Countries’ readiness to deal with large-scale crises: analysis, measure, and World classification

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Abstract
A country’s preparedness to face crises is a multidimensional competence that depends on several attributes (economic factors, governance features, infrastructure and institutional endowments). This paper proposes a new approach to rank countries based on their degree of preparedness to deal with large-scale crises. The measured characteristics of countries have made it possible to compile an index of preparedness to face shocks and, therefore, predict their performance against the COVID-19 health crisis to verify the relevance of the proposed composite index. Fortunately, it appears that countries with a high degree of preparedness according to our aggregate index were able to respond adequately and effectively to this crisis. This is reflected in a lower mortality rate and more administered tests.

Keywords COVID-19 · Large-scale crisis’s · State’s power · Readiness · Governance · Aggregate index · Resources

JEL Classification H12 · H54 · C53

Introduction
COVID-19 was a real shock to societies, to policy makers, to firms, to businesspersons, and to thinkers all around the world. By its multidimensional nature and its broad and deep impact, it has changed our conception of the world, of the society, of the role of the state and of the hierarchy of values (Da Silva, 2020; Ezzahid, 2020). These changes are likely to persist for many decades to come. This event has been able to transform working practices, the status of health care for society and for individuals, moral values, geopolitics, etc. Briefly, COVID-19’s triggered cascading effects over time and across different aspects of human life (Zuccato et al., 2018). A lesson from this crisis is how important it is for societies and states to take advantage of the tools’ space that is supposed to help cope with and mitigate the short and long-term effects of this category of events.
By definition, a large-scale crisis is one that affects almost all human spheres of activity, threatens large sectors of the economy and seriously reduces or threatened to do the well-being of individuals. A large-scale crisis can emerge from a shock affecting one sector that will spread through many channels to other sectors. One of the major stylized facts of a large-scale crisis is the fact that its components are inseparable. We cannot disentangle one component of this crisis and treat it separately from the other components. A large-scale crisis produces almost limitless socio-economic repercussions and a global trauma. Conventional systems installed to deal with similar risks are no longer operational. A large-scale crisis generates "obstacles of unprecedented magnitude and global reach ..., struck with unprecedented magnitude and ferocity" (Kissinger, 2020, April 3).

A country is made up of the society, the state and the resources, implicit or explicit, tangible or intangible, which they use to achieve their various endeavors. What is important when we are faced with a crisis is the resources we have, how quickly we mobilize them, and how adequately and effectively we deploy them to manage a crisis. These resources determine resilience and the way through which states adapt to crises without dramatic and irreversible costs.

This paper is structured as follows. In the second section, we will discuss the sources of country’s readiness. In the third section, we explain the structure and how we construct the index of preparedness. In the fourth section, we develop an aggregate index to gauge and hierarchizes countries from the point of view of their capacity to deal with large-scale disruptions. In the last section, we provide some concluding remarks.

**Readiness: definition and determinants**

Lessons from the past two decades highlighted the issue of stability and resilience of economic and social systems to disruptive events. After the 2008 financial crisis, emphasis was placed on the design and development of financial stability to maintain the balance between private interests and the stability of the financial and economic systems as a public good. Currently, with the COVID-19 health crisis, it is also a question of stability and resilience of countries not only of their economic system but even more; their health, social and ecological spheres.

Work on the issue of readiness to fight disasters such as the COVID-19 pandemic is mainly based on studies on global warming and its impact on the survival of the inhabitants of archipelagos (Rampengan, 2014). Currently, a number of studies attempt to extrapolate these approaches to provide a broader framework for measuring countries’ preparedness to face natural, health, technological, ecological, or economic disasters.

Readiness is defined as the “ability to deal with what might or will happen”. In a constantly changing and complex world, only continuous and multifaceted availability of tools can help address emerging known and unknown risks such as epidemics, tsunamis, wars and terrorism against large networks such as Internet, electricity grids and payments systems. We must pinpoint out that we distinguish here between the countries’ capabilities (i.e., the capabilities of states) and their ability to deploy them now and here to deal with a real and devastating situation. Indeed, what is important is the liquidity of the state’s power / capacity, not its size, especially when a large-scale crisis erupts and if not contained it can cause profound damages probably for long periods or irreversibly.

The work on disasters and crises reveals the existence of ex ante vulnerabilities that contribute massively to amplify the negative consequences/effects of crises. Thus, one of
the preconditions to deal successfully with crises is to identify the sources of vulnerabilities and fragilities that are conductive to the propagation of shocks. This raises the question of whether the systems are resilient enough to cope with shocks and crises based on their initial conditions.

An example of this work is the development of the Tsunami Resilience Index, which takes into account 35 three-dimensional indicators. In addition, the Hyogo Framework for Action (HFA) uses a set of 31 capacity indicators to track the goals and priorities of areas at the national level (United Nations, 2005). Likewise, the Global Risk Index of the Institute for the Environment and Human Security (EHS, 2011) uses 28 indicators in several areas: exposure to natural hazards, real estate’s sensitivity, infrastructure, economic capacity and capacity to adaptation.

Several studies therefore consider that to cope successfully with the most devastating crises it is necessary to be prepared effectively for the worst scenarios in order to allow sufficient resilience and rapid recovery (Ezzahid, 2020; Ademola et al., 2012). Thus, preparing countries to contain the consequences of crises requires that authorities take action before any disruption and with the support of other stakeholders to mitigate the impact of crises on lives and livelihoods. This approach to crisis preparedness is not a new concept in the research world; however, it was developed in the areas of resilient livelihoods and sustainable living.

By definition, disaster preparedness is the state, which enables stakeholders/actors/participants to mobilize, organize and provide rapid responses to deal with an imminent or actual disaster or in the aftermath of a disaster. Thus, an ability to assess readiness levels would help identify strengths and weaknesses in the system and prepare for possible restructuring. Capacity building is a central part of disaster preparedness in the context of a pandemic or a major economic crisis.

COVID-19 has spurred the debate on the preparedness of states for such large-scale crises. Indeed, the work of academics, researchers and institutions is currently focusing and making greater efforts to put forward analyses and an approach to categorizing the capacities of States to respond to this new typology of crisis (Coccia, 2020a, 2021; Hale et al., 2021). Recent work seeks to find factors capable of consolidating the degree of preparedness of States for the occurrence of non-usual crises. The results of recent studies demonstrate the strategic positioning of countries in the management of the COVID-19 pandemic crisis, in order to detect the structural factors associated with better preparedness to support policy responses to limit the negative effects given by higher mortality related to COVID-19 and similar infectious diseases in society.

Theoretically, a relevant evaluation system must refer to a comparative dynamic taking into account temporal and space-related invariants. In other words, a classification and comparison system is able to institute a procedural approach to assess the ability of individuals, organizations and other subjects to achieve strategic objectives using, as a reference, performance (Benati & Coccia, 2019). The usefulness of setting up a classification index is increasingly useful for decision-making in ex-ante or ex-post crisis situations.

The analysis of the reactions of States to the occurrence of the COVID-19 crisis makes it possible to detect their performance in this area. Achieving this performance is able to quantify and identify the factors that allow States to be in perfect preventive preparation to confront large-scale crises.

Recent work on the issue of State preparedness has proposed heterogeneous approaches that still give rise to further in-depth studies. Research from the University of Oxford, for example, has set up an index that measures the rigorous of the containment policy adopted by European countries. The countries in this index are ranked by the degree of stringency.
where countries like Italy and Spain have been ranked in the highest quantile due to their highly restrictive policies. Even at the level of developing countries such as Morocco, the containment policy has been more effective in describing the fact that proactive policies based on institutional and political solidity are the most appropriate (Firano and al. (2020a, 2020b)). There is also another index that has been developed that takes into account food security. This index proposes a categorization of countries in the world according to their degree of preparedness to deal with a pandemic variant (Cameron and al., 2019). According to this indicator the United States and the United Kingdom are the two major nations with such a high degree of preparedness, this is the result attributed before the occurrence of the COVID-19 pandemic.

In a multidimensional work, the Lowy Institute in 2021 proposed a composite indicator to measure the performance of States during the COVID-19 crisis. In the same spirit, Ant-tiroiko (2021) proposed an analysis based on socio-economic, institutional, cultural and also technological determinants to know how these affect the response capacity of States in the presence of the pandemic. As part of a similar approach, the approach proposed by Coccia (2021a, 2021b) to demonstrate that Asian countries have an effective proactive and preventive policy on the other hand, Western countries are in a reactive logic which limits their ability to respond in time and space. This result is also corroborated by other results that indicate that Asian countries are stricter in managing the crisis than other countries in the world, which allows them to emerge more quickly from the crisis (Abuza, 2020, Ritchie et al., 2020).

The resilience and preparedness of states to deal with these extreme situations are now of crucial importance to researchers and public policy makers. It is no longer a question of achieving economic and social balance, but rather of maintaining it in the face of potentially unpredictable shocks. Indeed, guarding against such uncertain events is a delicate task, but it remains the only solution to ensure a better future for coming generations. Indeed, the strength/capability of a country to face, mitigate and manage the devastating effects of a large-scale crisis emanates from the components and interactions of its society (social sphere), from the values that bind and tie the members of the society together (societal sphere), the tangible and intangible resources at its disposal (sphere of resources), the institutions which frame and shape decision-making in the political sphere (sphere of the governmental or institutional apparatus), the legitimacy of the governing groups (ideological sphere), and elite leadership now and here at the command (the sphere of leadership). In this sense, preparedness of countries for large-scale crises goes far beyond the material conception of resources and availability of other valuable intangible resources.

**An aggregate index**

Measuring the degree of a state’ preparedness to contain the consequences of large-scale crises is a big challenge that requires the aggregation of indices that take into account several dimensions. Thus, the choice of the indicators to be used for the construction of the composite index deserves a well-grounded theoretical justification.

The analytical anchoring adopted in this case is based on the identification of the indicators that reflect the responsiveness of States to short- and medium-term shocks according to an indicative approach in which we establish a set of characteristics that determine the response capacity of a state and that we can measure via the statistical database at our
disposal. These characteristics are economic, social, infrastructural, political and institutional aspects that facilitate rapid and effective response to crises. Thus, the indicators were selected primarily based on their relevance to the aspect being measured, availability of data, comparability between countries and data reliability.

**Economic capability indicators**

National preparedness to detect and manage risks requires huge financial resources necessary to build public health systems and develop the right responses at the right time. Economic capacity includes all available resources and operational facilities in a country. In this axis, economic growth is retained to describe the potential of countries to mobilize material resources. Also, we take account of the purchasing power of economic agents measured by per capita GDP. The variable relating to health expenditures is also introduced to describe supply of health services by the country’s health system in case of a surge in demand for health services. It is now well recognized that there is a direct link between the adequacy of health financing and key indicators associated with an effective response to a crisis that may lead to rapidly increasing needs, particularly for personnel and consumables such as personal protective equipment and vaccines, which can be difficult to obtain without the necessary financial resources.

**Institutional capacity and governance indicators**

The COVID-19 crisis has highlighted the relevance of the governance of institutions and the institutional capacities of States. Good governance guarantees greater flexibility for decision-makers and an optimal response to needs, especially in the event of a crisis. This article adopts the governance index instead of the democracy index based on the indicators proposed by D Kaufmann and al. (2010).

Governance is by definition the traditions and the institutions by which authority is obtained and operationally exercised in a country. These include (a) the process of election, monitoring and replacement of governments; (b) the government’s capacity to effectively formulate and implement public policies; and (c) respect by citizens and the state for the institutions that govern economic and social interactions.

1. We can measure these dimensions with: first by the voices and responsibility: indicator of the capacities of the citizens of a country to participate in the selection of their government, as well as freedom of expression, freedom of association and of the media. Second by political Stability and Absence of Violence / Terrorism: the likelihood that the government will be destabilized or overthrown by unconstitutional or violent means, including politically motivated violence and terrorism.

2. We can measure these dimensions with: first by the government Effectiveness that capturing perceptions of the quality of public services, the quality of the civil service and the degree of independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government’s commitment to these policies. And regulatory Quality with Capturing perceptions of the government’s ability to formulate and implement strong policies and regulations that enable and promote private sector development.

3. We can measure this dimension with: Rule of law: measures confidence in the rules of society and in particular the quality of contract enforcement, property rights, the police and the courts, as well as the likelihood of crime and violence. And corruption control that captures the extent to which public power is exercised for private gain.
The introduction of the governance index is able to describe the institutional depth of the countries and especially that the work on the issue of state preparedness indicates that the institutional factor is very decisive and that allows a proactive action that has allowed Asian countries to succeed in the management of the pandemic more effectively than their Western counterparts (Anttiroiko (2021)).

**Infrastructure and energy indicators**

The ability to respond rapidly to crises depends largely on the quality and coverage of transportation and communications facilities and the quality and level of interconnections between various networks whatever their nature is. In addition, the development of this infrastructure is a sine qua non condition for the effectiveness of monitoring and regulation, since the flows of people, information and goods depends on it. Furthermore, physical means and infrastructures facilitate the spread of contagion and enable public health personnel to access, monitor and provide care to populations at risk or affected by infectious disease outbreaks. The communication infrastructure is also important, especially the availability of cell phones and the Internet, which can be instrumental in dealing with the consequences of disaster management as in the case of COVID-19.

**Health indicators and military capability**

The existence of an effective and efficient health system facilitates health crises management. Moreover, the state of health systems reflects the level of development of countries. Indeed, the more developed a country the more sophisticated is its health system. Early detection of health crises suggests robust surveillance and effective investigative capacity to rapidly characterize, monitor, and respond to diseases. This capacity requires health facilities with the ability to access and monitor the entire geography and population through the mobilization of personnel and resources. Finally, the health system must be able to coordinate activity with other countries and international organizations and this depends on the capacity available to the health system.

In this regard, several variables were considered. In particular, the number of personnel, health expenditures, out of pocket expenditures and the number of hospitals in the countries. Moreover, in this paper, we introduce military capabilities, which were also very decisive in the management of the COVID-19 crisis in the sense that the military forces contributed massively to the management of the crisis in several countries. Thus, countries with significant military capabilities will find it easier to manage large-scale crises Table 1.

**Index construction methodology and the database**

Developing a multidimensional index necessitates the application of statistical tools and data analysis techniques. Aggregation by the (linear) mean is the most commonly used. It is based on weighted and standardized individual indicators. Standardization rescales

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4 We measured health and infrastructure via the following variables: Fixed telephone subscriptions, Incidence of tuberculosis, Individuals using the internet, out of pocket expenditure, Physicians per 1000 people, Logistics performance index.
| Variables                                              | Mean  | Maximum | Minimum | Std. Dev | Skewness | Kurtosis |
|--------------------------------------------------------|-------|---------|---------|----------|----------|----------|
| Alternative and nuclear energy                         | 6.76  | 55.58   | −1.01   | 10.01    | 2.26     | 8.23     |
| Community Heath workers per 1000                       | 0.44  | 3.65    | 0.00    | 0.45     | 2.64     | 15.75    |
| Control of corruption                                  | −0.02 | 2.47    | −1.87   | 1.00     | 0.60     | 2.50     |
| Current health expenditure of gdp                       | 6.26  | 24.26   | 1.03    | 2.79     | 1.22     | 6.27     |
| Current health expenditure per capita                  | 867.57| 10,623.85| 4.34   | 1526.07  | 2.78     | 11.43    |
| Domestic general government health to total budget     | 3.24  | 24.11   | 0.06    | 2.29     | 1.45     | 7.08     |
| Energy imports net of energy                           | −37.41| 100.00  | −1942.00| 197.68   | −3.73    | 21.91    |
| Fixed telephone subscriptions                          | 4 698 123 | 368 000 000 | − | 20 330 192 | 10 | 133 |
| Fixed telephone subscriptions per 100,000              | 18,74 | 135,60  | −0.70   | 20.03    | 1.32     | 4.76     |
| Gdp growth annual                                      | 3.36  | 27.96   | −64.05  | 5.15     | −2.09    | 23.85    |
| Gdp per capita current us$                              | 11,980,06 | 189,422,20 | 2.36  | 20,334,46 | 3.49    | 20.20    |
| Government effectiveness                               | 0.27  | 150.00  | −2.48   | 3.95     | 22.65    | 709.94   |
| Incidence of tuberculosis per 100,000                  | 133.48| 1590.00 | 0.00    | 195.03   | 2.87     | 14.17    |
| Incidence of tuberculosis                              | 22.66 | 100.00  | 0.00    | 28.58    | 1.11     | 2.90     |
| Logistics performance index                            | 2.85  | 4.23    | 1.21    | 0.58     | 0.55     | 2.51     |
| Military expenditure to gdp                            | 2.27  | 117.35  | 0.00    | 2.94     | 16.89    | 568.96   |
| Military expenditure to general budget                 | 7.55  | 57.48   | 0.00    | 6.55     | 2.06     | 8.70     |
| Military expenditure current usd                       | 8 040 000 000 | 752 000 000 000 | − | 45 300 000 000 | 12.16 | 168.21 |
| Out of pocket expenditure                              | 1070.87| 76,367.00 | 0.08   | 7488.74  | 7.84     | 66.18    |
| Physicians per 1000 people                             | 3.45  | 69.32   | 0.00    | 10.10    | 6.03     | 38.11    |
| Political stability and absence of terrorism           | 0.15  | 17.60   | −3.31   | 1.70     | 4.62     | 39.42    |
| Population total                                       | 30 521 656.00 | 1 400 000 000,00 | 10.00 | 122 000 000,00 | 8.94 | 88.80 |
| Population ages 15 64 of total population              | 85,10 | 3373.70 | 11.89   | 229.88   | 12.47    | 167.27   |
| Population ages 65 and above to total population       | 7,05  | 28.00   | −5.85   | 5.14     | 1.01     | 3.01     |
| Population density people per surface                  | 380.49| 21,389.10| 0.14   | 1854.90  | 8.60     | 80.58    |
Table 1 (continued)

| Variables                              | Mean  | Maximum | Minimum | Std. Dev | Skewness | Kurtosis |
|----------------------------------------|-------|---------|---------|----------|----------|----------|
| Population growth                      | 1.47  | 17.51   | -10.96  | 1.56     | 1.47     | 15.08    |
| Regulatory quality                     | 0.93  | 87.00   | -2.65   | 9.09     | 9.25     | 87.64    |
| Renewable energy consumption           | 31.99 | 98.34   | 0.00    | 31.15    | 0.70     | 2.10     |
| Surface area by km                     | 652 464,00 | 17 098 250,00 | 2.00 | 1 880 764,00 | 5.66 | 39.79 |
| Tuberculosis case detection rate       | 73.77 | 240.00  | 2.80    | 18.63    | -0.83    | 5.59     |
| Voice and accountability              | -0.02 | 1.80    | -2.31   | 1.00     | -0.20    | 2.00     |
the variables in the same way so that their type, scope, depth, and relevance are comparable. Thus, we standardize all the variables used in this paper. As for the method of weighting and dimension reduction, we have opted for the main component used in factor analysis. The basic principle is to arrive to an optimal weight that take into account the most important and significant degree of correlation (covariance) to gauge the response capacity of a state. As such, the proposed Readiness Aggregate Index (RAI) is constructed as a composite index of the sub-indices that make it up and that describe the relevant dimensions. The RAI is constructed as follows.

$$\text{RAI} = \sum_{i=1}^{n} x_i I_i$$

where RAI refers to the Readiness Aggregate Index, $x_i$ refers to the weight of the $i$th sub indicator $I_i$ represents the indicator/dimension that is already standardized. The data used are from the World Bank database and covers the period 1990–2020 and all the indicators discussed are described above. The following table shows some summary statistics of the different gross variables.

We normalize and standardize the variables intervening in each axis to put them on an identical scale with expectation zero and variance one. We use factorial analysis to construct the aggregate index via extracting a single factor grouping all the relevant and non-redundant characteristics of the input variables. Factorial analysis made it possible to obtain indices for each sub-category of variables determining the readiness of countries of the panel. Table 2 presents some variables and their degree of contribution in the formation of sub-dimensions. The choice of variables in Table 2 was made according to the contribution of each variable in the dimension to be explained and variables

| Variables | Economy | infrastructure | energy | military |
|-----------|---------|----------------|--------|----------|
| Alternative and nuclear energy | 1.2177 | 1.5409E−6 | −0.9999 | 0.2388 |
| Current health expenditure | 1.2127 | 2.2318E−7 | 0.005893 | 1.0000 |
| Domestic health | | | | |
| Energy imports | 0.8942 | | | |
| Fixed telephone subscriptions | | | | |
| GDP growth (annual %) | 1.2177 | 2.4278E−6 | | |
| GDP per capita (current US$) | 0.4295 | | | |
| Government Effectiveness | | | | |
| Individuals using the Internet | | | | |
| Logistics performance index | | | | |
| Military expenditure (% of GDP) | | | | |
| Military expenditure (% of BD) | | | | |
| Military expenditure (US) | | | | |
| Population ages 15–64 | 0.8291 | | | |
| Population density | −0.000198 | | | |
| Population, total | | | | |
| Renewable energy consumption | | | | |
| Surface area (sq. km) | | | 0.9999 | |

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| Population, total | | | | |
| Renewable energy consumption | | | | |
| Surface area (sq. km) | | | 0.9999 | |
that do not add additional information were discarded. The criterion used to select these variables is the eigen value Tables 3, 4 and 5.

Subsequently, we tried to group the sub-indices into an index describing the countries’ readiness to respond to crises.

The factor measuring the response capacity of states is positively related to governance variables, economic determinants, and health and infrastructure factors. Indeed, a country with high economic and health infrastructures is theoretically capable to face and handle crises. Indeed, a highly reliable and developed infrastructure contributes positively to facilitate crises management. Our governance indicator is quite informative about crisis response, since institutional and public management factors make it possible to undertake the necessary and efficient actions in disaster situations. However, our results show that energy dependence weakens the response capacity of countries. We can formulate the following hypothesis here: countries with huge military spending are

| Table 3 | Contribution to the preparedness index |
|---------|----------------------------------------|
|         | Factor contribution (Mean construction over year–1990 to 2020) |
| Governance | 0.50933 |
| Economics   | 0.47042 |
| Health      | 0.20056 |
| Infrastructure | 0.17904 |
| Energy      | −0.02457 |
| Military    | −0.12802 |

| Table 4 | Correlation matrix between sub indexes |
|---------|----------------------------------------|
|         | Cross-correlations                      |
|         | Economic | Governance | Infrastructure | Energy | Health | Military |
| Economics | 1.00000 | 0.59842 | 0.24056 | −0.01781 | −0.01012 | −0.06730 |
| Governance | 0.59842 | 1.00000 | 0.07877 | 0.00085 | 0.32666 | −0.18077 |
| Infrastructure | 0.24056 | 0.07877 | 1.00000 | −0.06878 | −0.03068 | 0.10737 |
| Energy | −0.01781 | 0.00085 | −0.06878 | 1.00000 | −0.00060 | −0.01441 |
| Health | −0.01012 | 0.32666 | −0.03068 | −0.00060 | 1.00000 | 0.03777 |
| Military | −0.06730 | −0.18077 | 0.10737 | −0.01441 | 0.03777 | 1.00000 |

| Table 5 | Cluster analysis |
|---------|------------------|
|         | Rank | Cluster |
|         | 1 | 2 | 3 | 4 |
| [0, 50) |    | x  |    |    |
| [50, 100)|   |    |    |    |
| [100, 150)|  x |    |    |    |
| [150, 200)|  x |  x |    |    |
| [200, 250)|  x |    |  x |    |
those with the lowest levels of governance and democratization, which is detrimental for the effective handling of large-scale crises (see correlation table in the appendix).

**Results’ discussion and corroboration**

The construction and compilation of the multidimensional State Readiness Index allows to classify countries according to their rank. This has allowed us to classify countries in relation to their level of preparedness to deal with large-scale crises. The graph below shows the evolution of the readiness index over the analyzed period, which is notable in the analysis by region and country. This index confirms that the major powers manage to maintain their level of preparedness over time, especially for the United States, England, Germany, and Canada. On the other hand, the MENA region and the countries of South Asia and Africa are ranked low in terms of state preparedness to handle extreme situations. The Latin American region is well positioned and this is due to the nature of its social systems, which are quite robust.

To allow a better interpretation and homogenous results obtained using this index, we have tried to set up groups of countries in terms of their readiness to respond to LSC using cluster analysis. The cluster analysis resulted in four groups of countries ranked according to the evolution of their rank between the 1990s and 2019.

The classification of the clusters highlights the following. Cluster 1 includes countries with a low level of preparedness and may be in a critical state in the event of a crisis. Cluster 2 includes countries in a mean position with a good degree of preparedness. Clusters 3 and 4 are composed of countries with high degrees of crisis facing preparedness and therefore have the means to effectively respond to systemic crises (see figure).

Prior to the COVID-19 crisis, the degree of preparedness was heterogeneous among countries around the World. Developed countries have degrees of preparedness as high as those of many developing countries do or emerging countries do. The only peculiarity is to note that countries with a very preponderant social component were also very well prepared for the crisis (former communist countries, see Fig. 1).

Similarly, the graph below shows the evolution of the number of countries belonging to a cluster. The results show an almost perfect stagnation in the number of countries.
belonging to a cluster. Thus, in terms of the preparation of States and their ability to face crises, we notice that there has been no great change and that countries in the panel follow the same trend Fig. 1.

The performance of our index depends on its ability to measure the degree of preparedness of states to face, manage and overcome the consequences of large-scale crises. Thus, we have used our index to see how accurately it predicts the achievements and failures recorded due to the COVID-19 pandemic. The relationship between the readiness index and the number of administered tests in the population indicates a positive relationship. Thus, countries that are more prepared tend to test their citizens more often. This is obviously dependent on two elements: available resources and agility to deploy them Fig. 2.

In addition, a review of the number of cases and the number of deaths following the pandemic crisis indicate the power of our index. In fact, a positive relationship emerges between the number of cases and the degree of preparedness of countries. In fact, the more fragile a country is, more abundant cases are registered and vice versa. Furthermore, we found an inverse relationship between the proposed indicator and the COVID-19 mortality rate. Countries with a high degree of preparedness tend to have lower mortality, which allows us to validate their reactive capacity to deal with large-scale crises such as COVID-19 (Fig. 3).

Analysis of the time-profile of a country’s readiness index by region indicates stagnation in the average classification of countries by region. As such, we note the supremacy of the North American zone, of the European zone and also the Latin America and this over more than 20 years. The evolution in the MENA zone indicates deterioration in the rating of the countries in this region since the event of the subprime crisis in 2008 (Fig. 4).

Moreover, we have implemented the correlation matrix between the different regions of the world and the results obtained confirm that the structure of dependence is significant between the geographical areas of the world. We have noted, for example, that the Asian zone is highly correlated with the South Asian zone, this implies that in terms of preparedness to face crises each zone is liked positively by the situation in its neighbors.

This dependence prompted us to set up a distance analysis in order to identify areas with strong dependence. Through this analysis, we were able to provide the areas with strong dependence and the highest degree of proximity. In addition to the Asian zones, we have been able to unveil the dependence between the MENA Zone and the European zone and

Fig. 2 Evolution of the number of Countries by cluster
Central Asia. Likewise, the analysis of the degree of centrality of the zones indicates a significant importance of the European zone in the World and a high proximity of the latter with respect to the MENA and to the Africa zones (Fig. 5).
Concluding remarks

In an era characterized by deep complexity, the importance of networks, and a density of flows between countries, species, individuals, groups of actors, and actors of different types it is highly probable to assist to frequent large-scale crises. It is a matter of national security to develop competencies to deal with this category of crises. For this, it is worth to gauge and measure to what extent countries are ready to face these crises.

In this paper, we raised the fundamental question of the capacity of countries to deal and to face large-scale crises. Of course, the quality of the reaction of states depends largely on the initial conditions for deploying resources. Availability of good conditions: economic, social, political and governance facilitate the response to any future crisis, even one of a large scale.

The index developed in this paper is part of this reflection. Indeed, from the initial conditions concerning all the intrinsic attributes of a country, we have developed a country preparedness index to face large-scale crises. The relevance of the index is correlative with its ability to describe the capacity of countries to respond quickly and effectively to possible crises. The results obtained confirm that the preparedness index that we developed is able to describe the quality of responses from countries confronted to COVID-19 crisis. It can be seen that the countries highly ranked are those that responded actively to the crisis in terms of tests and in terms of the number of deaths, i.e. that is to say, the death rate.

The proposed index is special because it incorporates several dimensions of analysis and several variables describing the capacities of States. In addition, this indicator has the advantage of being dynamic over time. In other words, it introduces the evolution over time of countries’ socio-economic, political, institutional and other practices. Moreover, the proposed measure remains insufficient in the sense that not all variables are very representative of the approximate dimensions. It should also be noted at the epistemological level that the dimensions and variables used describe an inventory and not an adaptive policy at the time of the crisis, which makes it possible to limit the conception of the notion of preparedness in the proposed analysis.

Grouping countries according to their index using the clustering technique (K-means) allows to divide the world into 4 categories in terms of preparedness to face large-scale crises. Thus, the developed and emerging countries as well as the countries of Latin America are classified in the most dynamic clusters and are the most able to respond to shocks. Other clusters are at high risk of spread due to the inability of these areas to respond actively to large-scale crises.

The readiness indicator is therefore a valuable tool to monitor the degree of preparedness and responsiveness of countries. Additionally, it can be updated at a continuous
manner as conditions change in a country or region of interest, making it an indispensable 
ear early warning indicator. As such, it can serve as a leading indicator in times of instability 
and disruptions in order to achieve more effective crisis management.

The use of this type of classification via composite indices has several objectives: first 
of all, it makes it possible to know the strengths that allow States to respond effectively to 
large-scale crises so that the world has the capacity to reproduce this example. Moreover, this 
indicator is able to determine the weak points of each country in order to overcome them and 
achieve better management in the future. Also, monitoring the dynamics of this performance 
over time will allow continuous improvement in terms of the management of public policies.

Further analysis of the index by region revealed a great dependence between the degrees 
of preparedness of countries to face large-scale crises. Indeed, we have noticed that the 
MENA zone depends largely on Europe and the readiness levels of these two zones are cor-
related and it is the same for South Asia and East Asia. Finally, we were able to remark the 
stability of the degrees of preparation by geographical area and the preponderance of the 
countries of Europe and North America. In the same wake, we found that the MENA Zone 
has regressed in terms of preparation to deal crises after the 2008 financial crisis.

The approach used in this paper is based on a concatenation of the different dimensions 
that can contribute to strengthening the degree of response of States to large-scale shocks; 
however, this approach can be deepened to take into account the nonlinear relationships 
that may exist between the different variables and also the moderating relationships that can 
amplify or mitigate the risks. Also, the multidimensional nature of the readiness of States 
makes it difficult to limit themselves to a single index to describe such a complex dynamic.

Appendix

See Fig. 6 and Table 6

Fig. 6 Distribution of Preparedness index for all countries
### Table 6  List of Countries in the panel

| Countries | Afghanistan | Cameroon | Fiji | Jamaica | Mexico City | Philippines | Suriname |
|-----------|-------------|----------|------|---------|-------------|-------------|----------|
| Albania   | Canada      | Finland  | Japan | Micronesia, Fed. Sts | Poland | Sweden |
| Algeria   | Cayman Islands | France | Jersey, Channel Islands | Moldova | Portugal | Switzerland |
| American Samoa | Central African Republic | French Guiana | Jordan | Monaco | Puerto Rico | Syrian Arab Republic |
| Andorra   | Chad        | French Polynesia | Kazakhstan | Mongolia | Qatar | Taiwan, China |
| Angola    | Channel Islands | Gabon | Kenya | Montenegro | Reunion | Tajikistan |
| Anguilla  | Chile       | Gambia, The | Kiribati | Morocco | Romania | Tanzania |
| Antigua and Barbuda | China | Georgia | Korea, Dem. People's Rep | Mozambique | Russian Federation | Thailand |
| Argentina | Colombia | Germany | Korea, Rep | Myanmar | Rwanda | Timor-Leste |
| Armenia  | Comoros     | Ghana | Kosovo | Namibia | Samoa | Togo |
| Aruba     | Congo, Dem. Rep | Gibraltar | Kuwait | Nauru | San Marino | Tokelau |
| Australia | Congo, Rep | Greece | Kyrgyz Republic | Nepal | Sao Tome and Principe | Tonga |
| Austria   | Cook Islands | Greenland | Lao PDR | Netherlands | Saudi Arabia | Trinidad and Tobago |
| Azerbaijan | Costa Rica | Grenada | Latvia | Netherlands Antilles | Senegal | Tunisia |
| Bahamas, The | Ivory Coast | Guam | Lebanon | New Caledonia | Serbia | Turkey |
| Bahrain   | Croatia     | Guatemala | Lesotho | New Zealand | Seychelles | Turkmenistan |
| Bangladesh | Cuba | Guinea | Liberia | Nicaragua | Sierra Leone | Turks and Caicos Islands |
| Barbados  | Curacao     | Guinea-Bissau | Libya | Niger | Singapore | Tuvalu |
| Belarus   | Cyprus      | Guyana | Liechtenstein | Nigeria | Sint Maarten (Dutch part) | Uganda |
| Belgium   | Czech Republic | Haiti | Lithuania | Niue | Slovak Republic | Ukraine |
| Belize    | Denmark     | Honduras | Luxembourg | North Macedonia | Slovenia | United Arab Emirates |
| Countries                      | Afghanistan       | Cameroon              | Fiji          | Jamaica                   | Mexico City             | Philippines              | Suriname                      |
|--------------------------------|-------------------|-----------------------|---------------|---------------------------|-------------------------|---------------------------|-------------------------------|
| Benin                          | Djibouti          | Hong Kong SAR, China  | Macao SAR, China | Northern Mariana Islands  | Small states            | United Kingdom             |                               |
| Bermuda shorts                 | Dominica          | Hungary               | Madagascar    | Norway                     | Solomon Islands         | United States             |                               |
| Bhutan                         | Dominican Republic| Iceland               | Malawi        | Norway                     | Somalia                 | Uruguay                   |                               |
| Bolivia                        | Ecuador           | Iceland               | Malaysia      | Norway                     | South Africa            | Uzbekistan                |                               |
| Bosnia and Herzegovina         | Egypt, Arab Rep   | India                 | Maldives      | Oman                       | South Sudan             | Vanuatu                   |                               |
| Botswana                       | El Salvador       | Indonesia             | Mali          | Spain                      | Venezuela, RB           |                           |                               |
| Brazil                         | Equatorial Guinea | Iran, Islamic Rep     | Malta         | Sri Lanka                  | Vietnam                 |                           |                               |
| British Virgin Islands         | Eritrea           | Iraq                  | Marshall Islands | Palau                     | St. Kitts and Nevis     | Virgin Islands (U.S.)     |                               |
| Brunei Darussalam              | Estonia           | Ireland               | Martinique    | Panama                     | St. Lucia               | West Bank and Gaza        |                               |
| Bulgaria                       | Eswatini          | Isle of Man           | Mauritania    | Papua New Guinea           | St. Martin (French part)| Yemen, Rep                |                               |
| Burkina Faso                   | Ethiopia          | Israel                | Mauritius     | Paraguay                   | St. Vincent and the     |                           |                               |
| Burundi                        | Faroe Islands     | Italy                 | Mayotte       | Peru                       | Grenadines              |                           |                               |
| Cabo Verde                     |                    |                       |               |                           | Sudan                   |                           |                               |
| Cambodia                       |                    |                       |               |                           | Zimbabwe                |                           |                               |
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