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ORIGINAL ARTICLE

Challenges of instruments that should tackle multi-hazard and multi-risk situations: an assessment of the recent reforms of the European Solidarity Fund and the Solidarity and Emergency Aid Reserve

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Abstract
The European Union has some dedicated tools and mechanisms available to respond to natural hazard events including the European Union Solidarity Fund (EUSF). It follows the objective of granting financial assistance to Member States in the event of a major disaster with serious consequences. In the latest EU long-term budget plan—the Multiannual Financial Framework 2021–2027—the EUSF was merged with the Emergency Aid Reserve (EAR) to form the new Solidarity and Emergency Aid Reserve (SEAR). One additional significant change was made in 2020 which saw an extension of the scope of the EUSF. This extension allowed the EUSF to cover losses incurred due to major public health emergencies such as the COVID-19 pandemic. It is therefore now a multi-hazard and multi-risk financing instrument designed to financially assist during the emergency phase in case of an emergency event. We assess the consequences of these changes in the light of potential advantages as well as disadvantages compared to the prior EUSF structure. The results will be used to provide some policy recommendations as to how to move forward with the identified challenges. We especially recommend separating the EUSF from the coverage of large-scale public health emergencies and the emergencies covered by the EAR. Instead, we suggest establishing a new flexibility instrument that covers emergencies such as public health related ones as well as the ones within the EAR. The analysis gives some important insights, scientific as well as policy wise, about advantages as well as limitations of financial instruments that simultaneously should tackle different types of hazards and risks.

Keywords European Union Solidarity Fund · Emergency Aid Reserve · Solidarity and Emergency Aid Reserve · Multi-annual Financial Program 2021–2027 · Multi-hazard and multi-risk tools

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1 Introduction

Globally, the number of disaster events as well as their associated losses have been increasing over time (Munich Re 2018) with most of them being climate-related (Wallemacq and House 2018). Europe is particularly exposed to natural hazards, with an average economic loss of around € 6.68 billion per year and nearly 50 million people affected between 1980 and 2020 (World Bank 2021). Disaster events can have profound impacts on both the public (e.g., infrastructure) and private sector (e.g., households, businesses) (Carrera et al. 2015) and especially on the most vulnerable (Wallemacq and House 2018). In addition, disaster events can also cause large opportunity costs by, for example, reducing planned spending for development projects or by weakening a country's fiscal position and debt situation (World Bank 2021).

Enhancing disaster resilience can support the mitigation of these short- and long-term disaster impacts. The current notion is that resilience should be understood as multidimensional, for example, encompassing physical, social, financial, human, and natural dimensions, which can be complementary to each other (World Bank 2021; Hochrainer-Stigler et al. 2021). There are a number of important global agreements, i.e., the Paris Agreement, the Sustainable Development Goals (SDGs) as well as the Sendai Framework for Disaster Risk Reduction 2015–2030, that provide frameworks and guidelines for promoting disaster resilience and mitigating the impacts of climate change. Aligned with these guidelines and recommendations, the EU has introduced policies and frameworks such as the new EU Climate Adaptation Strategy or the European Green Deal (see World Bank 2021). Resilience dimensions are also reflected in the past and current EU cohesion policy (currently € 392 billion for 2021–27), which follows the main goal of strengthening economic, social, and territorial cohesion in the European Union by reducing development disparities between regions (for a review over past and recent reforms we refer to Bachtler 2022). The COVID-19 pandemic has highlighted the need for more flexible policies and mechanisms, leading to the introduction of the € 750 billion NextGenerationEU program, with the Recovery and Resilience Facility as the main pillar (see Csak et al. 2022 for a discussion).

The EU has created dedicated tools and mechanisms to respond to natural hazard events during the emergency phase, such as the Union Civil Protection Mechanism (UCPM), the European Union Solidarity Fund (EUSF), and the Emergency Aid Reserve (EAR) (EC 2021). The UCPM provides a framework for cooperation among EU Member States and associated countries, facilitating the coordination of resources and assistance during emergencies. The EUSF, on the other hand, follows the specific objective of granting financial assistance to Member States in the event of a major disaster with serious consequences. This fund provides rapid, targeted, and efficient financial assistance, helping to ensure a quick response to natural disasters. The EAR, although not related to natural hazard events, was designed to finance humanitarian and civilian crisis management and protection operations in non-EU countries in order to quickly respond to unforeseen events. The EAR and the EUSF have no fixed allocation in the Multiannual Financial Framework (MFF) and belong to the so-called special instruments which should ensure the flexibility of the EU budget and allow the EU to mobilize the necessary funds to respond to unforeseen events. As these instruments can solicit additional financial support, they are over and above the expenditure ceilings of the long-term budget. Nevertheless, the amounts reserved for flexibility instruments cannot go above their own resource ceilings (EC 2022a).

The Multiannual Financial Framework (MFF) 2021–2027, the latest EU long-term budget plan, introduced significant changes to existing disaster response tools. One notable change was the merging of the EUSF and EAR to form the Solidarity and Emergency Aid Reserve (SEAR). Additionally, the EUSF was extended to cover losses incurred due to major public health emergencies, such as the COVID-19 pandemic, while it was exclusively reserved for responding to natural hazards beforehand (EC 2022a). This paper assesses the consequences of these changes to the tools' structure and is based on the discussion in Hochrainer-Stigler et al. (2022) which is extended here within the broader context of multi-hazard and multi-risk management. The results will be used to provide policy recommendations on how to move forward with the identified challenges. We specifically recommend separating the EUSF from the coverage of large-scale public health emergencies and the emergencies covered in EAR as these risks are different in nature and therefore require different approaches to assess corresponding risks compared to natural hazard-related ones. As compound risks become a major challenge globally (Zscheischler et al. 2018, 2020), there is a need for targeted efforts based on the underlying risk. Careful examination is needed if such multi-hazards and corresponding multi-risks should be tackled with the same instruments or not (Ward et al. 2022). Our analysis has important implications for implementing multi-hazard and multi-risk instruments, as it provides a real-world example on a continental scale. We recommend that policy processes and tools for multi-hazard and multi-risk management incorporate different methodologies for risk assessment and management, tailored to the specific nature of the risks. There is no one-size-fits-all solution for addressing these complex issues.

The paper is organized as follows: Section 2 will give a short overview of the previous EUSF and EAR and the changes recently made. Section 3 will present a detailed analysis and assessment of the EUSF in regard to past changes which forms the basis for a set of policy recommendations presented in Section 4. Finally, Section 5 ends with a conclusion and outlook to the future.

2 History of the EUSF and EAR

In this section, we will discuss the performance of the EUSF in the past and the changes that have been made to its structure, including the expansion of its coverage and its merging into SEAR. Several studies have looked at the EUSF's past performance in detail (see Hochrainer-Stigler et al. 2017; Bachtler et al. 2018) and in regard to policy-related topics, we especially refer to van Lierop (2021); therefore, we only provide a short overview here (which is based on Hochrainer-Stigler et al. 2022).

2.1 The European Solidarity Fund (EUSF)

The EUSF was created in 2002 after the Central European floods, which triggered an unprecedented political will to institutionalize financial compensation for disaster-stricken EU Member States. It is an ex-post loss-financing vehicle for Member States and candidate countries and has undergone several changes until now with the most important shortly discussed next (for a detailed analysis we refer to Bachtler et al. 2018).

2.1.1 Initialization period 2002 and time until 2014

Originally, the fund provided financial aid for emergency measures in the event of a disaster causing direct damages above € 3 billion (at 2002 prices) or 0.6% of gross national income (GNI) (Council regulation 2002, Article 2(2)). Furthermore, 25% of the fund had to be available for allocation during the last quarter of the year (Council regulation 2002: Article 4(2)). However, even if these thresholds were not met, the fund could be mobilized in certain circumstances, such as when neighboring states were affected by the same major disaster or in the case of extraordinary regional disasters that affected the majority of a region's population and had serious effects on economic stability and living conditions (Council regulation 2002).

During this period, the payments from the EUSF were limited to financing operations undertaken by public authorities to alleviate non-insurable damages, such as restoring infrastructure (Council regulation 2002: Article: 3). The European Commission decided on the amount of aid to be granted and proposed its mobilization. The maximum annual budget was € 1 billion per year, while the amount annually available for extraordinary regional disasters was limited to 7.5% of the EUSF's annual budget (Council regulation 2002: Article: 3). However, the amount actually spent varied from year to year depending on the occurrence of natural hazards. A country affected by a disaster received a lower rate of aid of 2.5% for the part of total direct damage below the "major disaster" threshold and a higher share of aid of 6% for the part of the damage exceeding the threshold (Commission Report 2004).

2.1.2 Reform of the fund in the period of 2014–2020

The need to revise the EUSF in time for the new financial period of 2014–2020 was already recognized some years prior (A7-0398/2012 (2012) report). One emerging problem for the EUSF was the increase in the number of applications and rejections (the following discussion is based on Hochrainer-Stigler et al. 2017, see also EC 2019), which was not solely due to an increase in disaster events but also the unclear rules for funding "extraordinary regional disasters". This ambiguous term and unclear rules for funding such disasters created biased expectations among Member States applying for aid and resulted in a relatively large number of rejected applications. This was the main motivation behind the reforms in 2014 and led the Commission to propose a more precise definition of a regional disaster: Those regional events, whose damages exceed 1.5% of regional GDP at the NUTS 2 level, are to be considered regional disasters. Furthermore, a threshold of damages equaling 1% of GDP was set for EU outermost regions (Regulation 2014). Another concern was the long delay in financial assistance. The revised regulation simplified the administrative process and allowed advanced payments of up to 10% of the expected aid. In addition, eligible states had more time (12 weeks after the disaster) to submit their applications and the commission was to have a period of 6 weeks to assess them.

In a separate process, and perhaps more importantly, the EUSF funding rules were changed in the EU budget (MFF 2014–2020). The annual amount available was reduced by half to a ceiling of € 500 million (2011 prices), with at least one-quarter of the annual amount to remain available on the 1st of October each year to cover any needs arising for the remainder of that year. Any unallocated funds could be used in the following year, but not thereafter. In exceptional cases, the new legislation also allowed the use of funds

allocated for the following year. A summary of changes can be found in Bachtler et al. (2018). No further changes were made after the 2014 reform up until the outbreak of the COVID-19 pandemic in 2020.

2.1.3 Special extension of EUSF since COVID-19

As a part of the EU coordinated package responding to the COVID-19 pandemic, the scope of the EU Solidarity Fund was extended by a modifying regulation which was adopted on 1 April 2020. The amendment included public health crises within the scope of the EUSF, allowing its mobilization for "a major public health emergency having taken place on the territory of the same eligible State." A "major public health emergency" is defined as "any life-threatening or otherwise serious hazard to health of biological origin in an eligible State seriously affecting human health and requiring decisive action to contain further spreading." The public financial burden must exceed € 1.5 billion or 0.3% of its GNI (Regulation 2020/461). Similar to the threshold approach for financing public spending for disasters, a threshold approach was adopted for major public health emergencies as well. Countries affected by a major public health emergency receive a lower rate of aid of 2.5% of the total amount of public spending below the € 1.5 billion threshold (or below 0.3% of its GNI) and a higher share of aid of 6% of the total amount of public spending above the same threshold. The actual costs and EUSF payments for all seventeen Member States and the three accession countries which received assistance from the EUSF for the pandemic cumulated to around € 530 million of assistance (EC 2022b).

2.2 The Emergency Aid Reserve

Before discussing the recent changes within the MFF 2021–2027, where the EUSF was merged with the Emergency Aid Reserve, it is important to understand this tool first. The Emergency Aid Reserve, similar to the EUSF, is a special instrument outside the multiannual financial framework, designed to provide necessary funds for responding to unforeseen events such as emergencies and crises. It facilitates a rapid response to specific aid requirements of third countries following unforeseen events and is primarily used for humanitarian operations, civil crisis management and protection, and dealing with migratory flows at the EU's external borders. The annual budget for the EAR was € 280 million (2011 prices) between 2014 and 2016 and could be utilized for up to $n+1$ year. Moreover, the amount from the previous year must be used first, and the annual amount from year n not used in year $n+1$ lapses. Table 1 provides further details on capitalization levels and annual usage for the 2014–2020 period.

To illustrate, in 2014, there was no carryover from the previous year, but € 98.1 million of the fund were used. This resulted in a carried-over amount of about € 198.9 million (i.e., € 297 million minus € 98.1 million) to the following year. As a result, more than € 501 million (i.e., € 198.9 million plus € 303 million, in current prices) were available in 2015. That year, € 282.5 million of the fund were used, and therefore € 219.4 million were carried over to the following year. Interestingly, as the carried-over amount was always smaller than the actual usage for the next year and as the carried-over amount has to be used first, no funds lapsed in the period between 2014 and 2020. In the new MFF 2021–2027, the EAR has been expanded to cover emergencies within EU Member States as well.

Table 1 Emergency Aid Reserve use and further information

Year	2014	2015	2016	2017	2018	2019	2020
Annual amounts (in 2011 prices)	280	280	280	300	300	300	300
Annual amounts in current prices	297	303	309	337.8	344.6	351.5	358.5
Carried over from the previous year	0	198.9	219.4	98.6	61.7	34.1	45.6
Annual usage	98.1	282.5	429.8	374.7	372.2	340	
Carried over to the following year	198.9	219.4	98.6	61.7	34.1	45.6	
Lapsed	0	0	0	0	0	0	0

Source: European Commission (2020)

2.3 Merging the EUSF and EAR: the MFF 2021–2027

The Multiannual Financial Framework (MFF) for the period 2021–2027 has an overall commitment ceiling of € 1074.3 billion (Csak et al. 2022). As already indicated, this period has seen the merging of the EUSF and EAR to create the Solidarity and Emergency Aid Reserve (SEAR). The new SEAR has a maximum annual budget of € 1.2 billion, of which a maximum of 50% may be mobilized to finance assistance for emergency situations resulting from major disasters covered by the EUSF (Council Regulation 2020). In cases where the remaining resources in the SEAR are not enough to cover the amounts required for EUSF assistance during a disaster year, the Commission may draw on the annual amounts available for the SEAR in the following year up to a maximum of € 400 million, but only under exceptional circumstances. More specifically, it is stated that the SEAR may be used to finance:

> (a) assistance to respond to emergency situations resulting from major disasters that are covered by the European Union Solidarity Fund, the objectives and scope of which are set out in Council Regulation (EC) No 2012/2002; and
> (b) rapid responses to specific emergency needs within the Union or in third countries following events which could not be foreseen when the budget was established, in particular for emergency responses and support operations following disasters not covered by point (a), man-made disasters, humanitarian crises in cases of large-scale public health, veterinary or phytosanitary threats, as well as in situations of particular pressure at the Union's external borders resulting from migratory flows, where circumstances so require (Council Regulation 2020).

It is important to note that under point (a), major public health emergencies that occur within the same eligible state as discussed in the previous section are also covered. As with the previous EUSF procedure, any unused portion of the annual amount can be carried over to the next year and must be used first. However, the new structure is complex and has created uncertainties, which will be explored further in Section 3. Furthermore, it was already pointed out by van Lierop (2021) that with regard to financial resources, the European Parliament voiced its concerns regarding the merger of the EUSF with the EAR, especially as the allocation of the EUSF remains uncertain since it depends on the amounts of allocation under the EAR (as discussed in detail in Section 3) and that the broadening of the EUSF's scope will require a larger budget. These and further related questions will be looked at in detail in the next section.

3 Assessment of recent reforms of the EUSF and SEAR

While various comprehensive assessments on the performance of the EUSF have been conducted in the past (Hochrainer-Stigler et al. 2017, Bachtler et al. 2018, EC 2019, World Bank 2021, EC 2021, van Lierop 2021), few assessments of the new SEAR have been done yet. We are especially interested in some specific challenges from a multi-hazard and multi-risk perspective, such as expanding the cover of the fund to include public health emergencies as well as the merging of the EUSF with the Emergency Aid Reserve and the related funding rules. The analysis is based on Hochrainer-Stigler et al. (2022) and expanded to include related multi-hazard and multi-risk challenges.

3.1 The EUSF and COVID-19

It is generally acknowledged (Bachtler et al. 2018) that the underlying reason for the establishment of the EUSF was to show practical solidarity in cases where Member States' own capacity to cope with a natural hazard event is exceeded (Commission Report 2004). One indicator for a country's capacity to cope with such events is its ability to finance emergency operations and to cover uninsurable losses (Hochrainer et al. 2010; Hochrainer-Stigler et al. 2017). The two different threshold levels for disaster losses (i.e., absolute losses or percentage of GNI) established in the past for the EUSF implicitly assume a solidarity aspect related to the ability of a country to cope with a disaster. Now, due to the COVID-19 pandemic, many governments have implemented massive fiscal stimulus packages which have led to weak fiscal positions and mounting debt. As a consequence, also the ability to cope with natural hazard events has decreased and the risk of experiencing serious fiscal stress has risen significantly.

As a case in point, Hochrainer-Stigler (2021) calculated fiscal resources and the risk of not being able to cope with disaster events for all European countries under a pre-COVID and a COVID-19 scenario. The study used probabilistic methods to model all-hazard loss distributions and combined them with available fiscal resources, including options such as budget diversion and loans, to assess the stress levels a government may experience. One major outcome of this analysis was that EU member countries are much more susceptible to fiscal risks due to hazard events compared to the pre-COVID period. For our EUSF analysis, this indicates that the need for assistance during a disaster event from the EUSF is much higher now than before, due to the decrease in coping capacity as a result of the pandemic. However, the COVID-19 pandemic has considerably depleted the EUSF, with around € 530 million being used to assist with the pandemic alone, leading to a decrease in funding availability.

From a multi-hazard and multi-risk perspective, the study indicates that the pandemic and natural hazards are dependent on the same fiscal resources of the country, thereby increasing the importance of the EUSF in such situations where the coping capacity of a country is low. However, as both the pandemic and hazard events will be financed from the same fund, these risks are dependent in terms of decreasing the availability of funding. It can be concluded that the assistance to disaster events and large-scale public health emergencies from the same fund is diametral to the concept of solidarity as both are intrinsically related and include negative feedback loops. If a public health emergency occurs, it drains resources from the EUSF while, at the same time, the need for assistance from the EUSF increases in countries in the event of a disaster. Simultaneously, the risk increases that the

EUSF is not able to provide the assistance to do so due to limited funding availability (and vice versa). We provide ways forward in meeting this challenge in the discussion section.

3.2 Actual and counterfactual past performance of the EUSF and Storylines

To provide a comprehensive evaluation of the European Union Solidarity Fund (EUSF) performance, we begin by presenting detailed budget allocation information for the 2014–2020 period in Table 2. Although the EUSF was not fully depleted in the past, it did experience significant stress, particularly in 2017 following the earthquake in Italy. However, relying solely on past performance and capitalization levels is insufficient to gauge the adequacy of the fund's current funding levels.

Table 2 shows that in 2014, the EUSF budget amounted to € 530.6 million, of which € 126.7 million were spent, leaving around € 403.9 million carried over to 2015. The total capitalization for 2015 was approximately € 945.1 million (€ 403.9 million plus € 541.2 million), of which € 82 million were used from the carried-over amount, and the remaining € 321.1 million (€ 403.9 million minus € 82 million) lapsed and were not carried over to the subsequent year. In 2016, the full 2015 allocation of € 541.2 million was carried over, and when combined with the 2016 allocation of €552 million, resulted in an overall 2016 budget of €1,093.2 million. Only €33.1 million was used, which was taken from the carried-over amount. The rest, €508 million, lapsed and was not carried over to 2017. As a result, approximately € 552 million was carried over to 2017, added to the annual allocation of € 563.1 million, which brought the total budget to € 1115.1 million. However, the total use of the fund in 2017 was € 1268.2 million, requiring a front-loaded payment of € 294 million from the 2018 budget. Ultimately, € 153.1 million was used, and € 140.9 million was transferred back to 2018. In 2018, the total available budget was € 421.2 million (€ 574.3 million annual allocation minus the front-loaded € 153.1 million), of which € 155.9 million was used, leaving € 265.3 million carried over to 2019.

We highlight two aspects emerging from the data: firstly, despite historically sufficient funding levels, the EUSF experienced severe stress in 2017 due to the earthquake in central Italy (van Lierop 2021), requiring upfront usage of part of the following year's budget to cover the necessary pay-outs. Following the event, the required pay-outs were higher than two full annual budgetary allocations. Coverage could only be provided thanks to unspent funding from the previous year and upfront usage of part of the following year's budget. Upfront usage of capital was only possible due to the 2014 EUSF reform, which was therefore crucial for the fund's capacity to cope with the 2017

Table 2 EUSF payments between 2014 and 2020

Year	2014	2015	2016	2017	2018	2019	2020	Total
Annual amounts in 2011 prices	500	500	500	500	500	500	500	3500
Annual amounts in current prices	530.6	541.2	552	563.1	574.3	585.8	597.5	3944.7
Carried-over from previous year	0	403.9	541.2	552	140.9	265.3	553	
Frontloaded from the following year	0	0	0	294	-294	0	0	
Annual usage	126.7	82.8	33.1	1268.3	155.9	298.1		1964.9
Carried-over to the following year	403.9	541.2	552	140.8	265.3	553		
Lapsed	0	321.1	508.1	0	0	0		829.2

Source: European Commission (2020)

pay-outs. Second, pay-outs were mainly allocated to mainland Europe, while only small payments were made to the outermost regions. In contrast to mainland Europe, the outermost regions are quite exposed to cyclone risk and, thus, potentially high losses.

In that regard, Ciullo et al. (2021) developed climate impact storylines (Van den Hurk et al. 2023) based on downward counterfactuals which allow constructing and analyzing plausible realizations of the past which are used as an input for the 2017–2018 EUSF capitalization levels within mainland Europe. In more detail, they constructed counterfactuals (what-if-scenarios) by considering tropical cyclones Ophelia and Enawo in 2017 and Berguitta in 2018. The historic realizations of these cyclones had no impact on the outermost regions but, counterfactually, they could have resulted in significant damages and impacts for La Réunion (Enawo in 2017 and Berguitta in 2018) and the Azores Islands (Ophelia in 2017). The fact that they took a different, less damaging path was purely coincidental. Using these plausible past events, in the sense that they could have happened (but did not) and corresponding losses, the pay-outs and resulting capital losses for the EUSF relative to such counterfactual events can be calculated and compared with historic data.

Figure 1 shows capital simulations using pay-outs from historic and downward counterfactual tropical cyclones. Results show that capital losses could have been much higher in 2017 and that these could have prevented recovery in 2018 (see the red line in Fig. 1), potentially requiring further exceptional budget anticipation from the year 2019. We, therefore, conclude that the past performance of the EUSF is not indicative of adequate capitalization levels as the EUSF would have been under severe stress and potential default under alternative plausible past occurrences in the outermost regions. We also want to note that the analyzed hazards are very different compared to those in mainland Europe. More importantly, this also indicates that forward looking multi-hazard and multi-risk based assessments for the fund need to be developed to ensure the robustness of the fund over time. As will be discussed further below, it becomes evident that the diverse range of risks that the fund currently covers requires the application of various methodologies. However, prior to exploring these methodologies, one must first investigate multi-risks and their possible interactions between the EUSF and the Emergency Aid Reserve, both of which have now been integrated into the SEAR.

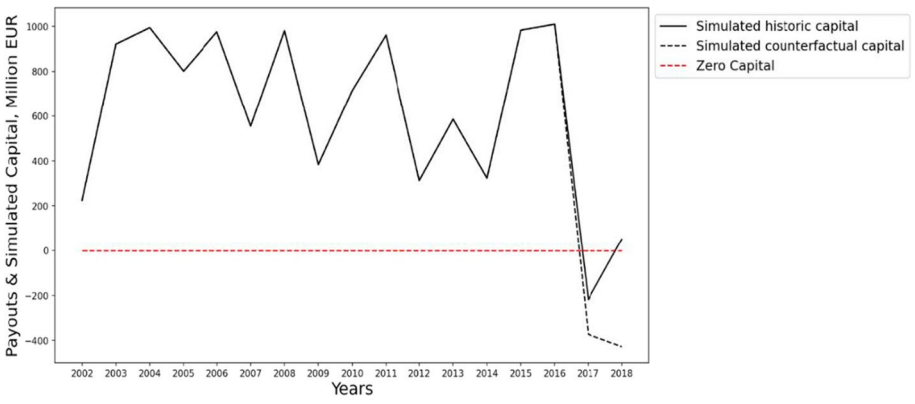

Fig. 1 Simulation of capital using historical (solid black line) and downward counterfactuals pay-outs (dotted black line). The dotted red line indicates zero capital levels. Source: Adapted from Ciullo et al. (2021)

3.3 Capitalization levels and risk of SEAR

It has already been indicated that to understand the capitalization level of SEAR and corresponding pay-outs and limits, a more detailed discussion is needed. It should be noted that, similar to the EUSF, the SEAR budget relies not only on the disasters of the current year, but also those of the previous year. In fact, if there are no pay-outs in a given year, the full unused budget can be carried over to the following year, up to a limit of € 1.2 billion (in 2018 prices). In other words, in a year without pay-outs, the total annual amount available in the following year is € 2.4 billion. However, if SEAR experiences a shortage of funds for the EUSF, it can overspend next year's appropriations by up to € 0.4 billion. These rules are similar to previous ones, but with different total amounts of funding availability.

For a given year, a quarter of the annual budget is frozen and only becomes available from October 1st. This is to guarantee that the applications being filed later in the year also have access to some funds. As a result, only 75% of the budget is usable in the first three quarters of each year. Additionally, to ensure that both the EUSF and EAR have enough capital within a year, 50% of the available 75% of the annual budget is reserved for EUSF coverage, while the other half is reserved for EAR-related obligations, until September 1st. Importantly, any amount taken as overdraft in the previous year is subtracted from the EUSF amount of the current year. After September of each year, the budget division is no longer valid, and any remaining amount can be used by both channels.

Summarizing, there are essentially three key periods of the annual budget: Period 1 covers the time between January 1st and September 1st ; Period 2 covers the month of September; and Period 3 covers the time from October 1st to the end of the year. Figure 2 shows the general case that illustrates this complex budget allocation mechanism: At the start of the year, 75% of the annual budget is available for use, as 25% is reserved for the last quarter. Until September, half of the available funds are split between the EUSF and EAR. When funding is needed for disasters, a portion of the budget is allocated accordingly. Any unused funds roll over to the next period, which starts in September, and can be used for either EUSF or EAR. Once October arrives, the full annual budget is available, as the previously reserved 25% becomes usable. At the end of the year, any unused budget rolls over

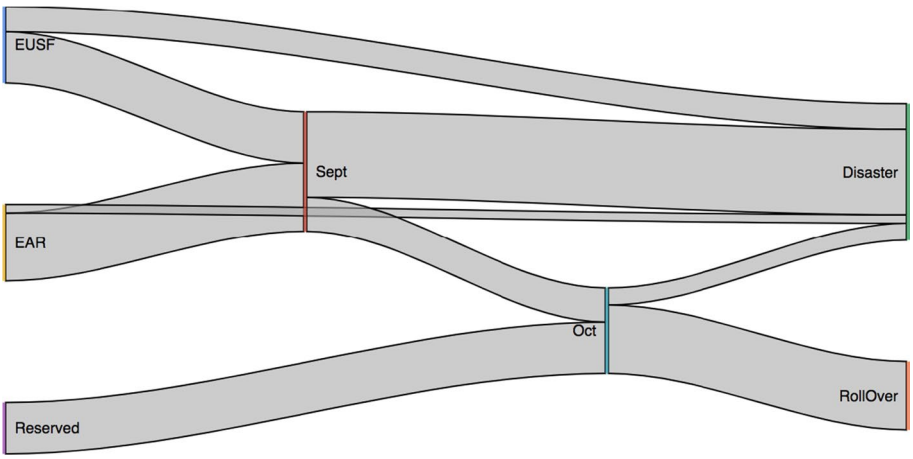

Fig. 2 SEAR budget allocation illustration. Hochrainer-Stigler et al. 2022

to the following year, up to a limit of € 1.2 billion. The budget for the next year takes into account the roll over and overdraft from the previous year.

This funding scheme has implications for different types of risks, which will be demonstrated using three distinct scenarios that should represent best and worst-case scenarios (in terms of available capital). In the first (standard) scenario, in year n without any roll-over or overdraft from the previous n-1 or the subsequent year n + 1, the EUSF and EAR each have €0.45 billion until September. From September onwards, the additional funds available for the EUSF could range from € 0 (EAR uses up the budget) to € 0.75 billion (EAR uses no fund). Furthermore, the SEAR can access up to €0.4 billion to cover EUSF-related shortages. In the second (worst-case) scenario with the assumption of a €0.4 billion overdraft from year n-1 and no unused budget rolling over, only €0.05 billion are reserved for the EUSF before September in year n, unless it further overdraws from the following year n + 1. In a third, more complicated scenario, an overdraft occurs in year n-1 in the first period due to one large disaster but no more events happened during this year. Although there was an overdraft in year n-1, € 0.75 billion could still roll over to year n. The total budget in year n would therefore be € 1.55 billion (€ 1.2 + 0.75 − 0.4 billion). However, according to the allocation rules for EUSF coverage before September in year n, only € 0.18 billion are reserved for the EUSF (€ 1.55 * 75% * 50% − 0.4 billion).

While the current payment scheme for multi-risks can result in underfunding for the EUSF, this can be easily fixed by offsetting the overdraft from year n-1 with the annual surplus of that year. However, this does not address uncertainties regarding pay-outs for the EAR and the allocation of the EUSF over time, which depends on EAR allocation amounts.

4 Discussion and policy recommendations

The SEAR is essentially a multi-hazard and multi-risk instrument designed to financially assist during the emergency phase in case of an event. Such events can be natural hazard or health related through the EUSF or related to specific emergency needs within the European Union or in third countries through the EAR. All of these events which are eligible for funding would draw from the same annual amount provided by SEAR. We identified several challenges of this fund, most prominently in regard to dependencies between different kind of risks, including diametral effects of funding needs and funding levels, the increase in uncertainties of inter-annual payments due to the compensation scheme, as well as the quantification of capitalization levels needed so that the SEAR is robust in the long run (e.g. will not get fully depleted). These challenges and the following possible policy recommendations discussed are not only related to the specific instrument analyzed here but have wider applications as well.

The first multi-risk dependency we discussed was in regard to solidarity aspects for natural disasters and public health emergencies. We argued that the assistance to disaster events and large-scale public health emergencies from the same fund is diametral to the concept of solidarity as both are intrinsically related through at least two channels. Firstly, if a public health emergency occurs, it drains resources from the government and increases the need for assistance from the EUSF in case of a disaster. Secondly, the public health emergency will draw large resources from the EUSF and at the same time increase the risk that the EUSF is unable to provide assistance in case of a natural disaster event. More generally speaking, combining dependent risks usually increases the capitalization

requirements for financing them compared to the independent case (Pflug and Romisch 2007). This holds true for the two channels mentioned above as well, i.e. related country and EUSF resources. In case that such different kinds of risks are combined within one funding instrument, either the dependency between the risks must be quantified to a satisfactory level or funding instruments have to be constructed individually for each kind of risk. Regarding the latter, one straightforward possibility is to create a new flexibility instrument dedicated to public health risk, however, it could also be embedded within other programs such as those related to public health and emergencies under the European Agency for Reconstruction or the Recover and Resilience Facility of the NextGenerationEu programme. The important point to make here is that such a separation eliminates the aforementioned dependencies and, therefore, joint risks (Hochrainer-Stigler 2020).

The fact that the EUSF has never been depleted in the past has up to now been used as an argument that its funding levels are adequate. In our analysis we provided an example based on a counterfactual approach for cyclone risks in the outermost regions showing that this was only due to sheer luck. Consequently, we identified the challenge to determine the necessary capitalization levels for the multi-risk fund, for which it is essential to provide quantitative estimates of potential pay-outs from the fund. This requires a full probabilistic assessment of all possible events and corresponding losses, which leads to a loss distribution that relates losses with probabilities of events (Mitchell-Wallace et al. 2017). Such information can be used to calculate expected pay-outs and determine the necessary capitalization levels. While corresponding models and techniques for natural disasters are well-advanced and ready to be used for a full multi-hazard assessment of the EUSF as well (see Hochrainer-Stigler et al. 2017 for the case of a total risk assessment approach), providing a detailed probabilistic assessment for public health emergencies and other similar events is challenging.

One of the reasons for this difficulty is the inherent randomness of natural hazard events that still can be quantified in a satisfactory manner using catastrophe modelling and extreme value statistics (Grossi 2005; Hochrainer-Stigler 2020). Such techniques used for the quantification of disaster risk cannot be applied to policy related decisions on funding eligibility as they do not exhibit such kind of inherent randomness. As in the case of SEAR, funding from the EAR is dependent on the European Commission's decision leading to an ambiguous decision process in regard to how much funding is given for what event. To avoid such ambiguity, standards similar to those of the EUSF should be introduced when providing support from the EAR.

Public health emergencies exhibit some kind of inherent randomness similar to disaster risk but the underlying event is fundamentally different (e.g. geophysical or atmospheric processes vs. transmissibility and virulence). However, it should be noted that there are current efforts to also provide a full probabilistic assessment for public health related risk (Madhav et al. 2021). Still, we argue that the EUSF should be separated from covering large-scale public health emergencies and those covered in the EAR, as multi-hazard and multi-risk situations should only be dealt with using the same instrument if the underlying nature of risk is of the same kind and quantification of risk is possible. However, it is crucial to deal with multi-risks within a coherent integrated framework, although not using the same instrument and approaches.

The storyline approach presented above, for example, could be used to analyze different funding sequences according to the past performance of the fund and expanded to include selected public health emergencies as well as emergencies eligible for funding (e.g. due to migration) from past events, essentially providing a counterfactual analysis (e.g. what-if-scenarios) and therefore circumvent a probabilistic assessment (see Shepherd et al. 2018). This dual approach can inform decisions about capitalization levels, providing a more nuanced and robust assessment. In addition, storyline approaches, such as the one

introduced above, are also one possible way to circumvent the need to provide a full but overwhelmingly complex picture of the situation and rather rely on counterfactuals which are much easier to grasp by respective decision makers (Sillmann et al. 2021).

In regards to the payment rules within a multi-risk setting such as SEAR (e.g. funding amounts are dependent on funding rules for both EUSF and EAR), there is uncertainty about how the annual budget will actually evolve. This is especially true for the part of the fund that is reserved exclusively for EUSF coverage before September 1st. While it is, in principle, good to show some flexibility in funding multi-hazard and multi-risk situations from the same budget, at the same time it can increase uncertainty of possible shortfalls during a given year and can decrease trust in these instruments if they fail when needed the most. The EUSF has been successful in the past, but this expansion to include health emergencies must be carefully managed to maintain trust in the system.

Finally, various suggestions are made in the aforementioned performance reports on how the EUSF could be linked to other instruments, especially risk reduction related ones. However, such strategies must acknowledge that there is unlikely to be a one-size-fits-all approach from the European to the individual Member State-level. This is because each EU country has its own 'history' of dealing with risk, which is difficult to change and align with a general structure. At the EU level, providing instruments that require Member Countries to take a pro-active approach for activating assistance is one possibility to address this reality (such as the EUSF part in SEAR) and to streamline some disaster and risk reduction related policy process across countries.

5 Conclusion

Europe has suffered major human and economic losses due to natural disasters and pandemics in the past. To cope with these challenges, the EU has established instruments and mechanisms that provide material and financial assistance when a disaster hits. The main instruments examined in this study are related to the emergency phase after an event including the European Union Solidarity Fund and its extension to cover public health emergencies as well as the Emergency Aid Reserve. These instruments have proven successful in the past in assisting EU Member States and a number of non-EU countries which were affected by disasters such as earthquakes, storms and floods. The EUSF is especially important for showing practical solidarity and has mobilized more than € 6.5 billion for interventions in 96 cases of disaster events between 2002 and 2020 (EC 2022c). When COVID-19 arrived in Europe, the EUSF additionally provided over € 500 million in emergency financial assistance (EC 2022b).

In the latest MFF 2021–2027, the EUSF and the EAR were merged to form the SEAR, a multi-hazard and multi-risk instrument designed to provide financial assistance during the emergency phase in case of events related to natural hazards, public health, or other kinds of emergencies. We analyzed the challenges as well as ways forward for such a multi-risk funding instrument and focused on dependency issues. We indicated that the assistance for disaster events and large-scale public health emergencies from the same fund is diametral to the concept of solidarity as both are intrinsically related. Therefore, we suggested to either separate the fund or to quantify related dependencies.

To indicate the risk of depletion of the fund, we adopted a storyline approach that demonstrated past instances where the EUSF would have been depleted based on plausible

events. While probabilistic approaches and advanced techniques exist for natural disasters to estimate average payments from the fund, such methods may not be applicable for policy-related decision-making processes, and currently not for health risks (with some exceptions). We concluded that multi-hazard and multi-risk situations should be only dealt with using the same instrument if the underlying nature of risk is of the same kind and quantification of risk is possible to the necessary detail. However, we also emphasized the importance of dealing with such multi-risks within a coherent integrated framework. To achieve this, we recommend using a toolbox approach and utilizing storylines instead of probabilistic assessments where necessary. This approach will enable appropriate integration of the various risks while maintaining the necessary level of detail for each specific type of risk.

Finally, due to the uncertainties of the inter-annual payment schemes for the EUSF and EAR we suggested that possible overdrafts are offset by the annual surplus of that year which could decrease uncertainties in capitalization levels needed across years considerably. The current structure of the SEAR, which includes several unpredictable and difficult to be quantified risks, requires continuous monitoring and updating of capitalization levels to detect emerging problems. Based on our analysis we more broadly recommend focussing on dependencies between hazards, types of risks and support schemes for multi-hazard and multi-risk instruments that can indicate ways forward how to solve related challenges.

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References

A7-0398/2012 (2012) Report on the European Union Solidarity Fund, implementation and application, 2012/2075(INI). European Parliament, Brussels. https://www.europarl.europa.eu/doceo/document/A-7-2012-0398_EN.pdf. Accessed 1 Aug 2023

Bachtler J (2022) Cohesion policy - where has it come from? Where is it going? European Court of Auditors 1, Luxembourg. https://www.eca.europa.eu/Lists/ECADocuments/JOURNAL22_01/JOURNAL22_01.pdf. Accessed 1 Aug 2023

Bachtler J, Begg I, Ferry M, Ogilvie J (2018) Ex-post evaluation of the EU Solidarity Fund 2002–2016. European Commission, Brussels. https://strathprints.strath.ac.uk/69924/1/Bachtler_etal_2019_Ex_post_evaluation_of_the_EU_solidarity_fund.pdf. Accessed 1 Aug 2023

Carrera L, Standardi G, Bosello F, Mysiak J (2015) Assessing direct and indirect economic impacts of a flood event through the integration of spatial and computable general equilibrium modelling. Environ Model Softw 63:109–122

Ciullo A, Martius O, Strobl E, Bresch DN (2021) A framework for building climate storylines based on downward counterfactuals: the case of the European Union Solidarity fund. Clim Risk Manage 33:100349. https://doi.org/10.1016/j.crm.2021.100349

Commission Report (2004) European Union Solidarity Fund annual report 2002–2203. COM (2004) 397 final, Brussels. https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2004:0397:FIN:EN:PDF. Accessed 1 Aug 2023

Council Regulation (2020) (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/PDF/?uri=CELEX:32020R2093&from=EN. Accessed 1 Aug 2023

Council Regulation (2002) No 2012/2002 of 11 November 2002 establishing the European Union Solidarity Fund. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32002R2012&from=EN. Accessed 1 Aug 2023

Csak Z, Luplow L, Pavel M (2022) Cohesion - what is it good for? European Court of Auditors 1, Luxembourg. https://www.eca.europa.eu/Lists/ECADocuments/JOURNAL22_01/JOURNAL22_01.pdf. Accessed 1 Aug 2023

EC (2019) Commission staff working document evaluation of the European Union Solidarity Fund 2002–2017, Brussels, 15.5.2019 SWD(2019) 186 final. https://ec.europa.eu/regional_policy/sources/evaluation/eusf_2002_2016/eusf_2002_2016_exec_en.pdf. Accessed 1 Aug 2023

EC (2020) Communication from the Commission to the Council and the European Parliament. Technical adjustment in respect of special instruments for 2020 (Article 6(1)(e) and (f) of Council Regulation No 1311/2013 laying down the multiannual financial framework for the years 2014–2020). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0066. Accessed 1 Aug 2023

EC (2021) Annual management and performance report for the EU Budget. Volume III Technical Annexes. European Commission, Directorate-General for Budget, Publications Office. https://op.europa.eu/en/publication-detail/-/publication/d0c162e2-ccba-11eb-ac72-01aa75ed71a1/language-en. Accessed 1 Aug 2023

EC (2022a) Flexibility and special instruments. European Commission, Brussels. https://ec.europa.eu/info/strategy/eu-budget/long-term-eu-budget/2021-2027/spending/flexibility-and-special-instruments_en. Accessed 1 Aug 2023

EC (2022b) Beneficiary States of the EU Solidarity Fund Interventions since 2020 - only major public health emergency. European Commission, Brussels. https://ec.europa.eu/regional_policy/funding/solidarity-fund_en. Accessed 1 Aug 2023

EC (2022c) Beneficiary states of the EU Solidarity Fund Interventions since 2002 - only disasters. https://cohesiondata.ec.europa.eu/stories/s/An-overview-of-the-EU-Solidarity-Fund-2002-2020/qpif-qzyn. Accessed 1 Aug 2023

Grossi P, Kunreuther, H (2005) Catastrophe modeling: a new approach to managing risk. Springer, Boston

Hochrainer S, Linnerooth-Bayer J, Mechler R (2010) The European Union Solidarity Fund. Mitig Adapt Strateg Glob Chang 15(7):797–810

Hochrainer-Stigler S (2020) Extreme and systemic risk analysis. Springer, Singapore

Hochrainer-Stigler S (2021) Changes in fiscal risk against disasters due to Covid-19. Prog Disaster Sci 10:100176

Hochrainer-Stigler S, Linnerooth-Bayer J, Lorant A (2017) The European Union Solidarity Fund: an assessment of its recent reforms. Mitig Adapt Strat Glob Change 22(4):547–563

Hochrainer-Stigler S, Velev S, Laurien F, Campbell K, Czajkowski J, Keating A, Mechler R (2021) Differences in the dynamics of community disaster resilience across the globe. Sci Rep 11(1):1–12

Hochrainer-Stigler S, Zhu Q, Ciullo A, Reiter K (2022) EU tools to respond to natural disasters. European Parliament, Policy Department for Structural and Cohesion Policies, Brussels. https://www.europarl.europa.eu/thinktank/en/document/IPOL_STU(2022)699637. Accessed 1 Aug 2023

Madhav N, Stephenson N, Oppenheim B (2021) Multi-pathogen event catalogs: technical note. World Bank. https://policycommons.net/artifacts/1806120/multi-pathogen-event-catalogs/2539044/. Accessed 1 Aug 2023

Mitchell-Wallace K, Jones M, Hillier J, Foote M (2017) Natural catastrophe risk management and modelling: a practitioner's guide. Wiley, Hoboken

Munich Re (2018) Topics Geo, Natural Catastrophes. Munich Re
Pflug GC, Romisch W (2007) Modeling, measuring and managing risk. World Scientific, Singapure
Regulation (2014) Regulation (EU) No 661/2014 of the European Parliament and of the Council of 15 May 2014 amending Council Regulation (EC) No 2012/2002 establishing the European Union Solidarity Fund. https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32014R0661&from=EN. Accessed 1 Aug 2023
Regulation (2020) Regulation No 661/2014 of the European Parliament and of the Council of 15 May 2014 Regulation (EU) 2020/461 of the European Parliament and of the Council of 30 March 2020 amending Council Regulation (EC) No 2012/2002 in order to provide financial assistance to Member States and to countries negotiating their accession to the Union that are seriously affected by a major public health emergency. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32020R0461&from=EN
Shepherd TG, Boyd E, Calel RA, Chapman SC, Dessai S, Dima-West IM, Fowler HJ, James R, Maraun D, Martius O, Senior CA, Sobel AH, Stainforth DA, Tett SFB, Trenberth KE, van den Hurk BJJM, Watkins NW, Wilby RL, Zenghelis DA (2018) Storylines: an alternative approach to representing uncertainty in physical aspects of climate change. Clim Change 151:555–571. https://doi.org/10.1007/s10584-018-2317-9
Sillmann J, Shepherd TG, van den Hurk B, Hazeleger W, Martius O, Slingo J, Zscheischler J (2021) Event-based storylines to address climate risk. Earths Future 9(2):e2020EF001783.
van den Hurk Bart JJM et al (2023) Climate impact storylines for assessing socio-economic responses to remote events. Clim Risk Manage 40:100500
van Lierop C (2021) European Union Solidarity Fund. Briefing, EPRS | European Parliamentary Research Service. https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/696193/EPRS_BRI(2021)696193_EN.pdf. Accessed 1 Aug 2023
Wallemacq P, House R (2018) Economic losses, poverty & disasters (1998–2017). UNISDR/CRED, Belgium
Ward PJ, Daniell J, Duncan M, Dunne A, Hananel C, Hochrainer-Stigler S, De Ruiter MC (2022) Invited perspectives: a research agenda towards disaster risk management pathways in multi-(hazard-) risk assessment. Nat Hazards Earth Syst Sci 22(4):1487–1497
World Bank (2021) Financial risk and opportunities to build resilience in Europe. World Bank
Zscheischler J, Westra S, Van Den Hurk BJ, Seneviratne SI, Ward PJ, Pitman A, Zhang X (2018) Future climate risk from compound events. Nat Clim Change 8(6):469–477
Zscheischler J, Martius O, Westra S, Bevacqua E, Raymond C, Horton RM, Vignotto E (2020) A typology of compound weather and climate events. Nat Rev Earth Environ 1(7):333–347

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