2024 Geographical Vulnerability Index

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I. Introduction

Geographic vulnerability refers to the susceptibility of a specific area to adverse impacts due to its environmental characteristics (Timmermann, 1981). In light of this, the work of the Data Group 3 proposes to analyze the existing Geographical Vulnerability Index, developed in 2023, and has a twofold objective:

- Improving the choice of the proxy variables for some of the sub-indexes through their redefinition and collection of data

- Enlarging the number of countries and years of observations with respect to the previous years in order to produce a time-series version of the index

The project started with a preliminary analysis of the latest version of the Geographical Risk Index, its econometric definition and the previous datasets, to underpin the starting point of our research. Then, the team proceeded with a refinement of the previous proxy variables, consistently with new developments in the data, and taking into account pre-existing data limitations.

Followingly, the focus moved to the data collection process, in order to produce the best possible years-countries enlargement, facing the trade-off between the two. In conclusion, we were able to gather data for 167 countries in a time frame of 13 years (2011 – 2023) and expand the existing Geographical Vulnerability Index to a time-series dataset.

II. Initial Data and Variables

The 2023 Geographical Vulnerability Index dataset presented different worksheets diving data and results of each sub-index, which remained unchanged for the 2024 score edition. The 6 dimensions of the index are represented by: Emissions per capita, Climate Change and Global Warming, Sustainment of Human Activity, Exposure to Natural Disasters, Access to the Sea and Natural Resources Rents.

The main issue faced has been that in different sub-indexes a time series was almost absent, presenting only the most recent year or an average of the last ones, furthermore in some cases we have found relevant problems in the identification of the proxy variables.

In the following paragraphs, we report the changes and improvements made for each sub-index and the reasons behind the adjustments. As for the foundation of our analysis, the 2023 Final Geographical Risk Index provided unique observations for 179 countries, without any time series analysis. Provided that, our project is aimed not only at building more accurate estimates for each sub-index but also to endow the existing data with a panel structure that analyzes geographical risk over time.

III.   Emissions

Per capita emissions represent the Carbon Dioxide (CO_2) emissions from fossil fuels and industry - land-use change is not included - of an average person in a country or region. Therefore, estimates provided are calculated as the total emissions divided by population.

In particular, this data is based on territorial emissions, which do not account for emissions embedded in traded goods, and emissions from international aviation and shipping, since they are not included in any country or region's emissions but they are only included in the global total emissions.

The final dataset includes 231 countries, with an increase of 23 countries (+11,1%) with respect to the initial one. Furthermore, there has been a major improvement in terms of time span: the new data range from 2004-2022 (19 years) with respect to the initial sub-index that covered only 5 years (2017-2021).

Please note that, in order to compute the final index, 2023 estimates have been assumed equal to 2022 data, due to lack of public data. The emissions per capita have been collected from Our World in Data website and have been updated on December 12th 2023 (the next update is expected on December 2024).

IV.   Climate Change

The most widespread variable used to track climate change is the annual estimate of mean surface temperature change, measured with respect to a baseline climatology. In particular, time-series temperature change, measured in Degree Celsius, is calculated as a weighted average of the Global Surface Temperature Change data distributed by the National Aeronautics and Space Administration Goddard Institute for Space Studies (GISTEMP) data over all stations within a given radius, with the closest stations weighted most heavily, in compliance with the method adopted by the UN Food and Agriculture Organisation (FAO) for estimating annual country level and global temperature change.

The final dataset includes 223 countries (with at least 5 observations), with an increase of 3 countries with respect to the previous dataset, which had 220 countries with 5 observations, 5 countries with 4 observations, 2 countries with 3 observations and one country with only 2 observations.

Additionally, in this case, there has been a substantial improvement in terms of time span, which went from 5 years (2017-2021) to 13 years (2011-2023). The data have been collected from THE International Monetary Fund website, tracking the last update of April 15th 2024.

V. Sustainment for Human Activity

The variable representing the Sustainment for Human Activity sub-index, in the 2023 version, tracked one observation for the year 2021 and counted for 239 countries, with different missing values among them. The previously selected proxy variable was represented by the ratio between the area of the land dedicated to agricultural activities and the total land area for each country.

In our analysis, we believed that this ratio was not able to fully take into account the density of the population, which is fundamental to underpin how agriculture sustains the entire population. Therefore, we decided to make several modifications to the existing data, without distancing further from the previous proxy variable.

Indeed, we have chosen as new proxy variable the agricultural land per person over the long-term, for each country. In this way, the population density of countries is rightfully entered in the equation.

The data are measured in hectares per person and collected from Our World in Data website. We have been able to reach a yearly time series of 73 years (from 1950 to 2023) for 197 countries.

VI. Exposure to Natural Disasters

The exposure to natural disasters sub-index has been previously based on the average between the percentiles of two variables, the ratio "Disaster per 100 squared kilometers" and the Human Development Index (HDI).

However, we have found some inconsistencies in the formulation of the proxy. Indeed, the first ratio has been calculated as the number of disasters between 2016 and 2021 (i.e. aggregating the data across years) to the land area for each country for 177 countries. This variable should be based on strong statistical assumptions, for example, that the disasters across years are i.i.d. or exogenous. Moreover, the social component should be integrated through the HDI, but the econometric choice of making an arithmetic average is not backed by any reasoning or evidence.

Therefore, we opted for finding a real exposure index on natural disasters. The research has been successful and produced yearly estimates from the World Risk Report in the time span from 2011 to 2023. With such measures, we were able to build an index about the exposure of counties' population to different types of disaster, reaching the highest coverage in 2023 with 193 countries.

VII. Sea Access

Geographical positioning of countries significantly influences their vulnerability evaluation, from a geopolitical point of view. Different countries face varying geopolitical and economic challenges based on their access to, or lack of, sea routes. Classifications based on geographic position include double landlocked or enclave nations, landlocked countries, those with access to multiple oceans, nations with a single ocean access, and those bordering an inland sea. Each category presents distinct risks and advantages which are fundamental to assessing geographical vulnerability.

In maintaining the consistency of our sea access sub-index from the original 2023 measure, we account for the heightened geopolitical risks faced by double/single landlocked countries, which of-

ten experience slower GDP growth, particularly in the developing world. Access to multiple oceans, while beneficial for trade, is also deemed slightly riskier due to natural disasters and strategic political vulnerabilities.

To enhance the reliability of our index, we have introduced an additional proxy: the number of bordering countries for each nation. A higher number of neighboring countries can escalate geopolitical tensions, as seen in the recent tensions arising globally.

The final score for each country is computed by arithmetically summing the individual scores derived from both sea access and the number of bordering countries, creating an index that ranges from 0 to 10. A score of 10 represents the highest level of geographical vulnerability while 0 means the lowest level of risk. The updated index covers 168 countries, gathering the latest geographical data provided by GeoDataSource website to ensure accuracy and relevance in our analysis.

VIII.   Natural Resources

Access to natural resources, including oil, natural gas, coal, minerals, and forest products, represents a critical geopolitical and economic concern for nations worldwide. Given the growing global population and the pressing challenges of climate change, the strategic importance and uneven distribution of these resources exacerbate geopolitical tensions and highlight geographical vulnerabilities. National economies, nowadays, depend heavily on these resources to meet the needs of increasing populations. In order to enhance the understanding of geographical vulnerability, we have updated the natural resources sub-index by gathering data from the World Bank Group.

The World Bank computes the total natural resources rents by country and geographical area as a percentage of annual GDP, providing a crucial indicator of resource distribution and economic dependence. Thanks to those data, we have been able to improve the original 2023 sub-index.

The index now includes an expanded time series that encompasses additional data from 2011 to 2021, enlarging the original panel by 4 additional years (2014-2020). This expansion increases the scope of our analysis significantly, with the final data set including 87 new countries and macro-areas, for a total of 267 countries, reflecting a more comprehensive global perspective. The methodology for calculating the index remains consistent with previous years' measure. It scales from 0 to 10, where 0 indicates an abundance of natural resources and 10 signifies a critical level of natural resources endowment. This standardized approach allows for a comparative analysis over time and across different geographical areas, offering relevant insights into the dynamics of resource availability and its implications for economic stability.

IX.   Recommendations for future index development

At the end of this work, the team would like to suggest some guidelines for the next year. Without considering the obvious suggestion to continue to update the dataset over time, a possible useful development would be a robustness check of the result through the definition of a second proxy variable for each sub-index. This would allow the future team to compare the results of the two proxies chosen for the single sub-index in order to find inconsistencies and differences that would help to better calibrate the choice of the right data to use.

X.   Conclusion

In conclusion, the work of expanding the time series for years and the number of countries reaches a satisfactory result. All sub-indexes have been widened temporally compared to the previous versions, as well as the number of countries in the majority of the cases. At the end, the cross-check across the six different sub-indexes produced a time series from 2011 to 2023 for 167 countries.

As observable from the data, the number of countries has been reduced with respect to the 2023 edition. However, this is due to a choice of selection of the final results. Indeed, last year many countries were considered in the final count even without owning a value for all the sub-indexes. We decided to include only those countries with a non-zero value for all the sub-indexes analyzed, with the aim of producing a more truthful ranking.

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