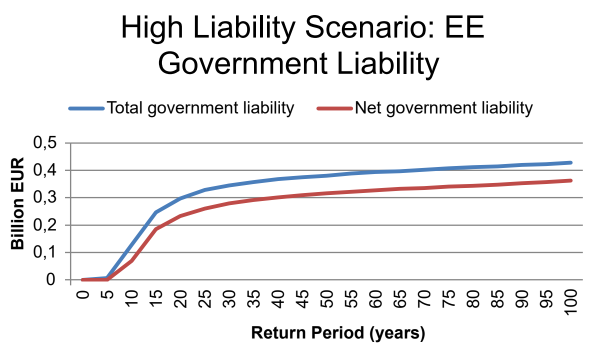

Low Liability Scenario: DK
Government Liability to GDP
Total government liability
Net government liability
% of GDP
Return Period (years)

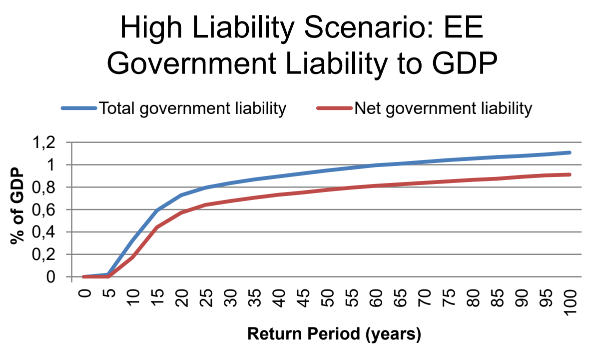

High Liability Scenario: DK
Government Liability
Total government liability
Net government liability
Billion EUR
Return Period (years)

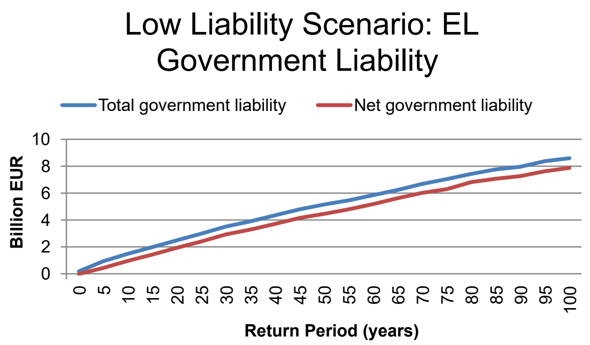

High Liability Scenario: DK
Government Liability to GDP
Total government liability
Net government liability
% of GDP
Return Period (years)

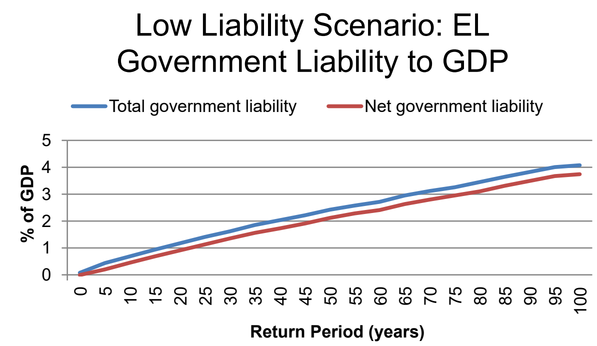

Low Liability Scenario: EE
Government Liability
Total government liability
Net government liability
Billion EUR
Return Period (years)

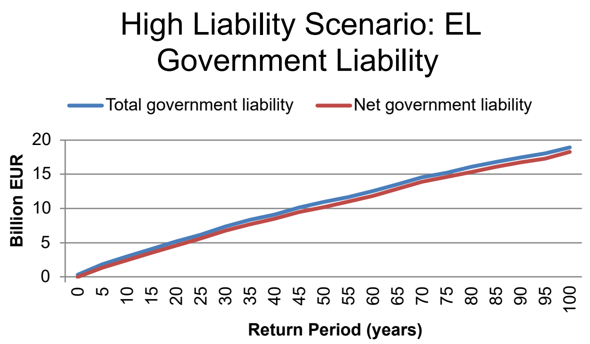

Low Liability Scenario: EE
Government Liability to GDP
Total government liability
Net government liability
% of GDP
Return Period (years)

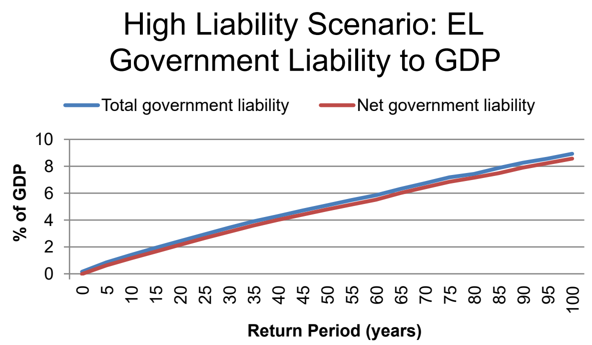

High Liability Scenario: EE
Government Liability
Total government liability
Net government liability
Billion EUR
Return Period (years)

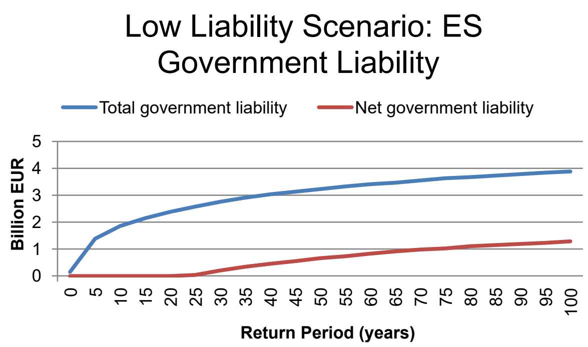

High Liability Scenario: EE
Government Liability to GDP
Total government liability
Net government liability
% of GDP
Return Period (years)

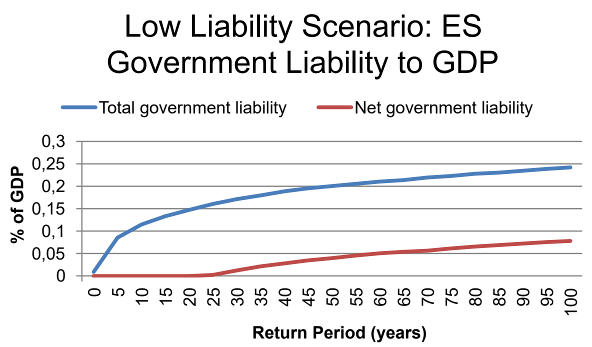

Low Liability Scenario: EL
Government Liability
Total government liability
Net government liability
Billion EUR
0 2 4 6 8 10
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Return Period (years)


Low Liability Scenario: EL
Government Liability to GDP
Total government liability
Net government liability
% of GDP
0 1 2 3 4 5
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Return Period (years)


High Liability Scenario: EL
Government Liability
Total government liability
Net government liability
Billion EUR
0 5 10 15 20
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Return Period (years)


High Liability Scenario: EL
Government Liability to GDP
Total government liability
Net government liability
% of GDP
0 2 4 6 8 10
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Return Period (years)


Low Liability Scenario: ES
Government Liability
Total government liability
Net government liability
Billion EUR
0 1 2 3 4 5
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Return Period (years)


Low Liability Scenario: ES
Government Liability to GDP
Total government liability
Net government liability
% of GDP
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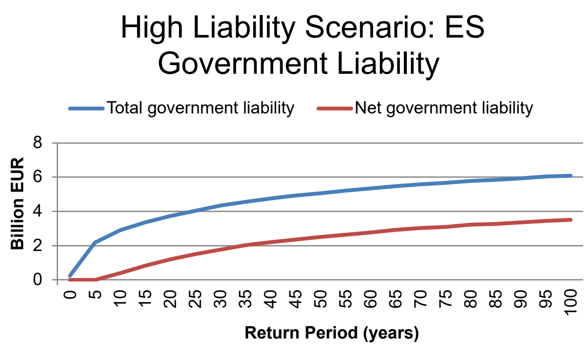
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Return Period (years)


High Liability Scenario: ES
Government Liability
Total government liability
Net government liability
Billion EUR
0 2 4 6 8
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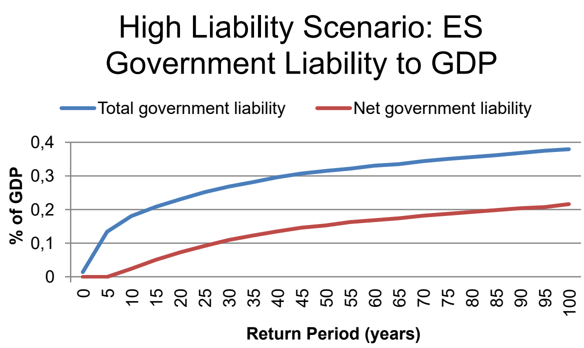
Return Period (years)


High Liability Scenario: ES
Government Liability to GDP
Total government liability
Net government liability
% of GDP
0 0,1 0,2 0,3 0,4
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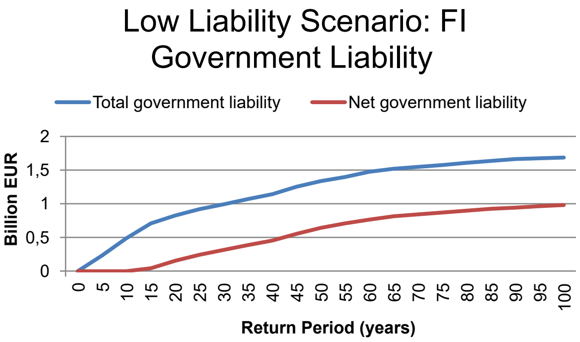
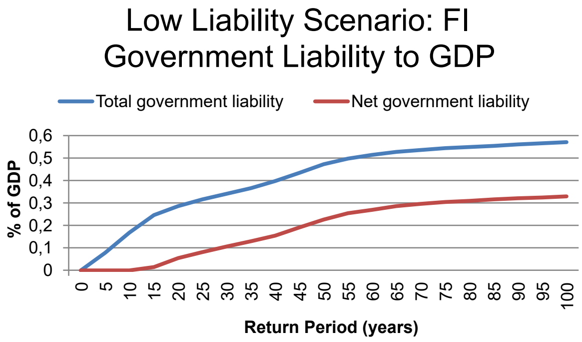
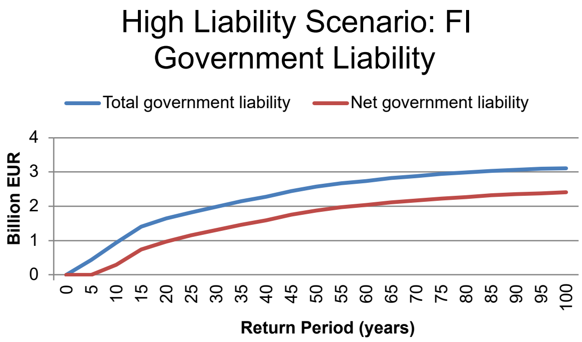
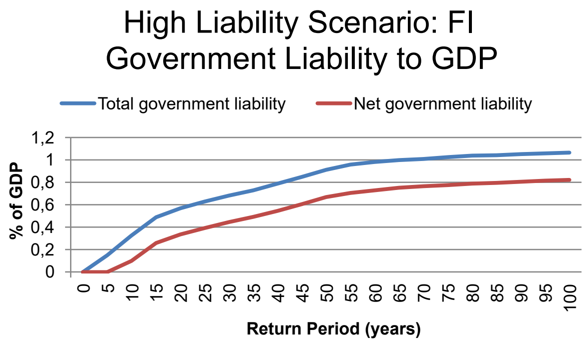
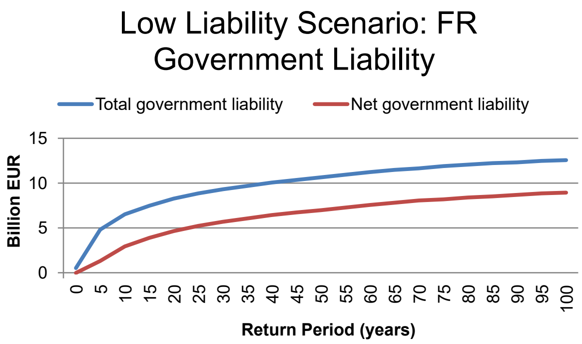
Return Period (years)

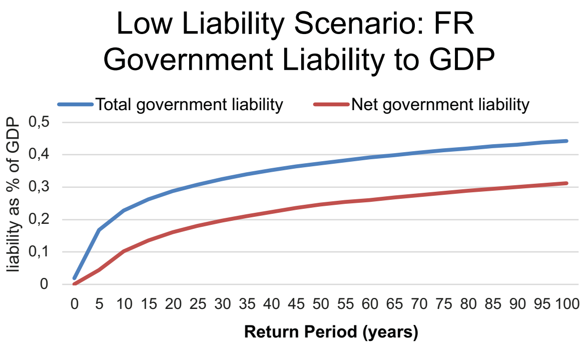

Low Liability Scenario: FI
Government Liability
Total government liability
Net government liability
Billion EUR
Return Period (years)

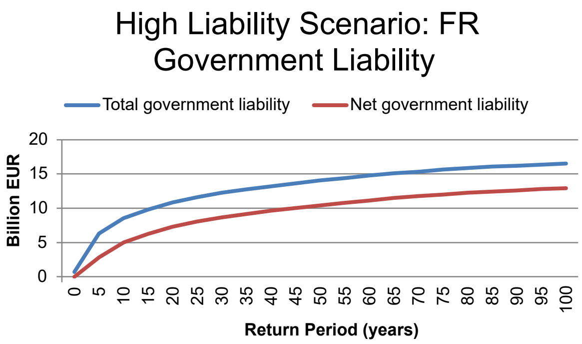

Low Liability Scenario: FI
Government Liability to GDP
Total government liability
Net government liability
% of GDP
Return Period (years)

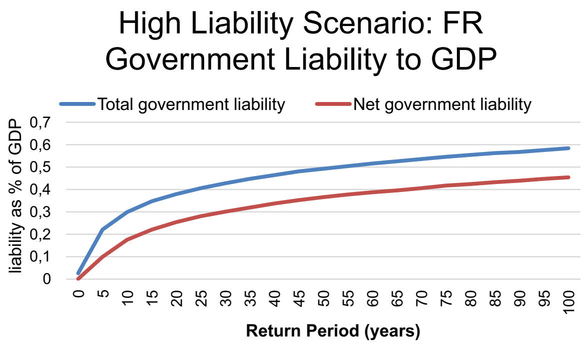

High Liability Scenario: FI
Government Liability
Total government liability
Net government liability
Billion EUR
Return Period (years)

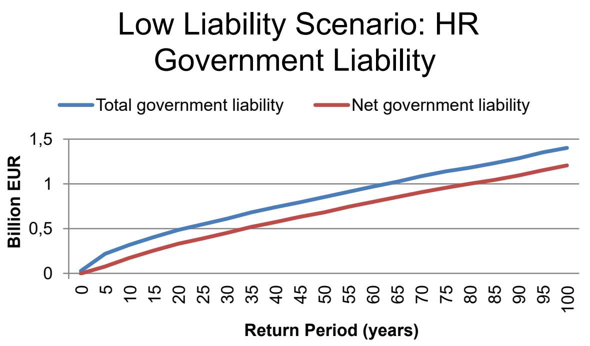

High Liability Scenario: FI
Government Liability to GDP
Total government liability
Net government liability
% of GDP
Return Period (years)

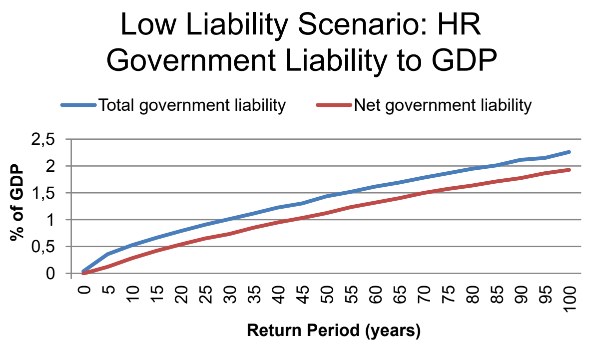

Low Liability Scenario: FR
Government Liability
Total government liability
Net government liability
Billion EUR
Return Period (years)

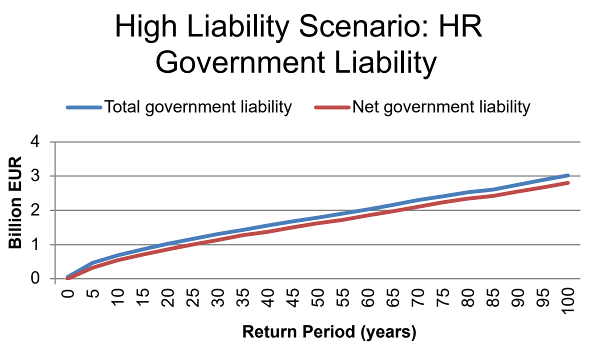

Low Liability Scenario: FR
Government Liability to GDP
Total government liability
Net government liability
liability as % of GDP
Return Period (years)

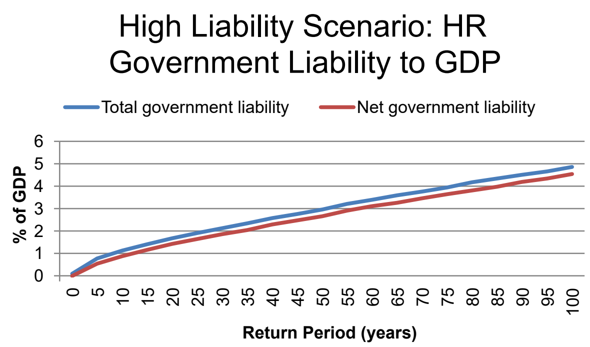

High Liability Scenario: FR
Government Liability
Total government liability
Net government liability
Billion EUR
Return Period (years)

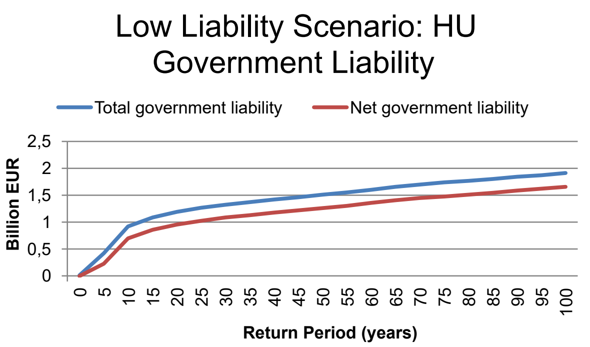

High Liability Scenario: FR
Government Liability to GDP
Total government liability
Net government liability
liability as % of GDP
Return Period (years)

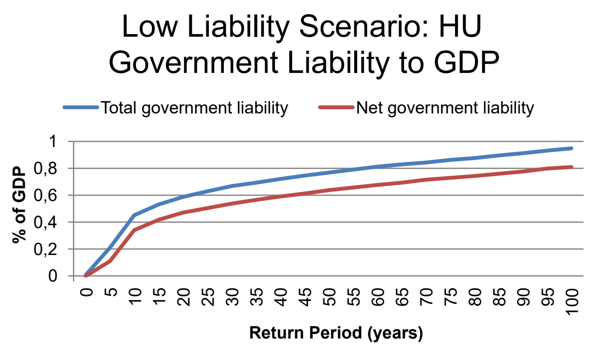

Low Liability Scenario: HR Government Liability
Total government liability
Net government liability
Billion EUR
Return Period (years)

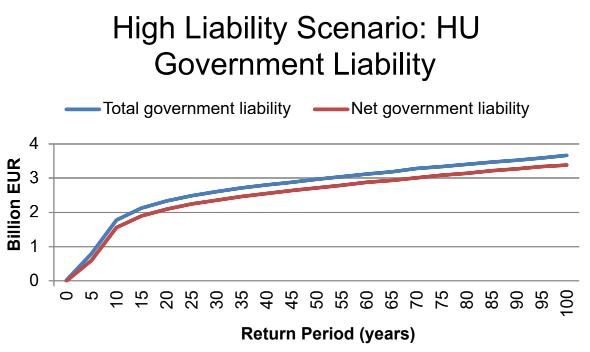

Low Liability Scenario: HR Government Liability to GDP
Total government liability
Net government liability
% of GDP
Return Period (years)

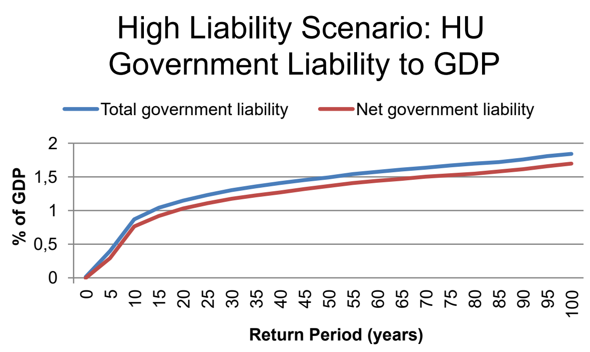

High Liability Scenario: HR Government Liability
Total government liability
Net government liability
Billion EUR
Return Period (years)

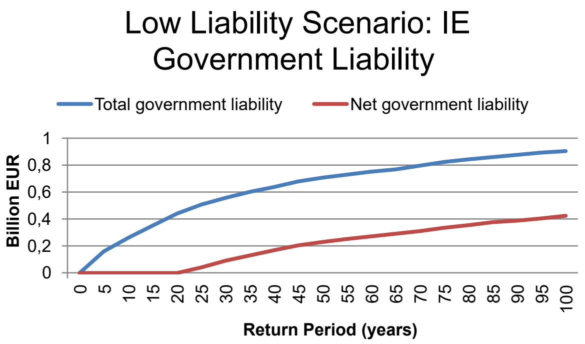

High Liability Scenario: HR Government Liability to GDP
Total government liability
Net government liability
% of GDP
Return Period (years)

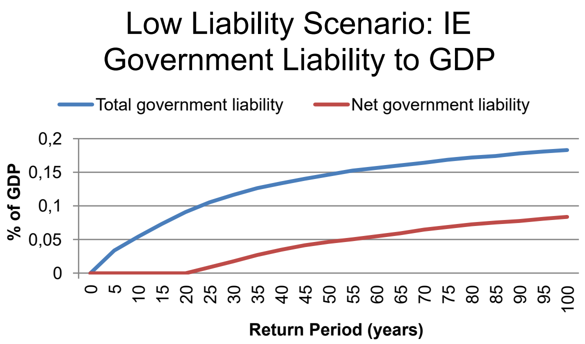

Low Liability Scenario: HU Government Liability
Total government liability
Net government liability
Billion EUR
Return Period (years)

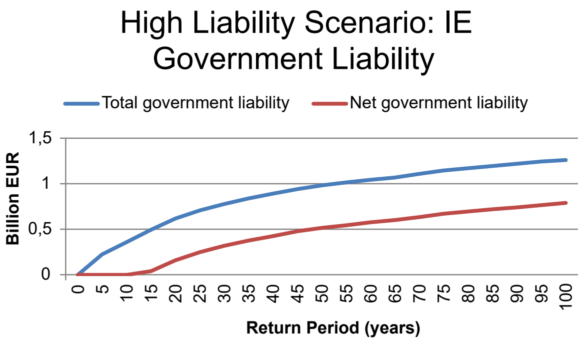

Low Liability Scenario: HU Government Liability to GDP
Total government liability
Net government liability
% of GDP
Return Period (years)

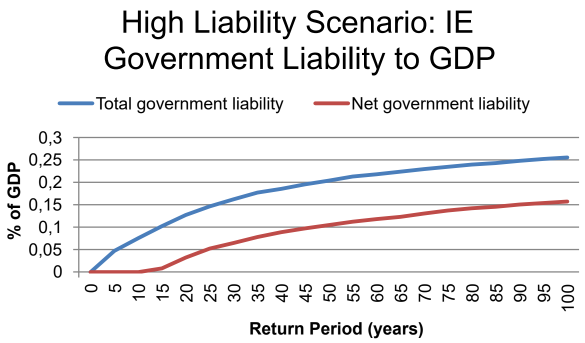

High Liability Scenario: HU Government Liability
Total government liability
Net government liability
Billion EUR
Return Period (years)

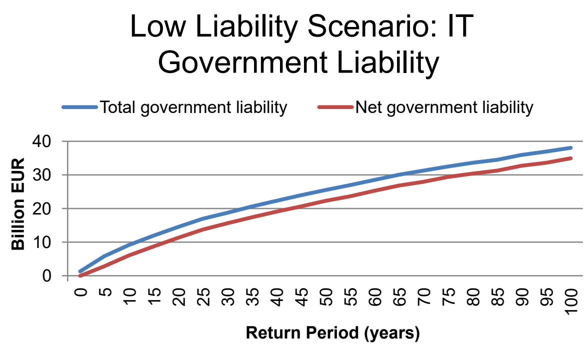

High Liability Scenario: HU Government Liability to GDP
Total government liability
Net government liability
% of GDP
Return Period (years)

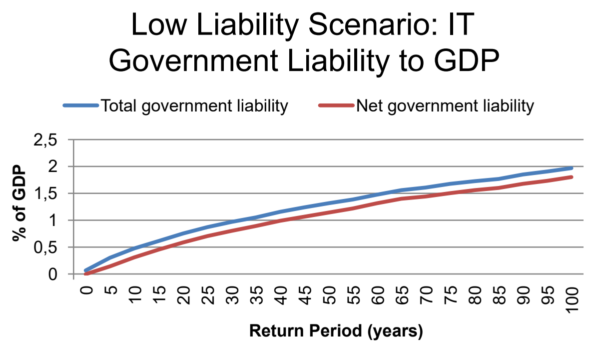

Low Liability Scenario: IE
Government Liability
Total government liability
Net government liability
Billion EUR
Return Period (years)

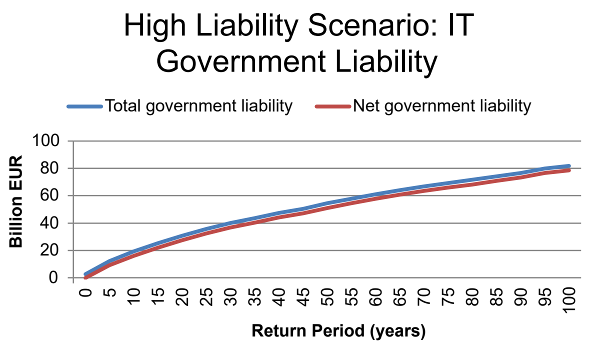

Low Liability Scenario: IE
Government Liability to GDP
Total government liability
Net government liability
% of GDP
Return Period (years)

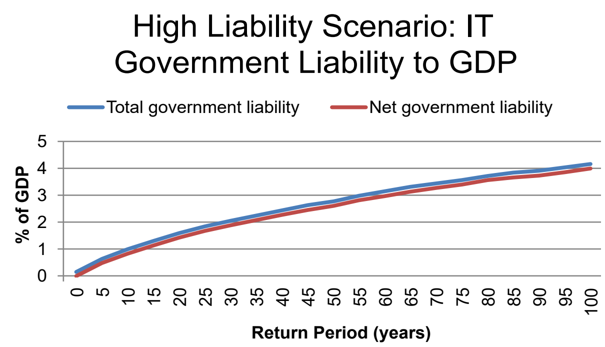

High Liability Scenario: IE
Government Liability
Total government liability
Net government liability
Billion EUR
Return Period (years)

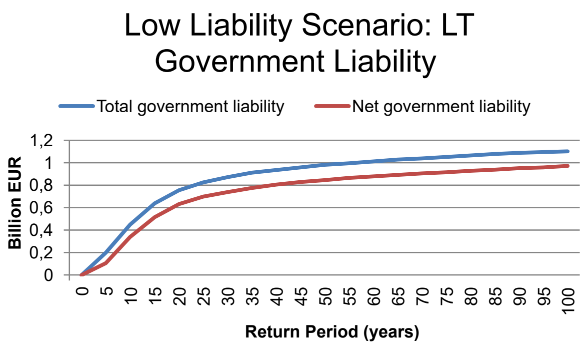

High Liability Scenario: IE
Government Liability to GDP
Total government liability
Net government liability
% of GDP
Return Period (years)

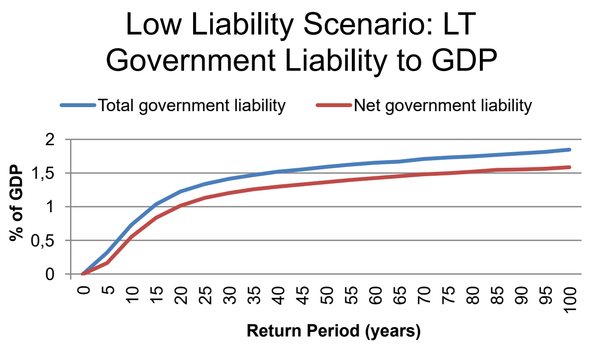

Low Liability Scenario: IT
Government Liability
Total government liability
Net government liability
Billion EUR
Return Period (years)

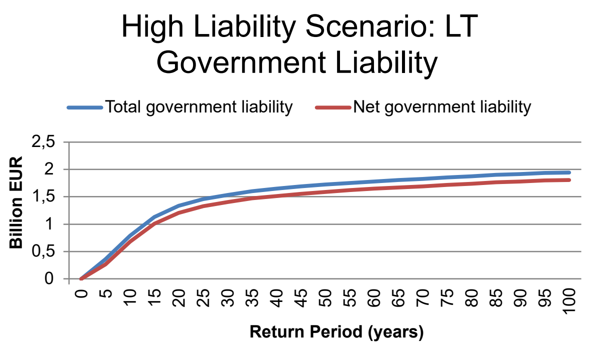

Low Liability Scenario: IT
Government Liability to GDP
Total government liability
Net government liability
% of GDP
Return Period (years)

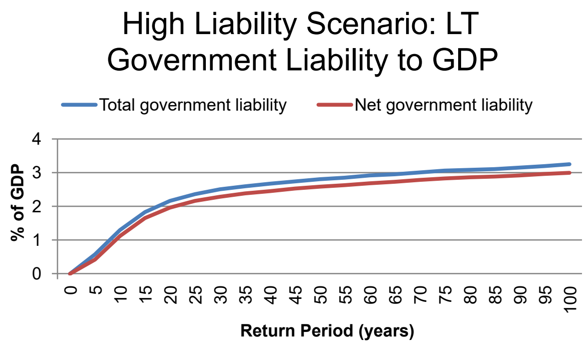

High Liability Scenario: IT
Government Liability
Total government liability
Net government liability
Billion EUR
Return Period (years)

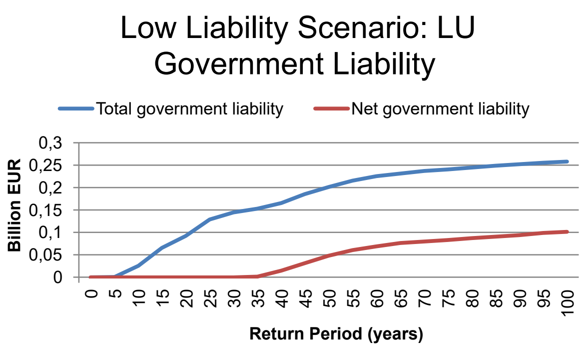

High Liability Scenario: IT
Government Liability to GDP
Total government liability
Net government liability
% of GDP
Return Period (years)

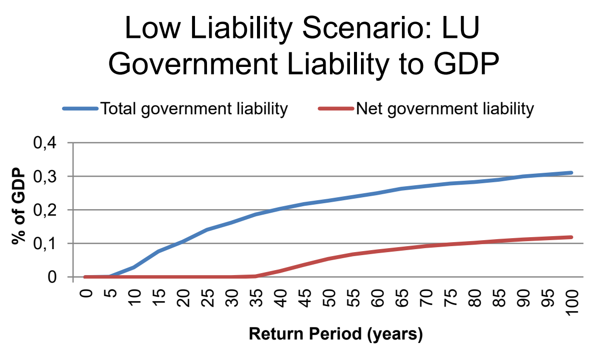

Low Liability Scenario: LT
Government Liability
Total government liability
Net government liability
Billion EUR
1,2
1
0,8
0,6
0,4
0,2
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Return Period (years)

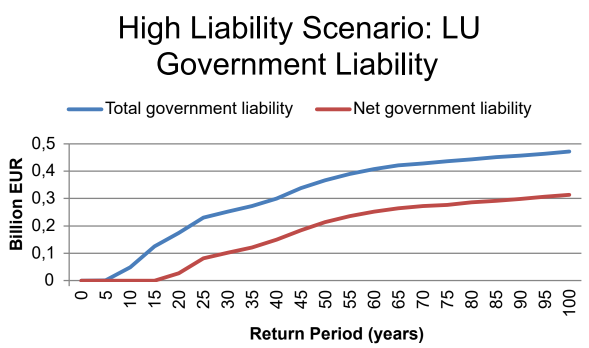

Low Liability Scenario: LT
Government Liability to GDP
Total government liability
Net government liability
% of GDP
2
1,5
1
0,5
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Return Period (years)

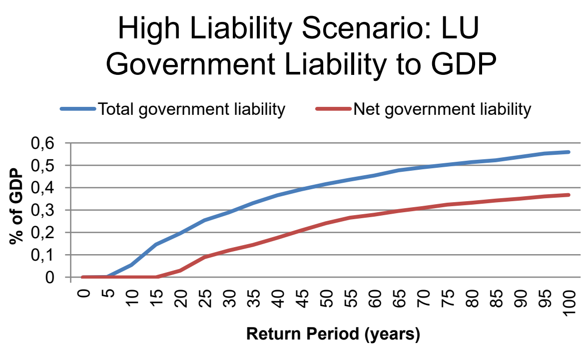

High Liability Scenario: LT
Government Liability
Total government liability
Net government liability
Billion EUR
2,5
2
1,5
1
0,5
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Return Period (years)

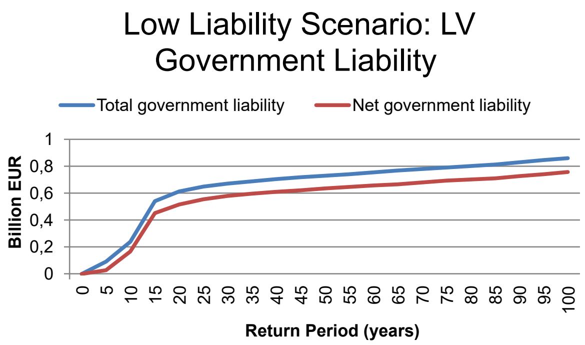

High Liability Scenario: LT
Government Liability to GDP
Total government liability
Net government liability
% of GDP
4
3
2
1
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Return Period (years)

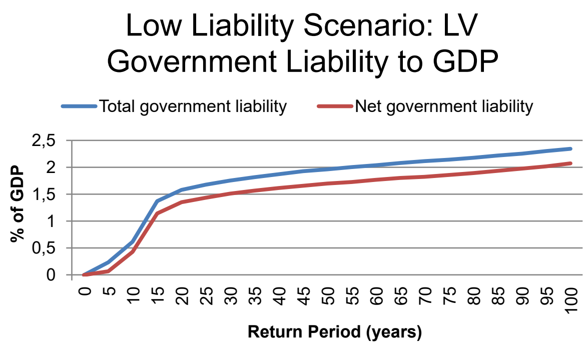

Low Liability Scenario: LU
Government Liability
Total government liability
Net government liability
Billion EUR
0,3
0,25
0,2
0,15
0,1
0,05
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Return Period (years)

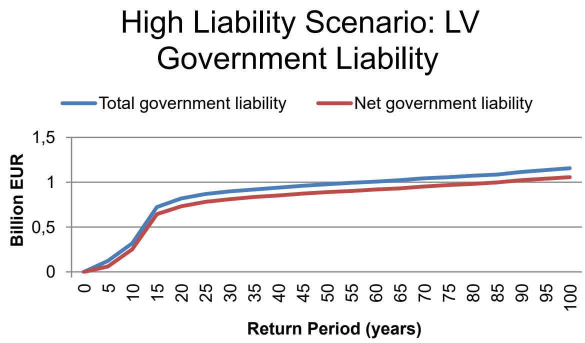

Low Liability Scenario: LU
Government Liability to GDP
Total government liability
Net government liability
% of GDP
0,4
0,3
0,2
0,1
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Return Period (years)

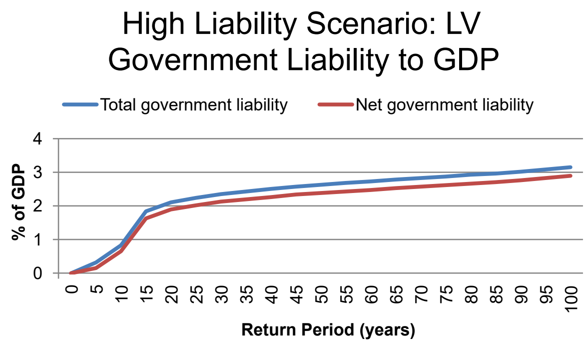

High Liability Scenario: LU
Government Liability
Total government liability
Net government liability
Billion EUR
0,5
0,4
0,3
0,2
0,1
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Return Period (years)

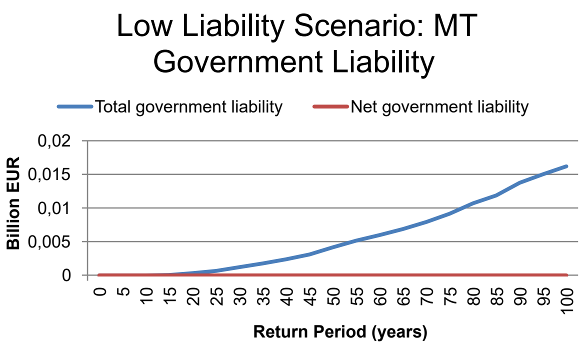

High Liability Scenario: LU
Government Liability to GDP
Total government liability
Net government liability
% of GDP
0,6
0,5
0,4
0,3
0,2
0,1
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Return Period (years)

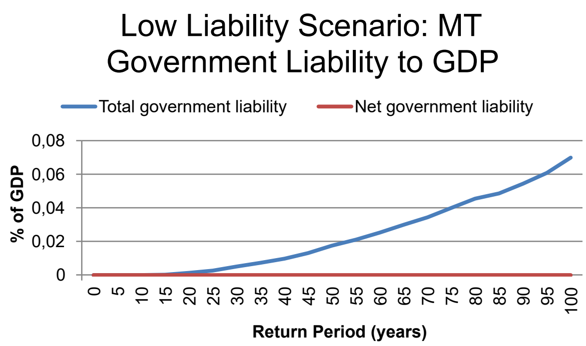

Low Liability Scenario: LV
Government Liability
Total government liability
Net government liability
Billion EUR
1
0,8
0,6
0,4
0,2
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Return Period (years)

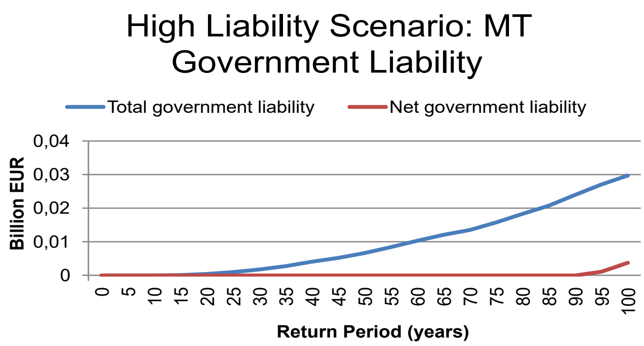

Low Liability Scenario: LV
Government Liability to GDP
Total government liability
Net government liability
% of GDP
2,5
2
1,5
1
0,5
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Return Period (years)

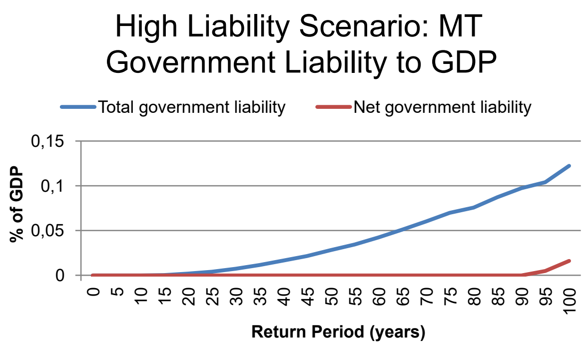

High Liability Scenario: LV
Government Liability
Total government liability
Net government liability
Billion EUR
1,5
1
0,5
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Return Period (years)

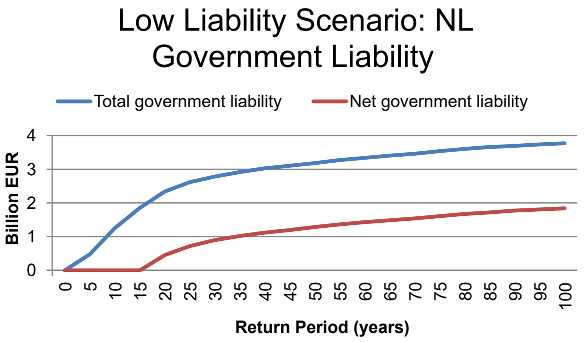

High Liability Scenario: LV
Government Liability to GDP
Total government liability
Net government liability
% of GDP
4
3
2
1
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Return Period (years)

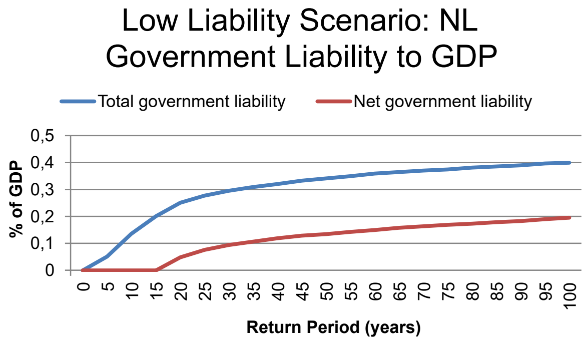

Low Liability Scenario: MT
Government Liability
Total government liability
Net government liability
Billion EUR
0,02
0,015
0,01
0,005
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Return Period (years)

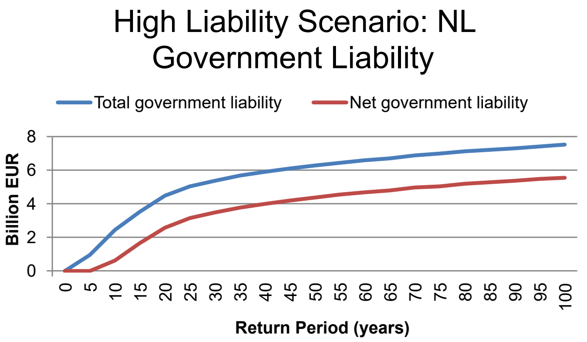

Low Liability Scenario: MT
Government Liability to GDP
Total government liability
Net government liability
% of GDP
0,08
0,06
0,04
0,02
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Return Period (years)

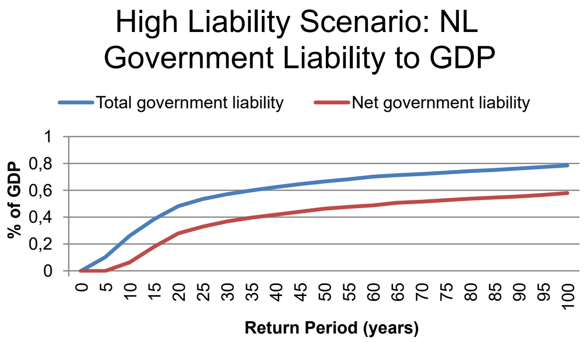

High Liability Scenario: MT
Government Liability
Total government liability
Net government liability
Billion EUR
0,04
0,03
0,02
0,01
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Return Period (years)

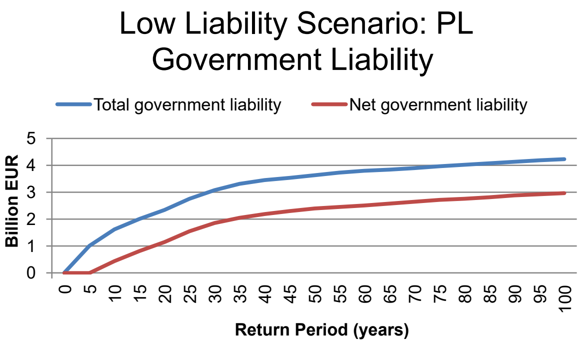

High Liability Scenario: MT
Government Liability to GDP
Total government liability
Net government liability
% of GDP
0,15
0,1
0,05
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Return Period (years)

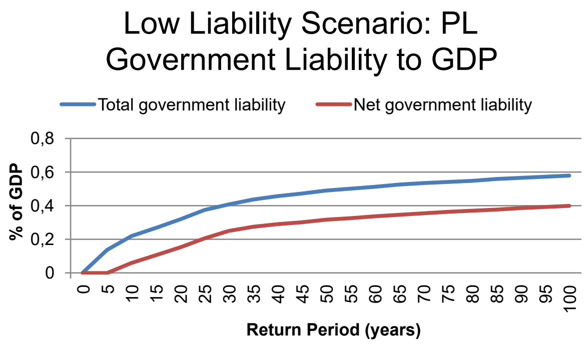

Low Liability Scenario: NL
Government Liability
Total government liability
Net government liability
Billion EUR
Return Period (years)

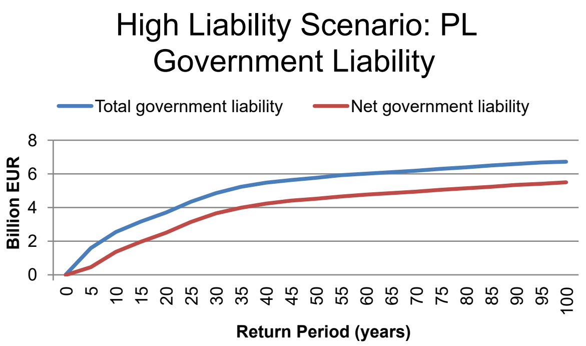

Low Liability Scenario: NL
Government Liability to GDP
Total government liability
Net government liability
% of GDP
Return Period (years)

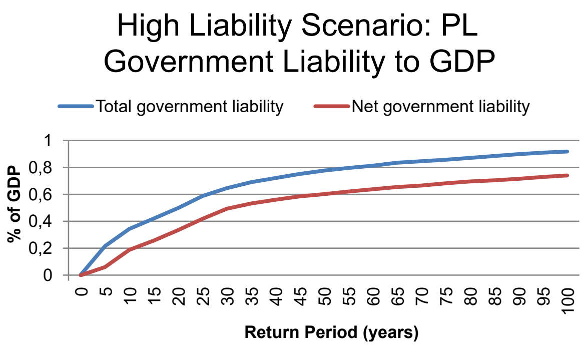

High Liability Scenario: NL
Government Liability
Total government liability
Net government liability
Billion EUR
Return Period (years)

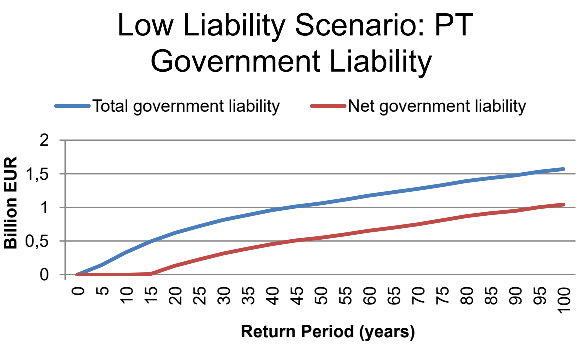

High Liability Scenario: NL
Government Liability to GDP
Total government liability
Net government liability
% of GDP
Return Period (years)

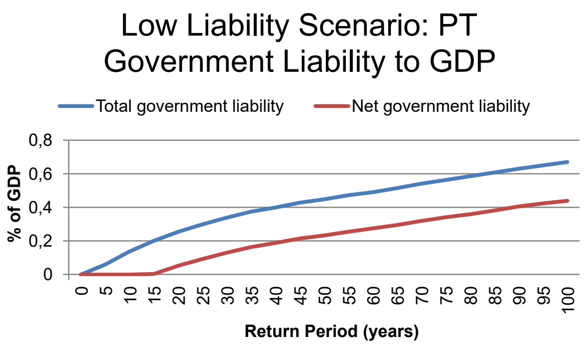

Low Liability Scenario: PL
Government Liability
Total government liability
Net government liability
Billion EUR
Return Period (years)

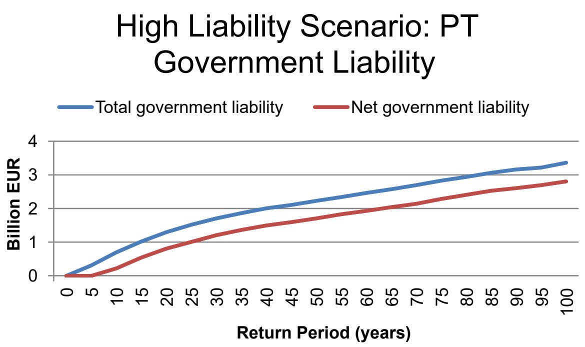

Low Liability Scenario: PL
Government Liability to GDP
Total government liability
Net government liability
% of GDP
Return Period (years)

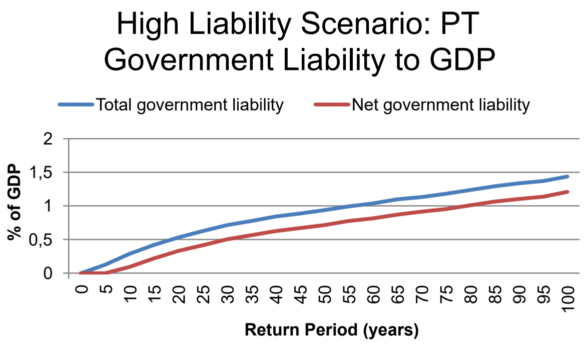

High Liability Scenario: PL
Government Liability
Total government liability
Net government liability
Billion EUR
Return Period (years)

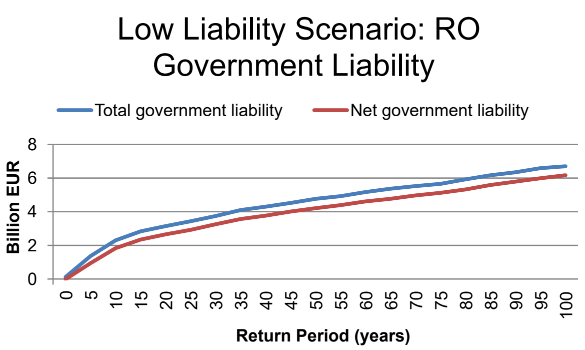

High Liability Scenario: PL
Government Liability to GDP
Total government liability
Net government liability
% of GDP
Return Period (years)

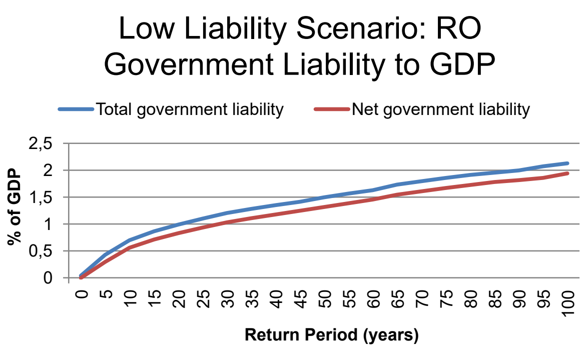

Low Liability Scenario: PT
Government Liability
Total government liability
Net government liability
Billion EUR
Return Period (years)

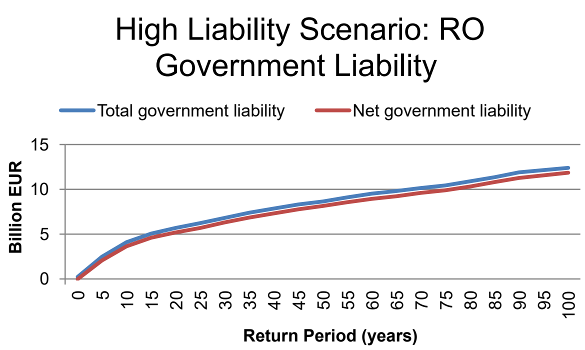

Low Liability Scenario: PT
Government Liability to GDP
Total government liability
Net government liability
% of GDP
Return Period (years)

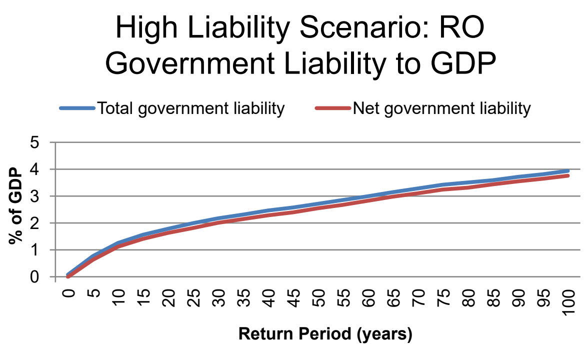

High Liability Scenario: PT
Government Liability
Total government liability
Net government liability
Billion EUR
Return Period (years)

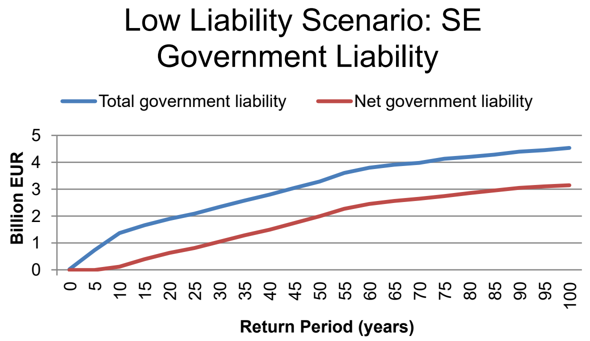

High Liability Scenario: PT
Government Liability to GDP
Total government liability
Net government liability
% of GDP
Return Period (years)

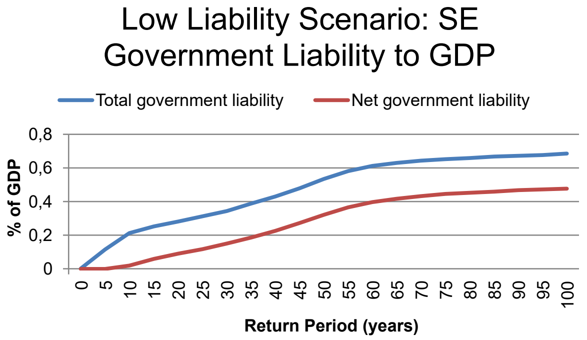

Low Liability Scenario: RO
Government Liability
Total government liability
Net government liability
Billion EUR
Return Period (years)

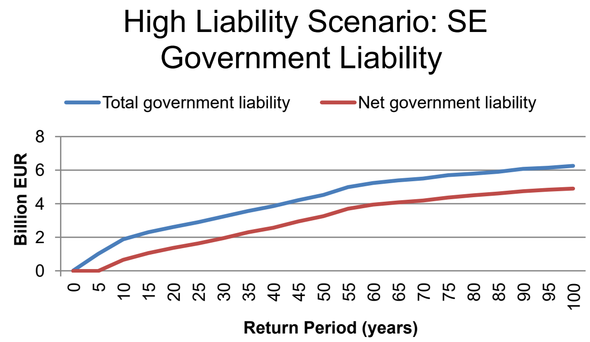

Low Liability Scenario: RO
Government Liability to GDP
Total government liability
Net government liability
% of GDP
Return Period (years)

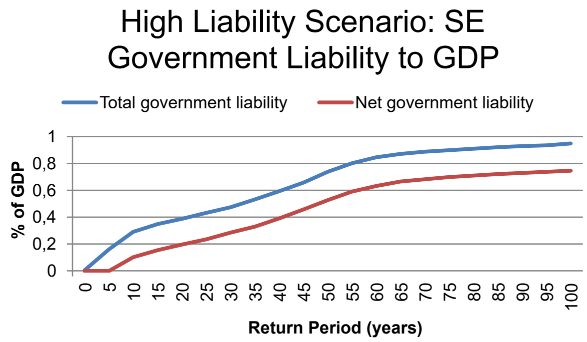

High Liability Scenario: RO
Government Liability
Total government liability
Net government liability
Billion EUR
Return Period (years)

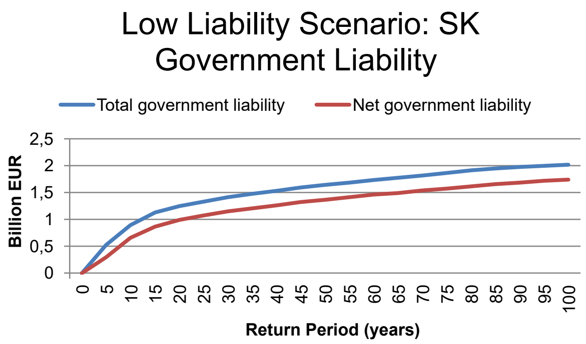

High Liability Scenario: RO
Government Liability to GDP
Total government liability
Net government liability
% of GDP
Return Period (years)

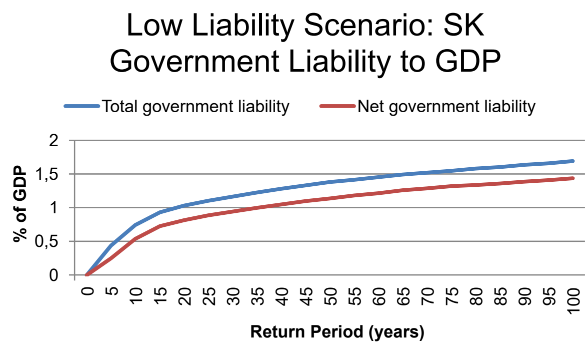

Low Liability Scenario: SE
Government Liability
Total government liability
Net government liability
Billion EUR
Return Period (years)

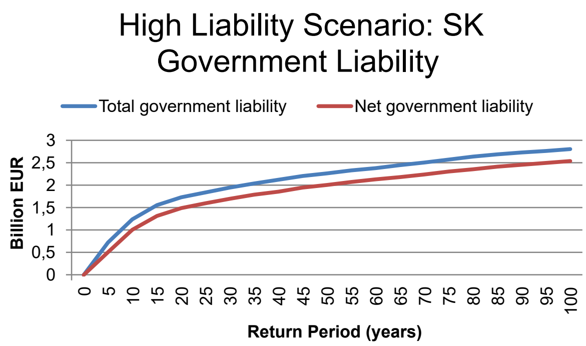

Low Liability Scenario: SE
Government Liability to GDP
Total government liability
Net government liability
% of GDP
Return Period (years)

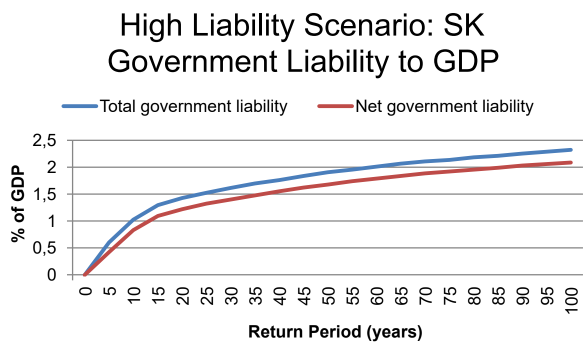

High Liability Scenario: SE
Government Liability
Total government liability
Net government liability
Billion EUR
Return Period (years)

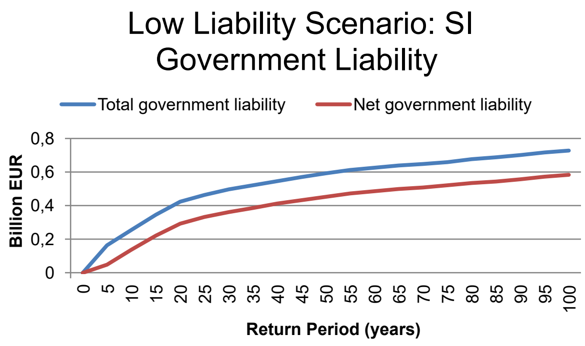

High Liability Scenario: SE
Government Liability to GDP
Total government liability
Net government liability
% of GDP
Return Period (years)

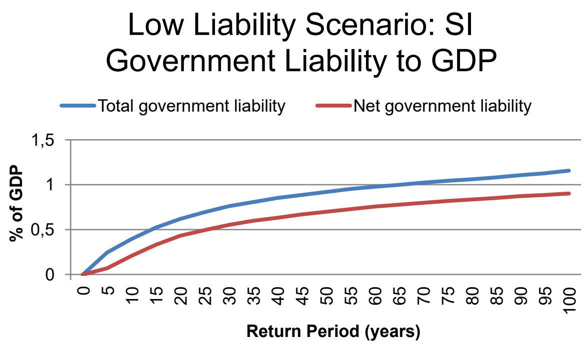

Low Liability Scenario: SK
Government Liability
Total government liability
Net government liability
Billion EUR
Return Period (years)

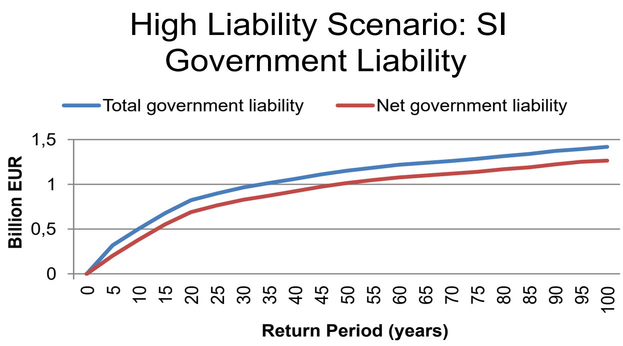

Low Liability Scenario: SK
Government Liability to GDP
Total government liability
Net government liability
% of GDP
Return Period (years)

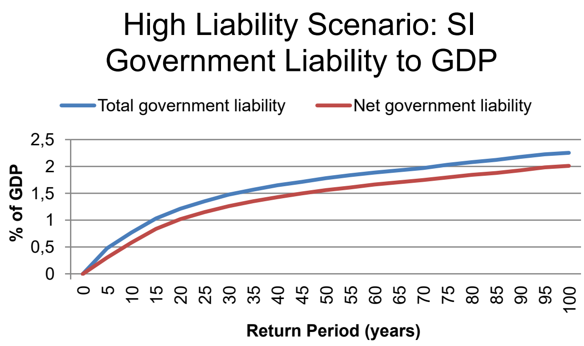

High Liability Scenario: SK
Government Liability
Total government liability
Net government liability
Billion EUR
Return Period (years)


High Liability Scenario: SK
Government Liability to GDP
Total government liability
Net government liability
% of GDP
Return Period (years)

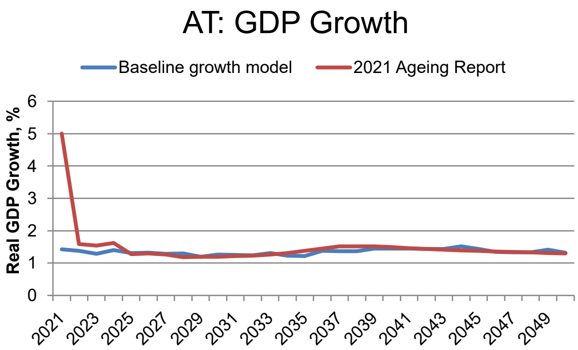

Low Liability Scenario: SI Government Liability
Total government liability
Net government liability
Billion EUR
0,8
0,6
0,4
0,2
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Return Period (years)

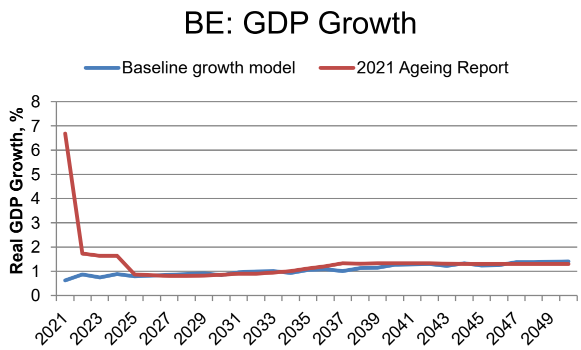

Low Liability Scenario: SI Government Liability to GDP
Total government liability
Net government liability
% of GDP
1,5
1
0,5
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Return Period (years)

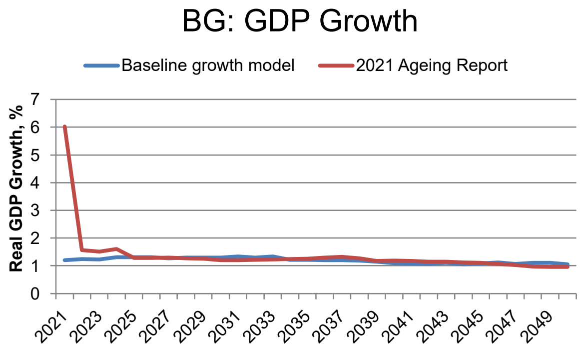

High Liability Scenario: SI Government Liability
Total government liability
Net government liability
Billion EUR
1,5
1
0,5
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Return Period (years)

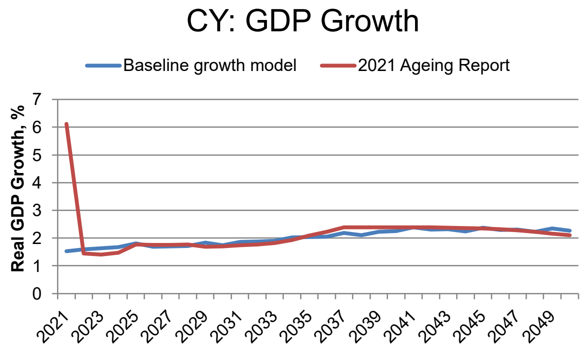

High Liability Scenario: SI Government Liability to GDP
Total government liability
Net government liability
% of GDP
2,5
2
1,5
1
0,5
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Return Period (years)

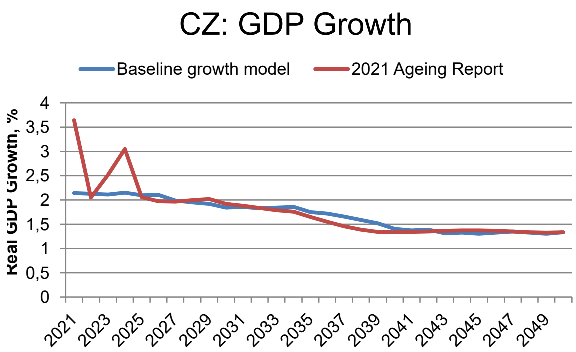
CALIBRATION OF BASELINE GDP TO EU AGEING REPORT

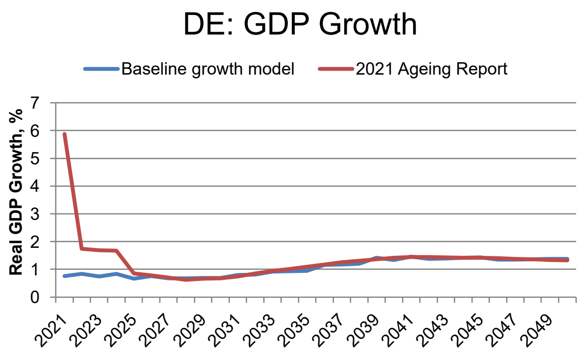


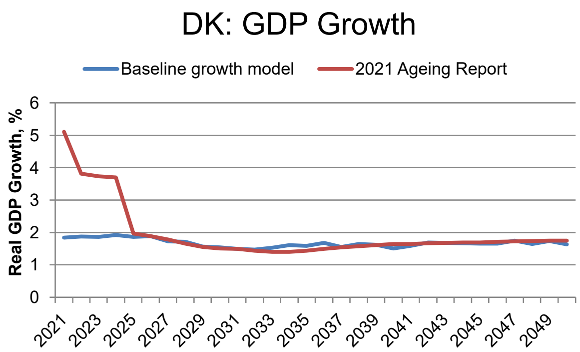


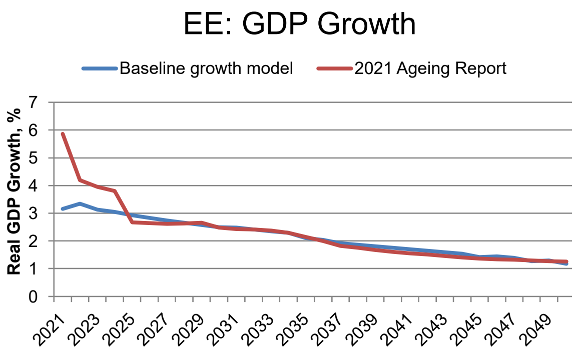


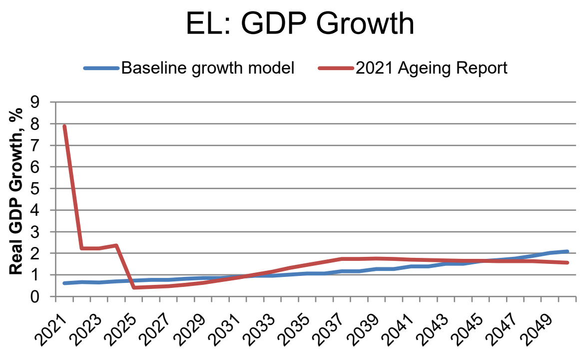








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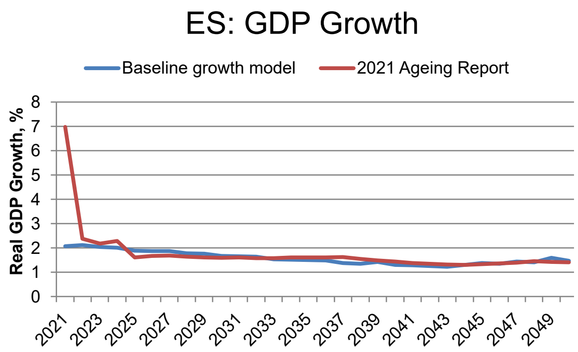
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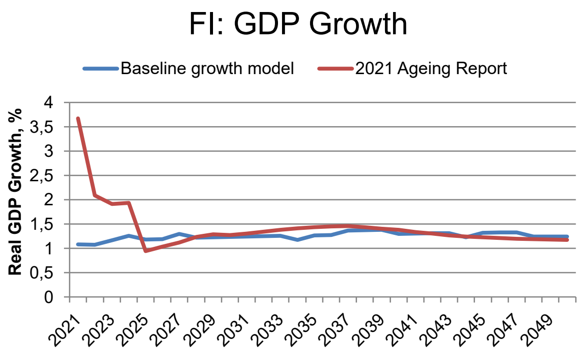
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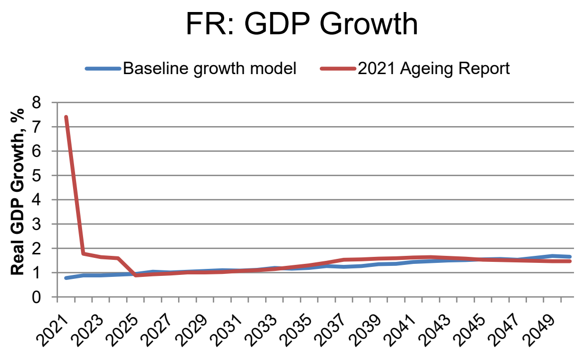
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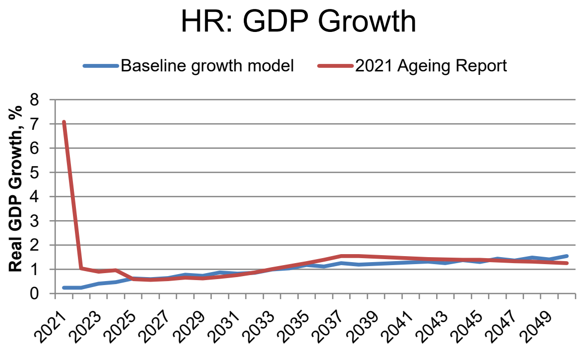
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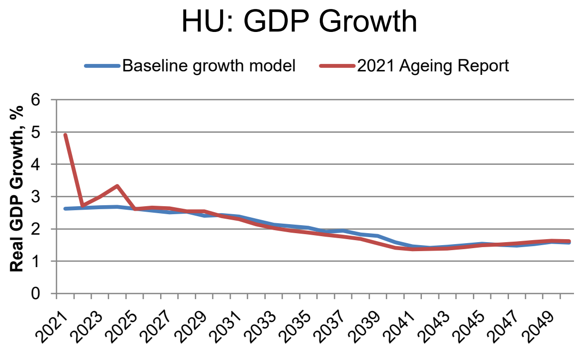
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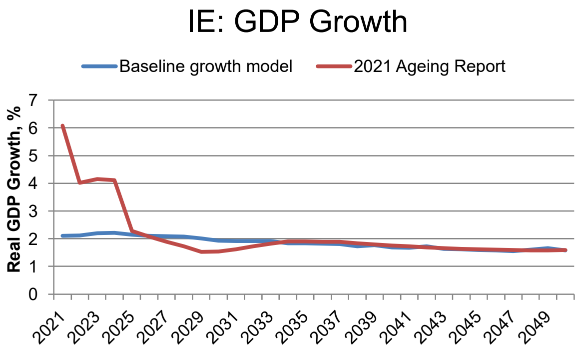
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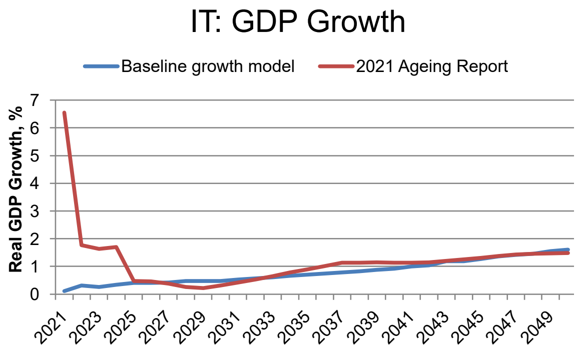
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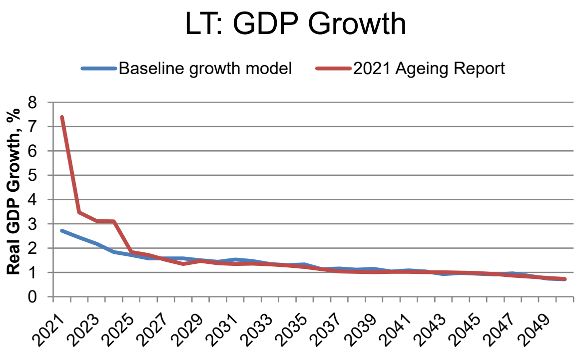
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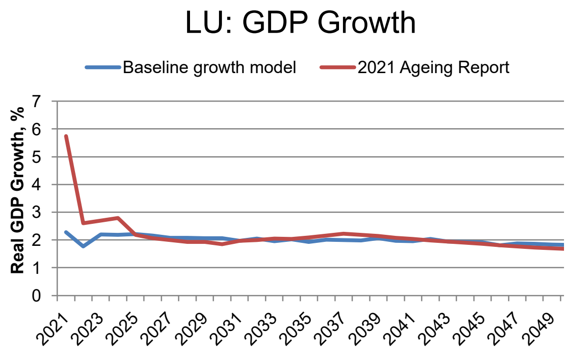
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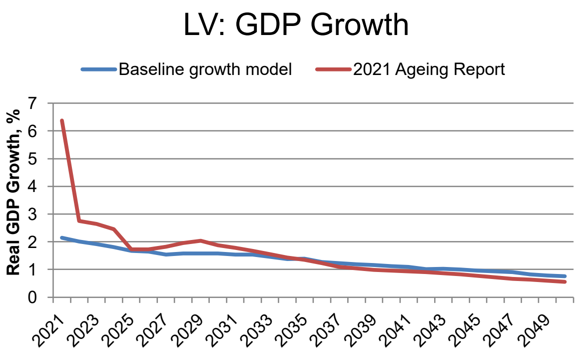
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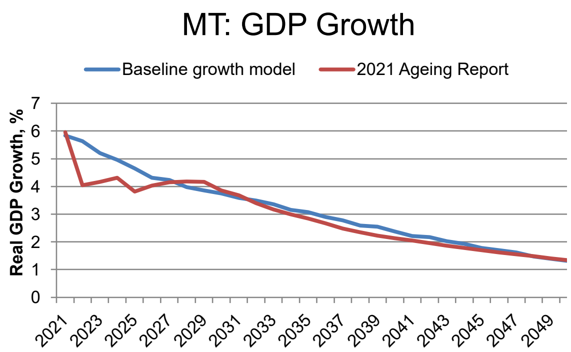
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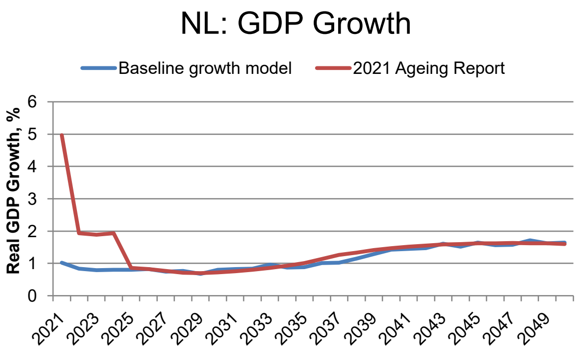
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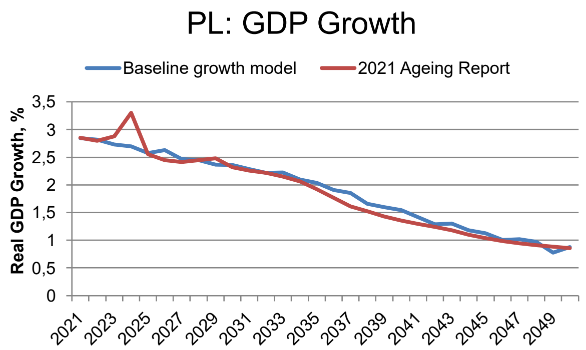
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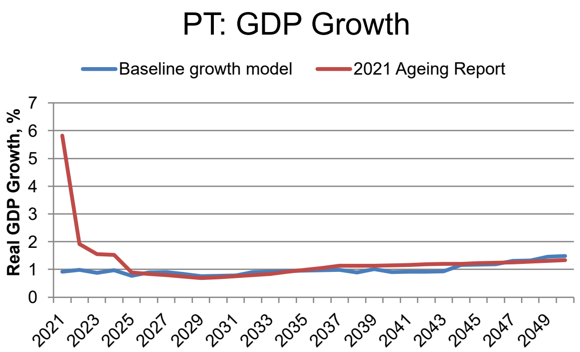
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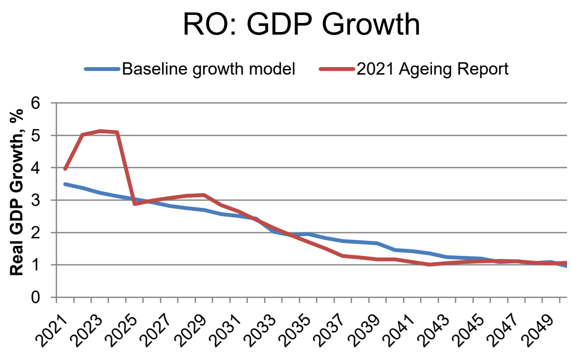
Real GDP Growth, %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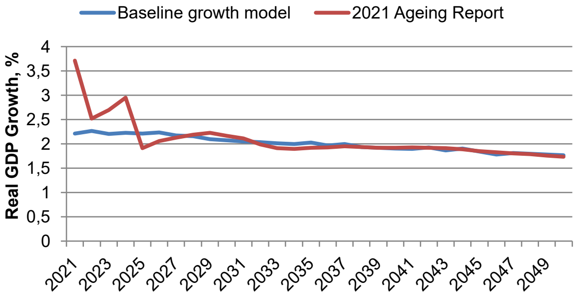
Real GDP Growth, %

SE: GDP Growth



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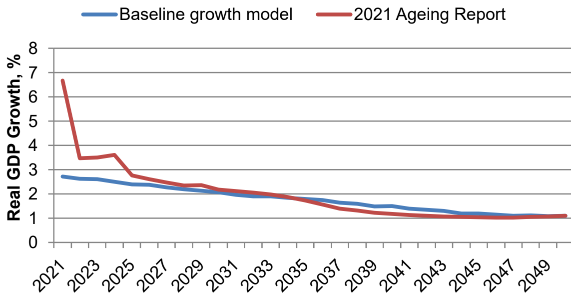


Annex 11.
Turkish Catastrophe Risk Insurance Pool (TCIP)

Devastating earthquakes in the Marmara region of Turkey in 1999 caused an economic loss of about US $10 billion, of which only US$800 million was insured (reflecting low insurance penetration, especially for private property). The result was a significant burden on the public budget; the government faced a shortage of immediate funds and had difficulty in compensating affected households because of other competing priorities, such as restoring access to clean water, public services, and public assets and infrastructure as well as providing security. This funding gap led the government of Turkey to introduce a mandatory earthquake insurance programme; a 2000 decree establishing the programme was followed by a law adopted in 2012. The law had the following aims:

- Provide affordable earthquake insurance for every homeowner
- Allow for a true risk transfer mechanism
- Introduce claims-paying capacity to limit government's exposure
- Build national catastrophes reserves over time
- Improve the risk culture and the insurance consciousness of the public
- Rely on the distribution channels of the Turkish insurance industry

This programme was established with the support of World Bank technical assistance and the World Bank Marmara Earthquake Emergency Reconstruction Project.

Launch of this programme has led to the establishment of the Turkish Catastrophe Insurance Pool (TCIP), a governmental special-purpose organization under the Treasury of Turkey. Despite being a government organization, TCIP operates on private market principles, including prudent risk management and efficient operations. The initial capitalization for creating TCIP was provided as a loan to the government, which TCIP has repaid in full. To ensure the pool's efficiency, a decision was made to seek private management, and following a competitive tender the Dutch company Eureko Sigorta was selected to manage the pool until 2020. This arrangement has decreased TCIP's operating costs to 2 percent of annual written premium (the usual operational cost for such a business is 15 percent). In 2020, management of TCIP was transferred to a state-owned reinsurance company.

The mandatory earthquake insurance offered in Turkey covers only residential buildings and excludes their contents. There are three pricing factors that determine the premium: property location, type, and size. A 2 percent deductible is included in all coverage. As of 2019, coverage of disaster insurance in Turkey had reached 54 percent.

Table 24. Pricing of earthquake insurance: Premium and coverage

Rates Based on Zoones as per the Building Type(‰)	1st Zone	2nd Zone	3rd Zone	4th Zone	5th Zone
A-Steel, concrete	2.20	1.55	0.83	0.55	0.44
B-Masonry buildings	3.85	2.75	1.43	0.60	0.50
C-Other buildings	5.50	3.53	1.76	0.78	0.58

Source: TCIP 2015.

The TCIP policies sell through private companies and organizations (including banks and intermediaries), which retain a commission.

Among the difficulties that TCIP has faced is how to promote continuous sales and renewals of its policy. While the government has imposed checkpoints for verifying consumers' initial purchase of the insurance policy (e.g., when consumers apply for a mortgage, connect to utility services, or use land registry services), it is difficult to enforce the purchase of the policy the next year after the checkpoint has been passed. To increase sales, TCIP offers some benefits for renewals, such as discounts for purchasing the policy several years in a row, or a discount when a whole condominium is insured—for example, a 10 percent discount is applied for renewing a policy, a 20 percent discount is applied after four renewals, and a 20 percent discount is applied if all units in the condominium are insured.[a] TCIP also seeks to promote sales through public awareness campaigns carried out by the government, schools, other institutions, opinion leaders, etc.

TCIP's loss adjustment process and the subsequent payouts to Turkish consumers are based on the replacement cost. TCIP has paid out a total of US$49 million in claims (altogether, about 22,000 claims have been received after 539 damaging earthquakes). According to TCIP, the most recent major earthquake—in Van on October 23, 2011—caused losses estimated at about US$40 million.

TCIP has accumulated significant reserves—amounting to US$1.4 billion—since its inception. Investment of the accumulated reserve funds is guided by the national law and follows a safe investment strategy, with the funds mostly invested in government securities. In 2017, about US$3.25 billion of reinsurance protection was purchased. The government of Turkey also provides reinsurance support to TCIP. TCIP also uses other mechanisms for guaranteeing availability of financing, such as catastrophe bonds (CAT bonds). The second CAT bond, called Bosphorus Ltd., was issued in 2015 in the amount of US$100 million for a three-year period. As of 2017, TCIP's total claims payment capacity was US$4.2 billion (TCIP 2017).

Sources: TCIP 2015; Gurenko et al. 2006; World Bank and GFDRR 2018.

a. See TCIP, "Tariff and Instruction of Compulsory Earthquake Insurance," http://www.tcip.gov.tr/mevzuat-tarife.html.

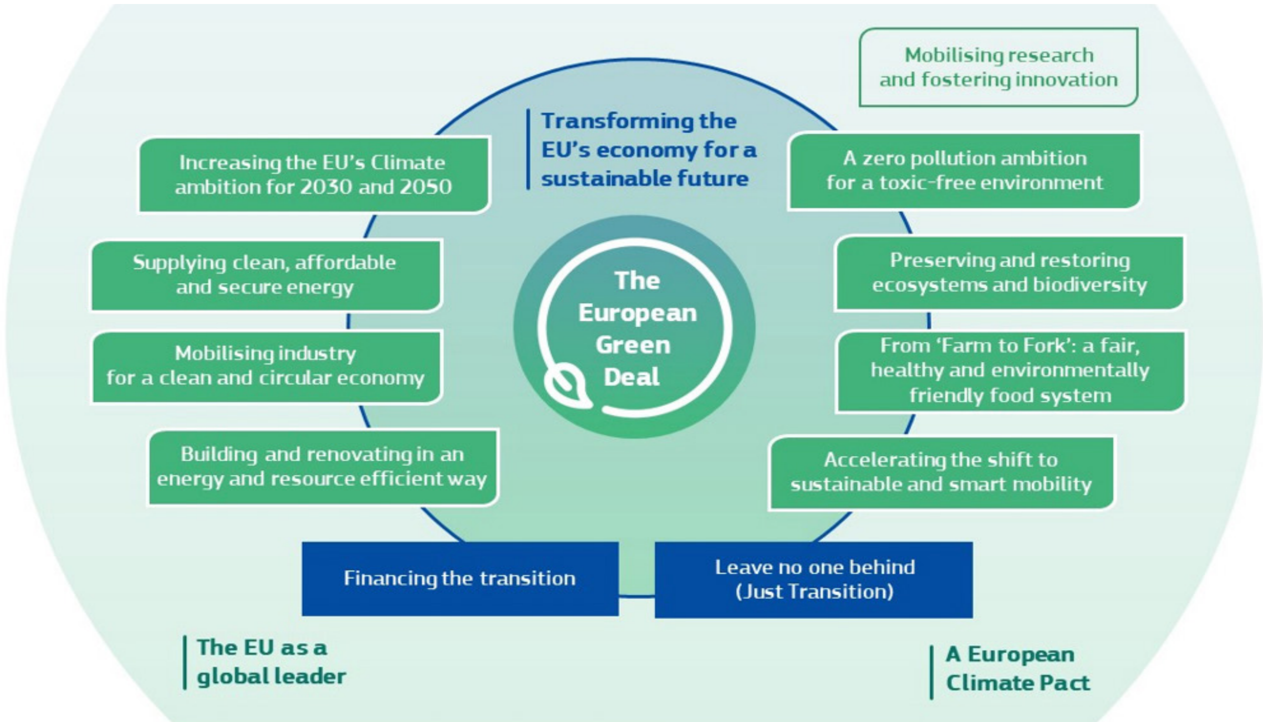
Annex 12.
The Need to Develop a Green and Resilient EU

Failure to address climate change has been identified as one of the highest potential socio-economic risks to our society it is estimated that the risk to assets from inaction is around US4.2 trillion in 2015 prices (The Economist Intelligence Unit, 2015). Couple this with the estimates of weather-related loss from Lloyd's of London (2017) which report that weather related loss increasing to US$200 billion in the past decade it is clear that action is needed now. Lloyd's attribute this increase in loss is attributed to climate change and development patterns, which are leading to a rise in concentration of people and assets in high-risk regions such as coastal and urban areas.

The increased risk posed by climate change is forcing countries to rethink their priorities and principles for achieving societal well-being and economic development. Proactive and robust actions are crucial to safeguard the continued potential of sustainable development. If prioritized according to countries' objectives, needs, and risks, such actions can help reduce and manage climate risks, accelerating development and poverty reduction.[63]

The EU Green Deal recognizes the threat of changing climate to the EU MS and citizens; it outlines a series of objectives to achieve sustainable development. The European Green Deal (2019) for instance, aims to achieve United Nation's 2030 Agenda and the sustainable development goals in the EU. The focus of the Green Deal is to address the challenges of a changing climate and environmental degradation through mobilizing private sector for green investments, green finance, and the process for greening national budgets[64]. The existing Green Deal should be complemented through the development of pre-arranged financial instruments to help build financial resilience and aide recovery from climate hazards when they become disasters.

Figure 53. EU Green Deal: key pillars



Source: European Commission, "A European Green Deal," https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52019DC0640&from=EN.

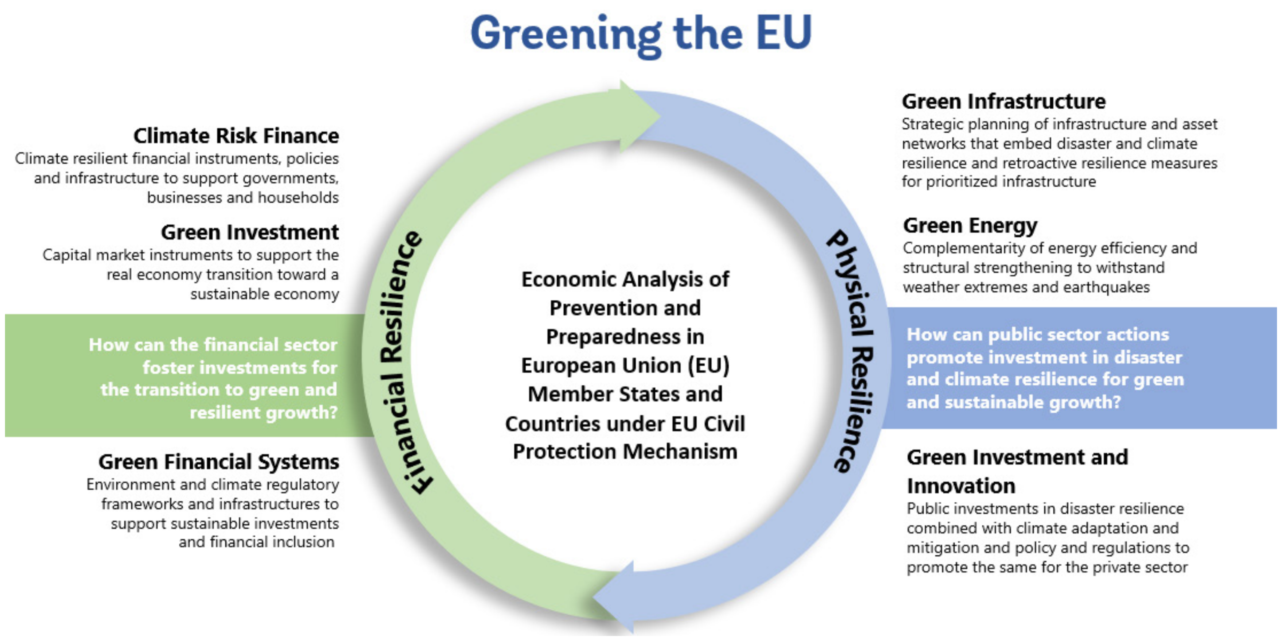
63 Hallegatte Stephane, Jun Rentschler, Julie Rozenberg. 2020. Adaptation Principles—A Guide for Designing Strategies for Climate Change Adaptation and Resilience. Washington, DC: World Bank.
64 https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52019DC0640&from=EN

While some fundamental regulations are in place to address climate change, there is a need to complement these with policies and finance for disaster resilience. It is expected that the financing available for disaster and climate resilience will increase in Europe in coming years through a variety of programmes. However, it should be noted that authorities responsible for disaster risk management may need additional support to advocate for increased allocations within national budgets and EU allocations, and that sectoral ministries may not prioritize funding for disaster prevention and preparedness due to a lack of awareness of the issues. Moreover, support to authorities to learn about, access, and use different funding sources will be critical.

Financial resilience and physical resilience complement and reinforce each other; financial resilience includes actions to both address the growing climate risks and prevent the creation of new ones through climate risk finance. The World Bank 2020 Adaptation Principles[65], for instance, suggest that climate risk finance should be implemented across all priority areas for climate change adaptation and resilience policy. This includes, for example, actions to: (i) ensure financing is available to all and that support is provided to the most vulnerable, (ii) increase the resilience of government assets, (iii) develop insurance sector, social protection systems, businesses, (iv) manage contingent liabilities to disasters as part of the planning and budgeting process, (v) develop financial strategies, and (vi) communicate and mitigate the disaster and climate risk exposure of the financial sector and pension systems.

Climate change is a threat to sustainability of the private sector; therefore, both government and private finance can be harnessed to support real economy transition towards a sustainable economy, which also aims for a greater resilience to physical impacts of climate change. This can be done through green investments and financial systems. Green investments aim to ensure that private sector investments align with climate adaptation and mitigation objectives. Green financial systems include actions to ensure that national regulatory framework and infrastructure support such investments.

Figure 54. Financial and physical resilience for greening the EU



Source: World Bank.

65 Hallegatte Stephane, Jun Rentschler, Julie Rozenberg. 2020. Adaptation Principles—A Guide for Designing Strategies for Climate Change Adaptation and Resilience. Washington, DC: World Bank.

Developing market-based risk transfer instruments to support financial resilience to climate change allows countries to secure finance to climate hazards before a disaster happens. The alternative to a market-based solution would be securing significant development partner financing or reallocating budget resources from existing and future projects. Neither option looks feasible in the current environment given the increased need for resources stemming from the COVID-19 pandemic. Every effort will need to be made to use finite resources to Maximize Finance for Development (MFD).[66] This will require working with the private sector.

The insurance sector has a valuable role to play as risk manager, underwriter and investor to build economic resilience and entrepreneurial pathways for addressing climate change goals and targets. The industry is contributing significantly to building financial resilience to extreme events and other physical risks by providing risk information and risk pricing expertise, offering innovative risk transfer products and services, and improving the distribution channels and payout mechanisms. It is also supporting the transition to a low-carbon economy through its underwriting business, investment strategies and active reduction of its carbon footprint (Geneva Association, 2019).

Finance alone cannot solve the challenges posed by climate change and needs support of other policy levers to drive change; investments aimed at achieving and integrating multiple objectives make technical, financial, and social sense. Achieving reductions in GHG through energy efficiency savings in buildings typically, and should, require a complementary structural strengthening to ensure that buildings constructed prior to modern codes – most of the European built environment – are resilient to snow, wind, and seismic loading. As highlighted in the World Bank (forthcoming (a)) report, there is opportunity to ensure simultaneous improvements in fire safety, modernization and functional improvements and ensuring access for people with disabilities. Integration of these objectives saves money, reduces disruption and is more sustainable over the short and long-term. Similarly, the study highlighted that early warning systems must be accompanied by public preparedness and readiness for action and enhanced coordination to achieve the highest return on investment.

66 https://www.worldbank.org/en/about/partners/maximizing-finance-for-development

Annex 13. Mexico's reserve fund FONDEN

FONDEN, Mexico's Trust Fund for Natural Disasters, was established as a mechanism to support the rapid rehabilitation of federal and state infrastructure affected by adverse natural events. FONDEN was established in BANOBRAS, Mexico's state-owned development bank. Funds from FONDEN can be used for the rehabilitation and reconstruction of (i) public infrastructure at the three levels of government (federal, state, and municipal); (ii) low-income housing; and (iii) certain components of the natural environment (e.g., forestry, protected natural areas, rivers, and lagoons).

FONDEN is funded through the federal budget and market-based risk transfer mechanisms, including insurance and catastrophe bonds. The federal law requires that an amount of no less than 0.4 percent of the annual federal budget should be available. In case the fund is exhausted, the law stipulates that additional resources must be transferred from other programmes and funds.

FONDEN is activated with the declaration of emergency. Once this declaration has been made, the federal agencies and/or state government(s) can apply for funding and the damage assessment process can begin. The affected federal and state agencies must demonstrate that the magnitude of reconstruction needs exceeds their financial capacity and file specific requests detailing the extent of the damage and estimated cost of reconstruction. Based on this, the appropriations can be approved.

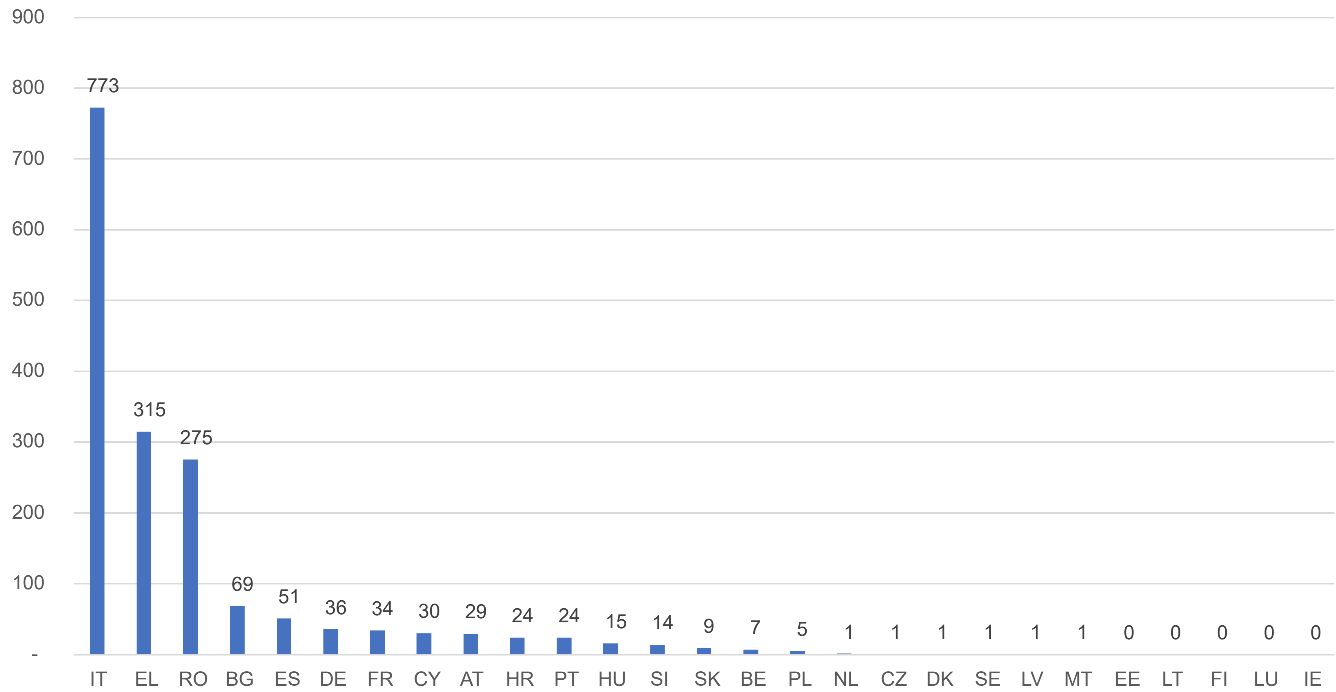
FONDEN provides funds directly to service providers in benefit of housing reconstruction and population support, response activities, and reconstruction of public assets. For public assets, FONDEN resources finance 100 percent of the reconstruction costs for federal assets and 50 percent of those for local assets; however, the second requests for FONDEN's support are reduced to 50 and 25 percent respectively. For private housing, during response, FONDEN can provide funds directly to the private companies contracted to, for instance, clean debris and allow for immediate occupation of the affected property. For reconstruction, FONDEN can provide construction materials and tools to poor houseowners, with some funds allocated to pay for labour and specialized advisory services, acquire lands, or construct new housing, but this support is limited to low-income households.

Source: World Bank *forthcoming (b).*

Annex 14.
Analysis of Earthquake Fatalities and Flood Population Affected

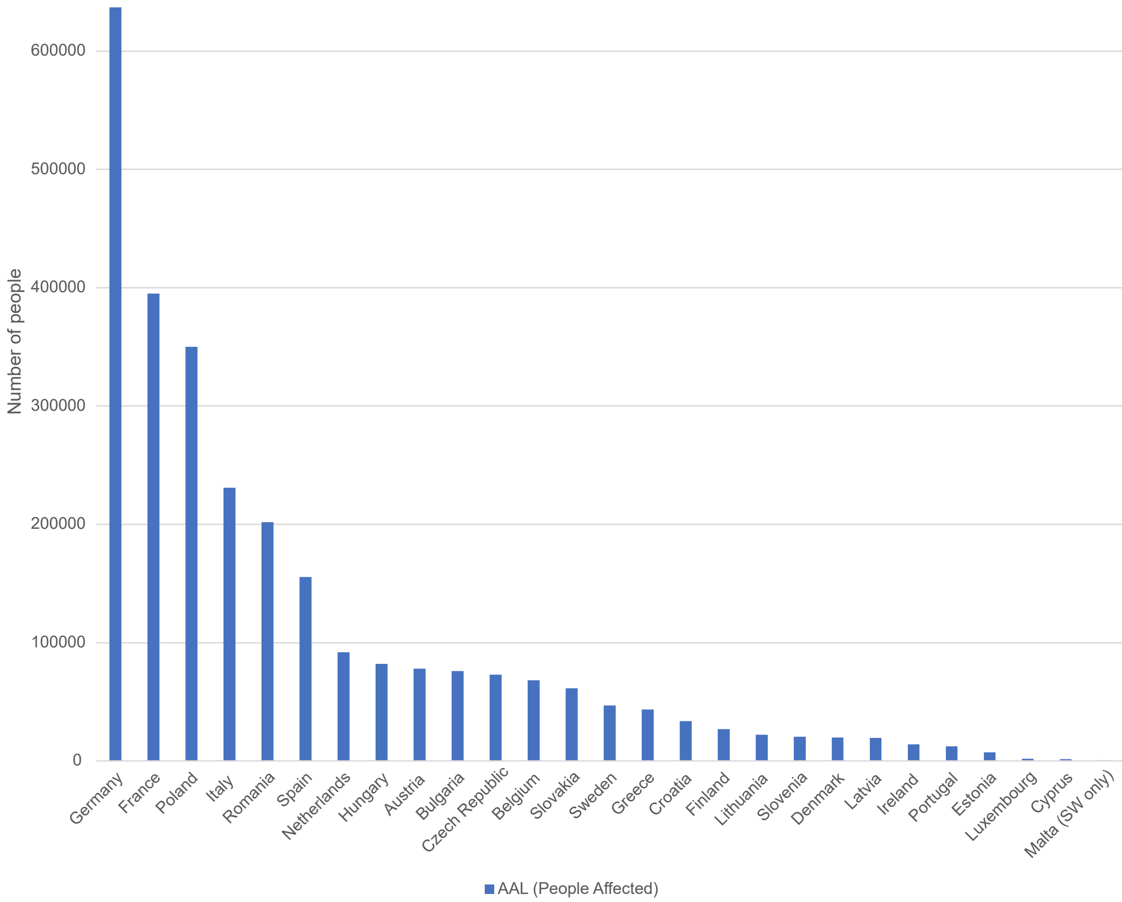
In addition to estimating economic loss resulting from direct damage to buildings, the estimated number of fatalities due to earthquakes, and population affected by floods, were estimated. In both cases 100% of the population was distributed to residential buildings, assuming a night-time distribution of population typical of risk analyses, and in the absence of robust movement data to model distribution of population under a daytime scenario, which was out of scope. Seismic fatalities are a function of simulated building damage level, and injuries are not included in this analysis. For floods, the population is assumed to be 'affected' if there simulated asset location is inundated to a depth of 0.2 meters or more (i.e., the depth threshold at which asset damage is assumed to begin). Indirectly flood-affected population are not included. The results are summarized in the charts below.

Figure 55. Estimated average annual fatalities from seismic events in EU Member States



Source: GEM, 2020.

Figure 56. Estimated average annual number of people affected by flood events (river and surface water floods) in EU Member States



Source: JBA, 2021.

- Italy, Greece and Romania are shown to have the greatest seismic risk in terms of fatalities (Figure 55) with Italy averaging over 770 fatalities per year – more than twice that of Greece and Romania, which in turn show over four times the annual average fatalities than the next country, Bulgaria.
- In terms of annual average number of people affected by fluvial and surface water flood-ing, Poland and Romania appear at 3rd and 5th in the ranking of EU MS – higher than their rank for economic AAL. Germany, France and Italy are the other countries in the top five. The ma-jority of countries have less than 100,000 people affected by floods annually, while the top three countries each have an estimate exceeding 350,000 per year (*Figure 56*).

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