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ECONOMIC RESILIENCE TO NATURAL HAZARDS AND ITS MEASUREMENT

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ABSTRACT: Natural hazards affect both developing and developed countries and cause negative effects. The extent to which societies are affected depends on many factors. For this reason, the issues of both vulnerability and resilience to natural hazards are increasingly and widely addressed in the literature. Of these, work on the economic impact of natural hazards is particularly noteworthy. There is also some work on economic resilience to natural hazards.

The aim of this paper is to present the issue of economic resilience to natural hazards, including the scope of the term and its relationship to disaster resilience. For the purpose of this study, a literature review was carried out. The originality of the study lies in the adoption of the author's definition of economic resilience to natural disasters, the development of an appropriate model and the attempt to construct a measurement tool. According to the author, shaping economic resilience is dependent on the risk and vulnerability of natural hazards. The issue of economic resilience to natural hazards should be considered through the lens of three phases: preparation for natural hazards, adaptation to changing circumstances, recovery and capacity building to respond to potential future disasters. Measuring economic resilience to natural disasters based on the three phases requires further work related to inter alia verifying the availability of data based on the selected study group. The model that has been created can help countries that are often exposed to natural hazards to build up their economic resilience to these hazards.

KEYWORDS: economic resilience, natural hazard, resilience

Introduction

The origin of the term *resilience* dates to the 1970s and is linked to the publication of Holling (1973). Original Holling's definition is as follow: "Resilience determines the persistence of relationships within a system and is a measure of the ability of these systems to absorb changes of state variables, driving variables, and parameters, and still persist."

In this definition, resilience is the property of the system and persistence or probability of extinction is the result. Stability, on the other hand, is the ability of a system to return to a state of equilibrium after a temporary disturbance. The more rapidly it returns, and with the least fluctuation, the more stable it is. In this definition, stability is the property of the system, and the degree of fluctuation around specific states is the result (Holling, 1973). C. Folke reduces this explanation to the following statement: "a way to understand the capacity of ecosystems to absorb change" (Folke, 2016).

Over time, the issue has become more widely addressed by researchers. The issue of resilience became the theoretical foundation for the work with active adaptive management of ecosystems (Folke, 2016). In the 1990s, the resilience concept was developed by The Beijer Institute of the Royal Swedish Academy of Sciences and authors like: Costanza, Holling et al. 1995, Folke, Walker, focusing on the interface of ecology and economy (Folke, 2016).

It should be emphasised that in the literature can be found many definitions of the term. This diversity is dictated by its use in many scientific disciplines. Holling's explanation is related to ecology. However, it is worth highlighting that the term was originally used in psychology, according to the impact of traumatic experiences on the individual and the family (Flemming & Ledogar, 2008; Boczkowska, 2019). Nowadays, a growing number of scientific disciplines are addressing this issue. In view of the subject of the article, we will refer to those related to it in general and more specifically. Here are some examples of definitions:

- The ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management" (UNDRR, n.d.- a).
- Resilience is a critical strategy for regaining control after being exposed to vulnerability. It is a system's adaptive, absorptive, and transformative capacity to respond to, defend against, and recover from current and future vulnerability (Lv et al., 2024).
- Resilience reflects the ability of people, communities, societies, and cultures to live and develop with change, with ever-changing environments. It is about cultivating the capacity to sustain development in the face of change, incremental and abrupt, expected and surprising (Folke, 2016).
- Resilience is the ability of an entity or a system to recover from disturbance and disruption of some kind (Drobniak, 2012).

Based on the above definitions, some common elements can be identified: the system, change understood as a disruption with negative consequences, the ability to recover. Each of these can be developed according to the nature of the disruption, who is affected by it, how to prepare for it and the ability to survive and evolve. 'System' can refer to the social and economic system at micro and macro levels, its ability to withstand, survive and evolve in the face of various types of crises (political, social, financial, economic, environmental). In this respect, it is important to assess the risks and respond appropriately to the crisis. According to C2ES: "Risk is a function of threat and vulnerability. Vulnerability is determined by sensitivity, exposure, and adaptive capacity of an individual or system" (C2ES, 2019).

Taking into account the response to the risk of the threats or the threats that have arisen, the authors point to three elements: adaptive, absorptive, and transformative capacities (Lv et al., 2024). Adaptive capacity focuses on the intrinsic features of a system that impels it to exist. In contrast, adaptation stimulates a system to adapt to its environment. "Absorptive capability describes taking deliberate precautions and addressing possible risks, uncertainties, and pressures" (…). It also means the ability to bounce back after a traumatic event (Lv et al., 2024). And the last, transformative capacity, is mainly analysed in the literature in the context of urban studies and climate adaptation and includes the complexity of transformation processes with a wide range of actors, policies and management (Sousa et al., 2024).

In turn, the UK Department for International Development highlights four common elements of the term resilience: context; disturbance; capacity; and reaction (DFID, 2011).

A further question about resilience relates to the categories of resilience that have been addressed in the literature, namely:

- area: regional resilience (Giacometti et al., 2019), urban resilience (Resilient Cities Network, n.d.; Cariolet et al., 2019), rural resilience (Błąd, 2022),
- ecology and environment: ecological resilience, climate resilience (de Graaf-van Dinther & Ovink, 2021; Kurtz & Elsamahi, 2023), disaster resilience (DFID, 2011; Keating et al., 2017),
- economy and finance: economic resilience (Hallegatte, 2014), financial resilience (Hamid et al., 2023).

The different categories determine the different material scope of the term in question, but what they have in common is the question of why resilience needs to be developed and what it means to provide it. One category of resilience is economic resilience, and within this category, we can talk about economic resilience to natural hazards. However, we can easily find general explanations of economic resilience in the literature rather than economic resilience to natural hazards. The exception is Adam Rose's publication, which not only provides a definition but also undertakes a cost-effectiveness analysis of developing economic resilience to natural hazards and provides examples of measures (Rose, 2014).

The aim of this paper is to present the issue of economic resilience to natural hazards, including the author's definition and model, based on which a selection of indicators for measuring economic resilience to natural hazards has been presented. The research problem outlined in this publication is concerned with the conceptual scope of the concept of economic resilience to natural hazards. The following research hypotheses were adopted:

H1. What is the relationship between disaster resilience and economic resilience to natural hazards.
H2. What are the factors that shape economic resilience to natural hazards?
H3. Is it possible to measure economic resilience eto natural hazard?

For this study, a literature review was carried out.

Disaster risk and economic resilience to natural disasters

Before explaining the concept of economic resilience to natural hazards, reference should be made to the term disaster resilience. The definition of this term is presented inter alia Keating et al. (2017). What makes it stand out is the approach it takes in relation to well-being: "The ability of a system, community or society to pursue its social, ecological and economic development objectives, while managing its disaster risk over time in a mutually reinforcing way".

Based on this definition of disaster resilience, its three components should be highlighted: ability, development objectives and disaster risk. The issue of ability is referring to anticipate, withstand and recover from any kind of shock, disruption or stress that a region may experience (U.S. EDA, n.d.). But what is the meaning of these terms? Zseleczky and Yosef (2014), define shocks within a development context: "as external short-term deviations from long-term trends, deviations that have substantial negative effects on people's current state of well-being, level of assets, livelihoods, or safety, or their ability to withstand future shocks. These negative effects may be short-lived or longer lasting. The onset of many shocks is unexpected, but in some cases, such as drought or conflict, the shock may be expected year after year, though the individual, community, or system lacks the resilience to prepare for or mitigate it. In other cases, such as climate change, the general shock could be expected, but the effect on a particular individual, community, or area could be unexpected".

In turn, "stressors are long-term pressures (e.g. degradation of natural resources, urbanization, political instability or diminishing social capital) that undermine the stability of a system (i.e. political, security, economic, social or environmental) and increase vulnerability within it" (Choularton et al., 2015).

And disruptions, in general meaning, "is a situation in which it is difficult for something to continue in the normal way; the act of stopping something from continuing in the normal way" (Oxford, n.d.).

When discussing the issue of ability, it is necessary to ask the question of whose ability is about. In the situation of a natural disaster, we are talking about the socio-economic system, individuals, households, and communities.

The next component of the disaster resilience definition is development objectives. Today, development goals are adopted at the global level, as exemplified by the UN Millennium Development Goals and now the Sustainable Development Goals, and at the regional, national and local levels of government. They include measures aimed at overcoming problems in the social, economic and environmental dimensions. Moving towards the concept of disaster risk: "The definition of disaster risk reflects the concept of hazardous events and disasters as the outcome of continuously present conditions of risk. Disaster risk comprises different types of potential losses, which are often difficult to quantify. Nevertheless, with knowledge of the prevailing hazards and the patterns of population and socioeconomic development, disaster risks can be assessed and mapped" (UNDRR, n.d. – d).

The following issues are related to disaster risk:
- disaster risk management (UNDRR, n.d. – e; EC, 2019),
- disaster risk reduction (UNDRR, n.d. – f),
- disaster risk assessment (UNDRR, n.d. – g).

The UNDRR disaster risk assessment includes: "the identification of hazards; a review of the technical characteristics of hazards such as their location, intensity, frequency and probability; the analysis of exposure and vulnerability, including the physical, social, health, environmental and economic dimensions; and the evaluation of the effectiveness of prevailing and alternative coping capacities with respect to likely risk scenarios" (UNDRR, n.d. – g).

What is more, "disaster risk results from the complex interaction between development processes that generate conditions of exposure, vulnerability and hazard" (UNDRR, n.d. – h).

With regard to disaster risk, it should be made clear that for the purposes of this article, we are talking about natural disasters. According to the European Environment Agency (EEA), a natural disaster is "a sudden and destructive change in the environment without cause from human activity, due to phenomena such as floods, earthquakes, fire and hurricanes" (EEA, n.d.). In turn, in Polish legislation we find the following the term „natural catastrophe" and its explanation: "is an event related to the action of forces of nature, in particular lightning, seismic events, strong winds, heavy rainfall, prolonged extreme temperatures, landslides, fires, droughts, floods, ice on rivers, lakes and reservoirs, mass outbreak of pests, plant or animal diseases or contagious human diseases, or the action of any other element" (Act, 2002). The law also refers to the concept of a natural disaster, which includes both a natural catastrophe and a technical failure. It should be noted that in the literature on the subject, there is also used the term "natural hazards". For example, the United Nations Office for Disaster Risk Reduction (UNDRR) explains it as follows: "Natural hazards are predominantly associated with natural processes and phenomena" (UNDRR, n.d. – b). What is more, on the website of this institution, we find information that "Hazards may be natural. Disasters are not" (UNDRR, n.d. – c). Therefore, taking into account Polish law, there is a discrepancy in the terminology used. The United Nations University report, Interconnected Disaster Risk, takes a similar view (UNU-EHS, 2021). Therefore, in this text, we will use the term natural hazard.

Having defined disaster resilience and related terms, the concept of economic resilience needs to be explained. In the literature, we find mainly general explanations of economic resilience. However, there are also some authors who address the issue in relation to natural disasters. According to Briguglio et al. (2009) "economic resilience refers to the policy-induced ability of an economy to recover from or adjust to the negative impacts of adverse exogenous shocks and to benefit from positive shocks".

Adam Rose pointed out the static and dynamic economic resilience. The first is defined as: "the efficient use of remaining resources at a given point in time to produce as much as possible". In turn, the second: "the efficient use of resources over time for investment in repair and reconstruction, including expediting the process of adapting to change" (Rose,2014).

What is more: "the concept of economic resilience includes two key components. The first is the ability of an economy of households, firms or an economy to withstand or absorb an economic shock. The second is a more dynamic component which relates to the ability of households, firms or the economy more widely, to adapt to changing circumstances and strengthen their ability to respond to potential future shocks" (Cardiff University, n.d.). Further, "Resilience can take place at three levels:
(1) microeconomic – individual behaviour of firms, households, or organisations,
(2) mesoeconomic – economic sector, individual market, or cooperative group,

(3) macroeconomic – all individual units and markets combined, though the whole is not simply the sum of its parts, due to interactive effects of an economy" (Rose, 2004).

The issue of economic resilience is primarily considered in the context of development (U.S. EDA, n.d.) and well-being, because of crises and their negative consequences for individuals, households and communities (Choularton et al., 2015). Natural hazards can be sources of crises that affect the economy. Thus, Hallegatte (2014) picks up on this theme and highlights the welfare disaster risk (as was mentioned above). In his opinion, the welfare disaster risk in a country can be reduced by reducing the exposure or vulnerability of people and assets increasing:

a) macroeconomic resilience – reducing aggregate consumption losses for a given level of asset losses,

b) microeconomic resilience – reducing welfare losses for a given level of aggregate consumption losses.

The exposure means location, attributes, and values of assets that are important to communities.

In turn, vulnerability is the likelihood that assets will be damaged or destroyed whey exposed to a hazard event (EU & WBG, 2021).

When analysing the two terms, disaster resilience and economic resilience, in a general sense, it is important to point out the common elements: change, suddenly triggered by a negative factor (hence crisis), the ability to survive and recover. For the purposes of further discussion, we are going to define economic resilience to natural hazards as follows: it is the ability of a socio-economic system to withstand a natural disaster, adapt to changing circumstances and to strengthen its ability to respond to potential future natural hazards. It is important that economic activities that produce goods and services can be carried out in accordance with the needs of the people. It is therefore necessary to protect production assets from natural hazards and, in the event of damage, to restore them as quickly as possible or invest in new technology. It is worth noting that some authors have even provided empirical support for the creative destruction hypothesis. Presenting evidence that natural hazards provide opportunities for capital improvement and the adoption of new technologies, they demonstrate a long-term growth rate of GDP per capita in developing countries (Stanković et al., 2020).

Another issue that needs to be addressed in relation to disaster resilience and economic resilience is the way in which they are built. There are many articles on building resilience in a general sense or in relation to different sources of threats and the magnitude of those threats. Nowadays, the issue of resilience in the face of climate change is of particular interest. "Improving climate resilience involves assessing how climate change will create new, or alter current, climate-related risks, and taking steps to better cope with these risks" (C2ES, n.d.). These steps should be as follows (Global Climate Action & Marrakesh Partnership, n.d.):

1) Awareness-raising and advocacy – be clear that the future will not resemble the past; base this on science and examine different scenarios (e.g. 1.5-degrees and higher) and their impacts.

2) Carry out climate risk assessments at national, local (city/region), sectoral or organisational level and use a systems approach.

3) Develop and implement appropriate actions and interventions.

4) Mobilise resources – Build capacity and scale up actions.

5) Monitor and track progress.

6) Share knowledge, experiences and solutions.

de Graaf-van Dinther and Ovink (2021) define climate resilience "as consisting of 5 capacities or pillars: threshold capacity, coping capacity, recovery capacity, adaptive capacity, and transformative capacity.

1) Threshold capacity: the capability to prevent damage by constructing a threshold against environmental variation.

2) Coping capacity: the capability of a neighbourhood, city, or country to deal with extreme weather conditions and reduce damage during such conditions.

3) Recovery capacity: society's capability to bounce back to a state equal to, or even better than, before the extreme event.

4) Adaptive capacity: society's capability to anticipate uncertain future developments.

5) Transformative capacity: the capability to create an enabling environment, strengthen stakeholder capacities, and identify and implement catalysing interventions to transition proactively to a climate-resilient society.

The authors address the question of building resilience to climate change in different areas: rural (Keshavarz & Moqadas, 2021; Chirisa & Nel, 2020; Ristino, 2019) and urban areas (Sharma, 2023; Appau et al., 2024; Wang, 2022). Climate resilience is linked to disaster resilience. This is because of the many natural hazards that are a consequence of climate change (Shaw & Sharma, 2011; CSIRO, 2020). Lv et al. identified "major qualities of disaster resilience systems", which include: reflective, resourceful, robust, flexible, redundant, integrated, and inclusive (Lv et al., 2024). And what characteristics or factors shape economic resilience to natural disasters? In the context of economic resilience, we are talking about the socio-economic system, which consists of individuals, households, and companies. Resilience-building factors must enable the socio-economic system to (Figure 1):

- to prepare for a natural hazard so that its impact is less severe when it occurs,
- to adapt to changing circumstances,
- to recover once the natural hazard has passed and create the ability to respond to potential future natural disasters.
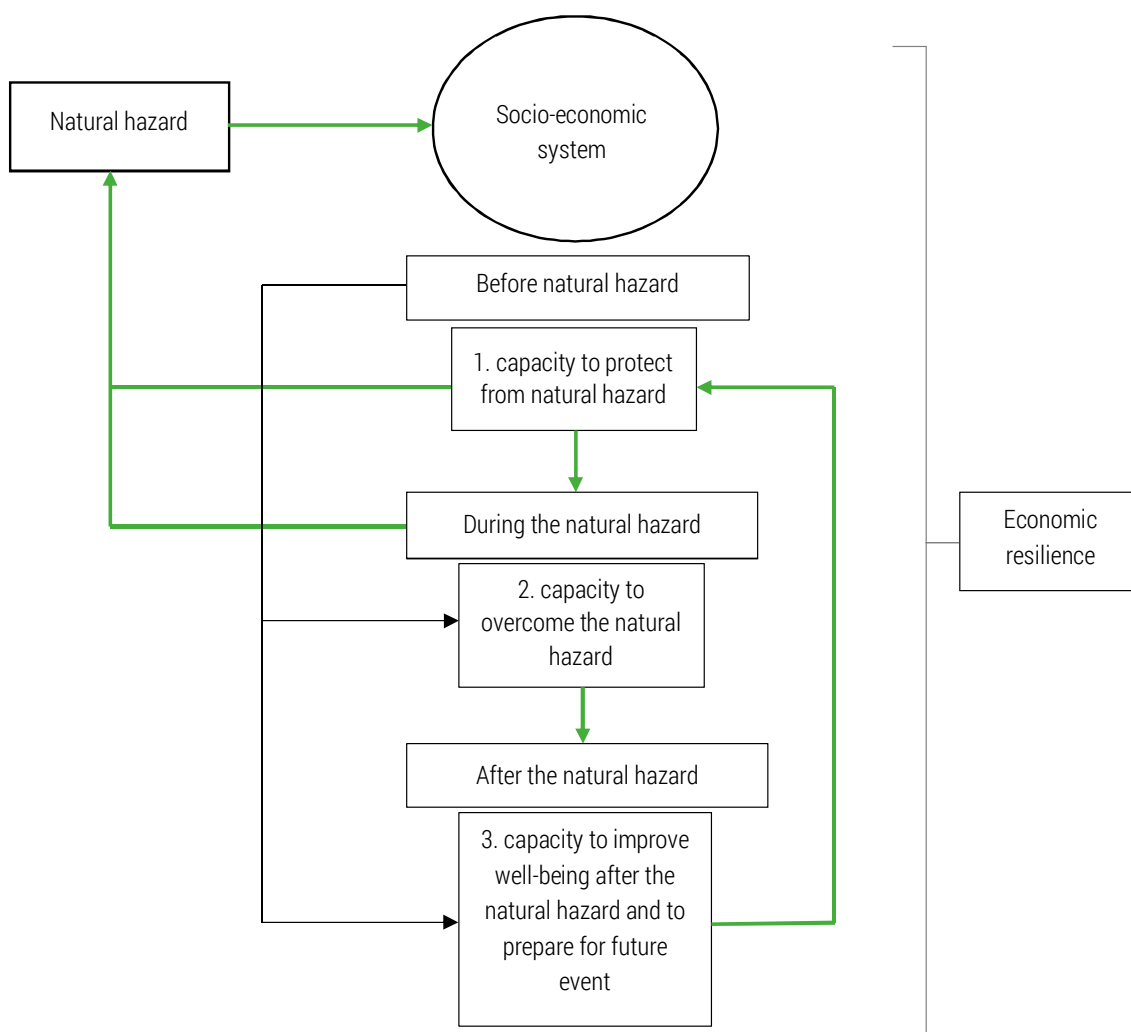

Figure 1. Model of economic resilience to natural hazards

Each of these phases requires specific actions using appropriate instruments. A selection of these is shown in Table 1.

Table 1. present the activities during each of mentioned phases

Phase	Activities
1. Before natural hazard	monitor the risk situation construction of infrastructure to protect against natural disasters (e.g. dykes) securing critical infrastructure design of buildings considering the risk of hazards (e.g. construction of bridges in highly seismic areas) securing food, water and fuel provision of necessary rescue equipment provision of necessary technical equipment training of residents on how to deal with natural hazards raising people's awareness of the potential for natural hazards to ensure an efficient system of risk communication access to insurance for households, businesses
2. During natural hazard	smooth and coordinated cooperation between the relevant services use of available material means to secure people, property, critical infrastructure request for external help (if needed) raising external funding
3. After natural hazard	Rebuilding houses, public buildings, roads, bridges Rebuilding the infrastructure to protect against natural disasters (if needed) Rebuilding the critical infrastructure Improvement of all activities and components of the first phase on the basis of lessons learned from the disaster

An example of the implementation of measures to build economic resilience to natural hazards, taking into account the three phases described in the model, is living with the constant threat of floods in Bangladesh (Hanlon et al., 2016). As part of the first phase, they are carrying out activities such as building shelters for the population, constructing dikes, and NGOs are implementing projects related to the cultivation of rice varieties resistant to salinity. In the second phase, they are developing systems for transmitting information about dangers by telephone. The third phase is reconstruction. However, limited financial resources and, above all, the weakness of the state and its institutions do not allow for the full development of economic resilience to the threat of flooding.

Having already defined the characteristics of disaster resilience and economic resilience to natural hazards and the issue of building them, it should be made clear that in both cases, building resilience aims to reduce the potential damage caused by the disaster and to return to pre-disaster conditions and further development. It should be remembered that the lower the coping and adaptive capacity of individuals, households, communities and countries, the higher their vulnerability (GIDRM, n.d.). Disaster resilience is primarily concerned with adaptation and mitigation to natural hazards in order to protect people and assets from the adverse effects of natural hazards. Economic resilience to natural hazards, on the other hand, aims at adaptation and mitigation to natural hazards for the production and provision of services. Building resilience to natural hazards also helps build economic resilience. For example, if measures are taken to secure roads and bridges in the event of a natural disaster, such secured infrastructure will not only help to evacuate people, but once the disaster has passed, it will also help to transport the resources needed for production and then the finished products to customers, and so on. Every disaster provides an opportunity to review the state of preparedness and, once the disaster is over, to make improvements that will help to protect people, their assets and their ability to produce and deliver services in the future. This raises the question of assessing disaster resilience, especially economic resilience. At this point, it is appropriate to recall Adam Rosa's exception: preparedness focuses on ways of enhancing resilience before the event, while resilience emphasises the reduction of economic losses due to an event during and after it. What is more: resilience differs from the concept of adaptation. Adaptation consists of two components: an active effect to reduce losses after an event and a passive absorption ("suffering") of the loss (Rose, 2004).

Economic resilience to natural hazard measurement

According to Choularton et al. (2015), resilience measurement typically involves measuring well-being outcomes (e.g. food security, health or poverty) as a function of vulnerability, resilience capacity and shocks. These conceptual frameworks explicitly measure wellbeing outcomes but give less attention to how to measure shocks. Shocks and stressors are often analysed separately from other measures or excluded from current resilience measurement practices (Sagara, 2018). In literature, we can find some examples of resilience indexes, for example: City Resilience Index prepared by ARUP in cooperation with Rockefeller Foundation (2019). Mentioned index includes 4 dimension (health and well-being, economy and society, infrastructure and environment, leadership and strategy), related to 12 goals and 52 indicators (ARUP, 2019). Another example is Resilience Index Measurement and Analysis (RIMA) developed by FAO (The Food and Agriculture Organization of the United Nations) to measure resilience to food insecurity (FAO, n.d. – a). There are also indices dedicated to disaster resilience. An example of the latter is the Australian Disaster Resilience Index, which has a three-tier structure. The first includes the dimensions of coping and adaptive capacity. The second expresses the main elements of coping (social capacity, economic capital, infrastructure and planning, emergency services, community capital, information and engagement) and adaptive capacity (governance, policy and leadership; community and social capacity) (Parsons et al., 2017). And the third includes sets of indicators that measure the status of an issue (Parsons & Morley, n.d.). Another solution in the form of a comprehensive disaster resilience index has been proposed by Iqbal Khan et al. (2022).

In case of economic resilience, Adam Rose distinguishes measurement methods on the basis of the two categories he identifies, namely: static economic resilience and dynamic economic resilience. "For static resilience, this can be done in terms of the amount of BI [business interruption] prevented by the implementation of a given resilience tactic or set of tactics comprising a resilience strategy. For dynamic resilience, the metric would be the reduction in recovery time in addition to the reduction in BI, though obviously the former influences the latter. In both cases, one needs a reference point or baseline to perform the measurement. For static resilience, this would be the maximum potential BI loss in the absence of the resilience tactic, while for dynamic resilience, it would be the duration and time-path of economic activity in the absence of resilience in relation to investment in repair and reconstruction" (Rose, 2016).

Measuring economic resilience requires defining the crisis situation, then the losses in terms of damage to stocks – i.e., property damage and damage to flows – i.e., damages to production of goods and services (Noy & Yonson, 2018), and of course, collecting appropriate data. It is also helpful to refer to exposure and vulnerability, and then to consider adaptation and mitigation activities. In the context of natural disasters and economic resilience, it is first necessary to adopt an appropriate definition of a natural disaster, taking into account its size, frequency and severity. In this matter of things, very helpful is the definition and the data collected by the EM-DATA database. EM-DAT globally records at the country level human and economic losses for disasters with at least one of the following criteria:

- 10 fatalities,
- 100 affected people,
- a declaration of a state of emergency,
- a call for international assistance.

EM-DAT contains data on the occurrence and impacts of over 26,000 mass disasters worldwide from 1900 to the present day (EM-DAT, n.d.).

According to Botzen et al. (2019) if we want to study the economic consequences of natural hazards, we can analyse the direct and indirect effects of natural hazards. These direct losses are usually estimated using catastrophe models (using Geographic Information Systems, GIS) and measured using empirical data. In turn, most research on the indirect impacts of natural disasters builds on the predictions of input– output (I-O) and computable general equilibrium (CGE) models (Botzen et al., 2019, p. 171) with using appropriate indicators, especially GDP. For example, within the Sustainable Development Goals, there is Goal 1 called 'No Poverty' and an associated specific objective 1.5: "By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental

shocks and disasters", with indicator corresponding to it: Direct economic loss attributed to disasters in relation to global gross domestic product (GDP) relevant to the specific objective (FAO, n.d. – a).

The exposure mentioned "represents the stock of property and infrastructure exposed to a hazard, and it can include socioeconomic factors", and vulnerability "accounts for the susceptibility to damage of the assets exposed to the forces generated by the hazard" (UNDRR, n.d. – h).

For the purposes of this study, based on the above solution to measurement resilience, a three-stage measurement of economic resilience to natural hazards is proposed:
1. preparedness to natural hazards.
2. coping and adaptive capacity to natural hazards.
3. recovery and preparation for future events.

Table 2. Selection of indicators to economic resilience to natural hazards

Phase	Indicators
1. preparedness to natural hazards	GDP per capita (current prices) [PLN] General government debt as a share of GDP [%] Income per capita [PLN] General government investment rate [%] Private sector investment rate [%] Registered unemployment rate [%] Investment outlays in enterprises in the private sector in relation to GDP [%] Outlays on R&D activity in relation to GDP [%] Outlays on innovative activities in enterprises in relation to GDP [%] Share of exports in revenue from sales of products, goods and materials [%] Outlays on fixed assets for environmental protection and water management per 1 inhabitant [PLN thou.] Export of goods (current prices) (million PLN) Import of goods (current prices) (PLN million) Sold production of industry (current prices) (PLN million) Local government units that have adopted and implemented local disaster risk reduction strategies in line with the national disaster risk reduction strategy
2. coping and adaptive capacity to natural hazards	Local government units that have adopted and implemented local disaster risk reduction strategies in line with the national disaster risk reduction strategy. Land use planning for hazards Emergency planning Age and type of dwellings Health response workforce Emergency response workforce Emergency service expenditure Remoteness Household support Access to services Wellbeing Crime and safety Place attachment Volunteerism Unemployment Broadband access Mobile phone coverage Community engagement strategies and plans Research and development Policy and legislation

Phase	Indicators
3. recovery and preparation for future events	Direct economic losses resulting from disasters as a proportion of global GDP (Target 1.5 SDG UN; Indicator 1.5.2) Direct economic losses in relation to GDP, damage to critical infrastructure and number of disruptions to essential services attributed to disasters (Target 11 SDG UN; Indicator 11.5.2) Official Development Assistance for climate change mitigation and adaptation (Target 7 SDG UN; Indicator 7 a 1) GDP per capita (current prices) [PLN] General government debt as a share of GDP [%] Income per capita [PLN] General government investment rate [%] Private sector investment rate [%] Registered unemployment rate [%] Investment outlays in enterprises in the private sector in relation to GDP [%] Outlays on R&D activity in relation to GDP [%] Outlays on innovative activities in enterprises in relation to GDP [%] Share of exports in revenue from sales of products, goods and materials [%] Outlays on fixed assets for environmental protection and water management per 1 inhabitant [PLN thou.] Export of goods (current prices) (million PLN) Import of goods (current prices) (PLN million) Sold production of industry (current prices) (PLN million)

Source: author's work based on Statistics Poland (n.d.), FAO (n.d.), United Nations Statistics Division (n.d.) and Parsons et al. (2017).

Table 2 contains a selection of indicators. In the first phase, those that serve to verify the macro-economic situation of the country, as well as the income situation of enterprises and their involvement in investments have been selected. They are intended to give an idea of the general condition of the state and enterprises before and after the natural disaster, as well as of the population. And thus provide an overall picture of the state of the economy prior to the event. By contrast, the indicator on the implementation of local disaster risk reduction strategies in line with the national disaster risk reduction strategy is intended to show the preparedness of local government units in the face of a hazard. The choice was dictated by the availability of data through the Central Statistical Office. Some of these indicators have been included in the third phase, so that comparisons can be made. In addition, in phase three, indicators were singled out which were linked to the relevant UN sustainable development goals. For the second phase, there have been selected some indicators from the Australian Natural Disaster Resilience Index.

While the availability of data for economic indicators should not be a problem, the availability of data related to phase two may be a problem, for example: Local government units that have adopted and implemented local disaster risk reduction strategies in line with the national disaster risk reduction strategy.

Measuring economic resilience to natural disasters based on the three phases requires further work related to possible weighting (the way weights are established , for examp,e conducting a survey among scientists; the question of weighing), introducing additional dimensions or verifying the availability of data based on the selected study group.

Conclusions

The article addresses the conceptual scope of the concept of economic resilience to natural hazards. It should be stressed that there is not much work devoted to this issue, especially in Poland. Therefore, this article is an attempt to fill this gap. The focus of this study is on economic resilience to natural disasters at the macroeconomic level. According to the author, the issue of economic resilience to natural hazards should be considered through the lens of three phases: preparation for natural hazards; adaptation to changing circumstances; recovery and capacity building to respond to potential future disasters. The paper contains the definition of the author, which has been the basis

for the model of the economic resilience to natural hazards. A comparative analysis of the terms and their scope shows that they are interrelated, with disaster resilience being the starting point for economic resilience to natural disasters. shaping economic resilience is dependent on the risk and vulnerability of natural hazards. And states prepare for this, inter alia, based on disaster risk management. This also has implications for the factors that shape economic resilience to natural hazards. This includes, inter alia, appropriate infrastructure and financial resources to fast recovery. It should be emphasised that tools such as natural hazard resilience indices are being developed but that no such tool exists for economic resilience to natural hazards. It should be emphasised that while tools such as natural hazard resilience indices are being developed, no such tool for economic resilience to natural hazards has been found in the literature. The paper aimed to fill this gap. However, there were some limitations that require the continuation of the research work, particularly the introduction of weighting, the verification of the adopted indices based on the availability of data for the selected research group. And finally, to test the tool. Particularly in a country like Bangladesh, which is hit by floods every year, the use of the model could help to introduce effective solutions in the framework of building economic resilience to floods by providing information to the government.

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Paulina SZYJA

ODPORNOŚĆ EKONOMICZNA NA ZAGROŻENIA NATURALNE I JEJ POMIAR

STRESZCZENIE: Zagrożenia naturalne dotykają zarówno kraje rozwijające się, jak i rozwinięte, powodując negatywne skutki. Stopień, w jakim dotknięte są nimi społeczeństwa, zależy od wielu czynników. Z tego powodu kwestie zarówno podatności, jak i odporności na zagrożenia naturalne są coraz częściej i szerzej poruszane w literaturze. Na szczególną uwagę zasługują prace dotyczące wpływu zagrożeń naturalnych na gospodarkę. Istnieją również prace dotyczące odporności ekonomicznej na zagrożenia naturalne. Celem niniejszego artykułu jest przedstawienie kwestii odporności ekonomicznej na zagrożenia naturalne, w tym zakresu tego terminu i jego związku z odpornością na klęski żywiołowe. Na potrzeby niniejszego opracowania przeprowadzono przegląd literatury. Oryginalność opracowania polega na przyjęciu autorskiej definicji odporności ekonomicznej na klęski żywiołowe, opracowaniu odpowiedniego modelu oraz próbie skonstruowania narzędzia pomiaru. Według autorki, kształtowanie odporności gospodarczej zależy od ryzyka i podatności na zagrożenia naturalne. Kwestia odporności gospodarczej na zagrożenia naturalne powinna być rozpatrywana przez pryzmat trzech faz: przygotowania na zagrożenia naturalne; adaptacji do zmieniających się okoliczności; odbudowy po zdarzeniu i budowania zdolności do reagowania na potencjalne przyszłe katastrofy. Pomiar odporności gospodarczej na klęski żywiołowe w oparciu o te trzy fazy wymaga dalszych prac związanych m.in. z weryfikacją dostępności danych w oparciu o wybraną grupę badawczą. Stworzony model może pomóc krajom, które są często narażone na zagrożenia naturalne, w budowaniu ich odporności gospodarczej na te zagrożenia.

SŁOWA KLUCZOWE: odporność, odporność ekonomiczna, zagrożenia naturalne