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"Natural" disasters and regional governance: Evidence from European NUTS-3 regions

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ABSTRACT

"Natural" disasters" have negative consequences for the affected areas, including significant economic impacts. Using a sample of European NUTS-3 regions over the period 2003–17, this paper examines the impact of disasters on regional economic growth and the influence of the quality of regional governance on post-disaster economic recovery. We match disaster data from the EM-DAT database, EUROSTAT, US Geological Surveys and Global Archive of Large Floods. We find that the occurrence of a "natural" disaster leads to an annual decline in regional growth of about 0.28 percentage points. Furthermore, we find that both the impact on the economy and the duration of recovery are influenced by the quality of regional institutions.

1. Introduction

Societies have always been confronted with relevant, unavoidable, and often unpredictable forms of exogenous shocks, namely "natural" disasters, which have immediate and tangible consequences in terms of deaths, injuries, and damage to the natural habitat. A disaster is the intersection of two opposing forces: the processes generating vulnerability on one side (socio-economic conditions), and the occurrence of a natural hazard event on the other side (Gizzi, 2022; Chaudhary and Piracha, 2021; Wisner et al., 2003). The first force cannot be labeled as 'natural' since human beings are often responsible for creating vulnerabilities (Quarantelli, 2005). This perspective is emphasized not only by United Nations Office for Disaster Risk Reduction (Chmutina and von Meding, 2019), but also by several contributions (e.g., Marshall, 2023; Kelman, 2020).

Several studies have examined the impact of "natural" disasters on the economy. However, despite the growing interest, due in part to the increasing frequency and severity of "natural" disasters (Swiss Re, 2022), the existing literature has not produced clear-cut results: differences in methodology, time periods, contextual factors, and characteristics of the geographic areas where events occur account for the wide variation in estimates of the impact of disasters on the economy (Cavallo and Noy, 2011). The findings reported in several research papers vary from negative to neutral or even positive across different time periods and geographic levels of analysis (Hochrainer, 2009; Leiter et al., 2009; Noy, 2009; Raddatz, 2007; Albala-Bertrand, 1993), a limitation that makes this topic a central and puzzling subject of current economic analysis.

There are several reasons for this drawback. The first reason is related to the degree of geographic disaggregation of the analyses, with most of the literature focusing on the country level rather than the local level. Barone and Mocetti (2014) show that the negative effects of "natural" disasters can be very large at the local level, even if they are negligible at the country level: Consequently, the exclusive focus on the national level prevents a proper assessment of the disaster and its impact on the local economy, rendering the country-level analysis almost useless. A second important limitation concerns the severity of the disaster: Existing literature has mostly addressed the issue simply by dividing events into two distinct groups, i.e., large and small events, without explicitly considering the role of graded disaster severity, thus omitting an important explanatory variable (Onuma et al., 2021). In addition, the EM-DAT dataset provides limited information on the magnitude and severity of natural hazards, making analysis of this aspect a major challenge. A third limitation relates to the overlooked role of local governance as a moderating factor in the relationship between the occurrence of a natural hazard and its economic consequences. Although the literature has addressed this issue extensively, it has only examined governance at the country level and focused on the

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relationship between the quality of the country's institutions and the effectiveness of disaster response (Bos et al., 2022; Dìaz and Larroulet, 2021). Since local institutions are the first responders after the event (Schneider, 1992) and are responsible for determining future risk-reducing measures (Pescaroli and Alexander, 2016), the level of quality of local institutions, i.e., regional governance,[1] must be considered in the analysis because it influences the recovery process and affects the timing of policy outcomes (Masiero and Santarossa, 2020).

This paper aims to fill some of these gaps by examining the impact of natural hazards on economic growth at a highly disaggregated level of analysis. Unlike the mainstream literature on this topic, we examine the impact of "natural" disasters using detailed data on 1028 European NUTS-3 regions, which is the finest level of disaggregation allowed by the EU's financial and economic accounts. We matched regional economic data with disaggregated data on "natural" disasters that have occurred in Europe over the past two decades. The picture we get shows a very high frequency of disasters over time and across regions: between 2003 and 2017, 452 natural events were recorded in European NUTS-3 regions. Each year, an average of 88 out of 1028 regions were affected by natural hazards (about 4 regions per year if we consider only disasters with at least 50 fatalities), with an average of almost 3 different NUTS-3 regions affected per event. In total, more than 1300 regions/events have occurred in Europe, forcing local authorities to frequently deal with a "natural" disaster and underlining the relevance of the issue for the affected areas.

To address this issue, we evaluate the impact of natural hazards on local economies using regional GDP growth. Specifically, we use the GDP growth rate of NUTS-3 European regions as the dependent variable in a model with the occurrence of natural events as the main explanatory variable. We choose GDP because it summarizes the overall economic impact of the hazard on the regional economy. After the baseline analysis, we investigate whether and to what extent the magnitude of the hazard is a significant explanatory factor for the observed changes in regional GDP. To this end, we construct a novel dataset from three different sources: the United States Geological Survey (USGS), the Global Archive of Large Floods (GAALFS), and Eurostat disaster data. This dataset, which we have named DisastEur, although it excludes wildfires and storms, allows us to derive precise measures needed to construct a severity indicator. Finally, we examine the moderating role that the quality of regional institutions plays on the relationship between the occurrence of "natural" disasters and post-event regional economic performance. Specifically, we examine whether regions with good institutional quality recover better and faster than regions with poor governance.

This paper contributes to the growing literature dealing with the economic impact of "natural" disasters in three ways. First, some work has explored this topic in contexts such as China (Guo et al., 2022) and the United States (Strobl, 2011) by conducting regional analyses and the use of GDP and income growth as indicators. However, it is essential to note that the unit of analysis in the case of China, i.e., Chinese provinces, encompasses a considerably larger geographical area and population compared to European NUTS-3 regions. This distinction renders Chinese provinces more similar to European countries than to the more fine-grained NUTS-3 regions. In addition, the characteristics and typology of disaster events in the US, as well as in China, differ significantly from those in Europe. Consequently, our study holds particular significance as it offers a focused and tailored analysis of European characteristics and the unique nature of disasters experienced in this region. Second, concerning disaster magnitude, Onuma et al. (2021) categorize events as either catastrophic or non-catastrophic based on their severity, but this classification is applied at the country level. This approach overlooks the potentially outsized impact that an event affecting even the national economy can have at the local level. In addition, the availability of comprehensive and detailed information on the severity of disasters in Europe is notably limited. Our effort, which results in the development of a novel dataset, moves steps towards enhancing the quality of analyses. Finally, several studies (e.g., O'Brien et al., 2012; Kusumasari et al., 2010) have explicitly emphasized the importance of the quality of regional institutions but have not included this aspect in their empirical analyses. Instead, other works (Bos et al., 2022; Dìaz and Larroulet, 2021; Tol, 2022) have estimated the role of the quality of country institutions in mitigating the economic impact of "natural" disasters, but without considering the role of governance at the sub-country or local level.

The remainder of this paper is structured as follows: Section 2 reviews the literature; Section 3 illustrates the data and methodology; Section 4 presents the results of the empirical analysis; Section 5 briefly discusses the findings; and Section 6 draws a conclusion.

2. Literature

Several researchers have contributed to the literature on the impact of "natural" disasters on the economy focusing on the impact on GDP. Since this paper deepens the impact of disasters in the year of the event and the recovery period immediately after the disaster, the following literature review will mainly deal with studies that focus on short-term analyses.

2.1. The effect of "natural" disasters on GDP

A large body of research has examined the effects of disasters on the economy and GDP. However, the majority of this research is based on empirical country-level analyses. Only sometimes scholars use GDP data at a more disaggregated level and conduct analyses at the district level (Coffman and Noy, 2011; Strobl, 2011; Xiao, 2011; Belasen and Polachek, 2009), provincial level (Guo et al., 2022), or municipal level (De Oliveira et al., 2020). None of these studies have been conducted in Europe: The first studies (Coffman and Noy, 2011; Strobl, 2011; Xiao, 2011; Belasen and Polachek, 2009) have been conducted in the United States, while the second (Guo et al., 2022) was carried out in China and the third (De Oliveira et al., 2020) in Brazil. Furthermore, the typology of events and the socio-economic context in Europe significantly diverge from those in China, the United States, and Brazil. As a result, while these prior contributions are undeniably valuable, they may not be fully equipped to comprehensively analyze the specific nuances and effects within the European context. Moreover, the work of De Oliveira et al. (2020) discusses GDP only marginally.

Other works have conducted analyses at a more disaggregated level than the country level but have focused on economic variables other than GDP: for example, rising expenditures (Masiero and Santarossa, 2020), VAT survey (Aguirre et al., 2022), personal income (Roth Tran and Wilson, 2022; Mu and Chen, 2016), house prices (Roth Tran and Wilson, 2022; Boustan et al., 2017), or the human development index and poverty levels (Rodriguez-Oreggia et al., 2013).[2]

One of the objectives of this paper is to evaluate the impact of "natural" disasters on the GDP of the NUTS-3 regions in the same year of the event. Indeed, Raddatz (2007) points out that most of the costs and significant negative impacts of climate hazards on GDP per capita occur precisely in the year of the event. However, as evidenced by

[1] In this paper, we use the term "regional governance" to refer to the institutional government of the NUTS-2 regions.

[2] Many studies (Noaj, 2023; Tasri et al., 2022; Peduzzi, 2019; Felbermayr and Groeschl, 2014; Fomby et al., 2013; Loayza et al., 2012; Noy, 2009; Raschky, 2008; Kellenberg and Mobarak, 2008; Raddatz, 2007; Toya and Skidmore, 2007) have found that socio-economic conditions, economic development and income levels in the impact of disasters play a crucial role in the impact of disasters. However, these aspects are beyond the scope of this paper. Tasri et al. (2022) make a good synthesis noting that unemployment and poverty variables have a significant effect on disaster loss and at the same time disaster losses have a significant impact on income inequality.

Cavallo and Noy (2011), analyses of the economic impact on GDP when a hazard occurs have shown mixed results: negative (Noaj, 2023; Klomp and Valckx, 2014; Hochrainer, 2009; Noy, 2009; Raddatz, 2007), uncertain (Onuma et al., 2021; Leiter et al., 2009) or even positive (Albala-Bertrand, 1993). Noy (2009) highlights that the occurrence of a hazard and the resulting property damage are always negative determinants of GDP growth. Klomp and Valckx (2014) and Hochrainer (2009) confirm that "natural" disasters usually lead to significant negative effects on GDP. In contrast, Albala-Bertrand (1993) argues that disasters can have a neutral or positive effect on the economy.

Because they focus on country-level impacts, these studies overlook the potential impacts of disasters at the local level, which are negligible when assessed at the country level, as Barone and Mocetti (2014) point out. They emphasize that the impacts of "natural" disasters are geographically concentrated and that their assessment through a cross-country approach may result in statistically insignificant impacts or overlook the real impacts on the local economy, as confirmed also by Bănică et al. (2020) and Marin and Modica (2017). Indeed, "natural" disasters strike more typically a local or regional part of a country than an entire nation (Escaleras and Register, 2012) with localized economic effects (Bănică et al., 2020). Deryugina (2022) confirms this by showing that impacts on certain economic variables, such as migration and income, are significant at the local level but may not be significant at the national level. Also, Cohen and Walker (2008) underscore that regional shocks as natural hazards have less impact on the national government's income than on that of the local region. Therefore, we put forward the following hypothesis:

H1: Regardless of the impact at the country level, the occurrence of a "natural" disaster has a significant impact on GDP at the local level.

By contrast, Cavallo et al. (2013) found that only disasters classified as large (above the 99th percentile) affect the performance of the economy after the event. In addition, much work addresses differences in economic impacts resulting from differences in disaster size and type (Roth Tran and Wilson, 2022; Onuma et al., 2021; Panwar and Sen, 2019; Shaari et al., 2017; Klomp, 2016; Cavallo et al., 2013; Fomby et al., 2013; Loayza et al. 2012; Noy, 2009; Chhibber and Laajaj, 2008). Loayza et al. (2012) point out that disasters affect economic growth differently depending on the type of hazard and the sector of the economy affected. Panwar and Sen (2019) confirm that dividing natural hazards into sub-groups based on the type makes the estimates more insightful. According to Cavallo et al. (2021), Strulik and Trimborn (2019), and Felbermayr and Gröschl (2014), estimated GDP responses vary proportionally with the magnitude of the disaster. Panwar and Sen (2019), Noy (2009), and Kousky (2014) confirm that larger disasters have a more negative effect. Moreover, only moderate disasters can have a positive effect on growth in some sectors of the economy, while severe phenomena never do (Shaari et al., 2017; Fomby et al., 2013; Loayza et al., 2012). Onuma et al. (2021) reiterate that disasters classified as "catastrophic" generally have negative impacts, while only those classified as "non-catastrophic" can have some positive impacts. Parker (2018) summarizes that major disasters exceed the economy's ability to remain resilient. On the other hand, Klomp (2016) points out that smaller disasters tend to have no impact on the economy. Therefore, we hypothesize the following:

H2: The impact of the occurrence of a natural hazard on GDP is correlated with the magnitude of the "natural" disaster.

In addition to these variables, Fomby et al. (2013) point out that the timing of the event is also an important characteristic. They find that negative impacts tend to occur immediately after the disaster, while positive impacts occur with some delay. Finally, Roth Tran and Wilson (2022) emphasize that the post-disaster response also depends on the severity and nature of the disaster.

2.2. The role of the quality of regional governance in the impact of "natural" disasters

In assessing the impact of "natural" disasters on economies and populations, the quality of institutions and political leadership must be considered as critical factors. In terms of impact on the affected population, government stability, government effectiveness, and strong institutions have a significant moderating effect on the death toll during "natural" disasters and play a kind of "protective shield" for the population (Raschky, 2008; Strömberg, 2007; Kahn, 2005). Kahn (2005) also notes that higher levels of government corruption could increase fatalities.[3] Calossi et al. (2012) further note that disaster severity may even be a consequence of corruption. In addition, political and institutional factors are also critical to the economic impact of "natural" disasters (Cavallo et al., 2021). Indeed, better institutional quality reduces the negative impact of the event on per capita income (Felbermayr and Gröschl, 2014), is associated with lower macroeconomic costs (Noy, 2009), decreases the general adverse impact (Boudreaux et al., 2023; Breckner et al., 2016), and makes possible the hypothesis of "Blessing in Disguise"[4]; (Kourtit et al., 2023). Dìaz and Larroulet (2021) add that property rights and freedom of international trade can also reduce the negative impact of disasters. Bos et al. (2022) support this view by confirming that effective government, low levels of corruption, regime permanence, and regulatory quality improve the recovery process after a disaster. On the other hand, a lack of government capacity increases vulnerability and can lead to inadequate disaster protection (Tol, 2021)[5] and poor quality of institutions can hamper the benefits of public expenditure for reconstruction (Basile et al., 2023).

When it comes to the impact of disasters, the quality of local institutions matters more than the quality of national institutions. Indeed, O'Brien et al. (2012) point out that disaster risk can be most effectively reduced by good local governments. Cutter (2005) also emphasizes that one of the factors that make a community more resilient is local governance. Schneider (1992) concurs in emphasizing that local governments are the first to address emergencies. Moreover, the quality of regional government institutions is one of the most important determinants of the shape of all crises in the EU (Rios and Gianmoena, 2020; Ezcurra and Rios, 2019), including "natural" disasters. The quality of local governments is crucial for the difference between timely or delayed recovery and between good or bad aftermaths, as they very often respond differently to the damage caused by the occurrence of a "natural" disaster. Ayala-Garcia and Dall'erba (2022) point out that local governments primarily take action to save the lives and physical integrity of residents and pay less attention to the damage caused by the occurrence of natural disasters. Moreover, Barone and Mocetti (2014) emphasize that inappropriate use of financial aid provided by the central government is not only less useful but may even affect long-term growth.

In this framework, the degree of quality of regional governance institutions is important not only after the event but also during the event and in the period leading up to it (Kusumasari et al., 2010). Institutions are able to adopt vulnerability reduction strategies, but these decisions are often influenced by political and cultural factors (Pescaroli and Alexander, 2016) and depend on the effectiveness of pre-emergency planning (Henstra, 2010). Local governments, however, are usually in trouble when faced with disasters and preparing to manage a crisis because they have limited knowledge, expertize, and skills to deal with it (Kusumasari et al., 2010). Good local governance is critical as they face many non-traditional issues during this time, ranging from repairing infrastructure to reducing vulnerability to future hazards (Crow et al., 2018). Moreover, Green (2005) points out that the adoption of wrong or not good policies can be considered one of the main causes of disasters. Therefore, we put forward the following hypothesis:

[3] Corruption is also one of the key indicators used to determine the quality of institutions in the QoG index (Charron et al., 2021).

[4] The scenario in which a region or country in the long run can stay better than before (Kourtit et al., 2023).

[5] The government capacity is the ability of the government to raise taxes and provide public goods (Besley and Persson, 2009).

Table 1
NUTS-3 regions excluded because they coincide with the NUTS-2 region.

n°	Country	NUTS-3	n°	Country	NUTS-3
1	Belgium	Bruxelles	15	Lithuania	Vilnius
2	Czech Republic	Praga	16	Hungary	Budapest
3	Germany	Berlin	17	Hungary	Pest
4	Germany	Hamburg	18	Netherlands	Utrecht
5	Spain	Asturias	19	Austria	Wien
6	Spain	Navarra	20	Portugal	Algarve
7	Spain	La Rioja	21	Portugal	Lisbon
8	Spain	Madrid	22	Portugal	Acores
9	Spain	Murcia	23	Portugal	Madeira
10	Spain	Ceuta	24	Slovakia	Bratislava
11	Spain	Melilla	25	Finland	Helsinki
12	Italy	Bolzano	26	Finland	Aland
13	Italy	Trento	27	Sweden	Stockholm
14	Italy	Valle d'Aosta			

Source: Our own elaboration on Eurostat data.

H3.1: The higher the level of quality of regional institutions, the lower the time of recovery.

According to Masiero and Santarossa (2020), low-quality local institutions may not only lead to incomplete or delayed recovery after a disaster but also hinder local economic growth. Then there is an additional hypothesis:

H3.2: The higher the level of quality of regional institutions, the higher the level of economic outcomes.

3. Data and methods

3.1. Data

To conduct our analysis, we obtained data from five sources: Eurostat, EM-DAT, GAALFS, USGS, and the QoG Institute. Our analysis covers the period between 2003 and 2017. Further details on the data and sources are provided below.

3.1.1. GDP

The GDP data used in our analysis are from the Eurostat database – Rural Development section. We compute the GDP growth rate on the total GDP at current market prices. A small number of countries were excluded due to incomplete or missing data: France was excluded due to missing GDP data at the NUTS-3 level before 2015; Albania and Norway were also excluded due to missing GDP data before 2007 and 2008, respectively. In addition, we also excluded the United Kingdom because the data were not available at Eurostat; Serbia and Montenegro were excluded because it was difficult to locate events at the NUTS-3 level.

Because local effects are identified as the difference between the country and regional effects, all NUTS-3 regions that match NUTS-2 regions are excluded (see Table 1 for the list of exclusions). Cyprus and Malta were also excluded as NUTS-2 and NUTS-3 regions overlap completely.

3.1.2. Disaster

The most commonly used database for disaster events in the literature is the Emergency Events Database (EM-DAT), provided by the Centre for Research on the Epidemiology of Disasters (CRED) of the Université Catholique de Louvain. This database collects information from various sources (UN agencies, nongovernmental organizations, insurance companies, research institutes, and press agencies) and is available from 1900 onwards. It contains disasters that meet one or more of the following conditions: at least ten deaths, at least one hundred people affected, the declaration of a state of emergency by the affected country, or an international request for assistance. The dataset contains information on the geographic location of the disaster, the date of the event, the number of people affected (injured, dead, and homeless), and, rarely, the magnitude of the event (CRED, 2021). From this dataset, we extrapolate information about the geographic location of the hazard.

Despite Felbermayr and Gröschl's (2014) criticism of possible selection bias in this database, EM-DAT was considered the best data source for hazard-driven analysis. Moreover, by limiting the sample to the European case, differences in economic development between countries are less pronounced than in the global context, an aspect that limits the issue of comparability.[6]

Moreover, information on the intensity and magnitude of natural hazards is very scarce. Therefore, to make our analysis more comprehensive, we will draw on additional data sources to gain a better understanding of the severity of these events. Specifically, we use flood data from the Global Active Archive of Large Flood Events (GAALFS; Brakenridge, 2023), earthquake data from the Earthquake Hazards Program (USGS, 2023), and extreme temperature data from Eurostat.

In the case of floods, we take the list of events, latitude and longitude coordinates for geolocation, and the severity index provided by GAALFS. For the earthquakes, we gather latitude, longitude, and Richter scale magnitude data from EHP. We made the decision, in line with USGS[7] guidelines, to consider a "natural" disaster - and then include in our dataset - all the earthquakes with a magnitude exceeding 5 on the Richter Scale. Finally, regarding extreme temperature occurrences, we use the Heating Degrees Days (HDD) index.[8] Following the USGS guidelines for earthquakes, our criteria for classifying all events as "natural" disasters" are as follows: An event is included in the dataset as a "natural" disaster" if the indicator for a given year in a region NUTS -3 exceeds the average of all other years in the dataset (2003–2017) by at least 20%.

In this study, we consider the natural hazards that occurred in Europe between 2003 and 2017.[9] From this baseline dataset, we excluded all man-made hazards classified as technological hazards by EM-DAT ("various accidents", "industrial accidents", and "traffic accidents"). Finally, only events that were unambiguously attributed to a specific NUTS-3 region were considered: The mere assignment of an event to a NUTS-2 level was not sufficient to conclude that it had occurred in the entire area, including all corresponding NUTS-3 regions. Under this criterion, 75 "natural" disasters out of 527 events were

[6] This selection bias is caused by the correlation shown between the economic development, specifically the GDP-per capita, of a country affected by a disaster and the probability of that disaster being included in the database (Felbermayr and Gröschl, 2014).

[7] https://www.usgs.gov/faqs/what-magnitude-does-damage-begin-occur-earthquake

[8] Eurostat compute this index summing all the degrees over the mean temperature of the NUTS-3 region (https://ec.europa.eu/eurostat/cache/metadata/en/nrg_chdd_esms.htm).

[9] All the disasters occurring in France, Norway, Serbia, Montenegro, Malta, and Cyprus were excluded due to the previously described problem on GDP data and of geolocation. Additionally, the disasters of the NUTS-3 listed in Table 1 were excluded.

Table 2
Descriptive statistics of disasters and NUTS-3 regions.

Year	Total Number of NUTS-3 regions	Nuts-3 regions affected		Number of Disasters	
		All Disasters	"Natural" Disasters	All Disasters	"Natural" Disasters
2003	1028	146	139	43	32
2004	1028	61	54	36	25
2005	1028	204	200	75	67
2006	1028	104	96	48	36
2007	1028	184	181	51	43
2008	1028	57	53	33	22
2009	1028	79	73	34	26
2010	1028	94	85	48	39
2011	1028	37	33	17	11
2012	1028	125	122	41	36
2013	1028	72	66	34	26
2014	1028	94	88	38	29
2015	1028	41	39	19	17
2016	1028	29	26	20	16
2017	1028	70	68	31	27
Total	1028	1397	1323	568	452
Average	1028	93	88	38	30

Source: Our own elaboration on EM-DAT data.
In columns (3) and (4) there is the number of NUTS-3 regions affected by all disasters (also those called technological) and by "natural" disasters (which are the focus of the analyses over time). In columns (5) and (6) there are the number of disasters (any type) and "natural" disasters.

excluded from the analysis. Table 2 shows the number of disaster events (including all hazards and natural disasters) and the number of NUTS-3 regions that were affected by them.

On average, 88 out of 1028 NUTS-3 regions (in 178 NUTS-2 regions) experience at least one natural hazard per year. In addition, the aforementioned 88 regions are affected by 30 "natural" disasters per year; thus, each disaster affects an average of approximately 3 NUTS-3 regions.[10]

On the other hand, Table 3 presents the descriptive statistics of the novel dataset DisastEur.

Similar to the previous case, extreme temperature events, including droughts, continue to be the most frequent hazard in Europe.

Table 3
Descriptive statistics of the disasters in the dataset DisastEuro.

	Extreme Temperatures (and droughts)	Floods	Earthquakes	Total
Number of events	445	100	75	620

Source: Our own elaboration on Eurostat, GAALFS and USGS data.

3.1.3. Quality of regional governance

Data on the quality of regional government institutions come from the European Quality of Government Index provided by the QoG Institute at the University of Gothenburg (Charron et al., 2021). The quality of government is measured by the EQI (European Quality of Government) index, which is based on the perceptions and experiences of over 129,000 respondents in 208 regions of the 27 EU member states. Perceptions relate to corruption, quality, and impartiality of three essential public services – i.e. health, education, and policing. Values for the EQI index range from −2.5 (for regions with the worst governance) to 2.5 (for regions with the best governance). Although there is little technical analysis of the methodology, this index is considered the best source for this type of analysis because, unlike other data sets - such as the World Bank's World Governance Indicators - it allows for an in-depth examination at the regional level (NUTS-2).

4. Methods

To test the previously stated hypotheses, we use two regression models.[11] The first is model A, which aims to test the first two hypotheses by examining how the occurrence of natural hazards impacts the GDP of NUTS-3 regions in the year of the event. We also use this model to delve into the differences in economic impacts based on the magnitude of the disasters. The second model is Model B, which examines the moderating role of the quality of regional governance after the event. The methodological path is shown in Fig. 1.

In both models, the dependent variable is always VarGdpNuts3, which is the GDP growth rate of 1028 European NUTS-3 regions. By using the GDP growth rate at this level of disaggregation, we are able to summarize the macroeconomic impact of the occurrence of natural hazards on the local economy. A detailed description of these models is provided in the following subsections.

4.1. Model A

$$\boldsymbol{VarGdpNuts}3 = \beta_0 + B_1\boldsymbol{event}_{i,t} + \beta_2\boldsymbol{regionalgovernance}_k + \beta_3\boldsymbol{VarGdpCountryAdj}_{i,t} + \beta_4\boldsymbol{regionalcorrection}_{i,t} + \beta_5\boldsymbol{crisis}09_t + \beta_6\boldsymbol{Crisis}10_t + \in_{i,t}$$

In this model, data related to NUTS-3 regions are indexed by *i*, while data related to NUTS-2 regions are indexed by *k*. The main regressor in model A is the variable *event*; depending on the models, it can take the following values:

1. *eventnuts3 (model 1):* This is a dummy variable that equals 1 if a NUTS-3 region was affected by a natural event in year *t* and 0 otherwise. This variable aims to examine the economic effect of the occurrence of natural hazards on the GDP of the affected NUTS-3 regions in the year of the event.
2. *disasterseverity (model 2):* This variable is a graded index of disaster severity, derived from the aggregation of severity indices of three

[10] If we also consider man-made disasters, the total number of regions affected increases to 93.

[11] The random effects specification is supported by three main reasons (Elhorst, 2014). Firstly, it provides a solution to the all or nothing way of utilizing the cross-sectional component of the data. Secondly, it avoids the loss of degrees of freedom that occurs in the fixed effects model when dealing with a relatively large N. Thirdly, it addresses the problem of not being able to estimate coefficients of time-invariant variables.

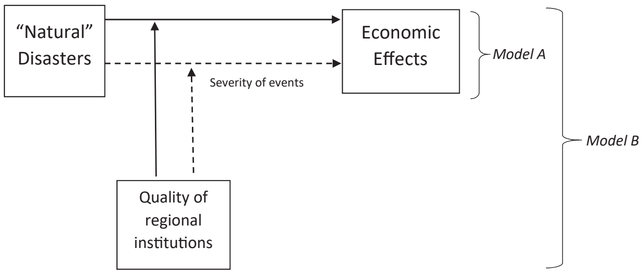

Fig. 1. Flowchart of the methodological path.

distinct types of natural hazards: earthquakes, floods, and extreme temperature (which can be also a proxy for the droughts events). As detailed in Table 4, we set the value of 1 for the major events and use a graded scale (0.25, 0.5, 0.75) for the other magnitudes ranging from 0 to 1. For flood events, we rely on the severity index provided by GAALFS, which categorizes the events as follows: 1 for large flood events, 1.5 for very large flood events, and 2 for extreme events. Subsequently, we designate events as major disasters – and set the index to 1 - when the GAALFS indicator reaches a value of 2. In the case of earthquakes, we have used the Richter Scale to compute the severity index. Following USGS guidelines, major earthquakes are defined as those with a magnitude exceeding 5.9 on the Richter scale. Likewise, in the case of extreme temperature events, we classify them as major when the index surpasses the average of other years by a margin of at least 20.0%. The complete set of values is presented in Table 4.

The index variable *disasterseverity* is computed as the sum of the three distinct severity indicators. If the total value exceeds 1, we set it at 1.

3. *top10:* This variable is an additional severity index, computed as a dummy variable. It assumes the value of 1 when a NUTS-3 region is affected by a "natural" disaster with a magnitude that falls within the top 10% of the severity distribution, and it takes a value of 0 otherwise. This variable is essentially introduced to run robustness analysis of *disasterseverity;*
4. *top5:* This variable is another index of severity, constructed following the same methodology as t*op10*. However, it differs in that it assumes a value of 1 when a NUTS-3 region is affected by a "natural" disaster with a magnitude that is within the top 5% of the severity distribution. This variable allows us to better analyze the effects of very large events and further strengthens the robustness of the other 2 severity indices.

4.1.1. *Control variables*

In addition to the primary variables of interest, all models include control variables. The first is a variable called *regionalgovernance*, which we calculated by standardizing the value of the EQI index for 2021 between 0 and 1. This index will also play a central role in the analysis conducted with Model B.

It is important to consider the impact of the subprime crisis that hit economies in 2009 and probably in 2010. To this end, we use the dummy variable *Crisis09*, which represents the impact of the subprime crisis in 2009. This variable takes the value 1 for 2009 and 0 for all other years. The second control variable, *Crisis10*, reflects the year immediately after the subprime crisis (2010). In addition, the models include variables that take into account the broader macroeconomic context in which the event occurs, specifically related to the GDP growth rates of countries and NUTS-2 regions. The reason for this is that although the countries are all European, the annual GDP growth rates among them vary widely. The first of these variables is *vargdpcountryadj*, which is the GDP growth rate computed on the GDP of the country after the subtraction of the GDP of the region NUTS-3. To account for the regional context (at the NUTS-2 level) and avoid problems of collinearity with the country's GDP growth rate, we run a separate regression analysis using only the country's GDP growth rate and the region's GDP growth rate (with the region's GDP growth rate NUTS-2 as the dependent variable). We then include the residual (*regionalcorrection*) of this regression in our models as an effect of the regional context on the GDP growth rate.

4.1.2. *Model B*

To investigate the moderating role of regional governance quality, which is the last hypothesis, we will use the following regression model:

$$\begin{aligned}\textbf{\textit{VarGdpNuts}}3 = {} & \beta_0 + B_1\textbf{\textit{event}}_{i,t} + \beta_2\textbf{\textit{regionalgovernance}}_k \\ & + \beta_3\textbf{\textit{event*governance}} + \beta_5 \text{var}\textit{GdpCountryAdj}_{i,t} + \beta_5\textbf{\textit{regionalcorrection}}_{i,t} \\ & + beta_6\textbf{\textit{crisis}}09_t + \beta_7\textbf{\textit{Crisis}}10_t + \in_{i,t}\end{aligned}$$

This model extends Model A to include the interaction term *event*governance*, which allows us to further explore the potential moderating role of regional (at NUTS-2 level) governance quality in the aftermath of the disaster.

To isolate the crucial role of good regional governance after "natural" disasters, we need to consider the interaction term *event*governance*, which is not present in model (A). This term can take the following values:

1. *Eventgovernance* (models 3a, 3b, 3c, and 3d): This variable refers to the interaction between *eventnuts3* and *regionalgovernance,* enabling us to delve deeper into the role of the quality of regional governance on the economic effects of "natural" disasters;
2. *Severitygovernance* (models 4a, 4b, 4c, and 4d): This variable reflects the interaction between *disasterseverity* and *regionalgovernance* and allows us to understand the impact of the quality of regional governance on the economic consequences of "natural" disasters considering the events weighted by the magnitude of the natural hazard.

The variables *eventnuts3*, *disasterseverity*, and their respective interaction terms (*eventgovernance* and *severitygovernance*, respectively) appear in models 3a and 4a in the same year as the dependent variable. Models 3b and 4b introduce a one-year lag, while models 3c and 4c and 3d and 4d provide the analysis with two and three lags, respectively. The role of regional governance in coping with the disaster may not be immediately apparent but may become clear after some lag. These models allow us to further explore the moderating effect of better-quality regional governance after the disaster.

Table 5 presents a description of all the dependent and independent variables used in the analysis, as well as data sources.

Table 4
Values of heating_severity, floods_severity, and earthquake_severity.

Value	*heating_severity*	*floods_severity*	earthquake_severity
0	no event	no event	no event
0.25	20–22.5% higher	Severity index = 1	5–5.29 Richter Scale
0.5	22.5–25% higher	Severity index = 1.5	5.3–5.59 Richter Scale
0.75	25–27.5% higher	Severity index = 1.5	5.6–5.89 Richter Scale
1	> 27.5% higher	Severity index = 2	> 5.9 Richter Scale

Source: Our own elaboration on Eurostat, GAALDS and USGS data.

Table 5
Description of all the dependent and independent variables.

Variables	Description	Data Source
Independent Variable		
VarGdpNuts3	The growth rate of the GDP of the NUTS-3 region *i* in the year *t*	Eurostat
Dependent Variables		
eventnuts3	Dummy of the occurrence of a "natural" disaster in the NUTS-3 region *i*	EM-DAT
disasterseverity	Index considering the occurrence of a natural hazard and the size of the disaster. It is the sum of the index severity of heating, earthquake, and floods	Eurostat, GAALFS and USGS
top10	Dummy of the occurrence of a disaster in the top 10% of the distribution in the NUTS-3 region i	Eurostat, GAALFS and USGS
top5	Dummy of the occurrence of a disaster in the top 5% of the distribution in the NUTS-3 region i	Eurostat, GAALFS and USGS
regionalgovernance	Index of the quality of regional institutions at NUTS-2 level. It is standardized between 0 and 1	QoG Institute
eventgovernance	Interaction between the dummy *eventnuts3* and the index *regionalgovernance*	EM-DAT and QoG Institute
severitygovernance	Interaction between the index *disasterseverity* and the index *regionalgovernance*	Eurostat, GAALFS, USGS and QoG Institute
vargdpcountryadj	The growth rate of the GDP of the respective country with the adjustment described above by the GDP of the NUTS-3 region	Eurostat
regionalcorrection	It is the residual of the regression between the GDP growth rate of NUTS-2 region and country	Eurostat
crisis09	Dummy of the Sub-prime Crisis. It is equal to 1 when year = 2009	
Crisis10	Dummy of the Sub-prime Crisis. It is equal to 1 when year = 2010	

Source: Our own elaboration.

5. Results

In this section, we present the results of the regressions by splitting the evidence on the two main analyses into the following two sections: (i) the immediate effect on GDP and (ii) the regional governance effect. The first subsection focuses on answering to the first two hypotheses concerning the immediate effect of natural hazards on the economies of NUTS-3 regions and the extent to which the magnitude of the economic impact can be explained by the severity of the events. The second subsection addresses the moderating role of the quality of regional governance after the event.

5.1. The immediate effects of "natural" disasters on the GDP of NUTS-3 regions

The results of our first analysis are presented in Table 6, which shows a significant negative effect of the occurrence of a natural hazard on the GDP of the affected NUTS-3 region. Specifically, our results show that when a NUTS-3 region is affected by a "natural" disaster, its GDP falls by approximately 0.28 percentage points in the same year of the event (Model 1), compared to a region that is not affected by the event.

This finding illustrates the relevance of the geographical disaggregation of the analysis. The occurrence of a "natural" disaster may cause local economic damages but impacts of this magnitude are rarely significant at the country level.[12]

In analyzing this effect, it should be emphasized again that the database used for this analysis includes all disasters regardless of their magnitude.[13] This could lead to an underestimation of the real economic impact of the most severe hazards. Indeed, Klomp (2016) points out that only about 10% of the disasters recorded at EM-DAT result in more than a hundred deaths. In our sample, 6.2% of disasters claimed more than 50 lives, and only 3.9% resulted in more than 100 fatalities. Therefore, as mentioned earlier, we also analyze the impact by considering the magnitude of the disasters.

The results of Model 2 (columns 2) in Table 5 show that the coefficients of *disasterseverity, top10,* and *top5* are significant, and all of them are larger (in absolute value) than the coefficient of *eventnuts3*. This result supports the hypothesis that larger natural events cause greater damage to the local economy. Thus, the magnitude of the hazard is likely to explain a substantial part of the negative economic impact of the occurrence of a "natural" disaster. Specifically, according to *disasterseverity*, a NUTS-3 region that is affected by a large disaster shows a decrease in GDP of about 0.55 percentage points. Following the values of the variables, if the disaster is smaller, it shows a proportional lower decrease.[14] If we consider the case of the variable *top5*, the effect of the magnitude becomes even more evident. Indeed, a NUTS-3 region affected by a disaster included in the top 5% of the severity distribution shows a decline in the GDP of about 0.86 percentage points, more than 3 times the decrease in the case not weighted by the magnitude of the events.

5.2. The moderating role of regional governance in the impact of "natural" disasters

The role of the quality of government institutions in moderating the impact of events on economic outcomes is presented in Table 7. This table presents the results of the models in which we use the interaction between *regionalgovernance* and the dummy variable *eventnuts3* to examine how the economic impact of natural hazards is moderated by the quality of regional governance (at the NUTS-2 level).

The findings presented in Table 7 show that the quality of regional institutions does not appear to exert a significant impact in either the year of the disaster or the subsequent year. However, two years after the event, the moderating effect of the quality of regional governance became clear. Ceteris paribus, despite the negative impact, the GDP growth rate of a NUTS-3 region turns positive if the index of regional governance is above 0.41. Then, regions with good governance tend to recover more quickly after a disaster, usually a year earlier, than regions with poor institutional quality. Nevertheless, even regions with weaker institutional quality eventually returned to growth three years after the event. Regions with good institutional quality continue to have a positive marginal economic effect. These results suggest that weaker institutional quality can hinder the post-disaster recovery process. Consequently, improving the quality of regional governance has a

[12] For instance, the median weight of an Italian NUTS-3 region on the country's GDP is about 2.69%. If we consider the outcome of the model (0.25 percentage points) using the weight on GDP, the negative effect is negligible at around 0.006 percentage points and is irrelevant to the dynamic of GDP.

[13] In the dataset there are earthquakes of magnitude 6.5 on the Richter magnitude scale, but also those with a magnitude of 4.0.

[14] This finding is further supported by using the death toll as a severity indicator, which confirm the direct proportional relationship between the magnitude of natural hazards and economic decline. Furthermore, it is also confirmed that, as we raise the threshold for defining bigger events (keeping *top5* or using a higher threshold of deaths to classify major disasters), the magnitude of this effect increases. Despite the use of the death toll as an indicator can raise concerns about endogeneity, it definitely helps in assessing the robustness of the estimated evidence.

Table 6
Outcomes of the panel regressions of model A: sub-models (1) and (2).

VARIABLES	(1) Vargdpnuts3	(2a) Vargdpnuts3	(2b) Vargdpnuts3	(2c) Vargdpnuts3
eventnuts3	-0.00283**			
	(0.00138)			
disasterseverity		-0.00545*		
		(0.00328)		
top10			-0.00698*	
			(0.00367)	
top5				-0.00859*
				(0.00445)
regionalgovernance	0.00538***	0.00604***	0.00609***	0.00611***
	(0.00139)	(0.00136)	(0.00135)	(0.00135)
vargdpcountryadj	0.971***	0.968***	0.968***	0.968***
	(0.0136)	(0.0136)	(0.0136)	(0.0136)
regionalcorrection	-0.272***	-0.272***	-0.271***	-0.271***
	(0.0531)	(0.0530)	(0.0531)	(0.0531)
crisis09	-0.00663***	-0.00688***	-0.00685***	-0.00682***
	(0.00163)	(0.00162)	(0.00162)	(0.00162)
crisis10	0.00300**	0.00344**	0.00299**	0.00300**
	(0.00144)	(0.00148)	(0.00144)	(0.00144)
Constant	-0.00310***	-0.00353***	-0.00358***	-0.00360***
	(0.000964)	(0.000947)	(0.000941)	(0.000940)
Observations	15,420	15,420	15,420	15,420
R-squared	0.649	0.648	0.648	0.648
Number of id	1028	1028	1028	1028

Source: Our own elaboration.

Table 7
Outcomes of the panel regressions of model B: sub-models (3a), (3b), (3c), and (3d).

VARIABLES	(3a) VarGdpNuts3	(3b) VarGdpNuts3	(3c) VarGdpNuts3	(3d) VarGdpNuts3
eventnuts3	-0.00361			
	(0.00291)			
eventnuts3 = L,		0.00465		
		(0.00336)		
eventnuts3 = L2,			-0.00699**	
			(0.00347)	
eventnuts3 = L3,				0.00598**
				(0.00282)
eventgovernance	0.00219			
	(0.00601)			
eventgovernance = L,		-0.0119		
		(0.00743)		
eventgovernance = L2,			0.0121*	
			(0.00686)	
eventgovernance = L3,				-0.0119**
				(0.00591)
regionalgovernance	0.00522***	0.00777***	0.00534***	0.00855***
	(0.00146)	(0.00143)	(0.00149)	(0.00156)
vargdpcountryadj	0.971***	0.961***	0.966***	0.969***
	(0.0138)	(0.0146)	(0.0153)	(0.0167)
regionalcorrection	-0.272***	-0.257***	-0.258***	-0.263***
	(0.0531)	(0.0537)	(0.0581)	(0.0618)
crisis09	-0.00660***	-0.00726***	-0.00651***	-0.00669***
	(0.00165)	(0.00169)	(0.00176)	(0.00182)
crisis10	0.00300**	0.00312**	0.00319**	0.00299**
	(0.00144)	(0.00144)	(0.00145)	(0.00146)
Constant	-0.00303***	-0.00440***	-0.00310***	-0.00519***
	(0.000976)	(0.000951)	(0.00101)	(0.00103)
Observations	15,420	14,392	13,364	12,336
R-squared	0.649	0.651	0.658	0.646
Number of id	1028	1028	1028	1028

Source: Our own elaboration.

direct impact on the local economy and can lead to a proportional increase in GDP growth rates. Moreover, delaying the recovery by just one year can make a significant economic difference, with a quantifiable impact of one to two percentage points in turning the situation positive after two years.

Further evidence of the crucial role that the quality of regional governance plays in determining the economic impact of “natural” disasters is provided by the results of the models in Table 8. Specifically, in the analysis, the dummy variable *eventnuts3* is replaced by the index *disasterseverity* (and then also the interaction term), also taking into account the magnitude of the natural hazards.

Table 8 reveals that, in the case of a major disaster, the effect of regional institutional quality becomes evident and important within

Table 8
Outcomes of the panel regression of model B: sub-models (4a), (4b), (4c), and (4d).

VARIABLES	(4a) VarGdpNuts3	(4b) VarGdpNuts3	(4c) VarGdpNuts3	(4d) VarGdpNuts3
disasterseverity	0.000431			
	(0.00650)			
disasterseverity = L,		-0.0157**		
		(0.00701)		
disasterseverity = L2,			0.00619	
			(0.00767)	
disasterseverity = L3,				0.00513
				(0.00891)
severitygovernance	-0.0154			
	(0.0156)			
severitygovernance = L,		0.0244*		
		(0.0141)		
severitygovernance = L2,			-0.0105	
			(0.0155)	
severitygovernance = L3,				-0.00859
				(0.0168)
regionalgovernance	0.00625***	0.00623***	0.00739***	0.00710***
	(0.00137)	(0.00138)	(0.00147)	(0.00137)
vargdpcountryadj	0.968***	0.963***	0.961***	0.973***
	(0.0136)	(0.0142)	(0.0153)	(0.0164)
regionalcorrection	-0.272***	-0.256***	-0.259***	-0.263***
	(0.0531)	(0.0542)	(0.0578)	(0.0620)
crisis09	-0.00686***	-0.00706***	-0.00717***	-0.00627***
	(0.00162)	(0.00166)	(0.00170)	(0.00179)
crisis10	0.00371**	0.00312**	0.00328**	0.00308**
	(0.00151)	(0.00145)	(0.00146)	(0.00146)
Constant	-0.00365***	-0.00354***	-0.00427***	-0.00442***
	(0.000953)	(0.000967)	(0.000997)	(0.000973)
Observations	15,420	14,392	13,364	12,336
Number of id	1028	1028	1028	1028
R-squared	0.649	0.651	0.658	0.646

Source: Our own elaboration.

just 1 year after the event. In addition, the threshold for the quality of regional governance to return to economic growth must be higher compared to the previous analysis. Specifically, only NUTS-3 regions with a regional government score exceeding 0.52 experience a positive GDP growth rate one year after the disaster.[15] The importance of regional institutions becomes even more pronounced. Indeed, achieving recovery from major disasters requires a heightened level of institutional quality, and this need comes before the other case.

5.3. Robustness checks

The use of different variables and data sources throughout the study may present some challenges. Firstly, the EM-DAT dataset used in the initial analysis provides a comprehensive record of all natural hazards that occurred in the selected countries during the specified time period. However, in the robustness analysis, sources are used that focus exclusively on earthquakes, floods, extreme temperatures, and droughts, and exclude wildfires, volcanic activity, and storms. For this reason, we decided to repeat the original analysis and exclude events not included in the robustness analysis (wildfires, volcanic activity, and storms). The results presented in Table 9 show a more significant decline in the GDP growth rate of the affected country.

We attribute this evidence to the observation that excluded events tend to have a relatively smaller impact on economic activity and population well-being than other types of natural hazards, such as earthquakes. Secondly, the positive correlation between the magnitude of the natural hazard and the size (in absolute terms) of the economic impact on the region's GDP is supported by three different measures of event magnitude, i.e., the disasterseverity, top10, and top5 indices. This threefold different approach to calculating the indices ensures the robustness of the results and overcomes potential problems associated with the choice of a particular calculation method.

6. Discussion

The first part of the analysis aims to examine the direct impact on the GDP of NUTS-3 regions. The results show that the impact of "natural" disasters on the local economy is significant and negative, demonstrating the local nature of hazard events. Moreover, the higher the severity of the hazard, the more negative the economic decline. It should be noted, however, that the result of the first regression may be underestimated due to the composition of the disaster database, as mentioned earlier: We included in the analysis all-natural events that occurred in Europe and met the requirements of EM-DAT, without exclusion by magnitude.[16] For example, the database also includes earthquakes of magnitude 4 on the Richter scale, which generally do not cause significant damage. Another point to address is the temporal impact of the month in which the event occurred. For example, a disaster that occurred in late December is unlikely to affect the GDP of that year but may affect the GDP of the following year (Raddatz, 2009). On the other hand, an event that occurred in early January may be more significant or experience a partial recovery. The analysis of variations in economic impact across different time periods of the year faces challenges. The distribution and the typology of events throughout the year (as shown in Table 10), makes very hard the possibility of analyzing the differences in economic impact across the different periods over the year. Indeed, the nature of hazards is heavily influenced by the season of the year, and delving into distinctions across months would need a different empirical approach that probably falls beyond the scope of this paper.

[15] In the previous estimation the threshold was 0.41.

[16] See Section 3.1.2.

Table 9
Robustness check on the difference between the 2 datasets.

VARIABLES	(1) Vargdpnuts3	(2) Vargdpnuts3
disasterindex	-0.00347**	
	(0.00171)	
Eventnuts3part		-0.00417***
		(0.00160)
regionalgovernance	0.00604***	0.00503***
	(0.00135)	(0.00141)
vargdpcountryadj	0.968***	0.971***
	(0.0136)	(0.0137)
regionalcorreciton	-0.272***	-0.272***
	(0.0530)	(0.0530)
crisis09	-0.00690***	-0.00661***
	(0.00162)	(0.00163)
crisis10	0.00397**	0.00308**
	(0.00155)	(0.00144)
Constant	-0.00351***	-0.00291***
	(0.000946)	(0.000972)
Observations	15,420	15,420
R-squared	0.649	0.649
Number of id	1028	1028

Source: Our own elaboration.

The second part of the analysis focuses on the impact of the quality of regional government institutions on the recovery process after a “natural” disaster. As the results show, NUTS-3 regions located in NUTS-2 regions with superior quality institutions resume growth earlier than the others. Looking at the negative impact of the “natural” disaster on GDP for all NUTS-3 regions in the same way, it can be seen that the regions with lower quality institutions (an index of regional government less than 0.25) fail to regain their pre-disaster GDP levels even three years after the disaster. Two years after the disaster, only NUTS-2 regions with a regional governance score above 0.57 were able to reach their pre-disaster GDP levels. Ceteris paribus, the difference in GDP levels three years after the disaster between regions with a regional governance score close to 1 and those with a regional governance score close to 0 is likely to be about 1.2 percentage points.

If we consider the severity index of the natural hazards, the threshold for regional governance that allows for non-negative growth is higher than in the previous case. Specifically, if we consider the economic impact of a disaster with the highest severity (*disasterseverity* = 1) one year after the event, only regions with a regional governance index higher than 0.7 can reach their pre-disaster GDP level. Ceteris paribus, the difference in GDP level two years after the event is more than two percentage points when regions with the highest quality of regional governance (*regionalgovernance* close to 1) are compared to those with the lowest quality (*regionalgovernance* close to 0). One possible explanation of the observation that the influence of regional institutional quality becomes evident more promptly in major disasters than in other cases could be the attention that larger events attract from central government, mass media, and society in general. This attention can lead to a more rapid allocation of resources and an earlier central role in managing resources and operations.

These findings underscore the critical role of local institutions, which, as Crow et al. (2018) and Kusumasari et al. (2010) point out, are the actors that face the greatest problems during disasters but also have the responsibility to make the best decisions that allow people to cope as effectively as possible (Henstra, 2010). The difference between good and bad governance in terms of economic impact is significant and can exacerbate the severity of the event. Green (2005) even emphasized that adopting the wrong policies can contribute to a disaster. Finally, consistent with the findings of Raschky (2008), we reemphasize that better institutions are one factor that can mitigate the negative impacts of “natural” disasters. Therefore, it is critical to examine any institutional weaknesses that could exacerbate the situation. This is an important signal that policymakers need to take into account, rather than continuing to emphasize only the natural dimension of disaster events in order to “find an alibi and try to escape responsibility” (Gaillard et al., 2007).

7. Conclusion

This paper examines the immediate impact of “natural” disasters" on the economies of European NUTS-3 regions, explores the differential impact depending on the severity of the natural hazards, and analyzes the moderating role of the quality of regional institutions (at the NUTS-2 level) after the event.

The results show that there is a significant negative effect on the GDP growth rate of NUTS-3 regions of about 0.28 percentage points. This suggests that many events may appear negligible when analyzed at the country level, while they are significant at the local level. Moreover, the extent of this negative effect exhibits a positive correlation with the severity of the disaster, increasing to 0.56 percentage points when we consider major disasters and to 0.86 when focusing on the top 5% of the severity distribution.

The second part of the analysis highlights the crucial moderating role played by the quality of regional governance institutions. Indeed, the difference between recovery and further losses is almost entirely in the hands of the institutions. The model results show that better quality of governance in the region is essential to achieve a better economic outcome in the shortest possible time. The delay of one year in the recovery of the regions with poorer quality institutions can cost up to two percentage points of the GDP of the region, and even more than two percentage points if we consider the disasters with large impacts.

Efforts directed at enhancing institutional quality should constitute a primary focus for moderating the effects of disasters. Peirò-Palomino et al 2020 practical recommendations for improving the quality of

Table 10
Monthly distribution of the NUTS-3 regions affected by hazards.

Month	Floods	Earthquakes	Storms	Extreme Temperatures	Droughts	Volcanic Activity	Wildfires	Tot	%
1	130	9	134	89	0	0	6	368	27.7%
2	19	1	35	29	0	0	3	87	6.6%
3	29	0	10	0	0	0	0	39	2.9%
4	44	3	0	1	0	0	0	48	3.6%
5	33	2	0	2	0	0	0	37	2.8%
6	63	5	9	53	0	0	20	150	11.3%
7	31	1	13	101	26	0	19	191	14.4%
8	32	4	28	15	9	0	6	94	7.1%
9	33	0	7	2	0	0	0	42	3.2%
10	37	0	13	0	0	0	4	54	4.1%
11	41	3	7	15	0	0	0	66	5.0%
12	19	1	29	102	0	0	0	151	11.4%
Tot	511	29	285	409	35	0	58	1327	100%

Source: Own elaboration on EM-DAT data.

institutions include measures such as simplifying regulatory complexity (Di Vita, 2018). Indicators of enhanced governance quality can be observed through reductions in unemployment and poverty rates (Charron et al., 2019). Moreover, initiatives aimed at raising awareness of natural risks, including the implementation of communication and information campaigns, are integral to improving institution effectiveness in disaster management. Several concurrent activities contribute to fortifying the institutional framework: elevating regulatory standards and requirements for construction to mitigate seismic risks (Mahadevia Ghimire, 2021), recruiting personnel with advanced expertize in the field (Barone and Mocetti, 2014), involving all the levels of institutions responsible for disaster management constructively (Shah et al., 2019), optimizing resource allocation (Wilson and Noy, 2023) and streamlining emergency policy procedures.

This paper is not free from limitations. The first and most important is the lack of additional socioeconomic data at the NUTS-3 level in Europe. This is a common major problem (Meyer et al., 2013; Hochrainer, 2009) that affects this type of work. Indeed, a higher number of socioeconomic variables at this level of disaggregation can improve the analysis and lead to better and more robust results. Second, there is the possibility that the granting of aid to the most affected areas may have an impact on the recovery of neighboring, less affected areas (Lima and Barbosa, 2019). In addition, an analysis of the possible spillover effects between NUTS-3 regions may be an interesting point to explore further, although it is beyond the scope of this study.

Some other questions and aspects can be investigated in future research. First, it would be useful to improve the quality of the disaster database. We tried to collect data in Europe at the local level, but it was a very challenging task. Our dataset DisastEur can be a step in this direction, but an expansion of the database used in Felbermayr and Gröschl (2014) could improve the quality of the analysis. Second, another aspect to explore is the difference in growth between different sectors of the economy. It would be useful to identify which sectors are more affected by disasters and whether there are sectors that experience growth in the short, medium, or long term, as has been studied in depth by Loayza et al. (2012). Finally, an examination of the differences in the economic impacts of different types of natural hazards, both on GDP and on different sectors of the economy, could also be useful.

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