Dynamics of the polycrisis: temporal trends, spatial distribution and interconnections of national shocks (1970-2019)

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Abstract

Non-technical summary

In response to the concerns of a growing number of societal crises, we trace the temporal trends, distribution and interconnections of national shocks on 175 countries from 1970 to 2019. Our analysis shows that shocks have not evolved uniformly over time on a global or regional scale. Nevertheless, shocks became more interconnected overall between 1970 and 2000, particularly around the Conflict-Technology-Climate nexus, before showing a regionally-dependent shift in behavior. This change in a context of world order realignment highlights the importance of cross-sectoral and cross-national tools for disaster and crisis management.

Technical summary

Polycrisis has emerged as a new property of the Anthropocene, driven by the co-interaction of multiple shocks and stressors. Although sector-specific studies offer insights into the changing frequency and intensity of these disruptions, a holistic, cross-sectoral analysis remains absent, limiting a more integrated understanding of the phenomenon. To fill this gap, we have compiled a database that contains the number of shocks (climatic, geophysical, ecological, economic, technological, conflict) covering 175 countries from 1970 to 2019. We provide evidence that, even if China, India, Indonesia, Philippines and the U.S. have experienced more shocks relative to other countries, shocks have not evolved uniformly over time on a global or regional scale. Our results show that shocks became progressively interconnected between 1970 and 2000, particularly around the Conflict-Technology-Climate nexus, before showing a regionally-dependent shift in behavior. This change underlines the importance of cross-sectoral and cross-national tools for disaster and crisis management, particularly for interacting risks in a context of realignment of the world order. In this respect, we urge that the emerging polycrisis research community must recognize these global and regional patterns.

Social media summary

Dynamics of the polycrisis reveal regional differences, with a possible shift in the interaction of shocks from 2000.

Keywords

Polycrisis; Shocks; Biosphere; Anthropocene; Social-Ecological Systems; Resilience

1. Introduction

The growing interconnections and intensification of pressures on social-ecological systems have dramatically changed the Earth's biosphere (Folke et al., 2021, Nyström et al. 2019). As a result, the contemporary notion of 'crisis' has evolved from a series of isolated discrete events to a permanent global condition in which crises are no longer episodic but rather seems to form a continuous backdrop: the 'polycrisis' (Helleiner, 2024; Lawrence et al., 2024). The polycrisis translates in "high – and advancing – risk across socioeconomic, political, and other dimensions" (Mark et al., 2024), including catastrophic risks (Arnscheidt et al., 2024). It altogether redefines the current notion and perception of risk (Keys et al., 2019; Wassénius & Crona, 2022) as well as resilience and vulnerability (Favas et al., 2024).

Showing no evident temporality or spatial reach of its effects, the 'polycrisis' questions our relationships with time and space in addition to challenging the suitability of governance structures and existence of blueprint responses. Polycrisis therefore calls for a change of paradigm in scientific theory (Jacobs, 2024), methods (Hopper et al., 2023) and models (Koasidis et al., 2023). Only a new research and policy agenda could identify adequate means of coping with the polycrisis, i.e., escaping evolutionary traps – behaviors and systemic relationships with detrimental outcomes for society but deeply rooted in the Anthropocene (Søgaard Jørgensen et al., 2023)–while supporting just transformations in times of deep turbulent uncertainty (Moore et al., 2023).

Characterizing the emerging polycrisis dynamics, by essence complex and nonlinear, is the first step in that direction. Yet it requires navigating across space and time, as crises have become capable of spreading across sectors and scales. The global financial crisis in 2007/2008, the rapid spread of the COVID-19 pandemic, the Russian invasion of Ukraine, three events that have severely impacted our social, energy, and economic systems through their rapid and far-reaching spread, are prime examples. It also demands to recognise that the capitalism-driven forces shaping and destroying the biosphere are those that govern the polycrisis dynamics and ultimately, the responses brought forward (Jayasuriya, 2023; Penner, 2023; Albert, 2024; Szepanski, 2024).

With this in mind, we map out the temporal trends, distribution and interconnections of shocks across 175 countries, from 1970 to 2019. We believe that this analysis, still undone in the emerging polycrisis research community, is a starting point to unpack and better understand the causal architecture of the polycrisis, as previously suggested by Homer-Dixon et al. (2015). Specifically, we contend that assessing the frequency, distribution and interconnectedness of temporal markers of the polycrisis, i.e., shocks, should serve as a basis for identifying propagation patterns and help define response diversity strategies (Walker et al., 2023).

This paper is structured as follows. Section 2 reviews the existing literature on shocks, both theoretically and empirically, from a Social-Ecological Systems perspective. Section 3 presents the materials, data and methods used to build the database of shocks. Section 4 details the obtained results in terms of temporal trends, distribution and interconnections of shocks. Section 5 discusses the results and their robustness, as well as underlines the limitations of the study and suggests perspectives for future research. Section 6 concludes.

2. Contextualizing shocks research

2.1. Shocks in Social-Ecological Systems

The thin layer of the Earth hosting life, the biosphere, comprises complex adaptive social–ecological systems (SES) characterized by feedbacks across multiple interlinked scales that amplify or dampen change (Fischer et al., 2015). SES are currently subject to a wide range of pressures, taking the form of continuous long-term stress (e.g., increasing seawater temperature for coral reefs) and shocks of rapid onset and duration, (e.g., dust storms). These pressures can interact (Lade et al., 2019) and, through direct or indirect mechanisms, cause abrupt changes that destabilize the systems, and ultimately bring them to cross thresholds upon which their behaviors change radically. For instance, gradual increases in sea surface temperature are pushing fish towards higher latitudes, while sudden market pressures can trigger overfishing in some regions. Together, these factors can drive fish stocks to ecological tipping points, beyond which their populations may suddenly collapse (Cottrell et al., 2019; Cooper et al., 2020; Free et al., 2020).

Shocks not only disrupt SES, but force them to reorganize, adapt and transform greatly and potentially in a lasting way. Potential destruction of specific essential ecosystem services can lead to various impacts amongst actors as well as increasing vulnerability to pressures. Extreme weather could for instance cause livelihood and wellbeing losses, but also increase the vulnerability of the ecosystem to future disasters (in reducing the amount of mobilizable resources for action, destroying key networks of interactions, etc.). This situation calls on drastic and swift measures to improve the system's capacity to cope and adapt to the disturbance (i.e., its 'resilience'). As societies, economies and technologies are becoming increasingly interconnected, concerns have been raised that responses to past shocks may be inadequate, or even counter-productive. Adaptation to shocks can therefore be maladaptive and lead to trap situations (Magnan et al., 2016). The cleaning operations after Sri Lanka's tsunami in 2004, for instance, facilitated salinity intrusion into the freshwater aquifer. Not only populations required water tanks and water tankers, but groundwater quality was not restored to pre-impact levels in many areas several months to over a year after the tsunami (Renaud et al, 2010). Another example is the initial delay in action of the European Central Bank and then the drastic austerity measures imposed on Greece (with the support of the International Monetary Fund) after its default on sovereign debt, which worsened the country’s situation and led the economic shock to spread to other eurozone members (Ireland, Portugal, Spain, Cyprus, etc.) (Varoufakis, 2016).

While the uncertainty surrounding the probability of occurrence and the severity of shocks is increasing, the trend is the opposite for drivers. At the heart of the emergence and propagation of shocks is the dominant system of production and distribution of goods and services, which has been referred to as the Global Production Ecosystem (GPE) (Nyström et al., 2019). Comprising an increasingly homogenous network structure and driven by predatory financial motives, the GEP steers away production from consumption. Not only does this situation lead to a mismatch between consumption and production, but it also paves the way to the reinforcement of hard-to-reverse feedbacks of unsustainable growth (Clapp, 2014). Human-driven changes in the biosphere become massive, with the core (i.e., “developed” economic hubs) draining the resources of the periphery (i.e., “less developed” peripheral regions) and transferring most of the resulting externalities back to it (Hickel et al., 2021; Fanning & Hickel, 2023). Global resilience, equity and sustainability diminish accordingly and steadily (Hamman et al., 2018; Tu et al., 2019). For instance, current levels of global inequalities are near the ones observed during the peak of Western imperialism (Rockström et al., 2023). The growing emergence of cross-scale conflicts can potentially cause ‘backlash’ dynamics, ultimately hindering just transformative processes (Olsson & Moore, 2024). In time, the unequal over-appropriation of resources, ecological degradation, social injustice, and debt– in many cases legacies from colonialism (Hickel et al 2023)– combined with the complexity of the networked system, constrain our ability to understand and manage shocks (Helbing, 2013).

2.2. Current frontiers of shocks research

Social-ecological research on shocks is rich, rapidly increasing and demonstrates a wide array of approaches - inherent to the field (Manyani et al., 2024). On a theoretical note, much attention has been devoted to the development of frameworks, trying to understand the interaction of threshold exceedances induced by natural hazards (Renaud et al., 2010; Filatova & Pohill, 2012). However, there are major disparities in scales and sectors, as an emphasis has been put on food systems, and especially fisheries (Hodbod & Eakin, 2015; Kaplan-Hallam et al, 2017), as well as climate tipping points (Kopp et al., 2016; Milkoreit et al., 2018). Still, recent progress is carried out, for instance with the introduction of a novel framework for social-environmental extremes (Balch et al., 2020) and the investigation at various scales of socio-political shocks and their ecological determinants (Herrfahrdt-Pähle et al., 2020). Additionally, the exploration of spillovers between major global shocks on the trends of global interconnectedness (Viña & Liu, 2022) and the reliance on the Dynamical Systems Modeling (DSM) framework (Radosavljevic et al., 2023) have been suggested as avenues for study of how shocks transmit in SES.

On an empirical note, several attempts have been carried out to map shocks and their interconnections. Biggs et al. (2015), for instance, assess the evolution of regime shifts, impacts, key drivers, underlying feedbacks, and management options over 300 case studies. Cottrell et al. (2019) build on the work of Gephart et al. (2017) to estimate the frequency of food production shocks (crop, livestock, aquaculture and fisheries) and show a notable increase in all major sectors across land and sea over the past 53 years. Fisher et al. (2021) evaluate how a specific climate shock (marine heatwave) modifies flows of users between fishery resources using a network analysis. Carper et al. (2021) quantify shock-response assessment regime over a period of 30 years (1989–2019) in the Rechna Doab basin (northeastern Pakistan). d'Errico et al. (2023) combine several datasets to study how different shocks (natural disaster, livelihood-related, health shocks) reduce households' resilience between 2014 and 2020. Hoyer et al. (2023, 2024) developed the Crisis Database (CrisisDB), comprising 168 societal crises (population decline or collapse, downward mobility or extermination of elites, uprisings, civil war, state fragmentation, external conquest, ruler assassination or deposition, etc.) spanning multiple time periods and regions, by systematically collecting historical information about the events characteristics. Finally, Shaban et al. (2024) analyze the extent to which contextual social-ecological conditions of entrepreneurial uncertainty, agricultural shocks, and poorly designed responses from institutions interact with tragic behaviors by farmers.

2.3. Gaps and opportunities

While research on shocks has been prolific, especially for climate, economic and ecological shocks, less attention has been devoted to their co-interaction conflict). A result is that empirical methods and data that help understand how components of the global system absorb, transmit and link together shocks are still missing (Kaplan-Hallam et al., 2017; Beauchamp et al., 2020). We hope that this study will contribute to fill this gap by building on the transdisciplinary character of resilience science, and bridging social-ecological systems knowledge with existing sectoral datasets from other communities. More precisely, natural disasters, catastrophic and global systemic risks appear as natural hubs of data and information. The rapprochement between polycrisis and resilience is all the more supported by the long standing tradition of shocks study in the field (Biggs et al., 2011), but also by its maturity and openness towards other approaches (Cumming & Peterson, 2017). It is further backed by the recent investigation of undesirable resilience and socio-technical lock-in (Dornelles et al., 2020), in order to make the adaptive capacity of SES to extreme changes more operational (Thonicke et al., 2020) and more suited for a conflict-prone environment (Méndez et al., 2022; Goldstein et al., 2023; Rist et al. 2024).

3. Methodology

3.1. Main stages of the research process

The approach used in this study involved five successive key stages (Fig. 1). First, we reviewed relevant literature to identify a framework of shocks, which classifies shocks in 6 categories depending on their core mechanism: climatic, geophysical, ecological, economic, technological, and conflict. Second, we surveyed existing regional or global datasets on shocks and found a total of 58 candidates. Relying on a set of criteria and pre-identified relevant indicators or proxy, we selected a set of six datasets (see below for further detail). Third, we standardized each one to comply with a formal and shared template, where geographical and temporal scales were reconciled with Python scripts. More specifically, we used the package country_converter (Stadler, 2017) on country data, then splitted former states into the corresponding current states (e.g. USSR before 1991) and we filtered out countries that were missing observations in at least one category (although providing a full pre-filtered dataset in the supplementary materials). Fourth, we assessed the robustness period of each dataset, identifying potential bias in each, before expressing the data in a single csv file. It has to be noted that, following our data check, the magnitude and impact of shocks (casualties, U.S. dollars, etc.) was deemed inconsistent across datasets, and as such, is not treated in the present analysis (only the number of shocks are presented). Fifth, we analyzed the results, and explored the temporal trends, distribution and interconnections of shocks over time through statistical analysis.

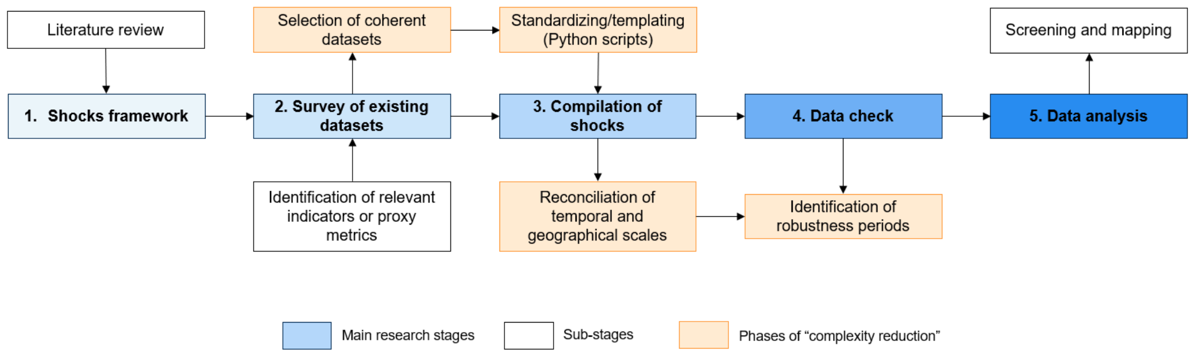

Figure 1: Main stages of the research process.

3.2. Datasets description

The six datasets collected, standardized, and compiled as well as selected indicators per shock category are presented in Table 1.

For climatic shocks, EM-DAT was selected due to its extensive coverage of shocks and prominent use in the field of natural disasters (Delforge et al., 2023). EM-DAT compiles over 26,000 disasters (10 deaths or above, 100 people affected or above, call for international assistance issued or state emergency situation declared) data from 1900 to the present day. It has been used widely, with, among others, linking to geocoded locations (Rosvold & Buhaug, 2021), infectious diseases outbreaks (Franzke & Czupryna, 2021), human displacement (Mester et al., 2023) and social-ecological variables (Nones et al., 2023). Only six types of shocks—drought, extreme temperature, flood, wet mass movement, storm, and wildfire—were classified as climatic, as they are majorly driven by climatic factors.

For geophysical shocks, we also relied on EM-DAT but extracted only a selection of disasters (earthquake, volcanic activity, dry mass movement, meteorite impact) which are considered to be mainly of geophysical origin.

For ecological shocks, we employed the dataset of Cottrell et al. (2019) for production shocks in different food sectors (i.e. crops, livestock, capture fisheries and aquaculture), and combined the Disease Outbreak News (DONs) dataset (Carlson et al., 2023) with EM-DAT for the epidemiological shocks (EM-DAT is used from 1970 to 1996 and DONs from 1996 to 2019). Reason for those two shocks to be classified together is that they mostly originate from ecological disturbances.

For economic shocks, we employed the dataset of Nguyen et al. (2022), which comprises 151 systemic banking crises, 414 currency crises and 200 sovereign debt crises. This dataset, which builds on the one of Laeven and Valencia (2020), has the advantage to be more systematic but also covers more countries over a longer period of time.

For technological shocks, we relied on EM-DAT, which comprises air shocks (e.g., plane crash), chemical spill, industrial collapse (e.g., bridge failing), miscellaneous collapse (e.g., house collapse), industrial explosion, miscellaneous explosion, industrial fire, miscellaneous fire, gas leak, industrial accident (general), miscellaneous incident (general), oil spill, poisoning (e.g., pollution of a water course), radiation, rail (e.g., train accident), road (e.g., truck accident), and water (e.g., cruise ship accident).

For conflict shocks, we used the updated version of the Global Terrorism Database (GTD) of LaFree & Dugan (2007) as well as the Uppsala Conflict Data Program (UCDP) version 24.1 of Hegre et al (2020). GTD is an open-source dataset on terrorism, which covers more than 200,000 cases of domestic and international terrorist incidents from 1970 through 2020. The UCDP is a continuously updated dataset on armed conflicts and organized violence (state-based non-state or one-sided violence) hosted by the Department of Peace and Conflict Research at Uppsala University.

Shock category	**Shocks types**	**Time coverage**	**Dataset used**	**Key reference**
Climatic	- Drought - Extreme temperature - Flood - Mass	1900 - 2023	EM-DAT	Delforge et al. (2023)

	movement (wet) - Storm - Wildfire			
Geophysical	- Earthquake - Volcanic activity - Mass movement (dry) - Impact	1900 - 2023	EM-DAT	Delforge et al. (2023)
Ecological	- Food production shocks (crops, fisheries, aquaculture, livestock) - Infectious diseases	1961 - 2013 1900 - 2023 1996 - 2024	Cottrell et al. EM-DAT DONs	Cottrell et al. (2019) Delforge et al. (2023) Carlson et al. (2023)
Economic	- Systemic banking crisis - Currency crisis - Sovereign debt crisis	1950 - 2019	Systemic Banking Crises Database	Nguyen et al. (2022)
Technological	- Air - Chemical spill - Collapse (industrial) - Collapse (miscellaneous) - Explosion (industrial) - Explosion (miscellaneous) - Fire (industrial) - Fire (miscellaneous) - Gas leak	1900 - 2023	EM-DAT	Delforge et al. (2023)

	- Industrial accident (general) - Miscellaneous incident (general) - Oil spill - Poisoning - Radiation - Rail - Road - Water			
Conflict	- Terrorist attacks - Interstate conflicts - Intrastate conflicts - Extrasystemic conflicts	1970 - 2021 1946 - 2023	GTD UCDP	LaFree & Dugan (2007) Hegre et al. (2020)

Table 1: Indicators, time coverage and scope of the compiled datasets.

3.3. Statistical analysis

Once the shocks were compiled in a common format and single file, we carried out a statistical analysis in several steps. First, we estimated the temporal trends of the shocks by unpacking the gross number of shocks. Second, we analyzed the distribution of shocks to uncover regional dynamics. However, the total number of shocks is not comparable across categories. For instance, the number of terrorist attacks recorded is two orders of magnitude greater than any other shock, thus the world total would only reflect the Conflict category. Thus, we followed a normalization process to avoid excess representation of one category over the others. The normalization consists in dividing each shock by the mean over the study period of the world total, to get a result around 1.

$$\bar{n} = mean(n_{world,y}) = \frac{\sum_{1970 \leq y \leq 2019} (n_{world,y})}{\left|\{y | n_{world,y} \neq 0\}\right|}, \text{ with } n_{world,y} = \sum_{c \in Countries} n_{c,y}$$

As we do not record 0s in the database, the mean is computed only on non-zero values, which has the final effect of giving less weight to sparse shocks, like Meteorite impacts. We then divide by the number of shocks per category *catSize* to get similar sizes. The normalized shock is given by:

$$\hat{n}_{c,y} = \frac{n_{c,y}}{\bar{n} \times catSize}$$

Thirdly, we analyzed the interconnections of shocks by summing up all pairs of shocks that appeared in a country during the same year. This allowed us to estimate the relative frequency of multi-shock occurrences. It depicts temporal co-occurrence of shocks in the same country in the same year, but does not necessarily imply an actual causation or other kind of relationship between them.

4. Results

4.1. Temporal trends

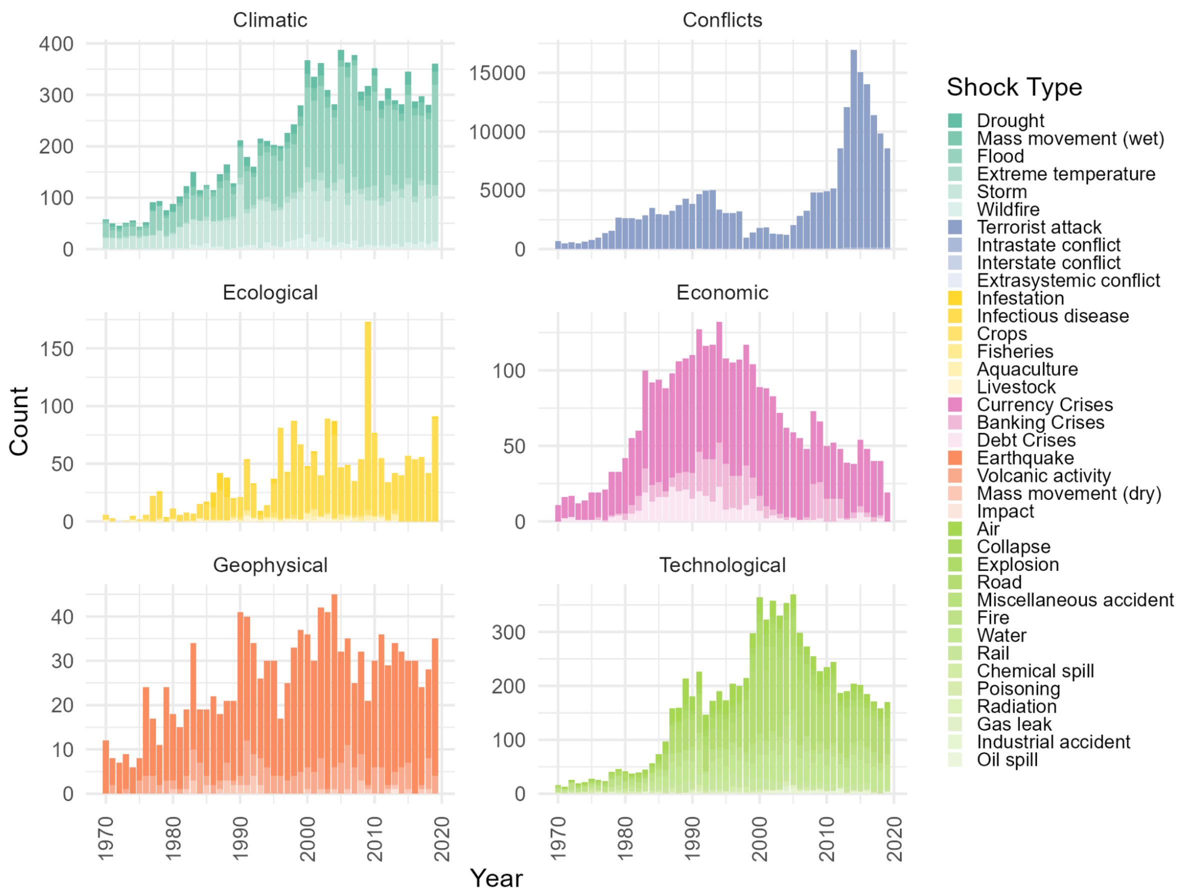

Figure 2: Number of shocks per category from 1970 to 2019, global scale. Note that Food production shocks (crops, fisheries, aquaculture, livestock) data stops in 2013.

The total gross number of shocks shows different dynamics depending on the category of shock considered (Fig. 2). For example, climate-related shocks increase steadily from 1970 onwards until they reach an apparent plateau in the early 2000s, which may be linked to the more robust and systematic selection of events from that time onwards for EM-DAT (see 'Limitations and future development' section). Conflict-related shocks follow a different pattern, with a slow increase between 1970 and 1980, a rising plateau between 1980 and 1995, a decline between 1995 and 2005 before what appears to be an exponential increase from 2005 onwards followed by a strong decrease since 2010. Ecological shocks vary considerably, with a first period from 1970 to 1985 being fairly mild, before becoming increasingly severe (except the mid 1990's drop), and peaking in 2009 with almost 160 shocks. Economic shocks follow a bell-shaped curve, with a peak over 100 shocks between 1987 and 1999, and are majorly driven by currency crises. Geophysical shocks show an increasing trend from 1975 to 2000 and a stagnation after, with important variations in between years. Technological shocks seem to follow a step function with a first stable period around 25 shocks per year from 1970 to 1980, a higher step around 150 shocks from 1985 to 2000, and an even higher step from 2000 to 2006 around 300 shocks, before falling to approximately 200 shocks per year in the 2010's.

4.2. Distribution

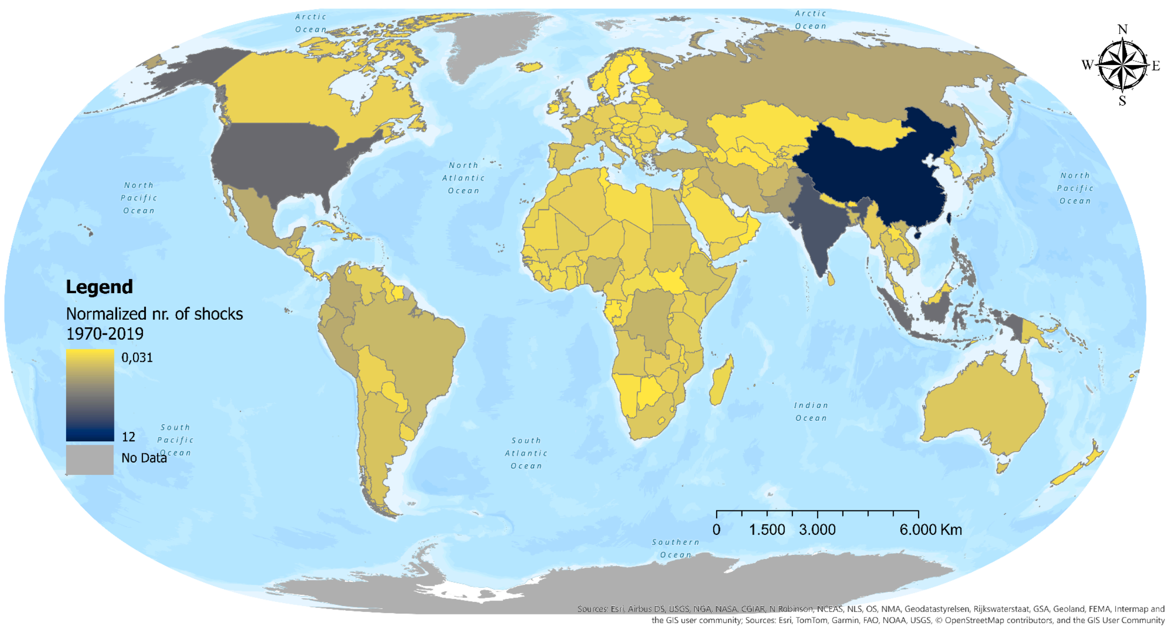

Figure 3. Normalized number of shocks per country from 1970-2019 including six categories: climatic, geophysical, ecological, economic, technological and conflict.

Normalized shocks show an uneven geographical distribution (Fig. 3), from near to zero counts for most countries of the African continent (except for Democratic Republic of the Congo and Nigeria) to nearly 12 for China. Other countries in South-East Asia are among those experiencing the most shocks, with India, Indonesia, and Philippines leading the count of normalized shocks per year. The U.S. also knows a relatively high number of normalized shocks per year, higher than the European Union, South-American countries, or Russia.

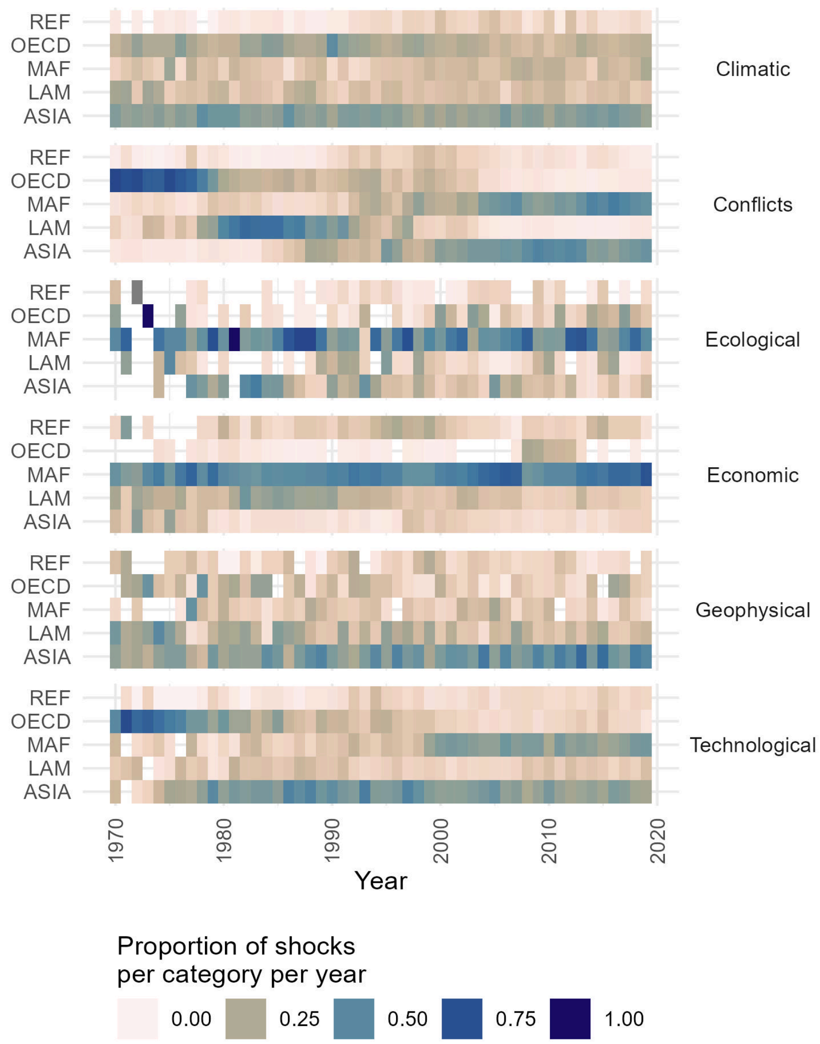

Figure 4. The share of shocks per category per year in each region. REF = the reforming economies of Eastern Europe and the former Soviet Union , OECD = The Organisation for

Economic Co-operation and Development 90 countries and the European Union member states and candidates, MAF = the Middle East and Africa, LAM = Latin America and the Caribbean, ASIA = Asian countries except the Middle East, Japan and the former Soviet Union states.

Over time, the distribution of shocks reveals disparate dynamics between regions (Fig. 4). Climatic shocks, for instance, affect mostly OECD and Asian countries. Conflicts seem at first mostly based in OECD (1970 - 1980), before being mostly present in Latin America and the Caribbean (1980 - 1990) and then in MAF and Asia (2000 - 2019), simultaneously. Ecological shocks appear majorly in the Middle East and Africa from 1970 to 2019, and to a lesser extent in Asia from 1975 to 1985. Economic shocks are driven by MAF, and seem absent in OECD countries until the Global Financial Crisis (2007 - 2008). Geophysical shocks emerge in every region, but Asian countries gradually take over as the leading one. Technological shocks concern first OECD countries (1970 - 1980) before Asia takes the lead (1980 - 2000) and until MAF countries reach a similar proportion of shocks per year.

4.3. Interconnections

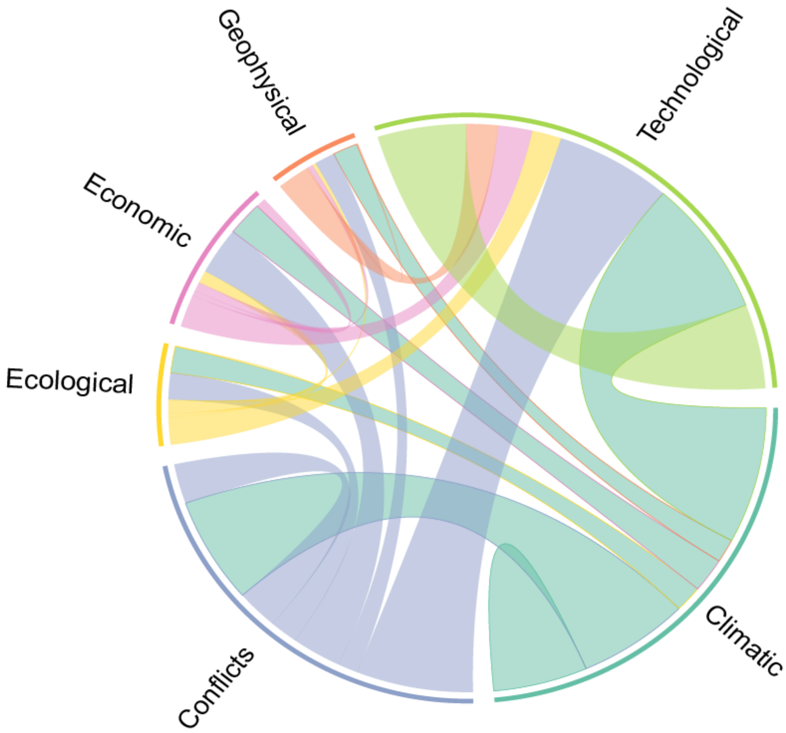

Figure 5: Multi-shock Circos plot per shock category (1970 - 2019). Connections between colored segments denote shock interactions, with line thickness indicating the relative frequency of multi-shock occurrences.

Figure 5 shows the interconnections among shocks categories, revealing those that are more interconnected to others. Four most frequent pairs appear: Climatic - Technologic, Climatic - Conflicts, Conflicts - Technological and Technological - Technological. We also observe that while many of the shocks are intra-category (e.g. intra-state conflict and terrorist attack), there are many connections across categories (e.g. infectious disease and drought). This interconnectedness depicts only temporal co-occurrence of shocks in the same country in the same year, but does not necessarily imply an actual causation or other kind of relationship between them.

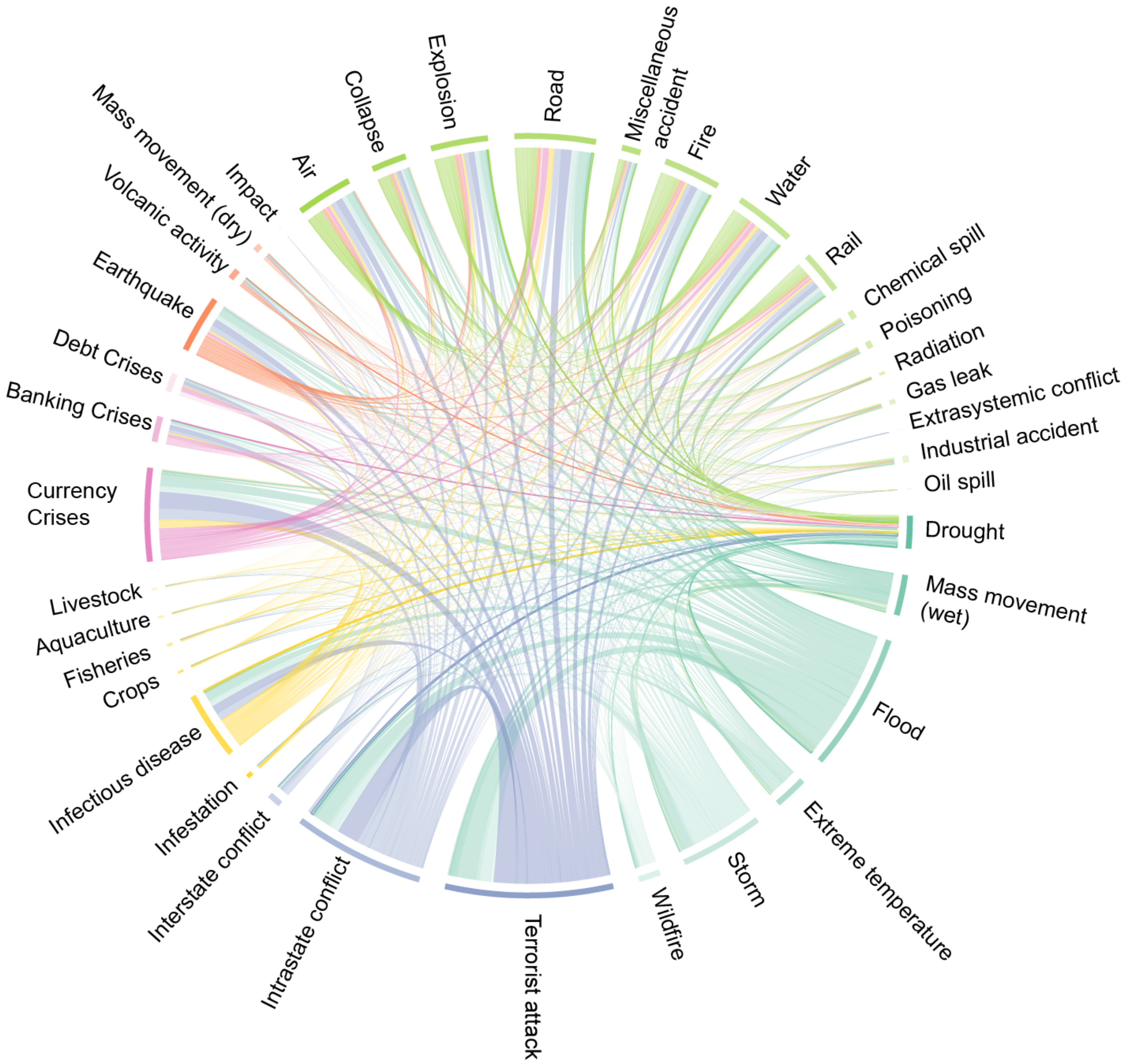

Figure 6: Multi-shock Circos plot per shock type (1970 - 2019). Connections between colored segments denote shock interactions, with line thickness indicating the relative frequency of multi-shock occurrences.

Figure 6 shows the interconnections among shocks, revealing those types of shocks that are more interconnected to others, like floods, terrorist attacks, intrastate conflicts, and currency crises. If no pair of shock types appears to be disproportionately represented, three most frequent pairs are still found in the co-occurrence analysis: Terrorist attack-Intrastate conflict, Flood-Terrorist attack, and Terrorist attack-Currency Crises, being terrorist attacks always present in these observations of co-occurrences as it is also the type of shock with the highest number of observations. The top three most frequent observations not accounting for any pair that contained terrorist attacks are: Flood-Currency Crises; Intrastate conflict-Currency Crises; and Flood-Storm.

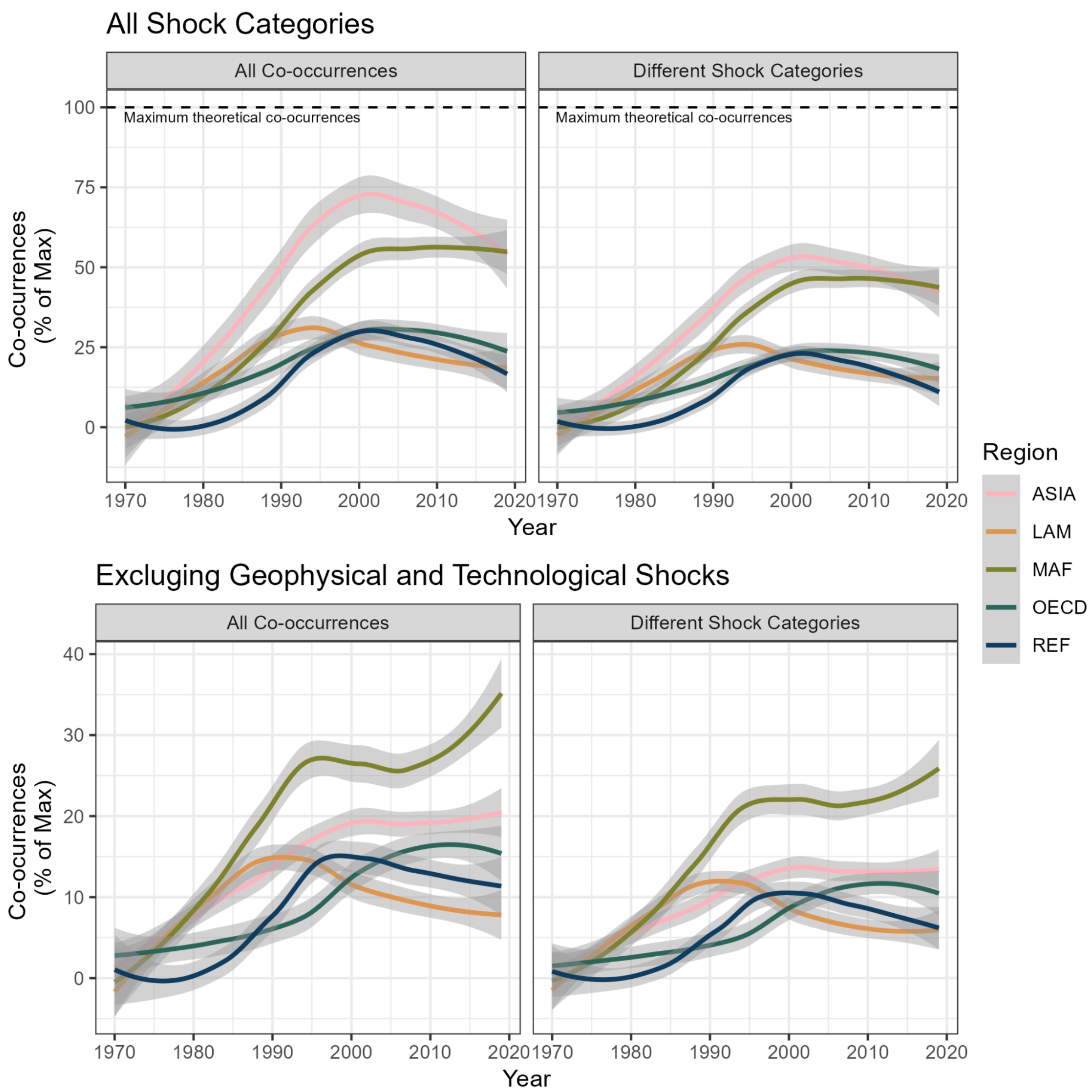

Figure 7: Co-occurrence of shocks by region and over time, for all shocks and all categories (top left), for shocks in different categories and all categories (top right), for all shocks and all

categories but geophysical and technological (bottom left), for shocks in different categories and all categories but geophysical and technological (bottom right). Estimates for co-occurrence of shocks in different categories shows the sum of synchronous shocks that belong to the same category (e.g., the pair Flood-Mass Movement (wet) would not be accounted for as both shocks belong to different categories). REF = the reforming economies of Eastern Europe and the former Soviet Union, OECD = The Organisation for Economic Co-operation and Development 90 countries and the European Union member states and candidates, MAF = the Middle East and Africa, LAM = Latin America and the Caribbean, ASIA = Asian countries except for the Middle East, Japan, and the former Soviet Union states. The theoretical maximum for co-occurrences corresponds to a state in which all countries experience one of every shock type per year.

The co-occurrence of shocks per region over time (Fig. 7, top left) shows that shocks have become more interconnected from 1970 to 2000 globally, with an average increase of 7% per decade. Yet, various dynamics can be observed. The ASIA and MAF regions, for instance, undergo a rapid and significant increase in co-occurrence, nearing 75% and 50% of the theoretical maximum in 2000, respectively. In contrast, co-occurrences in the LAM, OECD and REF countries are increasing more slowly (particularly REF, which only emerged late from 1980) and peak at a lower magnitude (30% of the theoretical maximum). Trends after 2000 remain divided in two groups of regions: Asia-MAF and LAM-OECD-REF, but with contrasted patterns. The co-occurrence of shocks fell steadily in all regions, except in the MAF countries where it stagnated. Moreover, the co-occurrence of shocks between categories appears less numerous than the co-occurrences between shocks but still following similar trends (Fig. 7, top right). This indicates that shocks are not also interconnected with shocks within their category, but also with shocks outside their category. When excluding geophysical and technological shocks to focus on the four categories that have mainly been hypothesized to contribute to the current sense of polycrisis, we find that co-occurrences after 2000 increase in MAF, and do not decrease anymore for Asia.

5. Discussion

5.1. A diverse polycrisis

Studying polycrisis dynamics empirically is fundamentally important as we move further into the Anthropocene, but also inherently difficult due to the challenge of formally defining crises across datasets that often vary in time span and spatial coverage. Focusing on the most concrete temporal markers of polycrisis dynamics, namely shocks, we have shown promising opportunities for an emerging research field, with implications for the conceptualization and management of polycrisis itself. The main lesson to be drawn from a close examination of the national number of shocks over time is that they vary greatly from one category of shock to another, and from one region to another. Still, most regions have experienced a relative increase of co-occurring shocks from 1970 to 2000, testifying to a more shock-prone and interconnected global context during that time-period. In such a setting, shocks are found to co-occur within and across all categories, further supporting the need to adopt a holistic viewpoint to embrace polycrisis research. However, co-occurrences interconnection is found to lower after the 2000 in all regions but Africa and the Middle East. Furthermore, the apparent plateau for LAM countries might indicate a stabilization phase or a shift in the nature and interaction of shocks, necessitating further investigation into the underlying causes. Understanding these dynamics is crucial for policymakers and stakeholders who wish to enhance just resilience and adaptive capacities, that is not only resilience “of what to what” (Carpenter et al. 2001) but also resilience “to whom” (Cutter, 2016).

5.2. Implications for disasters and crisis management

Overall, our analysis underscores the importance of integrating cross-sectoral policies that can address multiple interacting shocks. Traditional siloed approaches to crisis management may prove inadequate in the face of interconnected shocks and therefore, attention should be specifically paid to comprehensive models of interactions and cascading effects of various shocks, including early warning systems. For instance the development of a system that can detect and react to shocks in neighboring or trade partner countries (possibly using AI), as opposed to only within countries, could represent a step forward. A useful way to take advantage of the globalized and interconnected system could be an early warning and reaction system for multiple shocks as the ones described in this article. Designing interventions that can mitigate the impacts of potential crises, and exploring the role of governance at multiple levels (e.g. supranational, national, regional, local), institutions, and community-level responses in managing polycrises could provide insights into effective resilience-building practices.

5.3. Limitations and future development

The present study is limited both by its method and the data it relies on. Methodologically, the decision to normalize shocks was made to ensure a comparable number of shocks over all categories. We here decided to rely on a simple normalization, which we believe is the most explicit and as such, most understandable by a wide range of readers, yet there are plethora of available methods and indices that can be explored in the future with the dataset. In addition, the grouping of countries in REF, OECD, MAF, LAM and ASIA regions is rich from a socioeconomic perspective (in terms of colonizing history, power structures, cultural values, etc.), but is debatable from a biophysical (temperature, precipitation etc.) perspective.

All of the compiled datasets are subject to several biases. The first one is the temporal bias, as systematic reporting and monitoring becomes more reliable over time. This issue has been extensively discussed for EM-DAT and similar datasets as DesInventar (Panwar & Sen, 2019; Jones et al., 2023). More precisely, these datasets show underreporting data for a number of event categories such as earthquakes and hydro-meteorological disasters (Alimonti & Mariani, 2024; Joshi et al., 2024). Second, the threshold bias, which *de facto* evicts all events that do not meet the criteria thresholds defined by the original studies authors. Third is the hazard bias, meaning that our analysis is naturally limited to the shock types we have included, but misses some others, such as social unrest, migration, political crises and trade conflicts (Wyatt et al., 2023). Fourth is the geographic bias, as Global North countries have more available reporting on disasters than Global South countries (Mahecha et al., 2020). Fifth is the accounting bias, as the impact data for disasters (in casualties or U.S. dollars) is highly challenged as a large proportion of data between 1990 and 2020 is missing (Jones et al., 2022). Sixth and final is the systemic bias, when previous biases interact, compounding their effects.

We tried to limit those biases by having a comprehensive and transparent method, in which we (i) carried out an initial survey of existing datasets to select the best ones according to robustness and coverage criteria (systemic bias); (ii) compared the results from the selected datasets to other more specific datasets (threshold and hazard bias); (iii) standardized each dataset according to a common template (systemic bias); (iv) checked robustness periods of each dataset and did not use data which was deemed not robust (such as EM-DAT before 1970); (v) carried out a sensitivity analysis (time and geographical bias) and (vi) disregarded impact data. We believe that this protocol, still improvable, is the first step towards a comprehensive assessment of national and international shocks.

Future development of the present work could include the integration of more fine grained data (potentially combining regional and spatially-explicit datasets), the addition of slowly unfolding creeping changes - such as aspects of demography, loss of biodiversity, or the identification of emerging typologies of shocks combining the database with case studies. A more in-depth sensitivity analysis based, for example, on MYRIAD-Hazard Event Sets Algorithm (MYRIAD-HESA) of Claasen et al. (2023), and an exploration of how the use of impacts and drivers affects the robustness of the database could also be carried out in the future to better assess the robustness of our findings.

6. Conclusion

Polycrisis research faces theoretical and practical difficulties. To overcome this problem, we provide a first version of a global database of national shocks – some of the most concrete temporal markers of the polycrisis. Through a statistical analysis spanning 175 countries and ranging from 1970 to 2019, we identify the temporal temporal trends, global distribution and co-occurrence. We found that shocks have not evolved uniformly over time on a global or regional scale. For example, China, India, Indonesia, Philippines and the U.S. have experienced more shocks relative to other countries. The study also shows that shocks became more interconnected overall between 1970 and 2000, particularly around the Conflict-Technology-Climate nexus, before showing a regionally-dependent shift in behavior. This change underlines the importance of cross-sectoral and cross-national tools for disaster and crisis management, particularly for interacting risks in a context of realignment of the world order. In this respect, we suggest that the emerging polycrisis research community should be cautious in examining global patterns and not overlook regional trends. Finally, we believe that our contribution lays the foundations for future cross-scale research relevant in a shock-prone world, and we call for a broader engagement of the community to explore a possible shift in the nature and interaction of shocks from 2000 onwards.

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Author Contributions

Louis Delannoy: Conceptualization, Formal analysis, Methodology, Project administration, Supervision, Visualization, Writing – original draft, Writing – review & editing. **Alexandre Verzier**: Data Curation, Investigation, Methodology, Visualization. **Bernardo A. Bastien Olvera**: Formal analysis, Validation, Visualization, Writing – original draft, Writing – review & editing. **Felipe Benra**: Validation, Visualization, Writing – original draft, Writing – review & editing. **Magnus Nyström**: Writing – review & editing. **Peter Søgaard Jørgensen**: Conceptualization, Supervision, Writing – review & editing.

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Conflicts of Interest declarations

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability statement

Data for the number of national shocks (gross and normalized) per country and per year as well as code for producing figures can be accessed from the following repository: https://github.com/LouisD-KVA/Polycrisis-shocks

Declaration of AI use

We have used AI-assisted technologies for spellchecking, code checking and as inspiration for rewording individual sentences. After using these tools, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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Supplementary material

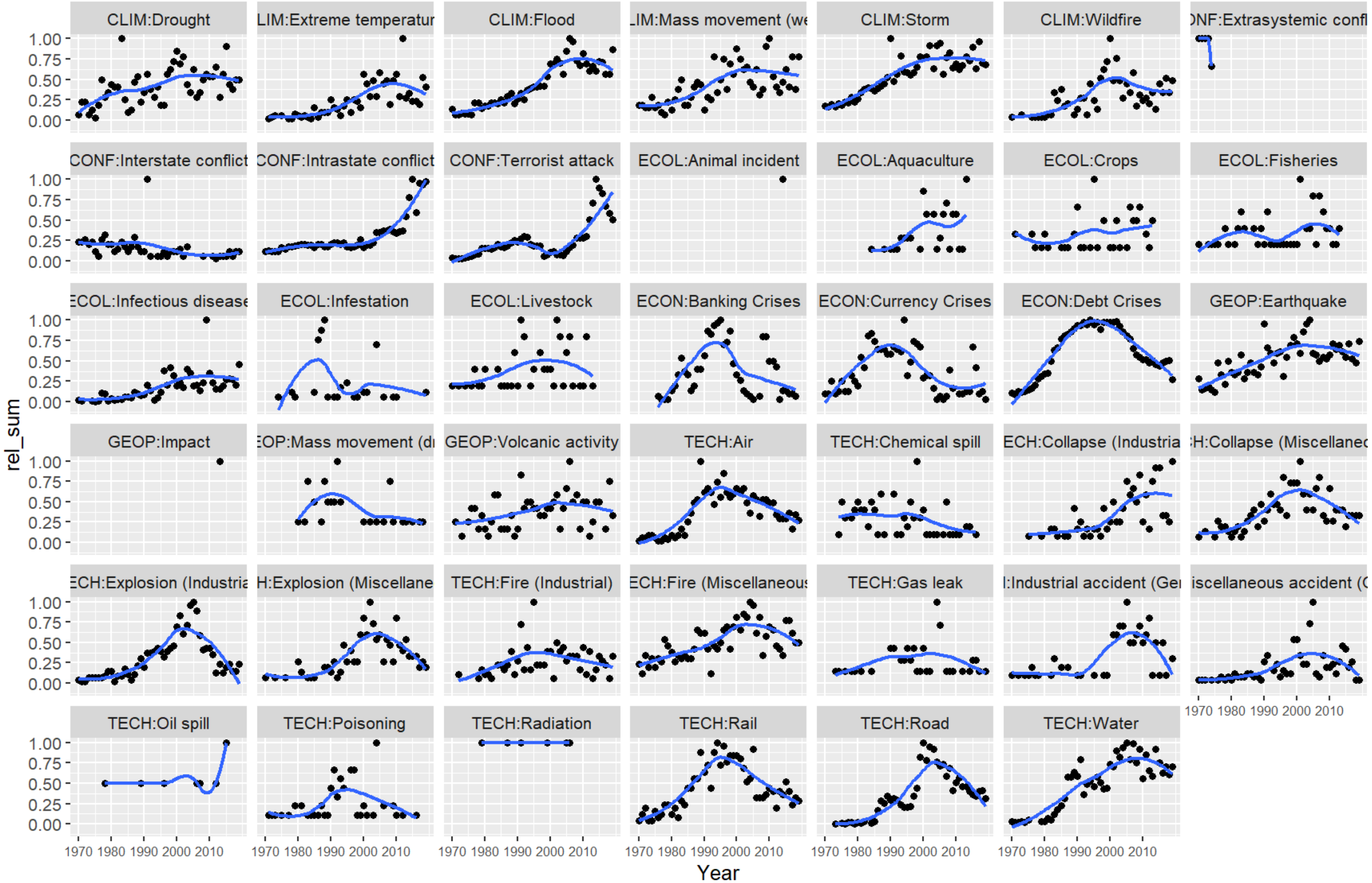

Figure SI-1. Relative sum of shock types over time (1970 - 2019). Each point represents the relative magnitude of a specific shock type within a given year, and blue lines are Loess smoothing.