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European Insurance and Occupational Pensions Authority

European Stability Mechanism

Sharing the risk: a European approach to natural catastrophe risk management

The increasing frequency and severity of natural catastrophes poses substantial economic and societal challenges across Europe. As risks continue to grow, insurance coverage for such events remains insufficient, leaving individuals, businesses, and governments exposed to financial losses. This paper demonstrates how a European-level risk-sharing mechanism can deliver significant diversification benefits and enable more cost-effective funding, crowding in the private sector. This paper presents modelling results showing how efficiency gains from a European risk pool for natural perils – combined with a loan-based backstop – can enhance the overall risk-bearing capacity and substantially reduce the insurance protection gap.

April 2026

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Acronyms

Cat XL	Catastrophe excess of loss
ECB	European Central Bank
EIOPA	European Insurance and Occupational Pensions Authority
ESM	European Stability Mechanism
EU	European Union
GDP	Gross domestic product
QS	Quota share
RP	Return period
VaR	Value at Risk

Country abbreviations

CODE	COUNTRY NAME	CODE	COUNTRY NAME
AT	Austria	IE	Ireland
BE	Belgium	IT	Italy
BG	Bulgaria	LT	Lithuania
CZ	Czechia	LU	Luxembourg
DE	Germany	NL	Netherlands
DK	Denmark	PL	Poland
EL	Greece	PT	Portugal
ES	Spain	RO	Romania
FI	Finland	SE	Sweden
FR	France	SI	Slovenia
HR	Croatia	SK	Slovakia
HU	Hungary		

Executive summary

Natural catastrophes impose a significant burden on society

Natural catastrophes, such as floods, heatwaves, wildfires, and storms are becoming increasingly frequent and severe, posing significant economic and societal challenges across Europe. As risks continue to grow, insurance coverage for natural catastrophes remains insufficient, leaving individuals, businesses, and governments increasingly exposed to financial losses, undermining resilience and recovery efforts.

Historical loss data and output from catastrophe models are used to explore the benefits of a risk-sharing mechanism combining a natural catastrophe insurance pool with loan-based backstop

Building on previous publications by the European Insurance and Occupational Pensions Authority (EIOPA) and the European Stability Mechanism (ESM), this paper explores the potential benefits of a European risk-sharing mechanism that combines a natural catastrophe insurance pool with a loan-based backstop mechanism. To do so, the paper considers both historical loss data and output from catastrophe models. This paper aims to provide a technical contribution to inform further discussions and decisions. It is well understood that the scheme needs to be embedded in a broader adaptation strategy and a clear policy to address demand-side deficiencies. To keep the analysis tractable, these issues are not further elaborated in this work.

A large protection gap in Europe needs to be closed

Depending on the estimation approach and the types of losses being considered, the insurance protection gap at the European level varies between 75% using historical loss data and 50% using a modelling approach. It can be even larger for individual countries and perils. There is significant variability among countries on how losses are insured.

European risk pooling unlocks efficiency gains

A European natural catastrophe insurance pool leverages the principle of risk diversification by pooling risks across countries and perils. This approach allows insurers to increase their capital efficiency, enabling them to underwrite more business and reduce the financial burden on policyholders. Individual pool members[1] will benefit from joining the natural catastrophe risk pool, provided that the pool collects risk-based premiums. Even when a specific pool member is not exposed to a certain risk, it benefits from the inclusion of uncorrelated risks, which reduces overall portfolio volatility and increases stability. Model simulations show that pooling risks across countries and perils could reduce overall capital to back the aggregated risk by up to 67% compared to standalone national solutions.

[1] Throughout this paper we use the term pool member as a synonym for any insurer, reinsurer, natural catastrophe scheme, or any other vehicle that joins the European risk-pooling mechanism.

A complementary backstop facility adds predictability and provides a financial safety net for extreme tail events

Complementing the insurance pool, a loan-based backstop provides initial funding and a financial safety net for extreme tail events that exceed the pool's capacity. By offering predictable and affordable funding, the backstop reduces the reliance on ad hoc government interventions and stabilises reinsurance costs for insurers. In the context of this study, simulations indicate that the backstop's required capacity ranges from €10 billion to €65 billion, depending on the risk appetite of the facility providing the loan and climate change dynamics. Over time, as the pool accumulates reserves, the likelihood of the backstop being called upon diminishes but remains critical for addressing severe scenarios.

The paper outlines a design proposal with the aim of sparking further policy discussions

This joint EIOPA/ESM project offers insights on the possible design of a European natural catastrophe insurance pool supported by a loan-based backstop facility. The analysis demonstrates how such a framework could strengthen private sector capacity, reduce volatility, and help narrow the protection gap while maintaining fiscal neutrality. Rather than provide definitive conclusions on every aspect of the policy design, the paper focuses on outlining the potential quantitative impacts to inform policy discussions.

Introduction

Quantitative analysis for a European risk-sharing mechanism for natural catastrophe insurance.

European risk sharing for natural catastrophe risks could lower the burden on fiscal budgets and reduce costs to society through improved risk management. Between 1981 and 2024, natural catastrophes caused more than €900 billion in direct economic losses within the European Union (EU), with one-fifth of these losses having occurred in the last few years of that time. However, over the same period, only a fraction of those losses were insured. Earlier publications by EIOPA in collaboration with the European Central Bank (ECB), and publications by the ESM, illustrated the key macroeconomic, financial stability, and fiscal implications of the EU's insurance protection gap for natural catastrophes and explained the potential benefits of European risk sharing (see ECB/EIOPA 2023 and 2024, Mayr and Skrutkowski, 2023, and Hahn and Mayr, 2024).

After these publications, several discussions have focused on the issue of capacity – namely how much risk insurers can cover. While there are indications that (re)insurers could provide additional coverage for natural catastrophes in Europe, several critical factors must be considered that could constrain this potential capacity:

- There is a significant insurance protection gap. For reasons such as unawareness, affordability constraints, and gap on the demand side, individuals and businesses may not seek or prioritise insurance coverage. On the supply side, factors such as high pricing, limited risk appetite, and data challenges create a support gap, restricting the availability and accessibility of insurance products.
- Europe is the fastest-warming continent, experiencing increasingly frequent and severe floods, storms (including hail), droughts, and wildfires. Increases in values, accumulation in risk zones, and inflation all contribute to growing losses.
- Insurance capacity is largely a function of the availability of reinsurance, yet reinsurance pricing is linked with the pattern of "hard" and "soft" market conditions, driven by supply, demand, and catastrophic events. This creates price volatility that could also impact the willingness of insurers to provide additional coverage.

This paper therefore examines a potential solution designed to provide additional insurance. Addressing demand-side challenges and the need to incentivise loss mitigation measures fall outside the scope of this paper. Nevertheless, the proposed mechanism could also serve as a platform for developing complementary policy measures aimed at strengthening demand-side resilience, for example by encouraging greater insurance penetration, supporting affordability initiatives, and promoting investments in risk reduction and prevention.

The aim is to provide a technical contribution to further the discussion on the potential development of a European risk-sharing mechanism. In parallel, several EU Member States are pursuing national initiatives to address insurance protection gaps, with developments expected. Building on previous publications by EIOPA (together with the ECB) and the ESM, this paper explores key aspects of a possible EU-level mechanism, including a conceptual structure and financing options. This mechanism corresponds to the fourth layer of intervention described in the previous EIOPA/ECB papers and does not constitute a new policy proposal. Going forward, further analysis and stakeholder engagement will be essential to advance the discussion on policy options and specific design features.[2]

This paper supports the policy discussion by quantifying the potential size and effectiveness of a European risk-sharing mechanism. By pooling extreme event risks across the EU, such a mechanism would enable more efficient capital allocation through diversification across Member States and perils. Combined with a public loan-based backstop, insurance capacity could be further enhanced by increasing capital efficiency, thereby reducing uncertainty and lowering the cost of covering natural catastrophes. This framework has the potential to make currently unprofitable risks more manageable by improving diversification and reducing volatility, enabling insurers to extend coverage to risks that might otherwise remain uninsured, while also freeing up capital to underwrite additional business. The key objective is to nurture an expanded private sector solution by incentivising an otherwise unavailable insurance capacity, with the loan-based backstop functioning as a catalyst without unduly exposing taxpayers to downside risks. European risk sharing aims to strengthen private sector solutions by offering complementary coverage for high-severity or tail events. It provides an additional layer of diversification that can enhance existing private or public frameworks, not by replacing them but by integrating with them to strengthen overall risk-sharing capacities. The pooling of risks at the European level is designed to benefit all participants.

Participation could build on existing national solutions, with membership potentially comprising both private sector participants and national schemes, such as those in France and Spain.[3] The pool could be owned by the private sector or the public sector (a hybrid ownership model could also be considered if relevant). Ultimately, disaster financing at the European level through a loan-based backstop seeks to enhance capital efficiency while reducing reliance on costly ad hoc national or European interventions.

Prerequisites for the successful implementation of a European solution

Risk-based ex ante pooling. To ensure adequate and cost-efficient risk sharing without crowding out private market initiative or impeding national solutions to address insurance protection gaps, risk pooling at the European level should be risk-based. Broad participation in the pool should prevent moral hazard and adverse selection and contribute to the largest possible diversification benefit. This supposes that participation in the pool should take place before the occurrence of a natural catastrophe and government involvement is not negotiable after an event. As risks would be mutualised in the pool, the diversification should ultimately also benefit each participating entity.

Fiscal neutrality of the backstop. To ensure fiscal neutrality in the medium term, i.e. to limit additional government spending and costs to society, the backstop's loan conditions must be market-based and insurers must bear their share of the loan for risks underwritten by the industry.[4] This means that any loan would be fully recouped from the members of the pool, while also allowing members sufficient time to absorb the costs. An extended repayment period would allow for intertemporal cost smoothing. Fees should accurately reflect the costs, and cost savings should be transmitted to policyholders and not unduly subsidise private insurance. The envisaged structure of the ESM backstop for the Single Resolution Fund may serve as a blueprint

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[2] For example, this may include, but is not restricted to, the practical implementation of such a mechanism and the questions of how to integrate incentives for adaptation measures, or how to address demand-side issues.

[3] See Insurance Compensation Consortium for Spain or the Compagnie Centrale de Réassurance for France.

[4] The backstop facility will raise the necessary funds on the capital markets and pass on its favourable financing terms to the members of the pool. However, members of the pool will be required to fully repay the loan, including all associated costs of the backstop facility. While the backstop ensures cost efficiency through its access to cheap financing, it does not aim to generate profit for itself.

for such a scheme because it embeds the principles of last resort and fiscal neutrality in the medium term. Insurance capacity should not be increased at the cost of the public. At the same time, public-(private-) financed adaptation measures should contribute to lowering the cost of disasters in the longer term. Furthermore, the financial health of the backstop facility should not be affected by the disaster event, to avoid higher funding costs at the point of disaster which, in turn, could spill over to the loan rates it charges.

Embedding (tail-) risk sharing in a broader strategy

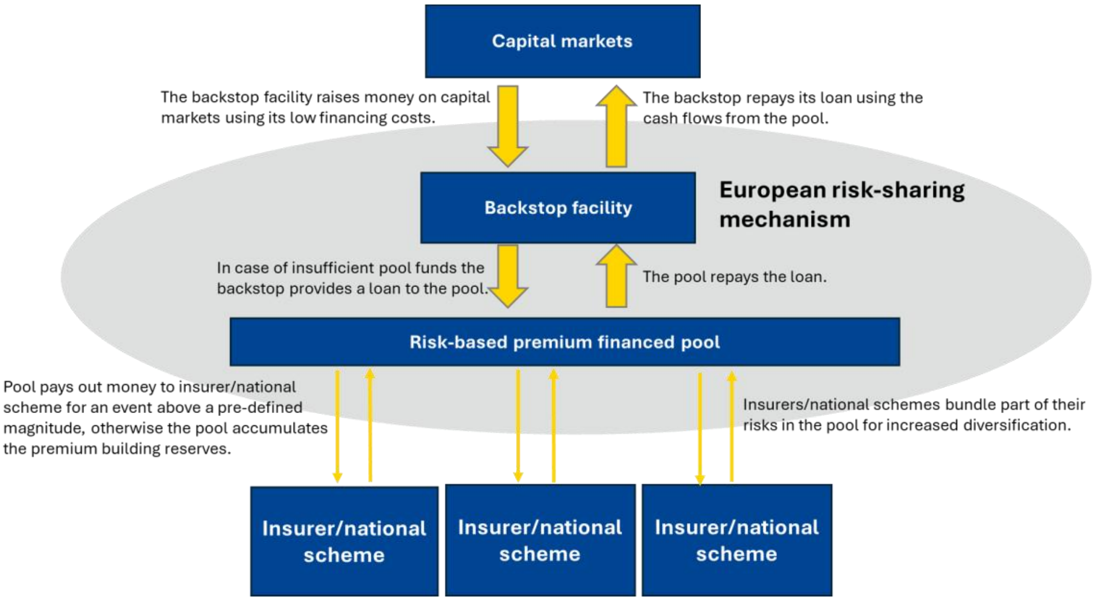
The solution presented in this paper aims to increase capacity for insurance coverage, but other initiatives to support risk awareness and insurance take-up are needed too. The insurance protection gap is a function of both demand and supply. On the one hand, the capacity constraints of insurers need to be well understood to appropriately calibrate the size of the pool and the backstop. On the other hand, insufficient demand is often a major driver of the large insurance protection gap.[5] Constraints to insurance coverage arising from demand-side factors need to be considered too and require solutions to strengthen uptake of insurance by households and businesses.

To lower the economic cost of disasters, a comprehensive private and public investment in risk mitigation and adaptation is needed. Narrowing the protection gap can best be achieved by increasing insurance coverage while limiting the exposure and vulnerability to natural hazards. A successful disaster risk management strategy needs to be accompanied by an adaptation regime that limits the likely damage of an event. In fact, improving physical resilience, through infrastructure investments, zoning laws, buildings codes, etc., can foster financial resilience, as communities and businesses become less vulnerable to extreme natural events (see the Network of Central Banks and Supervisors for Greening the Financial System, 2024). This has a positive feedback effect on both potential economic and insured losses, and eventually on the insurance protection gap. The insurance industry can further foster this development by promoting infrastructure investment and impact underwriting, or other incentives for more risk-aware behaviour (EIOPA, 2026).

Figure 1 shows how the various components of the European risk-sharing mechanism interact. At the foundation are the private sector insurers, and, where applicable, national schemes for natural catastrophe risk. A pool coupled with a backstop solution introduces a risk-sharing mechanism at the European level combined with a loan facility for extreme events that go beyond the capacity of both insurers and the pool. Given more affordable refinancing on the capital markets, the European backstop facility can offer its loans at competitive rates to the pool.

[5] For an assessment of various demand-side factors see EIOPA 2024.

Figure 1:
Interaction of all European risk-sharing mechanism components



Organisation of the paper

This paper describes the role and benefits of a European solution to natural catastrophe risk transfer. After briefly describing the objectives and requirements of a European scheme for natural catastrophe risks, the note introduces a quantitative analysis organised into two parts. Chapter 1 provides estimates of economic losses and insured losses for natural catastrophes based both on historical losses and using catastrophe models. It includes a brief discussion of the observed differences in results. Chapter 2 uses these findings to study in more detail the workings of a European insurance pool and a loan-based backstop mechanism. In particular, it analyses the impact of pooling risks across different countries and perils and offers first estimates of the required size of the pool and backstop. The concluding section summarises the findings, indicates potential policy options, and presents avenues for further research.

1. Estimation of the protection gap

The scale of the issue

In the last few years, many European countries have experienced catastrophes leading to billions of euros in losses. Economic losses from such events have become an increasing concern for most countries. At the same time, insurance protection levels tend to be low, though considerable differences across countries exist. Table 1 shows some examples of recent events in Europe, highlighting the economic impact of natural hazards.

Table 1
Illustrative list of natural catastrophes

Event	Economic loss	Insured loss	Commentary
2012 Earthquake in Italy	~€20.5 billion	~€2 billion	Large protection gap
2021 Ahr valley floods in Germany and adjacent countries	~€51 billion	~€13 billion	Costliest natural disaster in Europe
2024 Flooding in Valencia, Spain	~€11 billion	~€4.5 billion	Worst recorded loss event in Spain
2024 Central Europe floods	~ €9 billion	~ €4 billion	Same countries affected as in past severe events

Notes: Data are based on current amounts. This list serves illustrative purposes and is not meant to provide a comprehensive picture.
Sources: Artemis, Munich Re, Insurance Compensation Consortium (*Consorcio de Compensación de Seguros*)

Recorded historical data on economic and insured losses are a useful starting point for any analysis of insurance protection gaps. Such data provide a picture of the protection gap in the past, reflecting hazards within the respective time window, exposures, vulnerabilities, and insurance coverage measured at the time of the event.

However, some adjustments are required to allow a proper assessment of the historical loss data. This applies to both low frequency events (e.g. earthquakes, volcanoes) as well as more frequent events (e.g. hail, windstorms, floods). One may need to account for potential underreporting due to events falling below a certain loss threshold and actual total losses only being known after some time. While historical loss databases provide a good overview of past events, they may not capture all losses, particularly smaller ones. They may also not fully account for second-round macroeconomic effects (see Gavilan-Rubio and Peppel-Srebrny, 2025). The underreporting of losses is particularly pronounced for high-frequency perils like hail, where small losses may not be recorded. Over time, climate change trends impact the frequency and intensity of events, which would not be reflected in historical data. For example, a recent study has found significant increases in lightning and hail activity across most of Europe, which may not be reflected in historical loss data (see Battaglioli et al., 2023). Similarly, Alfieri et al. (2016) show that the expected damage from increasing flood risk is also a function of the chosen adaptation measure. Similar arguments can be made for low-frequency/high-severity events, which may be underrepresented due to data limitations in historical records and short time series.

Furthermore, replacement costs can increase significantly over time and need to be accounted for. The absence of a major natural disaster event over several years, for instance, may mean that the true extent of related losses, considering the current economy and building stock, remains insufficiently captured in historical loss databases. According to Swiss Re (2024) estimations, inflation-related factors explain around 40% of the growth in annual insured claims due to severe convective storms. Increased exposure values due to economic and population growth, urbanisation, and wealth accumulation are other important drivers of losses that need to be accounted for in a more prospective view.

A model-based approach provides a complementary or prospective view by covering aspects not sufficiently captured in historical loss data. Expected modelled losses are the sum of the values of all possible losses, each multiplied by the probability of that loss occurring. Modelled losses provide an expected current view that incorporates stochastic data on hazards, up-to-date exposure, current vulnerability, and insurance coverage, which unadjusted historical data cannot sufficiently capture. Necessarily, they also include expert judgment where data is scarce.

Similar to historical records, modelled results need careful interpretation. One issue is limited transparency, as many models are proprietary,[6] making it difficult for a general user to follow their underlying assumptions, methodologies, and data sources. Another concern is model uncertainty, as different models can yield significantly different results for the same event due to variations in structure and assumptions. Additionally, data limitations can affect reliability, as models may also rely on incomplete or outdated hazard, exposure, or vulnerability data, particularly in less-developed regions.

Comparing the historical data analysis with a model-based approach confirms the validity of the results presented in this paper. Based on our empirical data and modelling analysis,[7] the level of insurance coverage depends on whether a historical or expected view is taken. Under the model, approximately 50% of the economic losses are insured, compared to around 25% of historical losses. This difference in insured modelled losses can, among other things, be explained by the fact that insurance penetration has increased over the last few decades.[8] It is also important to note that the historical loss data include not only damage to buildings but also to infrastructure – such as roads, bridges, utilities, and agriculture-related losses, which in most cases being uninsured contribute to economic losses only, hence widening the protection gap. In contrast, the model focuses solely on properties. Since infrastructure is rarely insured, especially by private insurers, its losses are often borne by governments or remain unfunded. This results in a significantly larger protection gap for infrastructure compared to properties, which typically have at least partial insurance coverage.[9]

As observed in EIOPA's insurance protection gap dashboard[10] and the model-based results in this paper, insurance protection gaps vary significantly across countries. The countries with the highest protection gaps are Italy, Greece, Bulgaria, Portugal, Slovenia, and Romania. France, Spain, and Belgium have the smallest gaps, with less than 20% of losses uninsured. Comparing uninsured losses to gross domestic product (GDP), Greece followed by Italy and Bulgaria have the largest share. Earthquakes show the largest insurance protection gap (also confirmed in modelled data). Compared to other hazards, they are rare events that can cause considerable damage, which are insufficiently insured today. By contrast, windstorms show the highest

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[6] Transparency of proprietary models can be available for clients and regulators to understand underlying assumptions, methodologies, and data sources.

[7] See description of modelling analysis and historical losses used in Annex 1

[8] To illustrate how the insurance penetration has increased in Europe, the example of Germany can be helpful as (a) natural catastrophe losses in Germany contribute significantly to the overall losses in Europe and (b) because good data are available to allow for this analysis. Overtime the insurance penetration for natural catastrophe risks (calculated as an average of the insurance penetration in each German state over time) has significantly increased in Germany (from ~25% in 2012 to almost 50% in 2023).

[9] Building on existing national and EU structures, EIOPA and the ECB proposed a possible EU-level solution composed of two complementary pillars: 1. an EU public-private reinsurance scheme, and 2. an EU fund for public disaster financing. The data covered by the modelling approach capture only property data which could be assumed to be insurable (this links with Pillar 1 of EIOPA/ECB 's proposal). The historical data, however, capture both properties and overall infrastructure damage. For this paper, the losses related to infrastructure (Pillar 2) were not separated out.

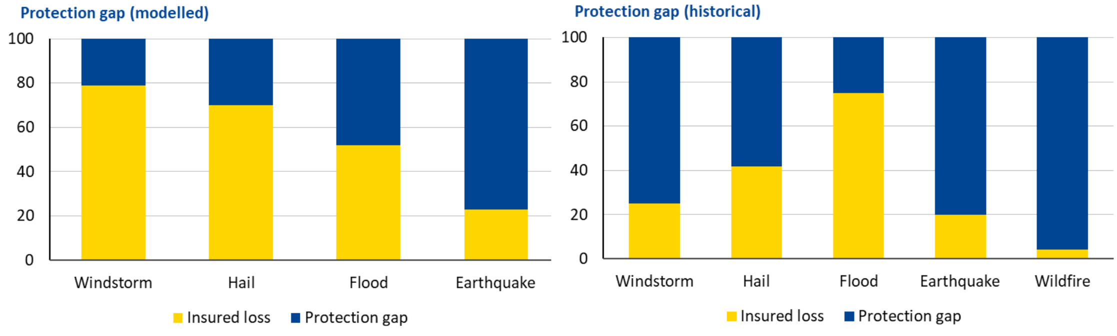
[10] Dashboard on insurance protection gap for natural catastrophes - EIOPA

insurance coverage (see Figure 2).[11]

Figure 2

Relative share of total economic and insured losses

(in %)



Sources: Moody's, European Environment Agency

[11] Windstorms typically produce comparatively small losses to infrastructure and agriculture (with exception of forestry), which explains their comparatively smaller share of economic losses.

2. Risk-sharing mechanism

The European risk-sharing mechanism

Introduction

As shown in Chapter 1, the insurance protection gap in Europe is significant. The main aim of European risk pooling of insurable, but currently uninsured, natural catastrophe risks is to achieve and redistribute efficiencies.[12] By pooling risks across countries and perils, a European solution can improve the diversification potential for all its participating entities (see also Prettenthaler et al., 2017 or Ciullo et al., 2023), which can then be redistributed in accordance with each entity's contribution to the overall risk. This enhanced diversification reduces the insurer's capital required, allowing insurers to increase their underwriting capacity without raising their capital base.

The following sections aim to quantify the potential size of the diversification effect achieved by pooling multiple risks across EU Member States. This effect is illustrated using both historical loss data and outputs from catastrophe models. Thereupon, the analysis estimates the size of a risk pool required to reduce the uninsured portion of risk to a moderate level (e.g. 10%), based on the modelled insured and economic losses presented in Chapter 1.

Box 1: Diversification and risk pools

Risk pooling is a fundamental concept in insurance, grounded in the law of large numbers. As independent risks are added to a (re)insurer's portfolio, the results become less volatile. For example, in a pool of insured vehicles, the actual number of accidents each year converges to the expected number as the size of the pool increases while, at the same time, volatility in results decreases. Losses in one area are essentially offset by gains in others, thus reducing the impact of a tail event. This reduced volatility of capital based on a larger pool of risks can help make predictions more accurate and help insurers better plan for costs. This means lower capital needs and costs can be achieved for the same level of protection offered.

In the case of natural hazards, risks are rarely entirely independent. For instance, if a flood event occurs, many people are exposed and will therefore claim simultaneously. However, by adding different perils (e.g. windstorms, volcanoes, earthquakes), countries or regions, and lines of business (e.g. property, motor, business interruption) to the portfolio, the insurer can reduce its risk concentration and partially eliminate this systematic risk by increasing its diversification potential (see Figure B.1). The less correlated (dependent) the risks are, the higher the diversification effect that can be achieved.

More diversified (re)insurers can therefore offer coverage at a lower price and, given the same level of capital, provide a higher level of protection. Natural perils are high-impact and low-frequency events and will, hence, cause higher fluctuations than typically observed from other events. This increases the importance of diversification for insurers' risk portfolios.

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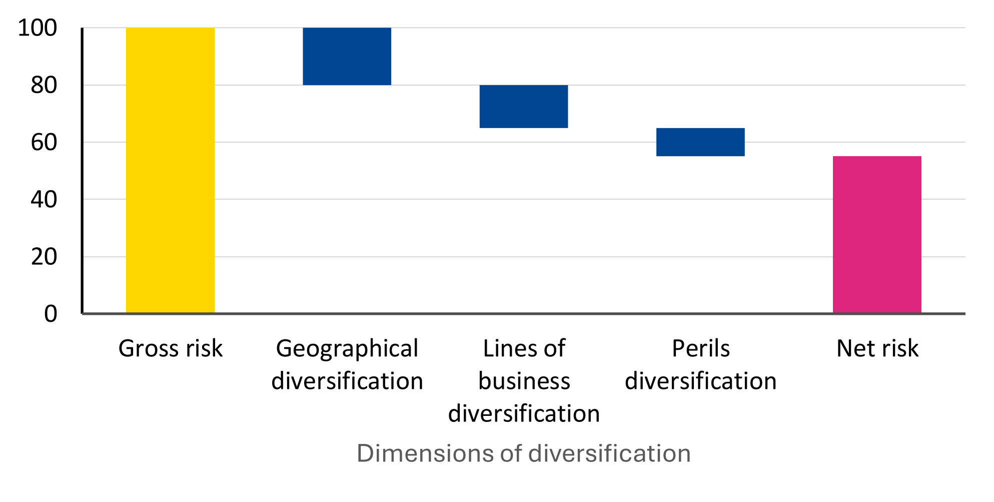
[12] NB: This paper focuses on the risk pooling argument. Administrative cost savings through operational pooling can also be substantial (see for instance Bollmann and Wang 2019) but are not part of this analysis.

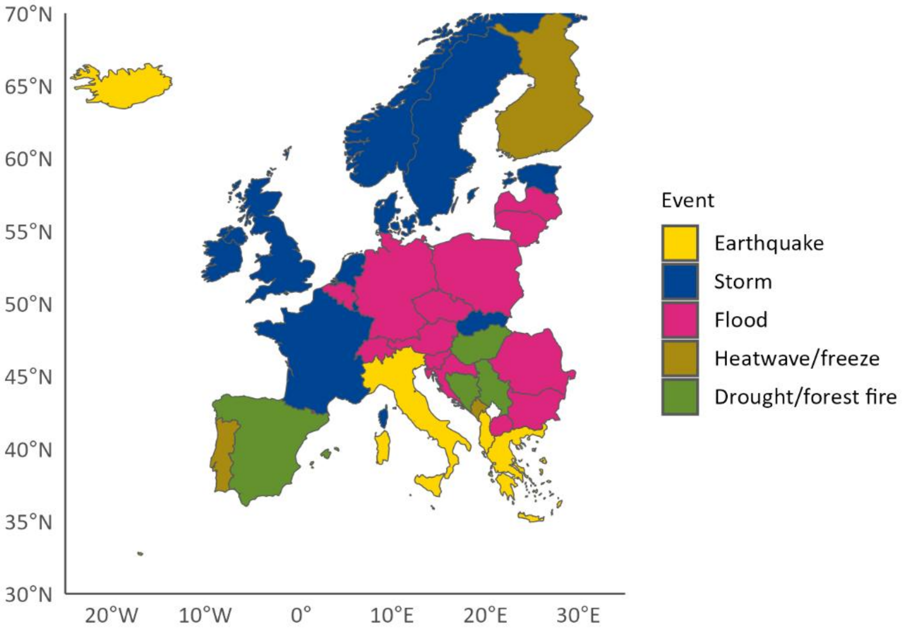
Figure B.1
Illustration of diversification impact
(as % of gross risk)



Note: This example is illustrative only and not based on model results.

Varying country exposures to natural perils highlight the significant diversification potential at the European level. As shown in Figure 3, the maximum observed economic losses from 1980 to 2023 differ significantly across Europe depending on which peril dominates and the corresponding difference in frequency and timing of losses. For example, geophysical events such as earthquakes are the most significant risk in countries like Greece and Italy, while hydrological events such as floods dominate in Central and Eastern Europe. Meanwhile, meteorological risks (including windstorms) are prevalent in Northern Europe, and heatwaves or other climatological events have had a significant impact in countries like Portugal and France. This demonstrates the natural potential for risk diversification.

Figure 3
Main exposure to natural perils by geography, based on maximum economic loss



Notes: Earthquakes, storms, and floods are used representatively for geophysical, meteorological, and hydrological risk respectively. They are the largest contributors to these events.
Source: Authors' calculations based on European Environment Agency data

In the following section, we show the potential impact of pooling based on historical and model-based data. To illustrate how pooling different regions and perils can result in lower capital needs, we ran two analyses, one using historical loss data and the other using catastrophe models. European insurance regulation, Solvency II,[13] requires insurers to hold sufficient capital to withstand a loss resulting from a severe event – one so rare it's expected to happen only once every 200 years (also called the 99.5% Value at Risk (VaR)).[14] We therefore analyse the impact of pooling on a 99.5% VaR assumption. Calculations run on expected shortfall, which measures the average loss in an extreme event, led to similar qualitative behaviour. Consequently, we only show results using VaR. A similar impact of pooling and diversification for uninsured losses can be found for historical data.

Illustrating the pooling effect

Using historical losses

Expected economic losses vary significantly across countries (see Figure 4). Given the scarcity of data, the estimates are subject to a degree of uncertainty. The graph illustrates the potential economic losses each country could face in the event of a very severe shock, as measured by the 99.5% VaR. To account for the uncertainty of these estimates, the range of plausible estimates (confidence interval) are included. The confidence intervals are based on the available data and the assumptions used in the analysis (see Annex 1 for details). The confidence intervals are relatively wide, underscoring the limitations in data availability and the inherent challenges in modelling extreme economic losses based on historical observations. It should be noted that these large confidence intervals stress the importance of further improving data collection efforts to enhance modelling accuracy, reduce uncertainty, and provide more robust insights for better addressing protection gaps in the future (more information in Annex 1).

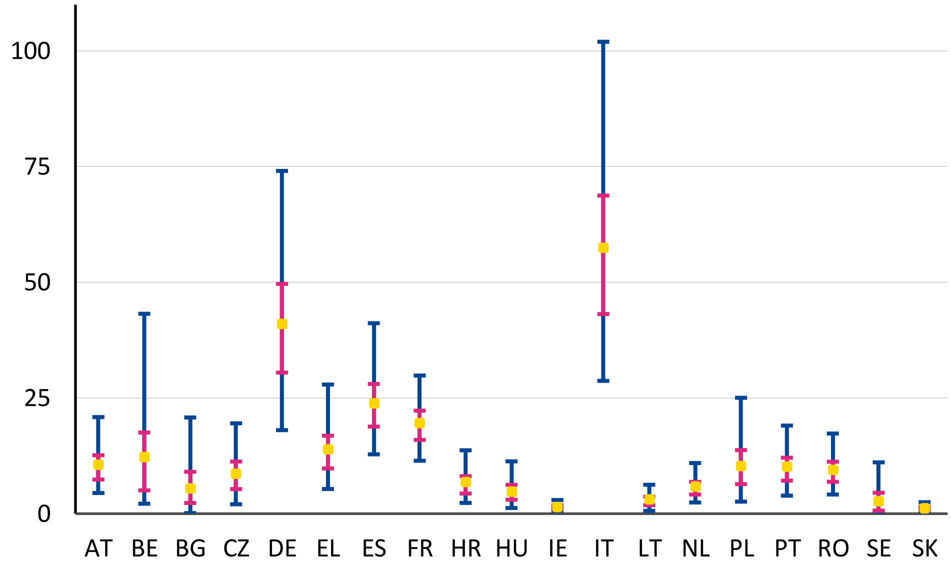
[13] This is a parameter for this study. The achievement of such a reduction in the protection gap would not only depend on the supply-side but also on the demand side.

[14] A 200-year return period loss is the same as a 99.5% VaR. Both represent extremely rare, severe loss events with only a 0.5% chance of being exceeded in any given year. A 200-year return period means an event is so rare it is expected to occur only once every 200 years. In probability terms, that's a 0.5% chance per year (1 ÷ 200 = 0.005 = 0.5%).

Figure 4

Expected losses using a 99.5% VaR

(in € billion)



Notes: The yellow dots show the expected economic losses for all events using a 99.5% VaR (1 in 200-year event). The blue (pink) whiskers indicate the 50% (95%) confidence interval. The following perils are included in the estimation of expected losses: Flood, windstorm, earthquake, wildfire, and hail.

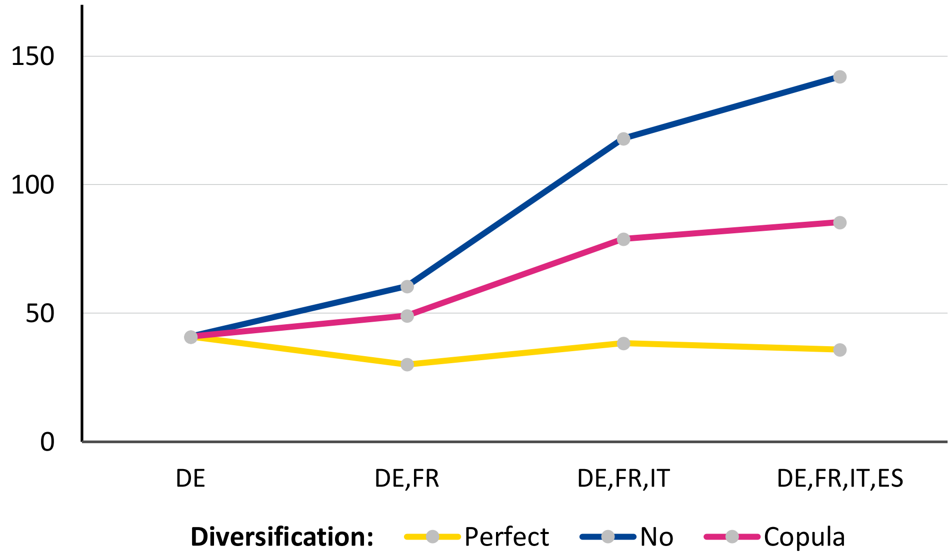
Source: Authors' calculations based on European Environment Agency data

Historical events, such as floods along the Danube or heatwaves, demonstrate that climate-related disasters in particular can impact multiple countries simultaneously. Hence, acknowledging that natural catastrophe risks are not completely independent, particularly in the tail of the distribution, we use t-copulae in our modelling to account for correlations between events. Due to the scarcity of data, the analysis was limited to Germany, France, Spain, and Italy. We sequentially add a country to the calculation of overall required risk capital, starting with Germany, to better illustrate the diversification potential as more countries are added to the pool.

The reduction in VaR observed in the aggregated scenarios demonstrates that pooling risks across countries can meaningfully reduce overall risks. Figure 5 presents an analysis of the VaR for the four countries alongside three aggregation scenarios: the "no diversification scenario",[15] the "perfect diversification scenario", and the copula approach. The "no diversification" and the "perfect diversification" assumptions provide reasonable lower and upper bounds, albeit not realistic. Wide confidence intervals notwithstanding, the results clearly indicate that diversification effects are significant. This underscores the potential benefits of European collaboration and risk-sharing mechanisms to strengthen resilience against natural catastrophes.

[15] The "perfect diversification" VaR (and expected shortfall) decrease sometimes as the number of countries increases. This is the result of this scenario assuming that natural catastrophe events in one country are entirely independent of those in others. The more countries are added to the pool, the greater the diversification, and the lower the overall risk. However, it is important to emphasise that the "perfect diversification" assumption is highly idealised and does not reflect real-world conditions, where events such as floods or heatwaves often impact multiple countries simultaneously. This is why more sophisticated approaches, like the Copula method, are necessary to account for correlations and provide a more accurate estimate of the aggregated risk.

Figure 5
Incremental risk capital impact of adding countries to the pool of risks using 99.5% VaR metric
(in € billion)



Notes: The lines in this graph show the incremental change in risk capital under different assumptions, whereby the blue line and the yellow line show the theoretical maximum (no diversification) and minimum (perfect diversification, uncorrelated) risks. The difference between the blue and the pink line indicates the diversification effect.
Source: Authors' calculations based on European Environment Agency data

In the following sections, we employ catastrophe models to overcome the date limitations of historical loss data and provide a more current and comprehensive assessment of risk. It offers broader coverage across both perils and geographic regions.

Using catastrophe models

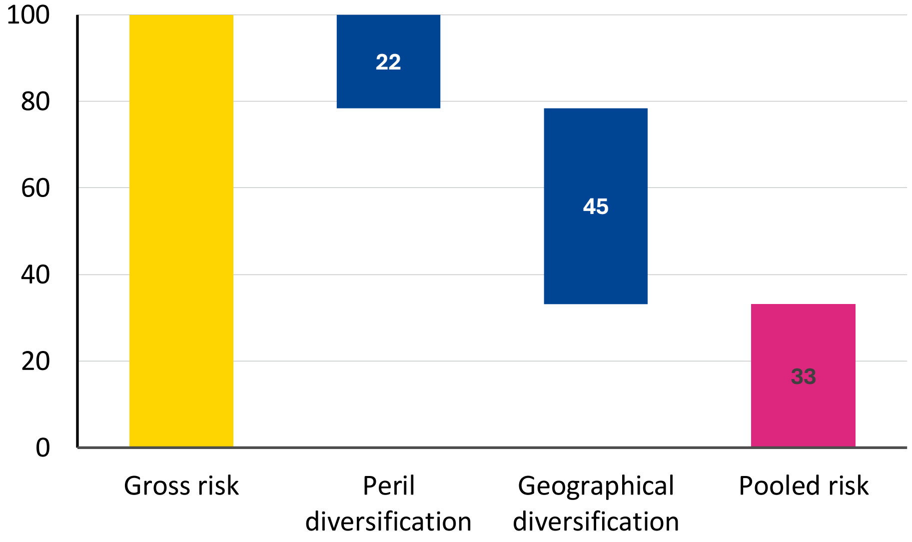
The results from catastrophe models also highlight a significant reduction in risk through diversification – both across different perils and at the European level. Figure 6 presents the 99.5% VaR estimates for the various perils and countries[16] included in this analysis (see Annex 1, Table A.1.1).

- **Step 1:** Summing the 99.5% VaR values for each peril and country individually gives the gross risk, representing a scenario where countries assess their risks in isolation and do not pool perils internally.
- **Step 2:** When each country pools its perils internally while considering risks independently from other countries, the overall gross risk is reduced by approximately 22%.
- **Step 3:** When all countries pool their risks together, leveraging geographical diversification, the risk is further reduced by approximately 45%, resulting in a net risk that is about 67% lower than the initial gross risk.

These findings, consistent with the historical data analysis shown in the previous section, underscore the substantial benefits of multi-peril consideration and cross-country collaboration at the European level.

[16] This study considers 21 countries. The same principle would apply for a different set of countries, but the results would differ.

Figure 6
Impact of diversification on the 99.5% VaR
(in % of gross risk)



Note: The graph shows the diversification impact of pooling different perils across 21 European countries (see Table A.1.1 in Annex 1).
Source: Authors' calculation based on Moody's data

Potential size of a European pool

Having demonstrated the significant diversification potential, we suggest a pool design that could contribute to a reduction of the insurance protection gap to around 10% at European level for properties. As an illustrative example we assume an improvement of roughly 40 percentage points relative to the status quo. The current protection gap from a modelling perspective is around 50% for properties. This would reduce the protection gap to 10%.

Reducing the insurance protection gap for property risks to around 10% at the European level strikes a balance between economic efficiency, affordability, and resilience – making it a desirable target for mature insurance markets. A protection gap below 10% indicates that most economically insurable property risks are being effectively transferred to insurers, thereby minimising the financial burden on individuals and governments. Insurance becomes economically inefficient when the cost of coverage exceeds the expected benefit. A low protection gap (e.g. 10–20%) typically reflects risks that are either uneconomical to insure or better managed through alternative mechanisms (see Schanz, 2018). It is important to note, however, that the model data do not cover all lines of business. The analysis includes property and motor[17] losses, but does not cover infrastructure and agricultural losses, meaning the overall protection gap would be larger.

Various risk-pooling structures can be explored to significantly reduce the protection gap. One such structure is a catastrophe excess-of-loss (Cat XL) arrangement, which provides coverage once total losses from a catastrophic event exceed a predefined threshold (i.e. attachment point). Losses above this threshold are then covered by the pool. An alternative approach could involve a hybrid structure, combining a Cat XL with a quota share (QS) mechanism. In this model, a fixed percentage of potential losses is shared between the pool

[17] Physical damage to the insured vehicle.

and the ceding party, allowing for broader risk distribution. The parameters used for the pool in this study are detailed in Table 3. The pool can be designed to trigger at either the country level or the European level, each option offering distinct advantages and trade-offs. A country-level trigger, used in this paper, offers simplicity and ease of implementation. Each country has a clear framework for when the pool becomes active. The attachment point of the pool can be set to the same return period across all participating countries, ensuring consistency and ease in the design. It also accounts for the fact that risks vary substantially across countries, in both likelihood of occurrence and expected impact.[18]

[18] A European-level trigger would be consistent with the level of pooling comes with greater complexity in design and governance. One of the main challenges is ensuring that the pool is equitable and responsive to losses, regardless of the size of the affected country. For example, a large-scale disaster in a small country might not meet the overall loss threshold required to trigger the pool at the European level, potentially leaving the affected country without sufficient support. To address this, the design would need to incorporate mechanisms to ensure that significant losses in smaller countries still activate the pool, such as proportional thresholds or weighted criteria that account for the relative size and risk exposure of each country.

Table 3
Model parameters for the pool

Parameter	Value	Commentary
Attachment point	50-year return period of economic losses per country	Usually based on the insurer's probable maximum loss or return period loss. Here the attachment point is set to a 50-year return period loss per country to ensure that the pool is triggered sufficiently regularly. A 50-year return period loss attachment point is above classic reinsurance which starts at around a 10-year return period loss. Considering a Cat XL with the above-mentioned attachment point, losses above 50 years go in the pool.
Limit	1,000-year return period loss of economic losses per country	Setting an appropriate limit for a natural catastrophe insurance pool depends on several factors, including regulatory expectations, risk appetite, and the pool's financial structure. A 500 to 1,000-year return period loss can be used for extreme tail risk protection, especially in public–private catastrophe pools or catastrophe bonds. A 1,000-year return period loss as used for illustration in this study can be considered as a robust, conservative benchmark for ensuring resilience against rare but devastating events.[19]
Quota share	50%	QS provide predictable loss sharing, which helps smooth out earnings volatility. A 50% quota share would ensure that both reinsurance and the pool are equally exposed to the risk. This also follows practices proposed in an extended role for SACE, a state-owned insurer in Italy.[20]

Notes: All parameters presented in this study are for illustrative purposes. They can be adjusted to fit alternative pool proposals, if required.

As outlined in the EIOPA/ECB 2024 paper, the private sector – through individual insurers, complemented by reinsurers, national schemes, or the proposed European pool – should serve as the primary line of defence against economic losses. The model calculations for both structures (one relying only on a Cat XL arrangement and the other on a combination of Cat XL and quota sharing) were based on the objective of limiting the total protection gap to a maximum of 10% of economic losses (the gold regions of Figure 7, "remaining protection gap < 10%"). Today, a portion is already covered by the private insurance sector or national schemes (the blue regions in Figure 7).

The introduction of a European pool (the "pool payout" – yellow regions of Figure 7) could help insurers or national schemes extend their coverage of the currently uninsured part by pooling and diversifying risks across the private sector.[21] Importantly, the remaining risks not covered by the Cat XL pool ("net of Cat XL", the pink regions of Figure 7) could be considered as additional business opportunities for the individually-covered private (re)insurance sector or considered for building schemes at the national level to cover. Through this risk-sharing pool, insurers can expand their capacity to underwrite risks, thus strengthening the private sector's contribution to closing the protection gap. The approach ensures the enhanced capacity and improved resilience it brings does not ultimately increase the burden of the taxpayer.

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[19] The 1,000-year return period loss limit is informed by the 2011 Christchurch earthquake experience. The Reserve Bank of New Zealand requires exposed insurers to have capital to withstand a 1-in-1000 year event (see Cole R., 2021). Setting a limit for an insurance pool carries several advantages. By capping the amount that the pool will cover, exposure to large losses can be managed. This helps ensure that the pool remains solvent and can continue to cover claims over time. Limits help the pool to predict potential payouts and manage funds accordingly. Having predictable claims costs allows for more accurate pricing of premiums and financial planning.

[20] See Examining Developments in the Italian Nat Cat Insurance Scheme

[21] Or the public sector in case of existing public national schemes

The design of the European risk-sharing mechanism directly influences the size and function of the insurance pool.

- In Figure 7 (left chart), a Cat XL pooling structure is applied. This approach targets the uninsured portion of losses, helping reduce the protection gap to 10% across all countries.

- In Figure 7 (right chart), a 50% QS layer is added to the Cat XL. This adjustment reduces the pool's payout (this results in a smaller "pool payout" - yellow area) and expands the potential role of the individually covered private (re)insurance market (as shown by the enlarged pink region compared to the left chart) or also national schemes.

The inclusion of a QS layer allows for a greater contribution from the private market or national schemes, while also reducing volatility and increased stability. Such a risk-sharing approach helps ensure that all stakeholders share financial responsibility. This alignment of interests:

- encourages prudent risk-taking and effective risk mitigation by all parties;

- prevents moral hazard, where excessive risk-taking could occur if losses are fully covered by public funds; and

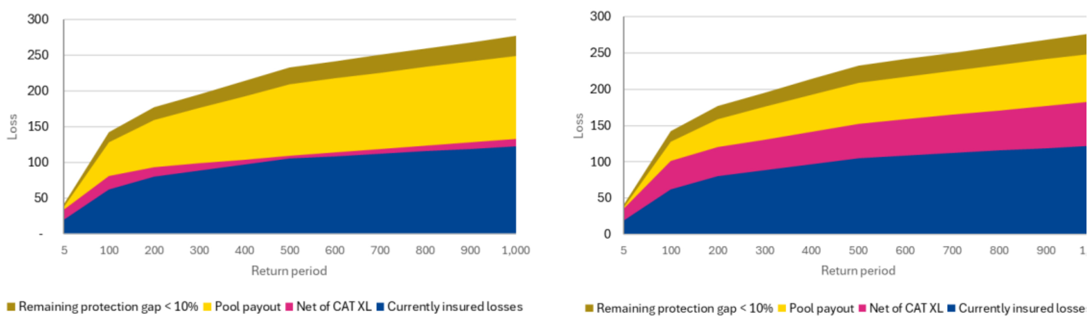
- preserves private sector involvement, ensuring that public support complements rather than replaces market-based solutions.

Therefore, the following analyses on the backstop will proceed under the assumption of a 50% quota share layer added to the Cat XL structure.

Figure 7

Reduction of protection gap using different combination of risk-sharing mechanisms

(Left panel: Cat XL only; right panel: hybrid Cat XL and 50% QS, both in € billion)



Notes: The blue area represents the currently insured losses, the gold area shows the remaining protection gap, the yellow area shows the pool payout, and the pink area shows the losses net of Cat XL (i.e. what would be left to the private insurance sector after application of the pool). The left-hand graph shows the risk-sharing mechanism using a Cat XL and in the graph on the right a 50% QS is combined with a Cat XL Note that pool payouts exist before a 50-year RP at European level as the attachment is defined at individual country level.
Source: Authors' calculations based on Moody's data

On average, the pool is expected to experience losses equal to approximately €3 billion for the Cat XL structure and roughly €1.5 billion for the Cat XL/QS structure. When all countries pool their risks together, leveraging geographical diversification, the 99.5% VaR of the pool is reduced by about 52%.[22] It would be important to adequately allocate costs and

[22] Compared to the simple sum of 99.5% VaRs of the countries which would result in lower capital needs for the pool.

diversification benefits to all pool members. Identifying the appropriate key for reattribution is crucial for a sustainable solution, applicable to both the pool and the backstop loan discussed in more detail in the following section.[23] A risk-based loss attribution accounts for an individual member's contribution to the risk and the diversification benefit that results from their inclusion. An individual member's exposure to the various perils/hazards is an important determinant of its share of the overall risk. Each pool member is responsible for its incremental contribution to the overall pool risk, accounting for the benefit of diversification it provides to the pool. The corresponding cost savings are, hence, a major factor in making this scheme more attractive than the status quo. While all members benefit overall from pooling, a larger diversification impact could also be attributed to those whose exposure differs most from that of others.

The insurance structure could be enhanced by insurance-linked securities, thus making the capital market part of the solution. The issuance of insurance-linked securities, such as catastrophe bonds, could help reduce the required pool size. Separate from the discussion in this paper, the pool could also act as a special purpose entity for the issuance of catastrophe bonds. The European insurance industry could enter a reinsurance contract with the pool. The pool would issue notes in the capital markets against regular coupon payments. This way, part of the expected losses can be transferred to the capital markets with corresponding impact on the losses to be distributed among pool members. At this stage, the insurance-linked securities market is still a niche market, and the broader scale potential in Europe needs further exploration (see Artemis report 2025).

Having established the pool size, we need a cost-efficient way to finance it. The pooling mechanism shows a way to optimise risk allocation in a European context for risks that are currently not insured. In a next section, we show how the additional capacity that could be generated through the pooling mechanism can be financed. To be viable, a solution that increases insurers' capacity needs to be financially attractive, i.e. profitable, while not causing additional burden to the taxpayer.

Role of the backstop

A loan-based backstop facility to the insurance pool to provide insurers with access to predictable and affordable capital can strengthen the risk sharing structure as a form of reinsurer of last resort. Such a public facility at the European level ideally has a very high credit rating and should be designed such that its own funding costs are not affected by the event it provides loans for to be able to provide alternative or additional funding for tail events. It should integrate seamlessly with existing risk-sharing mechanisms and align with the needs of key stakeholders. A high credit rating for the backstop facility and the remoteness of events intended to be covered ensures that low funding costs, after the inclusion of a small margin to largely operational expenses, can be passed on to pool members. For policymakers, it should greatly reduce reliance on ex-post government interventions, fostering a more sustainable approach to disaster risk management. For households and businesses, it aims to create a more stable and accessible insurance market, reducing the financial vulnerability of those most affected by natural catastrophes.

The loan design shares some similarities with the World Bank's development policy loan with a catastrophe deferred drawdown option. Both are loans designed to address losses

[23] The reattribution of diversification effects is not covered in this paper. Annex 3 provides a brief sketch showing how it could be approached.

resulting from severe events, even if the objectives differ. The backstop loan is intended to provide efficient funding with the aim to strengthen private sector capacity, whereas the World Bank's catastrophe loan is a bridge loan targeted at countries with immediate liquidity need in the aftermath of a disaster.[24]

The backstop arrangement allows for further cost efficiency gains. First, pooling risks ensures that diversification benefits can be reaped not only by combining different types of perils but also by leveraging geographical diversification across Europe. In a second step, financing the (peak) losses through a public loan can further reduce the cost for the individual pool member. This is particularly the case if a loan-based approach to financing the risk is more capital-efficient than insurers raising capital on the markets, meaning that the net present cost of the backstop is lower than the insurers' own cost of (mainly equity) capital. A backstop that is designed to cover losses and expenses but is not driven by profit considerations is likely to provide a more capital-efficient outcome (see Hahn and Mayr, 2024).

Combining pool and backstop in the risk-sharing mechanism

A backstop needs to be developed in tandem with a risk-sharing pool. A standalone pool would need to finance itself through capital market or reinsurance solutions. A loan-based backstop would offer an alternative mechanism for raising capital by providing loans to the insurance pool. The pool would serve as the counterparty for the loan payment, and the pool size provides an indication for the possible loan volume required from the backstop facility. The backstop facility's loan-based structure provides financial support during catastrophic events that surpass the capacity of existing risk-sharing layers. When a natural catastrophe exceeds the limits of reinsurance, the backstop provides a loan to the insurance pool. Participating insurers repay these loans over a medium-term horizon, allowing to spread out losses over time and facilitating repayment by the industry.

The way the pool is funded determines both the interaction between the pool and backstop and the frequency with which the backstop is called upon. In a premium-based approach, insurers would contribute a portion of their premia proportional to the expected losses of the underwritten risk they cede to the pool. This mechanism allows the pool to build up a reserve over time, atop an initial pool funding provided. The reserve ensures that the pool is equipped to cover losses up to its capacity, and the backstop would only be triggered in cases where the pool's funds are insufficient to cover the arising losses. An alternative approach, not shown in this paper, is to operate the pool without receiving any premium contributions. In this case, whenever a loss exceeding the attachment point occurs, the entire loss would be funded through a loan from the backstop. The pool, in this scenario, would only collect fees to cover its operational costs. Such a mechanism, however, would come at the risk of potentially insufficient provisioning by the pool members, who would eventually have to pay back the loan when it is triggered, even if the repayment schedule is stretched over a few years.

In either scenario, the terms of the loan provided by the backstop are predefined. The loan rate consists of three components: the risk-free rate, an upfront fee, and a small margin primarily intended to cover costs. The size of the backstop and likelihood of it being triggered is a function of the operation of the pool, the extent of pre-funding, and the level of a possible cap to the pool. The benefits to the individual pool members are largely defined by their cost

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[24] For reference, see IDA-CAT-DDO-Product-Note.pdf

of capital.

Simulation results indicate that the combination of a backstop and pool provides significantly higher capital relief compared to the current situation or a stand-alone pool. Based on the model described in Annex 2, we simulated the benefits of a pool combined with a backstop. For this exercise, we assume that the pool has a starting cash position of €10 billion, which may be provided by the backstop facility, for instance, in the form of a long-term interest-only loan.

The illustrative results are based on the assumptions described in the previous section on the potential size of a European pool and the following additional parameters:

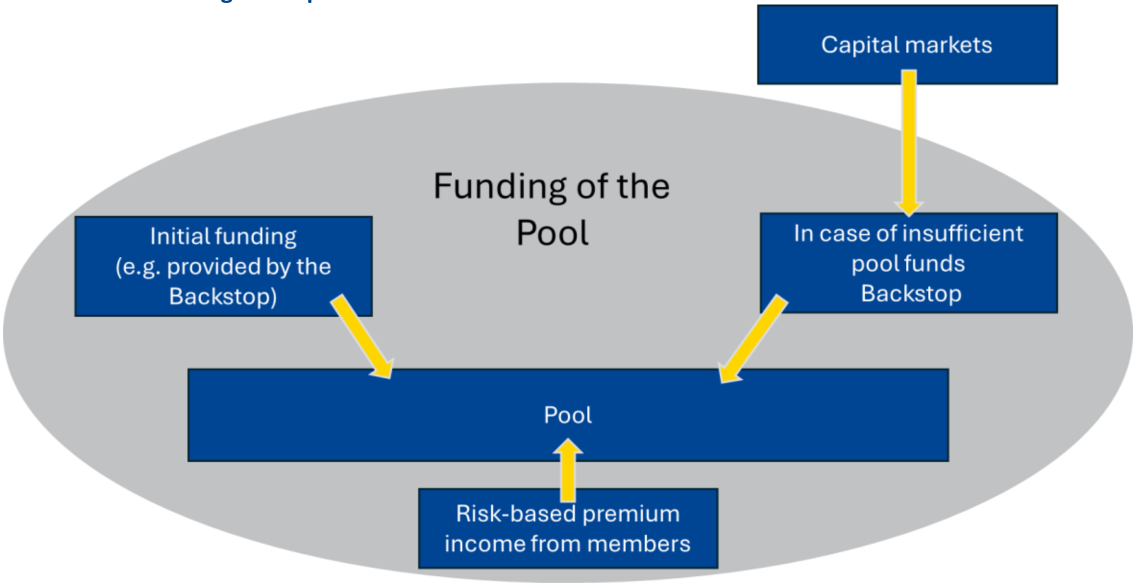
Table 4
Model parameters for the mechanism

Parameter	Value	Commentary
Pool's starting cash-position	€10 billion	A discretionary choice, the amount has been informed by the potential necessary payouts in the initial stages of the pool and the build-up of the pool over the years.
Natural catastrophe cost of capital	10%	The choice of cost of capital for natural catastrophe business has been informed, inter alia, by Swiss Re (2023) and Berry-Stölzle and Xu (2018) and takes account of the highly volatile business. It differs from the Solvency II cost of capital, which is an average over all business lines.
Pool's attachment point (return period)	50 years per country	See Table3
Limit (return period)	1,000 years per country	See Table3
Quota share	50%	See Table3

Notes: All parameters presented in this study are for illustrative purposes. They can be adjusted to fit alternative pool proposals, if required.

The analysis is divided into two components: the size of the backstop and its benefit to the members of the pool. The first part examines the required capacity of the backstop facility and the ability of the pool to build up a reserve. In contrast, the second part of the analysis adopts a different point of view by focusing on the individual members of the pool. It evaluates their expected benefits, including reduced cash flow volatility, enhanced financial predictability, and lower capital costs. Together, these components provide a comprehensive understanding of the mechanism's role in ensuring the resilience and effectiveness of the proposed risk-sharing framework, both from a collective and individual perspective.

Figure 8
Illustration of funding of the pool



Notes: The pool has three modelled sources of funding, the starting cash position of the pool, which could be provided by the backstop or another party, the risk based premia it collects from its members, and the backstop, which will provide a loan to the pool in case the funds of the pool are insufficient (see also Figure 1). The pool, the initial funding, and the backstop play an important role in the overall functioning of the system. In Figure 11 (12), 6.6 (8.1) percentage points of the overall effect can be attributed to the initial funding, and another 11.3 (3.5) percentage points can be attributed to the effect of providing the loan.

Size of the backstop

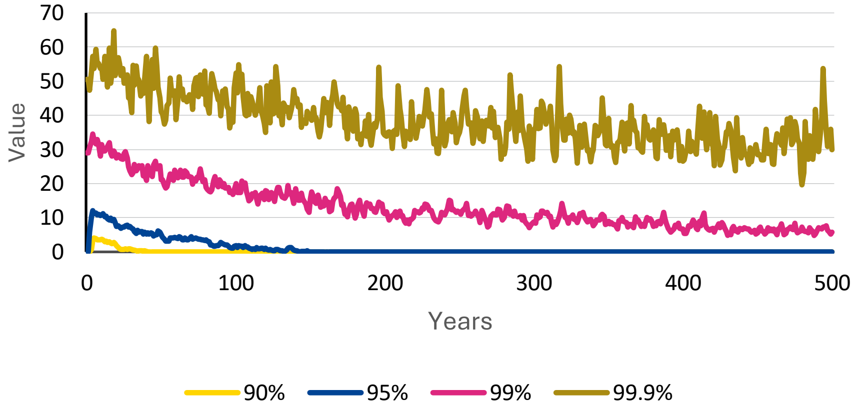
The required capacity of the backstop facility varies between €10 billion and €65 billion, depending on the risk covered by the backstop. Figure 9 shows the quantiles of the backstop's outstanding loans over time. It illustrates that the backstop has a maximum of €65 billion in outstanding loans when it covers very extreme scenarios, which have probability of 0.1%. For the losses of more frequent disasters (worst 5%), the maximum stays below €10 billion. These outstanding amounts are additional to the initial funding of the pool (€10 billion).

The higher the lending capacity of the backstop, the greater its ability to dampen volatility in losses and provide affordable liquidity during times of stress. This, in turn, can incentivise insurers to take on additional risks, thereby increasing overall risk coverage and thus reducing the protection gap. Ultimately, determining the size of the backstop is a policy choice, but it has significant implications for how and to what extent losses from catastrophic events are absorbed.

Figure 9

Simulation of outstanding loans of the backstop

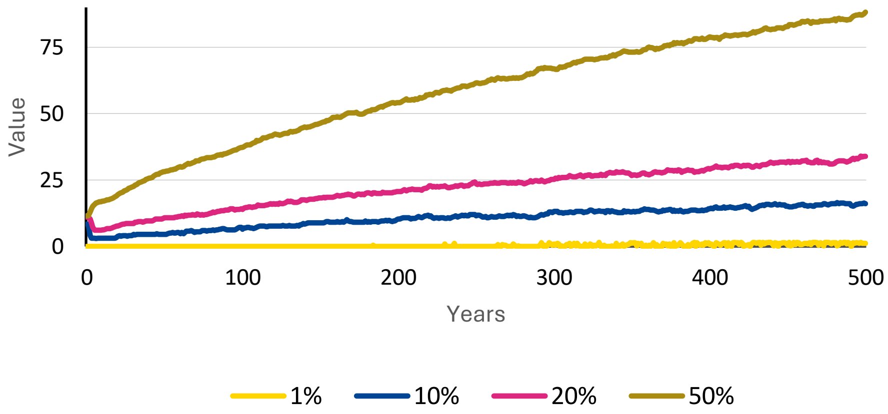
(in € billion)



Notes: The graph shows the outstanding loans of the backstop depending on the percentile applied. The amounts do not include the €10 billion initial funding of the pool.
Source: Authors' calculations based on Moody's data

The pool is likely to accumulate funds in most scenarios, thereby reducing the probability of the backstop being triggered over time (see Figure 10). The initial €10 billion funding for the pool ensures that it can build up funds in the early stages while also securing its ability to cover potential losses from catastrophic events in this ramp up phase. Depending on the severity and frequency of large disasters, the pool is expected to accumulate funds over time. Therefore, a threshold could be defined above which excess funds are redistributed back to the members of the pool. This threshold would then become the pool's steady state and could be set at the €65 billion level, which coincides with the current limit set for the backstop. The backstop remains a critical component of the proposed mechanism. Its continued importance lies in its ability to act as a stabilising force during extreme scenarios where the pool's resources may be insufficient to cover losses. By providing affordable and timely liquidity, the backstop ensures that the system remains operational and capable of fulfilling its risk-sharing role, even under severe stress conditions. This ongoing support not only enhances the resilience of the pool but also provides confidence to insurers, enabling them to maintain and potentially expand their risk coverage. Consequently, the backstop serves as a vital safeguard, ensuring the mechanism's long-term effectiveness in addressing the financial challenges posed by catastrophic events.

Figure 10
Simulation of cash position of the pool, including initial funding
(in € billion)



Notes: The graph shows the cash position of the pool based on different percentiles. The amounts include the €10 billion initial funding. The blue line indicates that in 90% of all cases the pool can build up reserves over time. Only in the worst 1% of all scenarios the pool does not manage to build up a reserve.
Source: Authors' calculations based on Moody's data

Benefit for the members of the pool

The pool/backstop combination can also decrease the volatility of cash flows for members of the pool (see Figure 11). The reduced volatility is driven by two key components: the pooling effect and the backstop's ability to provide loans when the pool lacks sufficient funds to cover losses.

- **The member-specific risk-sharing effect**: This effect comes into play when losses exceed the attachment point of the pool.[25] By sharing these losses among insurers, the individual volatility of cash flows is reduced, as the risk is distributed across a broader base. However, the effectiveness of this mechanism depends heavily on the pool's available funds. The pool can only absorb and mitigate losses if it has sufficient funds to do so. This means that the pool's ability to reduce volatility is influenced by two critical factors:
    - **Its initial funding**, which determines its capacity to cover losses and fulfil its risk-sharing role.[26]
    - **The diversification effect**, which reduces individual exposure by spreading risk across participants.
- **The backstop facility**: When the pool's funds are exhausted, the backstop is triggered. This ensures that a loan is provided to cover the shortfall, thereby maintaining the system's stability. While the loan must eventually be repaid, it is offered at very low funding costs, minimising the financial burden on participants. This means that even in severe scenarios, where the pool's capacity is exceeded, the backstop acts as a safety net. Further stability is achieved if the backstop facility's own funding costs are not affected by the natural catastrophe events, thus ensuring

[25] NB: The diversification impact is smaller than illustrated previously in the paper as this is the impact from the pool members' cashflow perspective who still need to pay all the losses, which are not captured by the pool (Cat XL and 50% QS).

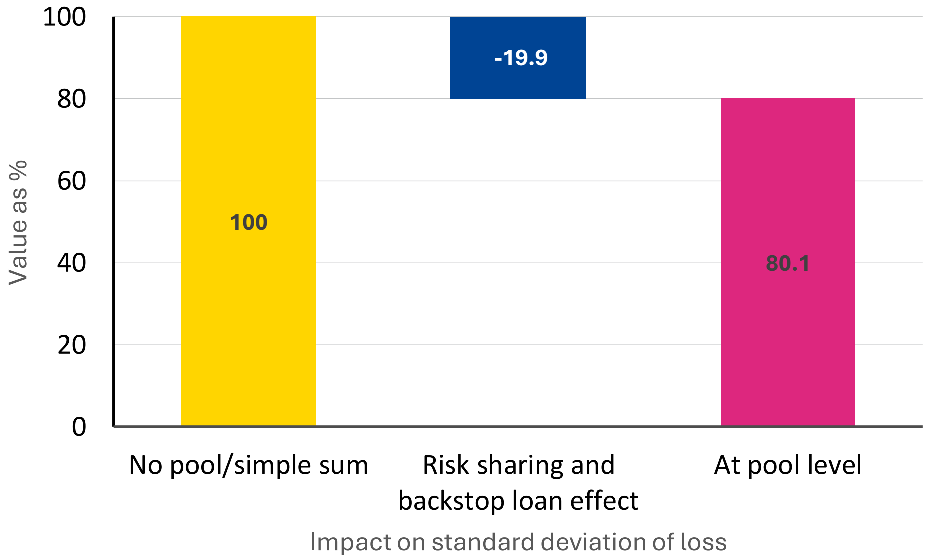
[26] As shown in Figure 11, the pool is (in most scenarios) able to build up a reserve. Therefore, the initial funding is mostly relevant in the starting phase of this risk-sharing mechanism to reduce volatility in results. To better illustrate the importance of the initial funding to dampen volatility in the early years the simulation has a time horizon of two years.

that the loan costs do not correlate with the occurrence of significant events.

The pool cum backstop is expected to work as a catalyst for enhanced natural catastrophe capacity. By improving cash flow predictability and reducing volatility, the proposed measure may increase insurers' willingness to underwrite significantly more, and at the same time more volatile business. This, in turn, contributes to narrowing the insurance protection gap.

Lowering volatility has important implications for both insurers and policyholders. For insurers, reduced cash flow volatility enhances financial predictability and improves the ability to manage capital and liquidity, ultimately strengthening their financial stability. This can also make insurers more willing to underwrite additional risks, contributing to a broader and more robust risk coverage. For policyholders, lower volatility can lead to more stable and affordable premia over time, as insurers are better able to manage their exposure to extreme events. This, in turn, helps to narrow the protection gap, ensuring that more individuals and businesses are protected against catastrophic losses.

Figure 11
Simulation of decrease in cash flow volatility
(as ratio of an unpooled scenario)

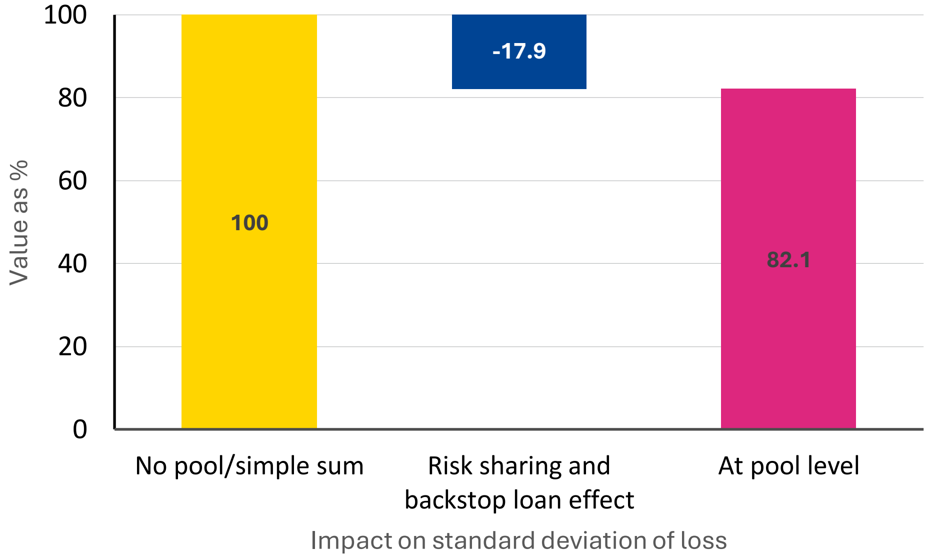


Notes: The chart shows the impact in the form of reduction in cash flow volatility following the introduction of an insurance pool cum backstop solution. The comparatively small impact of the backstop loan is due to the low frequency of being triggered. Effects are shown for the first two years.

Furthermore, the relatively low refinancing costs of the backstop will result in lower capital costs for pool members. Instead of raising funds on the capital markets, insurers can benefit from the backstop facility, which passes on its refinancing costs with a small markup, mainly covering the costs of servicing the loan and other operating expenses. Figure 12 illustrates this effect. On average, in years in which the backstop is triggered the net present costs are reduced by approximately 18%.[27] Lower capital costs enable insurers to offer more affordable premia to policyholders, thereby helping close the protection gap. Additionally, reduced capital costs free up financial resources for insurers, allowing them to expand their risk coverage and invest in other areas.

[27] If the net present costs are calculated across all scenarios (including those where the backstop is not triggered), the reduction would be around 10%. The lower impact reflects the backstop's design, which aims to trigger only under severe circumstances, ensuring it is not activated too frequently.

Figure 12
Simulation of decrease in net present costs
(as ratio of an unpooled scenario, only years when backstop is triggered)



Notes: The bar chart shows the decrease of net present costs for all scenarios for the years the backstop loan is active, assuming a 10% cost of capital and a risk-free rate of 2.5%. The impact on net present costs is calculated for all periods when the backstop loan is active.

Conclusion

A European natural catastrophe risk pool combined with a loan-based backstop would efficiently and significantly reduce the insurance protection gap while enhancing the private sector's capacity. We show the positive impact of pooling at the European level and offer examples of how a pool cum backstop can benefit insurers through reduced volatility and lower capital requirements.

This approach leverages the principle of risk diversification by pooling risks across countries and perils. It would allow insurers to achieve capital efficiencies, enabling them to underwrite more, and at the same time more volatile business and eventually reduce the financial burden on policyholders. Model simulations show that pooling risks across EU Member States and perils could reduce overall risk exposure by up to 67% compared to standalone national solutions.

Complementing the pool with a loan-based backstop provides a financial safety net for extreme tail events that exceed the pool's capacity. By offering predictable and affordable funding, the backstop reduces the reliance on ad hoc government interventions and stabilises reinsurance costs for insurers. In the context of this study, simulations indicate that the backstop's required capacity ranges from €10 billion to €65 billion. By providing cheaper funding, the backstop enables insurers to offer more affordable premia to policyholders, helping close the protection gap and increase insurance coverage for high-risk events. Additionally, competition among insurers is expected to drive premia down, ensuring that the benefits of reduced costs are passed on to policyholders, rather than simply increasing insurers' profit margins.

Given current climate change dynamics, the funding of the pool and the lending capacity of the backstop facility may have to grow over time. Climate-related events are increasing in frequency and severity, meaning that major catastrophes that are currently anticipated to occur once in a century may happen more frequently. Depending on the speed and severity of climate change, the backstop may require adjustments, particularly if the pool cannot accumulate sufficient reserves. While adaptation measures may mitigate the impact, sums insured could still increase (e.g. because more residential and commercial developments are being built in areas prone to natural disasters).

Reduced volatility contributes to more stability for insurers' underwriting policies. A European pool cum backstop increases stability of reinsurance costs for primary insurers. This solution is expected to reduce the swings from soft to hard market (and vice versa), thereby increasing planning certainty and, consequently, strengthening demand. This will also positively impact policyholders as competition and costs savings will eventually translate to lower premia. Nevertheless, the scheme discussed in this paper mainly takes a supply side perspective, making it even more crucial that the demand side is equally tackled. From the demand side, a European risk-sharing mechanism could, for example, increase consumer confidence. Households and corporates would be more likely to buy insurance if they trust that payouts will be made even after large-scale disasters. In addition, such a mechanism could signal stability and reliability, encouraging uptake. Insurance premiums are risk-based, hence mainly driven by expected losses. If risks are pooled, the probability of extreme losses for any single insurer decreases – translating into lower premiums, improving affordability for households and businesses. Finally, a European risk-sharing mechanism could also encourage market entry. Smaller or newer insurers may hesitate to enter markets with high climate or disaster risks. With risk sharing, barriers to entry fall, increasing competition and driving down prices.

This paper is a first attempt in quantifying the benefits of a European risk-sharing mechanism for natural catastrophe risks. The aim is to show the advantages of a European solution, which complements to the extent possible existing regimes and enables private sector involvement. Despite the clear objective of reducing the insurance protection gap, there are many design elements that need to be decided upon, each of which have their own merits but may lead to somewhat different results. This includes aspects such as the determination of the appropriate attachment point for the pool, the risk transfer method applied, the coverage limit, the trigger event (national versus European, single event or accumulated), the interaction with existing national solutions, etc. To keep the analysis traceable, the paper only shows a few possible avenues, even though alternative approaches have been assessed in the background. In the end, the objective of this paper is to highlight the implications of a European pool cum backstop but deliberately stops short of providing fully-fledged policy recommendations at this stage. The goal is to foster informed discussions without unnecessarily narrowing the available policy options.

Naturally, such a solution needs to be embedded in a broader regime, which this paper only touches upon, where directly relevant for the assessment. We have selected three aspects, which may deserve further, more in-depth elaboration in the future:

1. The integration of capital market solutions with the pool, like catastrophe bonds: Capital market solutions, albeit still comparatively underdeveloped in Europe, could play an important role in natural catastrophe risk transfer by tapping into the international capital markets. Catastrophe bonds, as well as other less common insurance-linked securities, may also serve as a useful means for a European risk pool to cede some of the risk assumed.

2. Reallocation of diversification effects and catastrophe losses to individual pool members: Eventually, risks and losses need to be downstreamed to individual pool members, so that it can inform their reserving and pricing policy. Annex 3 touches upon this subject, but further work is required to determine an incentive-compatible, sustainable allocation policy.

3. Adaptation policy and supply-side measures: As losses from natural catastrophe events grow, the importance of ensuring adequate adaptation measures rises. Such preventive measures are crucially needed to increase households’ and corporates’ resilience.

Finally, this discussion paper’s work highlighted the importance of good data quality. Given the rarity of extreme events, data are, by definition, scarce, making the collection and dissemination of granular data even more important.

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Annex 1 – Data and models used

Historical loss data

The historical losses are mainly based on the CATDAT dataset on economic losses and fatalities from weather- and climate-related events from RiskLayer GmbH.[28] These data have been made available by the European Environment Agency under institutional agreement and cover the years of 1980 to 2023.

Coverage of the historical loss data in the CATDAT dataset (Daniell et al., 2011 - Table 1): buildings destroyed; buildings damaged; infrastructure damaged; critical and large loss facilities; lifelines damaged; typologies affected; non-structural losses.

When needed for the analysis the data were used to fit a Weibull distribution (see also Prettenthaler et al, 2017). This distribution was then applied to estimate the economic losses, using standard risk measures, estimated at 0.5% annual probability of occurrence. The Weibull distribution is widely used in extreme value theory, particularly for modelling losses caused by natural catastrophes. An analysis using quantile-quantile plots and log-likelihood tests did not raise any concerns against modelling the data using a Weibull distribution. For the analysis, only countries with more than 10 data points were included. All perils occurring within a single year were aggregated into a single event. While modelling each peril individually would have been more accurate, this was not feasible due to the limited availability of data and historical events. A bootstrapping technique was applied to provide confidence intervals for the VaR and expected shortfall[29] estimates. Historical data have been normalised using the country's GDP.

It is important to highlight that confidence intervals are highly sensitive to input data, mainly driven by the scarcity of available data and high volatility therewithin. This sensitivity underscores the critical need for accurate, high-quality data to ensure the reliability of the estimates. Small imprecisions may lead to significant differences in expected losses, which can have a substantial impact on insurance premia. The use of standardised methods for data collection is equally important to enhance the comparability of data across different regions and time periods. Without standardisation, inconsistencies in data collection practices may introduce biases and further widen confidence intervals, undermining the robustness of the modelling process.

Moreover, reliance on different data sources for loss data can lead to varying results, as each dataset may have unique characteristics, methodologies, and levels of completeness. For example, one dataset might focus on losses in property while others also include infrastructure.

Additionally, given that the observed time horizon is relatively short compared to the quantile of the VaR (roughly speaking, 40 years compared to 200 years), it is highly likely that extreme events are underrepresented in the observed data. This underrepresentation may lead to an underestimation of potential economic losses, particularly in scenarios where losses have increased over time.

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[28] Risklayer GmbH - Global Catastrophe Risk Analytics Management

[29] Expected shortfall is calculated as the average risk beyond a certain confidence level (e.g. 99.5%). In contrast to VaR it is sensitive to the shape of the tail of the distribution.

Moody's RMS natural catastrophe models

Moody's RMS models[30] provide scientifically validated and comprehensive quantification of the relevant natural catastrophe perils throughout Europe. These models are designed to perform risk assessment and management. They provide users the ability to quantify the frequency, severity, drivers, and correlation of all key perils at local or aggregate levels. We utilised four suites of their pan-European high-definition (HD) models:

- Europe windstorm HD models: account for extra tropical cyclone and storm surge risk (on relevant countries).
- Europe Severe Convective Storm HD Model: accounts for hail, straight-line wind, and tornado risks.
- Europe Inland Flood HD Model: accounts for inland flood risk generated by both fluvial and pluvial sources.
- Europe Earthquake HD Model: accounts for shake, liquefaction, landslides, fire-following and tsunami (on relevant countries).

Table A.1.1
Countries and perils considered in the analysis

Number	Country	Earthquake	Flood	Windstorm	Severe convective storm
1	Belgium	✓	✓	✓	✓
2	France	✓	✓	✓	✓
3	Luxembourg	✓	✓	✓	✓
4	Ireland	✓	✓	✓	✓
5	Germany	✓	✓	✓	✓
6	Austria	✓	✓	✓	✓
7	Italy	✓	✓	x	✓
8	Netherlands	✓	x	✓	✓
9	Czech Republic	x	✓	✓	✓
10	Poland	x	✓	✓	✓
11	Slovakia	x	✓	✓	✓
12	Hungary	✓	✓	x	x
13	Denmark	x	x	✓	✓
14	Sweden	x	x	✓	✓
15	Finland	x	x	✓	x
16	Bulgaria	✓	x	x	x
17	Greece	✓	x	x	x
18	Portugal	✓	x	x	x
19	Romania	✓	x	x	x
20	Slovenia	✓	x	x	x
21	Spain	✓	x	x	x
	21 countries	15	11	13	13

Source: Moody's data

As input for the catastrophe models, Moody's RMS property economic and insurance industry exposure portfolios are used to estimate the economic and insured losses respectively. Both portfolios are specific to each country and peril combination. This paper considers residential, commercial, industrial, and motor lines of business. The analysis includes the following coverages: building, contents, and business interruption.

[30] Moody's Insurance Solutions – Catastrophe models and risks

Annex 2 – The size of the backstop

Determining the size of the backstop loan

To determine the size of the backstop, multi-year simulations for economic losses were used. The assumption is that the loss distribution does not change over time.

The initial parameters used are:

- $para_{gap}$ the ratio of economic losses to be covered before applying any limits (unless stated otherwise, this was set to 0.9 in the simulations)
- $para\_lim(i)$ is the quantile up to which for each country i the losses will be covered. (unless stated otherwise, this was set to 1 in the simulations)
- rp is the return period in years up to which the insurer covers all the losses on its own. Beyond this point, losses are shared between the pool and the insurer (unless stated otherwise, this was set to 50 in the simulations). This variable corresponds to the attachment point for the CAT XL.
- $ratio\_pool$ is the ratio of the losses above rp that are covered by the pool (unless stated otherwise, this was set to 0.5 in the simulations). This variable represents the quota share.
- rp_cap is the return period in years above which losses will neither be covered by the insurer nor the pool. (unless stated otherwise, this was set to 1,000 in the simulations)

The simulation was done using $n_{scen} = 5{,}000$ scenarios spanning over n years (unless stated otherwise this was set to 500). In each year k the following cash flows are considered. The premium income $p(k)$ and the cash-out flow $cash_{out}(k) = loss(k) + p_{above}(k)$, where $loss(k)$ is the loss payment to the policyholder. The premium income is split in the following way

$$p_{above} + p_{below} = E[\max\,(loss(k) - thres(rp); 0)] + E[\min\,(loss(k); thres(rp))]$$

where $thres(rp)$ is the $1 - 1/rp$ quantile of losses.

We assume that the insurer/country i can build up a reserve $r_i(k)$, if the $cash_{net}(k) = p(k) - cash_{out}(k) > 0$. At the start of each scenario the reserve is equal to 0, $r_i(0) = 0$.

If the premium plus the reserve is less than the payments to policyholder ($p(k) + r_i(k-1) < loss(k)$), then we assume that the insurer raises additional capital $debt_{new}(k)$, $debt_{new}(k) = loss(k) - [p(k) + r_i(k-1)]$. This additional capital $debt_{new}(k)$ can either be raised using capital market, for which we assume that the costs to do so are equal to the cost of capital, $coc(k)$, or by a loan from the backstop.

The efficiency of the various alternatives is measured by comparing net present cost $npc(a)$ for the capital needed. The discount rate is assumed the cost of capital $coc(a, s(j), k)$, which for simplicity reasons is assumed to be constant $coc(a, s(j), k)$=coc.

The pool functions the same way as the individual country. It can build up a reserve, which it can use for future losses. If the reserve of the fund plus its premium income is not sufficient to cover for the losses, the residual amount can either be raised on the capital markets or via the backstop.

Annex 3 – Allocation of diversification effects to pool members

In this paper, we identified the diversification effect pooling could achieve, notwithstanding the additional efficiency through joint operation, i.e. operational cost savings through economies of scale in managing several risks in a central manner (including reduced cost of information).

As a next step, one needs to define how to adequately allocate costs and diversification benefits to all pool members. Identifying the appropriate key for reattribution is crucial for a sustainable solution, applicable to both the pool and the backstop loan discussed in more detail in the following section.

A risk-based loss attribution accounts for the individual member's contribution to the risk and the diversification benefit that results from their inclusion. An individual member's exposure to the various perils/hazards is an important determinant of its share of the overall risk. The individual member, through its exposure contributes to both the overall risk of the pool and its diversification. Each pool member is ideally credited for its contribution to the risk reduction relative to a situation without its participation. Using catastrophe models, pooling risks across countries and perils reduces the combined pool's VaR by about 67% versus the sum of standalone VaRs. Individual members will also see capital relief, although the net reduction will be somewhat smaller once their premium contributions to the pool (or any backstop loan repayments) are considered.

Accounting for diversification of each member of the pool

Each pool member is responsible for its incremental contribution to the overall pool risk, accounting for the benefit of diversification it provides to the pool.[31] The corresponding cost savings are, hence, a major factor for making this scheme more attractive to the status quo. While all members benefit overall from pooling as described in Chapter 2, a larger diversification impact could also be attributed to those whose exposure differs most from that of others. To simplify the analysis, we focus on countries rather than individual members of the pool.[32] Adding countries to the pool leads to a total risk less than the simple sum. This diversification effect can be shared relative to each country's contribution.

There are several ways to allocate diversification effects to the respective pool members, each of them having their own benefits and drawbacks. In table A.1, we show an illustrative

[31] Technically, each member's contribution can be calculated as the difference between the pool risk with and without the respective pool member plus an apportionment that reflects the fact that both parts, the additional member as well as the existing pool contribute to the diversification effect. A simple subtraction would, however, allocate the entire benefit to the new member, thus overstating its contribution. The apportionment of the benefit could, for instance, be done on a pro rata or a proportional basis. A proportional risk attribution could hence be calculated as $RC_i = VaR_{inc,i} + {}^{1}/_{n}\left(VaR_p - \sum_{j=1}^{n} VaR_{inc,j}\right), i = 1, \ldots n$, whereby *RCi* is the risk capital attributed to the individual pool member, $VaR_{inc,i}$ is the incremental VaR and VaR_p the VaR of the whole pool. $VaR_{inc,i}$ is computed as the difference between VaR_p and $VaR_{p\setminus\{i\}}$ (VaR of the pool without member i.

[32] This would largely be aligned with a solo-level perspective, as cross-country business tends to be limited. It ignores, however, that individual members may have a regional focus and exposures can also vary considerably within a country.

example of a possible solution, using data from our previous analysis and applying a pro rata adjustment.

Table A.1

Attribution of diversification effect to individual pool members

(in € million)

Country included in pool	Stand-alone risk measure	Diversified pool	Incremental risk measure	Adjusted incremental risk measure
1	15,000		a = 12,000	$\boldsymbol{a} + \frac{(\boldsymbol{P}-\boldsymbol{X})}{4}$=13,750
2	30,000		b = 24,000	$\boldsymbol{b} + \frac{(\boldsymbol{P}-\boldsymbol{X})}{4}$=25,750
3	27,000		c = 22,000	$\boldsymbol{c} + \frac{(\boldsymbol{P}-\boldsymbol{X})}{4}$=23,750
4	29,000		d = 23,000	$\boldsymbol{d} + \frac{(\boldsymbol{P}-\boldsymbol{X})}{4}$=24,750
Total	**101,000**	**P = 88,000**	**X=81,000 < 88,000**	**88,000**

Notes: This illustrative example is based on dummy figures informed by real data, using a 99.5% VaR assumption. The incremental risk measure is the difference between the value with and without the additional country. For simplicity, we do not add countries sequentially but assume in each case a pool of X-1 countries adding one additional country. The sum of these incremental risk measures is smaller than the result for the diversified pool because all diversification effect is attributed to the added country. The difference between the pooling mechanism, hence, needs to be reallocated to each country in a following step. In this example, we do this on a pro rata basis, but one could also consider other forms of apportionment.

Sources: Authors' calculations based on European Environment Agency data

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