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Covid-19 Economic Vulnerability Index: EU Evidence

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Abstract

The COVID-19 pandemic outbreak caused many negative effects on both the global and national economies. To implement effective policies to mitigate the negative impact of a pandemic, it is necessary to identify particularly vulnerable areas. The objective of this paper is to rank the EU countries in terms of the level of vulnerability of their economies to the impact of the pandemic. For this purpose, the COVID-19 Economic Vulnerability Index (CEVI) was constructed. It replaces the 15-dimensional set of characteristics of the countries with one aggregate, synthetic indicator estimated for 27 EU member states. In the study multivariate statistical methods, including agglomerative clustering and multi-attribute methods of object assessment were used to analyse the effects of the pandemic. The research shows that EU countries have different levels of economic vulnerability to the impact of the COVID-19 pandemic. The southern European countries (Spain, Croatia, Greece and Italy), where the tourism sector plays an important role in GDP composition, are the most fragile. Germany and the Scandinavian countries proved to be the least sensitive to the negative impact of the pandemic. The CEVI can be an important part of the decision support system. It enables the identification of countries that show greater vulnerability to the economic impact of the COVID-19 pandemic and may help support countries that need help the most. The proposed index also indicates certain areas in the country's economy that make it more vulnerable. The CEVI in combination with other instruments can be a very useful tool to improve the economy's resilience and help it recover faster in the event of a pandemic shock.

Keywords: economic vulnerability, COVID-19 pandemic; multivariate statistical methods; synthetic measure

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1. Introduction

The end of the second decade of the 21st century turned out to be an exceptional period in the world economy. At that time, a pandemic broke out in China, which spread rapidly around the world. Individual economies shut down as an act of protection against the development of the disease on a massive scale. For the first time in a global economy, there was a sudden and significant increase in the isolation of economies. This had many negative consequences. However, despite the widespread lockdowns implemented in many countries, it was not possible to prevent the spread of the disease, but only to slow down the process.

The pandemic has had a very strong impact on the global and national economies. Its effects are visible in many areas, but especially in economic and social areas. Many people have fallen ill (151 million – as of 1 May 2021) and many have died (nearly 3.2 million)[1]. The fear of contracting the disease and the desire to counteract the development of the pandemic has led to a transformation of interpersonal relations in a direction that greatly limits direct contact. Massive government decisions on lockdowns triggered a significant reduction in production and economic activity, which in turn resulted in broken supply chains, increased unemployment and a fall in GDP.

However, not all countries felt the impact of the COVID-19 pandemic on their economies to the same extent. Some have been much more vulnerable to its effects, while others have been much less negatively affected by the COVID-19 pandemic. The vulnerability of economies to the impact of COVID-19 pandemics, that is the capacity of the economy to cope with the negative impact of COVID-19 pandemics, resist it and recover from its impact has been the focus of much academic interest. The objective of this paper is to measure, assess and rank the EU countries in terms of the level of vulnerability of their economies to the impact of the COVID-19 pandemic. For this purpose, an aggregate variable was constructed – the Covid-19 Economic Vulnerability Index (CEVI).

2. Literature review

A lot of research has been done in the area of vulnerability of economies in a short period of time. Various measures and models have been developed to assess the impact of the pandemic on economies. As this impact is multidimensional and very complex, synthetic indicators have predominated. A few of these are presented below.

Based on 11 variables, the European Investment Bank research team constructed the COVID-19 Economic Vulnerability Index [2]. The variables were divided into three groups of factors that influenced the resilience of economies to the COVID-19 shock: quality of healthcare and age of the population, the structure of the economy, as well as exposure and ability to respond to shocks. Using the index, the economic vulnerability to the impact of the COVID-19 pandemic of emerging market economies and developing countries outside the European Economic Area and the European Union was examined. EIB research found low-income countries to be most vulnerable to the impact of the pandemic. Heavy dependence on particular types of revenue is a strong driver of COVID-19 vulnerability. The resilience of a country's economic system and the quality of its healthcare are key factors in its vulnerability to COVID-19.

Luisa Marti and Rosa Puertas measured the vulnerability of economies to the impact of the COVID-19 pandemic using 15 simple indicators, which were grouped into three areas: health, social and work [3]. In each of these, the researchers constructed a vulnerability ranking for EU countries. They concluded that the level of wealth influenced vulnerability in the health and social spheres, but the relationship was not so clear with respect to work. They noted that economic development could lead to a high level of precarious employment, the fragility of which emerges in the face of extreme situations such a pandemic. Thus, a favourable situation in countries' health and social spheres had not always been enough to combat the spread of this virus.

A team of researchers from the University of Ibadan developed another measure – the Index for Measuring Uncertainty Due to the COVID-19 Pandemic. The index is a combination of news-and macro-based trends [4]. The news-based index involves the use of Google trends with plausible variants of words used to capture the pandemic, while the macro-based index identifies global factors such as oil price, stock price, the Dollar index, commodity index and gold price. The dynamic model appeared to be appropriate for modelling the stock returns of countries, and the addition of macroeconomic variables improved the predictive power of the models.

In a slightly different way, but also based on data from the capital markets, the vulnerability of economies to the impact of a pandemic was measured by a team of researchers from India [5]. They constructed a model in which

vulnerability to pandemic impact depended, on the one hand, on GDP dynamics and, on the other hand, on stock exchange quotations of 6 assets: S&P500, crude oil, gold, silver, natural gas and iShares 20 + Year Treasury Bond. The variables correlated moderately positively with the COVID-19.

In turn, Sam Diop, Simplice Asongu and Joseph Nnanna created two indices. The first was the COVID-19 economic vulnerability index, which consisted of 7 variables, and the second, the resilience index, based on 9 variables [6]. They surveyed 150 countries from around the world and constructed 4 scenarios relating to vulnerability and resilience characteristics, namely: low vulnerability - low resilience, high vulnerability - low resilience, high vulnerability - high resilience and low vulnerability - high resilience.

A resilience index, though in a different form, was also used by Sherillyn Raga and Dirk Willem te Velde in their research of the economic vulnerability [7]. The level of vulnerability to the impact of the COVID-19 pandemic is calculated as the difference between the economic exposure (divided into exposure directly to China, where the virus emanated; and indirectly through openness to the world) minus resilience to the shock (economic and health governance), which is the ability to act on the shock. The index is based on 16 components.

Mikolai Júlia, Keenan Katherine and Kulu Hill investigated how COVID-19 related health- and socio-economic vulnerabilities co-occur at the household level in the United Kingdom [8]. They concluded that the effects of COVID-19 are likely to be socially stratified. Poor health and socio-economic conditions cluster in the general population, which may exacerbate societal inequalities over time.

Also Megan Weier and Isabella Saunders from Australia pointed to a strong link between the vulnerability of economies to the impact of a COVID-19 pandemic and socio-economic disparity [9]. They showed that the Australian Social Progress Index identifies COVID-19 vulnerabilities and are of the opinion, a COVID-19 pandemic is likely to exacerbate social vulnerabilities, as it entrenches inequalities and affects certain socio-demographic groups more than others.

Another perspective was presented by Bhattacharya Mihir and Banerjee Panchali who created Economic Vulnerability Index (EVI) calculated on 5 sub-indices based on the unemployment rate, level of poverty, urbanisation and economic growth [10].

Many researchers use aggregate metrics in their studies. Synthetic approaches have the advantage of allowing a comprehensive analysis and evaluation of the complex phenomenon that is the pandemic's economic vulnerability.

3. Data and methods. Index construction

There is still a lot we don't know about COVID-19's health impact. What we do know is that the virus and subsequent lockdowns are having severe impacts on the global economy. Everyone has been affected, from major factories to small companies, restaurants, bars, and hair salons, as well as the informal economy. The introduction of social distancing, lockdowns, and travel restrictions as a result of the Covid-19 pandemic triggers a major shock to both demand and supply. It's causing a lot of uncertainty and creating many new challenges for people. The motivation to develop a new index, based on a set of economic indicators to rate countries' vulnerability to the crisis, stemmed from our needs for a clearer understanding of these effects.

Economic impact of the COVID-19 pandemic due to its complexity and multidimensionality is not easy to identify. An additional difficulty is an availability of statistical data, which should be consistent and comparable between countries. Such features are characteristic of the data from the Eurostat database, therefore the most variables selected for the following analysis come from this database. The list of variables has been complemented by 1 variable from The Johns Hopkins Coronavirus Resource Center, from which researchers developed an online interactive tool to visualise and track reported cases of coronavirus disease 2019 (COVID-19) in real-time [11].

We conducted our analysis of the impact of a pandemic using multivariate statistical methods, such as agglomerative clustering and multi-attribute methods of object assessment, such as the Hellwig's method described below. Such an approach is both flexible and efficient. It allows the researcher to include and exclude variables in a mostly objective way. The study covered all 27 countries belonging to the European Union in 2021. An initial list of 23 variables potentially characterizing the impact of the COVID-19 pandemic on the economy was further statistically analysed and reduced to 17 variables, based on the correlation matrix. In the next step, the remaining variables were divided into separate groups using the Ward method, and then the variables representing these cluster were selected

arbitrarily. After using this approach, the list of variables shortened to 15, which are shown in Table 1. The variables were grouped into 4 dimensions that form the index structure:

- Health
- People & Work
- Economy
- Business & Innovation

Table 1. List of variables used in COVID-19 Economic Vulnerability Index construction

No.	Variable	Year	Source	Description/Justification
			Health	
1	COVID-19 cumulative cases per 1 mln inhabitants	1 May 2021	The Johns Hopkins Coronavirus Resource Center	The cumulative number of confirmed cases per million people. STIMULANT
2	Practising physicians per hundred thousand inhabitants	2018	Eurostat	Practising physicians provide services directly to patients. The higher the number, the better the country performs under pandemic conditions. DESTIMULANT
3	Hospital beds per hundred thousand inhabitants	2018	Eurostat	See description in no. 2. DESTIMULANT
4	Health care expenditure as % of GDP	2018	Eurostat	Underfunded and poorly functioning healthcare systems make countries vulnerable to the health impacts of the pandemic DESTIMULANT
			People & Work	
5	Excess mortality	2020	Eurostat	The excess mortality indicator is computed as the relative difference (expressed in percentage) of the number of deaths in 2020 from its average over the period 2015–2019. Annual data for 2020 are estimated from weekly deaths data. The higher the value, the more additional deaths have occurred compared to the baseline. STIMULANT
6	Total unemployment rate as % of active population	2020	Eurostat	A low level of unemployment can withstand the impact of the pandemic without excessive welfare costs. STIMULANT
7	Share of population 75 years or over in total population [%]	2020	Eurostat	Older populations make countries vulnerable to the health and social impacts of the pandemic. STIMULANT
			Economy	
8	Decrease in GDP at market prices [%]	Q2.2020/ Q2.2019	Eurostat	The absolute value from the percentage difference between 1 and the dynamic index value for Q2.2020 compared to Q2.2019. The greater the value, the greater the decline in GDP; that is, the vulnerability of the economy increases. STIMULANT
9	Exports of goods, percentage change compared to same period in previous year	Q2.2020/ Q2.2019	Eurostat	The greater the value, the greater the decline in exports; that is, the vulnerability of the economy increases. STIMULANT
10	General Government deficit as % of GDP	2020	Eurostat	Above 3% GDP this variable is a stimulant. Only one country Denmark had a value below 3% GDP - so with the normalization procedure this variable received the lowest value - 0. STIMULANT
11	Gross Value Added (at basic prices) in wholesale and retail trade, transport, accommodation and food service activities, as % of total GVA	2018	Eurostat	The larger the share, the greater the vulnerability to pandemic impacts, as transportation, accommodation and food service activities are the sectors most affected by the pandemic STIMULANT
			Business	

12	Business expenditure on R&D as % of GDP	2019	Eurostat	The greater the value, the more innovative the economy is and the more resilient it can be to the impact of a pandemic DESTIMULANT
13	Share of enterprises introduced business process innovation (%, innovative core activities)	2018	Eurostat	See description in no. 12. DESTIMULANT
14	Number of commercial flights percentage change to previous year (%)	2020	Eurostat	Number of flights data include scheduled and non-scheduled commercial air flights. Data are expressed as the percentage change of the number of flights in 2020 compared with the previous year. Index of dynamic (2019=100) – calculated as index of dynamic. DESTIMULANT
15	Travel receipts in balance of payments as % of GDP	2019	Eurostat	The greater the value, the more the economy relies on tourism, i.e., the greater the vulnerability to the impact of a pandemic. STIMULANT

Source: authors' calculations.

All of the selected indicators are available for at least 95% of the countries in the analysis and are updated on a regular basis. Most of the data come with a delay, so the 2021 CEVI relies on 2018–2020 data (see tab. 1). When data are not available, we impute the missing values with their previous ones. In Table 1 we can observe two different types of variables: the stimulant and the destimulant. The first is such a variable (statistical feature), whose increase in value indicates an increase in the level of the complex phenomenon, and a decrease in value indicates a decline in the level of the complex phenomenon. On the other hand, an increase in the latter variable indicates a decrease in the value of the phenomenon [12, 13].

To compute the CEV Index, we first normalise each variable with two formulas, the first is for the stimulant [14]:

$$z_{ij} = \frac{x_{ij} - \min\limits_{i} x_{ij}}{\max\limits_{i} x_{ij} - \min\limits_{i} x_{ij}}, \tag{1}$$

and the second for the destimulant [15] to transform it into stimulants:

$$z_{ij} = \frac{\max\limits_{i} x_{ij} - x_{ij}}{\max\limits_{i} x_{ij} - \min\limits_{i} x_{ij}}, \tag{2}$$

where:
x_{ij} – *j-th* explanatory variable for *i-th* economy, i = 1, ..., 27, j = 1, ..., 15
z_{ij} – *j-th* normalised value of x_{ij}.

Such transformation meets the requirements of normalisation – deprives variables of their units and unifies their ranges to ⟨0,1⟩ for each variable. The normalised value was set to 0 for the minimum value of the explanatory variable and 1 for the maximum value of the explanatory variable (for stimulants) or transform the destimulants to the same pattern.

Next step is the aggregation of the 15 normalised indicators into four dimensions. Each of the four dimensions consists of the 3–4 indicators (see table 1). For each of these dimensions, we calculate the average values of indicators belonging to that dimension. The value of CEV Index is the arithmetic mean of the four dimensions. This procedure is iteratively applied to each economy. Then, the obtained results were multiplied by 100, for better visualization of the calculated values. Results close to 0 indicate lower vulnerability to the impact of the pandemic than those close to 100. In addition, it is possible to analyse for each country separately which of the analysed dimensions has a greater impact on the country's position in the ranking of economic vulnerability to the impact of the COVID-19 pandemic.

The authors have also applied Hellwig's taxonomic measure of development, but the difference between the created rankings was small (Spearman's rank correlation coefficient =0,98). Besides, with a taxonomic measure it would be difficult to distinguish individual dimensions of the examined phenomenon and to calculate individual variables influence on the aggregate value. Therefore, we chose a simpler procedure. Existing research [16] suggest that with a small number of variables and a small number of objects, the method in which a synthetic variable is created by averaging normalised variables gives comparable or even better ordering results than taxonomic methods of linear ordering (e.g. Hellwig's, TOPSIS). An additional advantage is that the procedure is much simpler, transparent and comprehensible, and thus can be widely used by practitioners. Moreover, unlike in the case of taxonomic measures, it is possible to divide the aggregate averaged measure into dimensions, which deepens the analysis of the studied phenomenon.

4. Research results. CEVI performance

The results of the analysis are presented in Table 2.

Table 2. COVID-19 Economic Vulnerability Index (CEVI) – performance by economy

Country	COVID-19 Economic Vulnerability Index, CEVI	Ranking among economies	Dimension Score (lowest vulnerability: 0 min-100 max: highest vulnerability)			
			Health	People & Work	Economy	Business & Innovation
Spain	67,2	1	56,4	84,0	67,2	61,2
Croatia	59,2	2	59,0	45,2	59,7	73,0
Greece	58,1	3	34,6	76,0	73,1	48,7
Italy	57,8	4	55,7	79,5	53,8	42,2
Cyprus	57,1	5	63,6	36,5	70,2	58,0
Slovenia	55,4	6	66,1	56,0	45,8	53,8
Poland	51,9	7	62,7	40,9	49,6	54,4
Malta	50,9	8	49,9	35,7	53,6	64,3
Latvia	50,8	9	59,6	36,1	46,3	61,1
Portugal	50,6	10	46,2	57,5	43,6	55,1
Romania	50,3	11	56,1	41,0	43,0	61,0
Lithuania	49,5	12	50,7	51,0	53,6	42,8
Hungary	47,7	13	53,7	31,2	48,8	56,9
Czech Republic	47,2	14	60,2	39,6	38,0	51,1
Slovakia	46,7	15	56,4	30,1	33,1	67,2
Estonia	45,9	16	65,7	35,2	40,6	42,2
Bulgaria	44,1	17	39,0	48,0	35,7	53,7
France	43,8	18	42,4	51,2	45,2	36,6
Luxembourg	42,2	19	77,4	31,0	19,5	40,9
Belgium	41,6	20	47,5	52,0	52,9	14,0
Ireland	39,7	21	65,0	12,2	27,0	54,7
Netherlands	39,6	22	56,2	37,2	35,7	29,5
Austria	36,8	23	23,3	42,1	52,6	29,2
Sweden	36,2	24	54,3	41,0	23,0	26,3
Finland	34,8	25	38,3	37,3	29,0	34,6

Denmark	32,7	26	47,2	26,0	23,0	34,7
Germany	27,3	27	16,6	44,0	26,6	21,7
Average Score	46,9		52,0	44,4	44,1	47,0

Source: Authors' calculations.

The most vulnerable economies are Spain, Croatia, Greece, Italy and Cyprus, with CEV Index scores between 57,1 and 67,2. At the other end of the scale are economies less vulnerable to the impact of the pandemic: Austria, Sweden, Finland, Denmark and Germany, with CEV Index scores between 27,3 and 36,8. The average score for the global index is 46,9 (out of possible 100). There were 13 countries below this average value, from 15th position inclusive to the end of the ranking. The average for dimension 1 is higher than for the other areas, which means that this area, on average, affects the country's ranking more strongly. Only 11 countries are below the average for this dimension.

For dimensions two and three, the average score was very similar at above 44. However, for the former, 16 countries scored below the average, and for the latter, 13 countries ranked below it. For the last dimension average value is slightly higher than the previous ones and score 47 – only 12 economies ranked below it.

The results of the COVID-19 Economic Vulnerability Index show that Spain is the leader among the analysing economies. That means that is the most vulnerable to the economic impact of the pandemic.

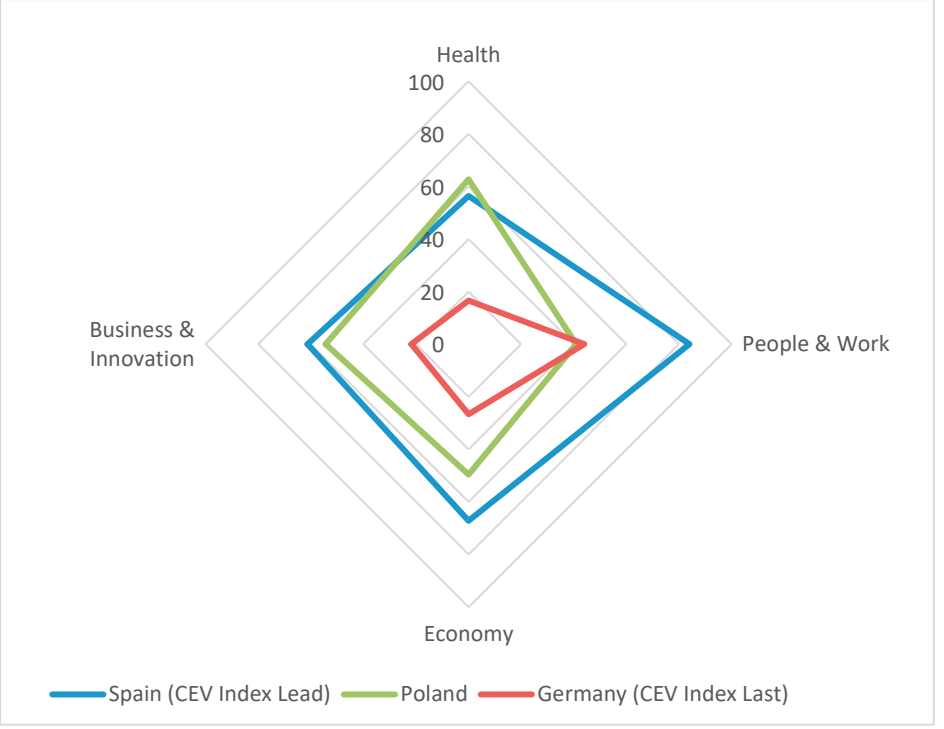

Fig. 1. COVID-19 Economic Vulnerability Index (CEVI) dimensions – Poland and the best- and the worst-performing economies

Source: authors' calculations.

Figure 1 presents performance across the four CEV Index dimensions for 3 countries. The first is Spain, which leads the ranking for the most vulnerable economy to the impact of a pandemic. The second is the country that ranked last – Germany. The third one is Poland, which is in 7th place and was chosen arbitrarily by the authors to show some important features of the index. Even though Spain leads the ranking, meaning that it has achieved the highest value

for the global index, Poland is ahead of Spain in the health dimension, so this dimension is performed at a worse level, which affects Poland's high position in the ranking. Germany is the worst-performing economy in this ranking of vulnerability, which means its economy is the least vulnerable to effect of the pandemic. Despite that, the score in second dimension "People & Work" is slightly weaker than in Poland (Fig. 1).

5. Conclusions

The research shows that even relatively simple statistical approaches can help to provide a more comprehensive and precise description of the COVID-19 pandemic's economic vulnerability. Multivariate statistics allow for more objective criteria selection and the use of various types of data, which is crucial for such complex phenomena.

European Union countries showed varying levels of vulnerability to the impact of the COVID-19 pandemic. The southern European countries (Spain, Croatia, Greece and Italy), where the tourism sector plays an important role in GDP composition, are the most fragile. These countries were already facing major labour market difficulties, and the pandemic exacerbated them. In addition, they were characterised by excessive deficits and relatively low levels of innovation.

On the contrary, Germany and the Scandinavian countries proved to be the least sensitive to the negative impact of the pandemic. They were characterised by greater stability of public finances, innovation, lower unemployment and a more favourable situation in health care.

The vulnerability index does not account for changing policy responses in each economy or the evolution of the pandemic. Countries with a similar level of CEV Index can experience different pandemic impacts depending on a variety of factors. Even if a country's economic vulnerability is low, it may nevertheless experience a significant shock if it is severely affected by the virus.

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