VULNERABILITY FOR OLD PEOPLE: DIFFERENCES AMONG EUROPEAN COUNTRIES

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Abstract. In this work we analyze the vulnerability of people aged 50+ living in 11 European Countries, taking into account for two aspects: a physical-economic dimension and a social one. Data come from the Survey of Health, Ageing, and Retirement in Europe (SHARE) and refer to the Covid-19 period, that is 2019-2020. Results show a geographical path of vulnerability: Mediterranean Countries register the higher vulnerability, especially in the Economic-Health domain.

1. Introduction

In 2022, over one-fifth percent (21.1%) of the EU population was aged 65 and over, with a median age of 44.4. The rapid aging of populations around the world, especially in the EU, presents an unprecedented set of challenges, including increased expenditures on health and long-term care and potential problems with old-age income security. Countries**,** as Italy, Portugal, Finland and Greece**,** present the higher share of people aged 65 or older in the total population, that is 23.8%, 23.7%, 23.1% and 22.7%, respectively, while Luxembourg (14.8 %) and Ireland (15.0 %) had the lowest shares (EUROSTAT, 2023). European Countries do not share the same behavior: the increase in the proportion of elderly people as well as the increase in the median age is higher in Mediterranean area. For instance, from 2012 to 2020 the median age of people living in Portugal, Spain, Greece and Italy have increased more than four years whereas Sweden is the only country with a negative variation (-0.1) (EUROSTAT, 2023). Moreover, the old-age dependency ratio suggests that in Luxembourg and Ireland there are one working age persons for every five persons aged 65 or over (the index is 21.3 % and 23.1 %, respectively)**,** whereas, in Italy (37.5 %) and Finland (37.4%) there are less than three working age persons for every person aged 65 or over. It is true that the growth in the relative share of older people may be explained by increased longevity. However, consistently low levels of fertility over many years have contributed to and are contributing to population ageing. Therefore, measuring vulnerability of aged people has become crucial. The concept of vulnerability has been developed and used in various disciplines. The term vulnerability is frequently interchangeably used with frailty, dependence, or loss of autonomy and literature suggests a strong connection between older age and vulnerability. In fact, older age may, *prima facie*, be associated with vulnerability, due to a higher risk of illness and chronic diseases and older adults may be more often in contexts of situational vulnerability due to their potentially greater need for health care.

Vulnerability is not a straightforward concept, and no consensus exists regarding its meaning and definition (Lee, 2014). We suppose that everyone has a degree of vulnerability and the higher the vulnerability the higher the (negative) impact on well-being, at any age. According to UNECE (2023), elderly people experience vulnerable situations when one or a combination of difficulties arise. Those changes involve personal, environmental, or societal dimensions and risk overwhelming elderly individual capacities and resilience, with a potential negative impact on their daily life. Thus, following this setting, here, we define vulnerability as a phenomenon that encompasses two aspects: a physical-economic dimension and a social one. The first one, the physical-economic dimension takes into account for both health status and economic factors, such as difficulty in dealing with unexpected expenses, ability to save, and adequacy of housing. The social dimension includes factors such as loneliness, family and friend relationships, and social participation.

From a methodological point of view, for the construction of composite indicators it is suitable to work with continuous variables. However, in the measurement of vulnerability, usually, we deal with categorical variables. To overcome this problem, for each dimension, we compute a composite indicator by using a two-stage procedure. First, for each country, individual data are aggregated using the first stage of the fuzzy multidimensional approach developed by García-Pardo *et al.* (2021). Then, data are aggregated across individuals.

We use data from the Survey of Health, Ageing, and Retirement in Europe (hereafter, SHARE) (Börsch-Supan, 2022). Data are collected at individual and household level and sample weights are used. Among the 28 countries listed in SHARE, the analysis is conducted for 11 European countries divided into Mediterranean countries (Spain, France, Greece, and Italy), Continental countries (Austria, Belgium, Germany, and Netherlands) and Nordic countries (Denmark, Finland and Sweden). By considering Mediterranean, Central and Nordic countries we aim at capturing three different path of vulnerability and asserting that there is a hidden dimension, namely the geographical dimension**,** that also play a role in the definition of vulnerability. The choice of these countries is guided by several reasons. Firstly, within the three geographical areas, we select countries with similar socio-demographic characteristics (i.e Spain, Greece and Italy have almost identical variation on median age). Then, since historically, for an economic point of view, there are three main different economic models coinciding with geographical area, so we are interested in finding if this is replicated also for vulnerability. Finally, we are interested in finding if there is the so-called the *longevity revolution* for Nordic Countries (see Fritzell *et al.*, 2022).

Comparisons among countries as well as a discussion of potential further research are provided. The rest of the paper is organized as follows. Section 2 provides a description of the method and the data. Section 3 presents the main results and Section 4 concludes with potential further research.

2. Data and methods

Data come from the Survey of Health, Ageing and Retirement in Europe (SHARE). SHARE is a multinational panel data survey, collecting data on medical, economic and social characteristics of individuals aged 50+. The survey covers 28 European Countries plus Israel, but here, as preliminary analysis, we focus on 11 countries that can be divided into three groups, namely Mediterranean Countries (Spain, France, Greece, Italy), Continental countries (Austria, Belgium, Germany and Netherlands) and Nordic countries (Denmark, Finland and Sweden).

We measure vulnerability by means of two dimensions: the Social domain (SOC) that accounts for 9 variables and the Economic and Health domain (ECH) with 8 variables. For the choice of the variables, we partially refer to Stranges (2013). The complete list of the variables**,** as well as the definition and the label in SHARE**,** are collected in Table 1 and Table 2.

To obtain the two indicators, we apply the first part of the methodology proposed by García-Pardo *et al.* (2021). In particular, we denote by U the population set and by h a non-continuous dimension with deprivation categories $j \in \{1, . . . ,k_h\}$. The symbol $c_{h,j,i} \in \{1, 2, . . . , n_j\}$ denotes the deprivation symptoms of each category j for individual i in dimension h, with $c_{h,j,i}= 1$ and $c_{h,j,i} = n_j$ we denote, respectively, the most deprived and the least deprived. Thus, using the membership function defined by Cheli and Lemmi (1995) the deprivation score in category j for individual i in the non-continuous dimension h is defined as follows:

$$e_{h,j,i} = \frac{1-F(c_{h,j,i})}{1-F(1)}\,, \tag{1}$$

where $F(c_{h,j,i})$ is the value of the j-th category distribution function for the i-th individual in dimension h.

Table 1 – *SOC: list of variables, description, SHARE label and deprivation ($c_{h,j,i}$).*

SOC	Description	SHARE	$c_{h,j,i}$
Voluntary	Activities in last year: done voluntary or charity work	ac035d1	If ac035d1=-2, -1, 0, $c_{h,j,i}=1$ ac035d1=2, $c_{h,j,i}=2$
SportSocCl	Activities in last year: gone to a sport, social or other kind of club	ac035d5	If ac035d5=-2, -1, 0, $c_{h,j,i}=1$ ac035d5=2, $c_{h,j,i}=2$
Polpart	Activities in last year: taken part in a political or community-related organization	ac035d7	If ac035d7=-2, -1, 0, $c_{h,j,i}=1$ ac035d7=2, $c_{h,j,i}=2$
CaspIndex	CASP index for quality of life and well-being".	casp	12 ≤casp≤20, $c_{h,j,i}=1$ 21≤casp≤29, $c_{h,j,i}=2$ 30 ≤casp≤ 38, $c_{h,j,i}=3$ 39≤casp≤ 48, $c_{h,j,i}=4$
Lonely	How much of the time do you feel lonely?	mh037_	mh037_=-2, -1, 0, $c_{h,j,i}=1$ mh037_=2, $c_{h,j,i}=2$
SadDep	Sad or depressed last month	mh002_	mh002_=-2, -1, $c_{h,j,i}=1$ mh002_=-5, $c_{h,j,i}=2$
Sn_satisfy	Social network satisfaction	sn_ satisfaction	sn_satisfaction =0,-1,-2,-9, $c_{h,j,i}=1$ sn_satisfaction =s, $c_{h,j,i}=s+1$, $s\in\{0,1,\dots,10\}$
LifeSatisf	Satisfied with life	lifesat	satisf = -99, 0, $c_{h,j,i}=1$ satisf =s, $c_{h,j,i}=s+1$, $s\in\{0,1,\dots,10\}$
LifeHap	Life happiness	lifehap	lifehap=99,4, $c_{h,j,i}=1$ lifehap=s, $c_{h,j,i}=5-s$, $s\in\{1,2,3\}$

Our Elaboration on SHARE data.

Once the variables are transformed by applying Equation (1), to construct the indicator at unit level, we need to aggregate them. We use a weight defined by means of two components, the first one, denoted by $w^a_{h,j}$ attaches more weight to categories in which the proportion of individuals in the population with deprivation in category j is smaller and the second one, $w^b_{h,j}$, attaches less weight to categories with redundant information. More in detail, $w^b_{h,j}$ is a function of the coefficient of determination that is, it is obtained using X_j as dependent variable and $X_1X_2 \dots X_{j-1}X_{j+1} \dots X_k$ as independent variables in a multiple linear regression model. Formally, we have:

$$w_{h,j} = w^a_{h,j}\, w^b_{h,j}\text{, with } w^a_{h,j} = 1 - \frac{1}{N}\sum_{i=1}^{N} e_{h,j,i} \text{ an } w^b_{h,j} = 1 - R^2_{e_{h,j,i},\, e_{h,-j,i}}. \quad (2)$$

In (2) the symbol $R^2_{e_{h,j,i},\, e_{h,-j,i}}$ denotes the coefficient of determination associated with the regression model.

Table 2 – *ECH: list of variables, description, SHARE label and deprivation ($c_{h,j,i}$).*

ECH	Description	SHARE	$c_{h,j,i}$
Fdistress	Household able to make ends meet	fdistress	fdistress=1,99, $c_{h,j,i}$ =1 fdistress = $c_{h,j,i}$ =s, s∈ {2,3,4}
AffUnExpens	Afford to pay an unexpected expense without borrowing money	co206_	co206_=-2,-1.0, $c_{h,j,i}$ =1 co206_=1, $c_{h,j,i}$ =2
AlpHealth	Health literacy: how often help needed	hc889_	hc889_=-2,-1,0,1, $c_{h,j,i}$ =1 hc889_= $c_{h,j,i}$ =s, s∈ {2,3,4,5}
ADL	Number of limitations with activities of daily living (adl)	adl	adl=-2,-1,0, $c_{h,j,i}$ =7 adl=s, $c_{h,j,i}$ =7-s, s∈ {1,2, … ,6}
Chronic	Number of chronic diseases	chronicw8c	chronicw8c =-2, -1, $c_{h,j,i}$ =1 chronicw8c =0, $c_{h,j,i}$ =8 chronicw8c =2s-1, $c_{h,j,i}$ =8-s chronicw8c =2s, $c_{h,j,i}$ =8-s s∈ {1,2, … ,7}
SelfPerHealth	Self-perceived health	sphus	sphus=1,2, $c_{h,j,i}$ =1 sphus =s, $c_{h,j,i}$ =6-s, s∈ {1, … ,5}
Ndoc	Num. of medical doctor seen/talked in 12 month	doctor	doctor≤ $q25$, $c_{h,j,i}$ =4 $q25$ <doctor≤ $q50$, $c_{h,j,i}$ =3 $q50$ <doctor≤ $q75$, $c_{h,j,i}$ =2 doctor > $q75$, $c_{h,j,i}$ =1 *where q# denotes the # quantile*
QIncome	Income	thinc2	doctor≤ $q20$, $c_{h,j,i}$ =1 $q20$ <doctor≤ $q40$, $c_{h,j,i}$ =2 $q40$ <doctor≤ $q60$, $c_{h,j,i}$ =3 $q60$ <doctor≤ $q80$, $c_{h,j,i}$ =4 doctor > $q80$, $c_{h,j,i}$ =5 *where q# denotes the # quantile*

Our Elaboration on SHARE data.

Keeping the formulas in (2) in mind, for a fixed dimension *h*, the *deprivation score for individual i* according to a set of non-continuous dimensions $j \in \{1, \ldots, k_h\}$ is given by:

$$e_{h,i} = \frac{\sum_{j=1}^{k_h} w_{h,j} e_{h,j,i}}{\sum_{j=1}^{k_h} w_{h,j}}. \tag{3}$$

Thus, the overall index for a given country is the average of those individual scores. In this way, the higher the value of the index, the greater the deprivation.

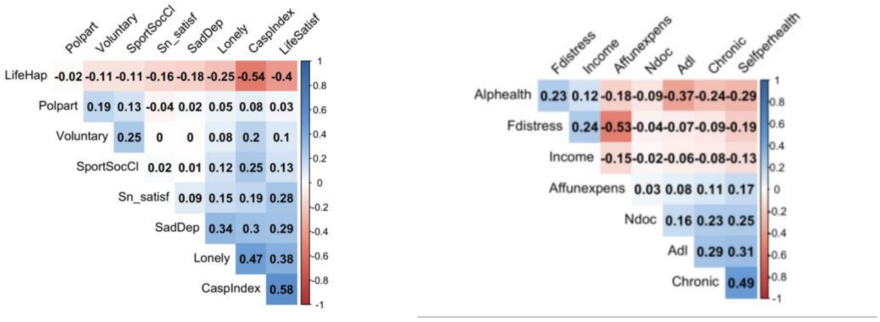
3. Results and discussion

Firstly, for both domains, we compute correlation coefficients. Figure 1 displays the results. Values do not exceed 0,58 for the Social domain and -0,53 for the Economic and Health domain and this satisfies one of the requirement in the construction of a composite indicators (Nardo *et al.*, 2008).

To compute the two vulnerability indices, we need to encode the original variables to obtain the deprivation symptoms of category j for individual i in dimension h, $c_{h,j,i}$, and, using Equation (1), the deprivation score in category j for individual i in the non-continuous dimension h, $e_{h,j,i}$,. Table 1 and Table 2 also report the transformation adopted.

The deprivation score in category j for individual i in the non-continuous dimension h, $e_{h,j,i}$,, is used to compute the two types of weights. Figure 2 and Figure 3 report the two corresponding weights for each country and all variables in Economic-Health and Social dimensions, respectively.

Figure 1 – *Correlation matrix for the variables in SOC (left panel) and ECH (right panel).*

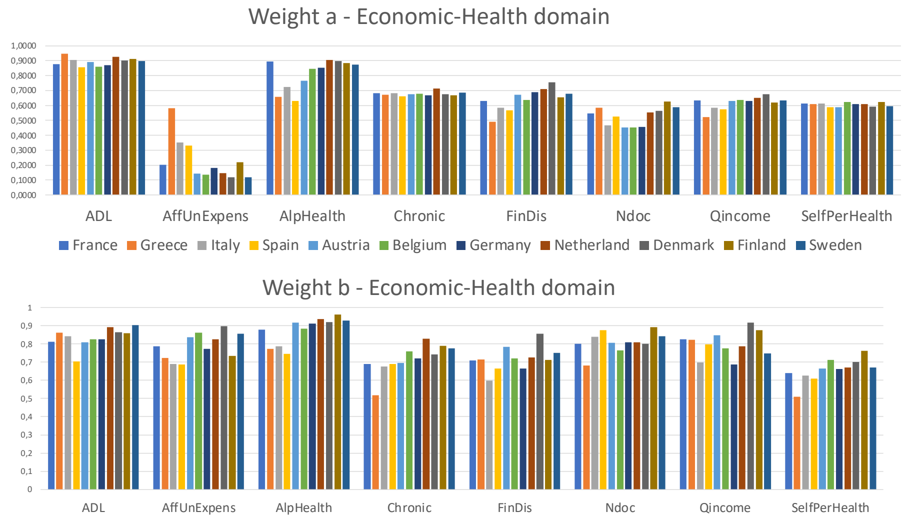


Our elaboration on SHARE data.

For the former domain, the variable *affUnExpens* registers the lower values according to the weight $w^a_{h,j}$. Since, according to $w^a_{h,j}$, less frequent deprivation should obtain higher weights, we can affirm that for this variable, almost all the individuals, in each country, reach the same values. The only exception is Greece, whose value is almost double the values achieved by other countries.

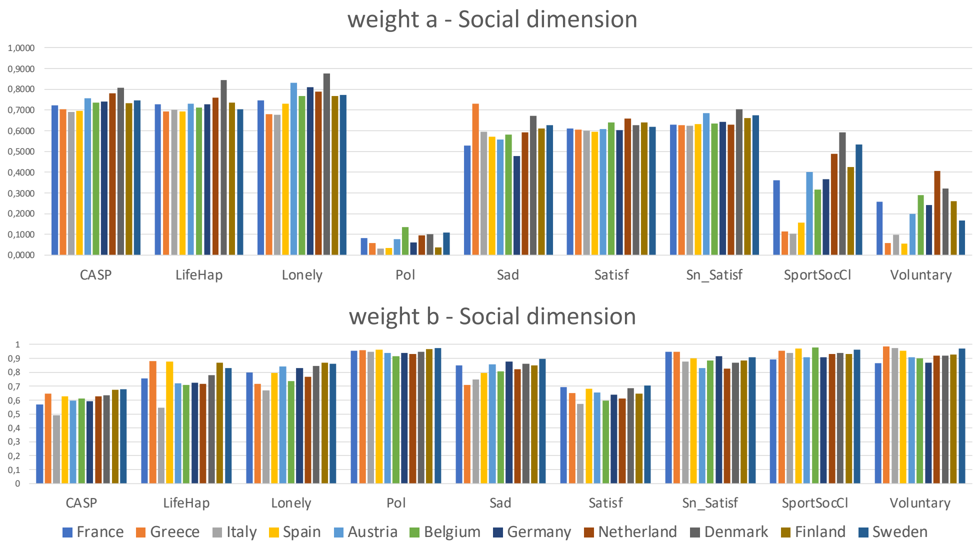
The same applies for variable *Pol* (Social domain) but in this case all the countries register similar values. For both dimensions, the values of the weight $w^b_{h,j}$ are similar and quite higher (between 0.5 and 1 for all countries and all variables). According to the weight $w^b_{h,j}$, categories that provide redundant information should be penalized, this means that the information collected using those variables is a bit redundant.

Figure 2 – *Weights for Economic-Health domain.*



Our elaboration on SHARE data.

Figure 3 – *Weights for Social domain.*

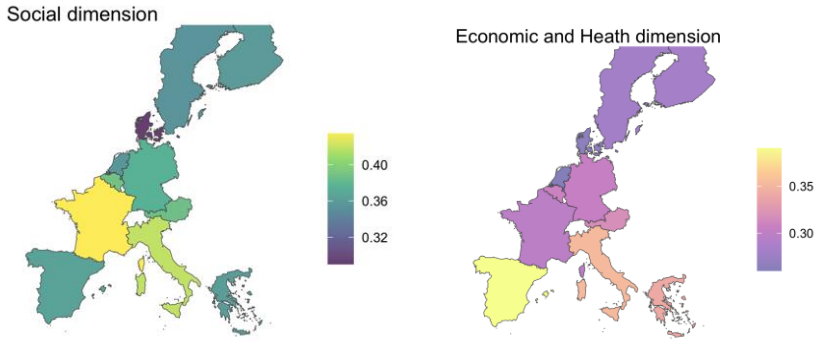


Our elaboration on SHARE data.

Before computing the composite indicator, we compute the overall weights, defined as the product of the above-mentioned weights (see Equation 2). Thus, we single out the maximum and the minimum as well as the average by country and for each variable. For the Economic-Health domain, the average values at country level range from 0**.**426 (Spain) and 0**.**546 (Finland)**,** whereas for the Social domain, the lower values is 0**.**303 for Italy and the maximum is 0.490 for Denmark. If we focus on countries, Netherland, Denmarck and Finland exhibit the higher values for almost all the variables, Greece is the only exception for *AffUnExpens* and Belgium for *Pol*. If we focus on variables, for the Economic-Health domain, the higher weights are for *ADL* and *AlpHealth* wherease, *Lonely* is for the Social one.

Figure 4 displays the results of the aggregation procedure. In both cases, the lighter the colour, the higher the deprivation. Especially for the Economic and Health dimension it is easy to find a sort of geographical path: Mediterranean countries display the lower values, then Continental and Nordic countries reach the maximum values.

Figure 4 – *Composite Indicator for Social and Economic-Health.*



Our Elaboration on SHARE data.

Table 3 reports basic statistics for Social and Economic-Health dimensions.
Figure 5 displays the scatter plot between Social dimension (horizontal axis) and Economic-Health domain (vertical axis). This figure proves the existence of the geographical path mentioned above, that sees a clear difference between Mediterranean countries and Continental and Nordic countries.

To enforce conclusion made by means of the scatter plot (Figure 5), we compute the bi-dimensional (Euclidean) distance among countries (Figure 6).

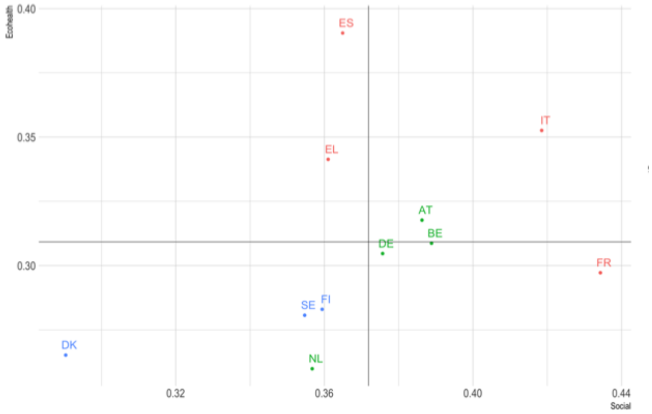
We note that there are three groups of countries which exhibit the lower distance, namely 1) Finland, Netherland and Denmark; 2) Austria, Belgium, Germany and Netherlands; and 3) Italy, France, Spain and Greece. This confirms the existing of a geographical path in vulnerability values.

Table 3 – *Basic statistics for both dimensions.*

	Min	1st Qu.	Median	Mean	3rd Qu.	Max
Social	0.2904	0.3581	0.3649	0.3719	0.3876	0.4343
Eco-health	0.2599	0.2819	0.3047	0.3092	0.3295	0.3905

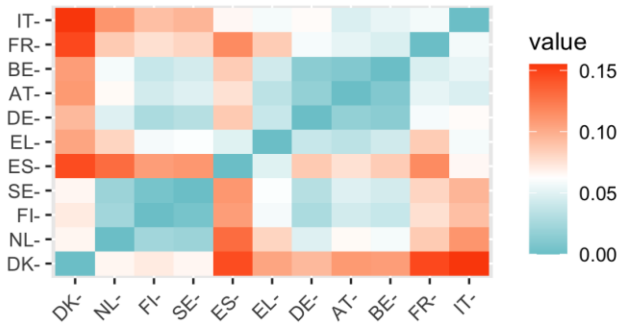
Our Elaboration on SHARE data.

Figure 5 – *Scatter plot of the two dimensions.*



Our elaboration on SHARE data. Colour: Red for Mediterranean Countries, Green for Continental Countries and Blu for Nordic Countries.

Figure 6 – *Country-distances.*



Our elaboration on SHARE data.

Finally, as a preliminary step for further research, we compute the "normalized" weights obtained applying Equation (3) and normalized to sum to 1, and we compare them with the weights obtained using as aggregation method the Arithmetic mean. Table 4 reports those values.

Table 4 – *Insight the method: Weighted mean vs Arithmetic means.*

Health & Economic (AM= 0.111)	Normalized weights	Social (AM=0.125)	Normalized weights
Fdistress	0.124	Voluntary	0.214
AffUnExpens	0.140	SportSocCl	0.068
AlpHealth	0.167	Polpart	0.159
ADL	0.011	CaspIndex	0.129
Chronic	0.163	Lonely	0.098
SelfPerHealth	0.125	SadDep	0.110
Ndoc	0.200	Sn_satisfy	0.114
QIncome	0.036	LifeSatisf	0.108
		LifeHap	0.214

Our Elaboration on SHARE data. In brakets the values of the weights in case of Arithmetic Mean

The comparison between the equal weighted approach (that is, the weights we have by applying the Arithmetic Mean, AM) and the weighted approach above discussed reveals the variables having the higher/lower impact. For instance, for the Health and Economic domain, *ADL* has the lower impact (0.011) that is about the 10% of the weight associated with the same variable in case of equal-weights, or, in other words, the impact of the weight of this variable is about 1%. The highest is for *SelfPerHealth*, that is, almost twice the value for equal weights.

4. Conclusions and further research

This paper presents a first attempt of defining and measuring vulnerability for selected European Countries by means of two specific dimensions. The results suggest that in this type of analysis, the geographical dimension plays a crucial role. This indicates the need to provide computations at a more detailed level, specifically at the regional level. The work can be developed in several directions. Firstly, it should be interesting compare the results obtained here with those obtained using a different approach that moves from the individual score to the country index. In this direction, we are also interested in applying the so-called Weighted and Penalized approach (Ciommi *et al.*, 2017; Mariani *et al.*, 2022). It could be also of potential interest to use Principal Components Analysis (PCA) or Categorical Principal Components Analysis (CATPCA) to select a subgroup of dimensions of vulnerability that reduces the number of original variables involved. Moreover, we could also use Cluster Analysis (CA), both hierarchical and non-hierarchal (in the case of non-hierarchical CA we can fix the number of groups equal to 3 and see if countries in each cluster coincide with the results displayed with the scatter plot. Finally, we want to try to combine the two dimensions into one (Mariani *et al.*, 2023).

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