Health-care preventive measures, logistics challenges and corporate social responsibility during the COVID-19 pandemic: break the ice

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Abstract

Purpose – *The study aims to analyze the role of coronavirus testing capacity to possibly reduce the case fatality ratio (CFR) in a large cross-section of countries. The study controlled health-care expenditures, logistics performance index (LPI), carbon damages, and corporate social responsibility (CSR) to understand the nature of causation between the CFR and stated factors.*

Design/methodology/approach – *The study used a cross-sectional regression apparatus for coefficient estimates and variance decomposition analysis (VDA) for forecasting relationships between the variables over time.*

Findings – *The results confirmed the W-shaped relationship between CFR and case-to-test ratio (CTR) in the presence of a LPI that exacerbates the CFR cases across countries. The VDA estimates suggest that carbon damages, logistics activities, and CSR are likely to influence CFR over time.*

Originality/value – *To the best of the authors' knowledge, the study is believed to be the first study that assesses the W-shaped relationship between the CFR and CTR in the presence of dynamic variables, which helps to formulate long-term sustainable health-care policies worldwide.*

Keywords *Sustainable development, Social responsibility, COVID-19 pandemic, Health-care expenditures, Corporate social responsibility, Logistics performance index, Carbon damages, Cross-sectional regression*

Paper type *Research paper*

1. Introduction

The COVID-19 pandemic mainly affects the global world and spreads out among the masses that damage global health-care infrastructure and economic activities. The supply chain process is particularly disrupted because of strict lockdown measures to contain coronavirus disease. In addition, corporate social responsibility (CSR) also affected the loss of their employees and their clients. Health-care expenditures enormously increase countries' national health-care bills that further effected the countries' economic policies. Carbon damages is another antecedent that causes the low immune system ultimately leads to infection with coronavirus disease. The more downward progress in testing coronavirus cases pulls many new patients who cannot control the spread of the virus among the masses. The study used the case to test ratio, logistics performance, CSR, health-care expenditures, and carbon damages, which were mainly evident during the wake of the COVID-19 pandemic, to understand the causal inferences of the stated factors on increasing case fatality ratio (CFR).

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An ample number of earlier studies worked on the stated topic; however, these studies could not explore any definite shape of the coronavirus pandemic. This study used different polynomials series of the case to test coronavirus ratio (CTR) and their effect on CFR in a large cross-sectional of countries to identify the possible shape of the COVID-19 pandemic. Ali *et al.* (2021) explored the relationship between wind speed, $PM_{2.5}$ emission, and COVID-19 cases in Pakistan and generally concluded that both factors cause increasing COVID-19 cases among their provinces. Further, both the variables confirmed the inverted U-shaped relationship with COVID-19 cases in most of their provinces, indicating adopting serious policy matters to minimize the cost of emissions to reduce the COVID-19 cases. Fan *et al.* (2020) surveyed the climate change vulnerability causing likely to spread COVID-19 cases in 291 Chinese mainland cities and found the inverted U-shaped relationship between relative humidity and infected cases.

Further, the study suggests that rising temperature is unlikely to contain pandemics in the future. Aljadani *et al.* (2021) considered a case study of Saudi Arabia's economy and examined the N-shaped relationship between environmental indicators and economic growth under the presence of the COVID-19 cases. The result confirmed the stated relationship between them. The study emphasized the need to improve air quality levels that can reduce coronavirus cases worldwide. Finally, Greyling *et al.* (2021) discussed the impact of strict lockdown on happiness indicators in the South African economy and found that lockdown substantially decreases happiness indicators in a country.

Moreover, fear of unemployment, greater use of social media, and a ban on alcohol sales also negatively affect the happiness index. The result supported the inverted U-shaped relationship between the happiness index and COVID-19 new deaths per day. The study concluded that the country's happiness index is associated with the country's health-care reforms and their measures to contain coronavirus disease. However, the strict lockdown should be reasonably substituted with micro and smart lockdowns to reduce the fear of being jobless in a country. Vinceti *et al.* (2021) surveyed the different waves of COVID-19 cases in Italy's economy and found that the infection rate follows an inverted U-shaped relationship between the first and second waves. The provinces where the incidence of the first wave increases the high infection rate tend to show the lower incidence in the second wave. The revere is holding for those provinces where the infection rate of the second wave is exacerbated as their incidence rate of infection is lower in the first wave. Thus, the need to adopt standardized operating procedures would be helpful to contain coronavirus cases in a country. Azimli (2020) found the greater volatility in the financial activities during the COVID-19 outbreak, leading to different asymmetries in the risk-return investment in other quantiles distribution. The quantiles distribution estimates suggested assessing more investment-risk return relationships to get insights into commodity markets that less affected the contagious outbreak. Anser *et al.* (2020) found the inverted U-shaped relationship between economic growth and poverty incidence in the wake of the COVID-19 pandemic in a panel of 76 countries that confirmed the rising global poverty headcounts during the pandemic recession. The study concludes that rising health-care inequalities, public debt burden and geographical conflicts are the leading cause of increasing COVID-19 cases that increases global poverty. Runkle *et al.* (2020) found a disproportionate relationship between humidity and extreme temperature, as humidity is considered the cursor of spreading COVID-19 cases, which is influenced by extreme temperature in the different cities of the USA.

Besides the non-linear relationship between COVID-19 cases and their potential determinants, the study evaluates the impact of the COVID-19 pandemic and CSR. The ample number of studies supported the findings that the COVID-19 pandemic negatively influenced the CSR activities that need to be strong enough between corporate clients and corporations during the pandemic crisis (He and Harris, 2020; Parker, 2020; Severo *et al.*, 2021; Aguinis *et al.*, 2020). Further, many studies advocated that the supply chain process

was mainly disrupted during the COVID-19 outbreak that needs to be strengthened through innovative sustainable strategies (Belhadi *et al.*, 2021; Sharma *et al.*, 2020; Yu *et al.*, 2021). The cost of carbon emissions is another critical factor that exacerbates COVID-19 cases via the channel of the low immune system (Razzaq *et al.*, 2020; Bashir *et al.*, 2020; Klenert *et al.*, 2020).

Based on the cited literature review, the study contributed to the earlier literature in three different dimensions. First, the study used the quad relationship between CFR and case-to-test ratio (CTR) to identify the possible shape of the COVID-19 outbreak in a large cross-section of countries, which remains unexplored in a given context. Second, the study used CSR and supply chain activities in coronavirus testing capacity, allowing for the synergistic relationship between the CFR and CTR that remains absent in the earlier literature. Finally, the study used health-care expenditures and carbon damages to control the relationship between CFR and CTR. This novelty leads to a more controlled environment and can devise sustainable health-care policies across countries. The contribution of the study leads to the following possible research objectives that explored in a large cross-sectional of countries:

- To examine the non-linear relationship between the CFR and case to test ratio in the presence of many controlling factors.
- To investigate the potential impact of logistics activities and CSR on CFR.
- To explore the negative externality of the environment and exacerbating health-care expenditures on CFR across countries.

These objectives were checked by using cross-sectional regression and an innovation accounting matrix to conclude the results.

2. Data source and methodological framework

The study estimated CFR and case to test ratio (denoted by CTR) based on total infected coronavirus cases, total deaths and total test ratios in a large cross-section of 56 countries by using the available information from Worldometer (2021, dated 30th April 2021). The formula for CFR as CTR is as follows:

$$\left\langle \begin{array}{l} CFR = \dfrac{DEATHS}{CASES} \\ CTR = \dfrac{TESTS}{CASES} \end{array} \right\rangle \tag{i}$$

where CASES show total infected COVID-19 cases, DEATHS show total deaths and TESTS shows total tests performed.

The study used square (denoted by CTR^2), cube (denoted by CTR^3), and quad (denoted by CTR^4) on actual tests performed to assess the hump-shaped relationship with the CFR factor. Further, the study used overall logistics performance index (LPI) (1 = low to 5 = high), health-care expenditures (current US$) (denoted by HEXP), the business extent of disclosure index (0 = less disclosure to 10 = more disclosure) (proxy used for CSR), and carbon damages (per cent of GNI) (denoted by CDAM). These variables served as explanatory variables. The data is taken from World Bank (2021) database. The most updated values of the stated variables available from the indicated database are used to estimate that these variables tend to have the same observation in the year 2021 against the daily COVID-19 series (sample of countries).

The sample of countries are as follows: USA, India, Brazil, France, Russia, Turkey, UK, Italy, Spain, Germany, Argentina, Colombia, Poland, Iran, Mexico, Ukraine, Peru, Indonesia, Czechia, South Africa, Canada, Chile, Iraq, Romania, Philippines, Belgium, Sweden,

Portugal, Pakistan, Hungary, Bangladesh, Jordan, Serbia, Switzerland, Austria, Japan, Lebanon, UAE, Morocco, Saudi Arabia, Malaysia, Bulgaria, Slovakia, Ecuador, Panama, Belarus, Greece, Croatia, Nepal, Kazakhstan, Tunisia, Bolivia, Paraguay, Kuwait, Dominican Republic, Moldova. [Source: Worldometer (2021)].

The study followed the recent scholarly work of Anser *et al.* (2021), Qin *et al.* (2021), Sharma *et al.* (2021), Popkova *et al.* (2021), and Evangeliou *et al.* (2021). These studies diversified work on different stated issues related to the COVID-19 pandemic, but not limited to COVID-19 testing capacity, supply chain operations, health-care expenditures, CSR, and carbon damages. Based on the stated studies, the study amalgamates all the critical issues in a given study to understand more insights about the COVID-19 vulnerability across countries. Equation (1) formulated based on the stated studies for robust policy inferences:

$$CFR = \beta_0 + \beta_1 CTR + \beta_2 (CTR)^2 + \beta_3 (CTR)^3 + \beta_4 (CTR)^4 + \beta_5 LPI + \beta_6 HEXP + \beta_7 CSR + \beta_8 CDAM + \varepsilon$$

$$\therefore \frac{\partial CFR}{\partial CTR} < 0, \frac{\partial CFR}{\partial CTR^2} > 0, \frac{\partial CFR}{\partial CTR^3} < 0, \frac{\partial CFR}{\partial CTR^4} > 0, \frac{\partial CFR}{\partial LPI} < 0, \frac{\partial CFR}{\partial HEXP} < 0, \frac{\partial CFR}{\partial CSR} < 0, \frac{\partial CFR}{\partial CDAM} > 0 \quad (1)$$

Where CFR shows CFR, CTR shows the case to test ratio, LPI shows LPI, HEXP shows health-care expenditures, CSR shows CSR, CDAM shows carbon damages, and ε shows error term.

Equation (1) shows that the relationship between CFR and CTR is likely to become a hump-shaped relationship between them, i.e. either it follows the inverted U-shaped relationship, U-shaped or W-shaped relationship. Further, it is expected that LPI, health-care expenditures, and CSR would positively impact CFR to decrease a substantial number of COVID-19 cases while increasing carbon damages likely to increase more CFR across countries. The study hypothesizes the following possible relationships that need to be tested:

H1. The CFR likely follows a rise and fall pattern based on increasing COVID-19 testing capacities.

H2. LPI would be likely to exert a positive impact on reducing the CFR.

H3. Health-care expenditures and CSR likely to decrease CFR.

H4. Carbon damages may increase the intensity of the CFR across countries.

These hypotheses need to check by using cross-sectional regression apparatus and variance decomposition analysis (VDA). The advantages of the stated regression techniques are as follows:

- The data requirement is not excessive.
- It is easy to understand and easy to apply.
- It absorbs time-varying and country-specific shocks because of performing the test at a single point interval.
- The forecasting analysis support the stated regression apparatus in a dynamic vector introgressive framework.
- The variance error decomposition analysis is quickly performed to assess the most influential factors on the response variable over a while.

Based on the stated attributes, the study used both estimators to get robust inferences.

3. Results and discussion

Table 1 shows the descriptive statistic of the variable and found that the average CFR is 2.243 with a high standard deviation value that indicates the higher dispersion of the CFR values across countries. Similarly, the mean value of CTR is 13.414, with a maximum value of 84.786 and a minimum value of 2.824. The larger dispersion of the stated variable also shows the more significant variability in the testing capacities in different countries. The moderate logistics performance is evident by the given data set, as the average value is 3.160. The supply chain activities during the COVID-19 pandemic remain weaker due to strict measures adopted by different countries to contain coronavirus. In addition, the increasing health-care expenditures and high CSR help reduce the CFR. Finally, carbon damages remain a volatile factor that may exacerbate the CFR across countries.

Table 2 shows the cross-sectional regression estimates and found the W-shaped relationship between the CFR and the test-to-cases ratio. The result implies that initially increasing coronavirus testing capacity helps decrease the CFR; afterwards, it begins to rise due to resuming economic activities. This phase does not remain for long, and it again begins to decline due to greater awareness received by massive advertisement and health-care agencies. In the end, the issue is still there, as the new coronavirus wave is more lethal that destroyed and disturbs the whole world, and it begins to increase the CFR.

Table 1 Descriptive statistics

Methods	*CFR*	*CTR*	*LPI*	*HEXP*	*CSR*	*CDAM*
Mean	2.243	13.414	3.160	1720.226	6.507	1.977
Maximum	9.246	84.786	4.200	10623.85	10	6.259
Minimum	0.305	2.824	2.180	41.909	0	0.188
SD	1.350	13.800	0.531	2324.340	2.488	1.445
Skewness	2.590	3.120	0.354	2.150	−0.675	1.324
Kurtosis	14.15	14.868	2.017	7.548	2.802	4.212

Notes: CFR shows case fatality ratio, CTR shows the case to test ratio, LPI shows logistics performance index, HEXP shows health-care expenditures, CSR shows corporate social responsibility, and CDAM shows carbon damages

Table 2 Cross-Sectional Regression estimates

		Dependent Variable: CFR		
Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
CTR	−0.723499	0.181537	−3.985408	0.0002
(CTR)2	0.037759	0.011289	3.344737	0.0016
(CTR)3	−0.000721	0.000246	−2.931641	0.0052
(CTR)4	4.32E-06	1.62E-06	2.664100	0.0105
LPI	0.936796	0.527525	1.775832	0.0822
HEXP	−9.15E-05	0.000113	−0.805990	0.4243
CSR	0.008268	0.070518	0.117244	0.9072
CDAM	−0.074615	0.135590	−0.550298	0.5847
Constant	3.201204	1.647047	1.943602	0.0579
Diagnostic Tests				
R-squared	0.366693	Mean dependent var		2.243945
Adjusted R-squared	0.258896	S.D. dependent var		1.350900
F-statistic	3.401698	Durbin–Watson stat		1.940008
Prob (F-statistic)	0.003679			

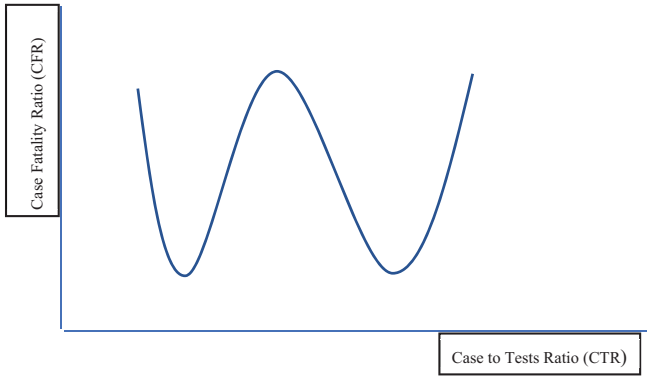
Notes: CFR shows case fatality ratio, CTR shows the case to test ratio, LPI shows logistics performance index, HEXP shows health-care expenditures, CSR shows corporate social responsibility, and CDAM shows carbon damages

Other results show that after resuming the economic activities, the logistics activities tend to begin fast, leading to the interaction between buyer and seller, ultimately increased CFR because of increasing socialization activities. The study was powerless to explain the impact of health-care expenditures, CSR, and carbon damages on the fatality ratio at the specific studied dates. Aljadani *et al.* (2021) emphasized the need to improve environmental quality indicators and financial activities to increase the COVID-19 cases. Ivanov (2020) predicted that the global health-care supply chain would largely be disrupted by increasing COVID-19 cases that need to be minimized through risk mitigation and adaptation framework to sustained logistics activities. Raoofi *et al.* (2020) emphasized the need to increase health-care expenditures to reduce coronavirus cases by achieving health-care sustainability. García-Sánchez and García-Sánchez (2020) argued that CSR is pivotal to sustained socio-economic activities during the pandemic recession. Popkova *et al.* (2021) suggested that financial activities should be responsible for social distancing to invest in economic projects to allow countries to be equipped with the pandemic crises globally. Mahmud *et al.* (2021) emphasized the need to formulate friendly corporate policies that respect their employees and believe in the stewardship relationships between corporations and their clients in the wake of the COVID-19 pandemic. Figure 1 shows the hump-shaped relationship between CFR and CTR across countries.

Figure 1 illustrates the W-shaped relationship between the CFR and CTR. The W-shaped shows a new emerging coronavirus wave that disturbed the whole economy. Although economies strive hard to increase COVID-19 testing capabilities to identify the early course of the infected virus, economic activities begin to decline. The greater need to increasing coronavirus testing kits and circulating the COVID-19 vaccination helps to reduce the spread of COVID-19 cases across countries. Figure 2 shows the recursive estimates of model stability and confirmed that the model is mainly stable at a 5% confidence level.

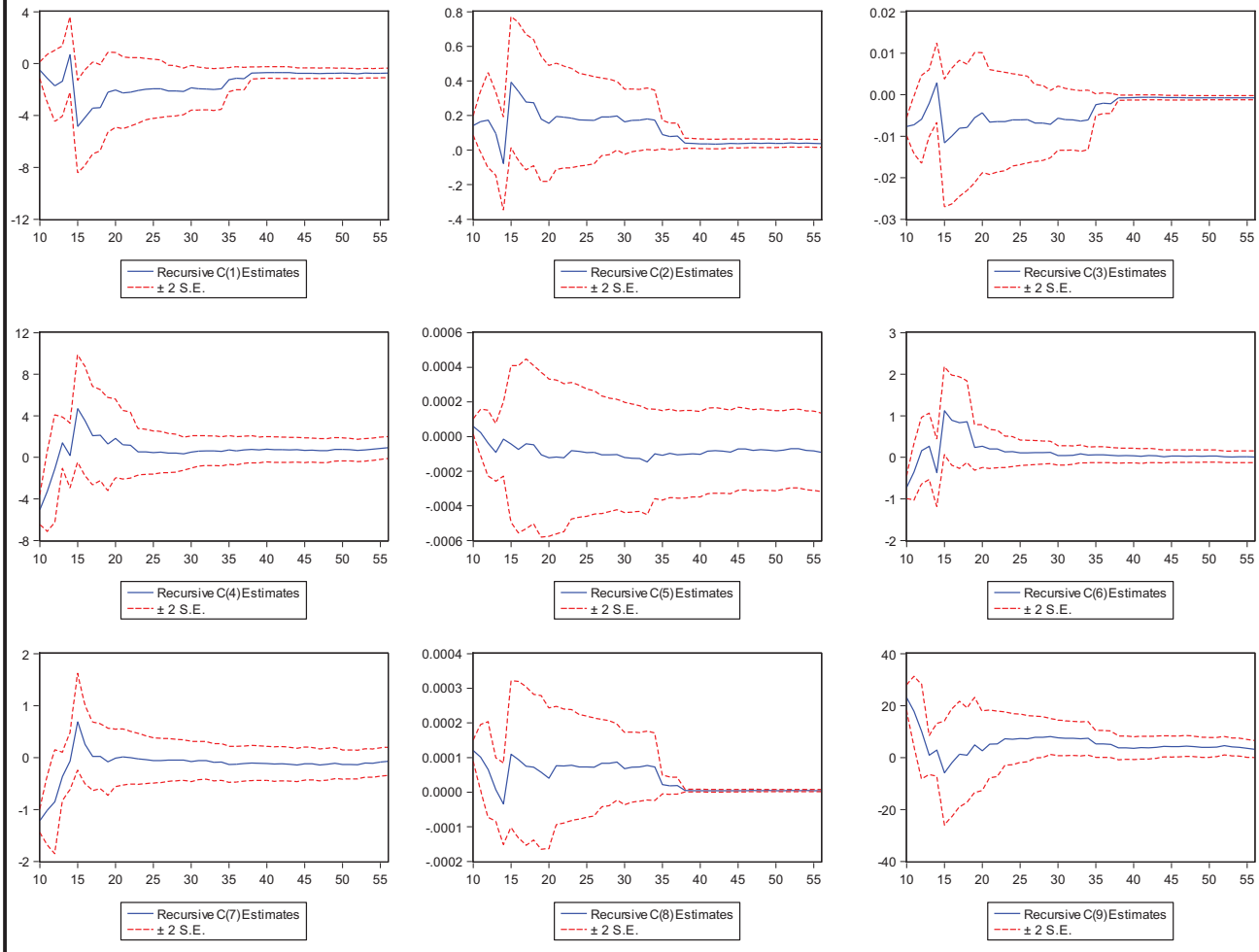
Table 3 shows the VDA estimates ad found that carbon damages would likely exert a more significant change in the CFR with a vaccine error shock of 19.708%, followed by LPI with 8.935%, CSR with 7.907%, and health-care expenditures with an estimated variance shock of 2.108%. The results emphasized the need to reduce carbo damages that are likely to infect more people because of low immune health. Further, health-care logistics activities need to supply a free flow of preventive surgical equipment and medicines to reducing health-care damages. Finally, the role of CSR remains to need a vital role to make a bridge between a corporation and their clients and take care of their

Figure 1 Hump-shaped relationship between CFR and CTR



Source: Authors estimate based on cross-sectional regression

Figure 2 Recursive estimates



Source: Authors estimate based on cross-sectional regression

employees about maintaining their safety and precautionary measures to escape from coronavirus.

4. Conclusions

The study analyzed coronavirus testing capacity in identifying the CFR to reduce infection across countries. Based on this importance, the CFR is monitored when coronavirus testing capacity increases. This study collected the cross-sectional data of total infected cases and deaths to obtain CFR. The data of coronavirus testing capacity further be gathered to estimate case to test ratio (CTR) in a panel of 56 countries. The study used few controlled factors that provide synergy while estimating the relationship between CRR and CTR across countries, including CSR, logistics performance, health-care expenditures, and carbon damages. The results confirmed the W-shaped relationship between CFR and CTR under the quad-polynomial series. The W-shaped represents the new emerging wave of coronavirus cases that largely infected the USA, India, Brazil, France, and Russia. The LPI

Table 3 Variance decomposition analysis for CFR

Months	*S.E.*	*CFR*	*CTR*	*HEXP*	*LPI*	*CSR*	*CDAM*
July 2021	1.360538	78.32854	0.022811	1.335842	0.143438	0.004063	20.16530
August 2021	1.500287	64.70898	0.020464	1.605743	7.566552	6.326623	19.77164
September 2021	1.522410	62.95039	0.027866	2.095935	7.815020	6.867653	20.24314
October 2021	1.536530	61.90225	0.056950	2.057665	8.365347	7.735802	19.88199
November 2021	1.544889	61.26367	0.627587	2.060186	8.464553	7.810619	19.77338
December 2021	1.549657	60.88742	0.687865	2.081561	8.680624	7.891017	19.77151
January 2022	1.552268	60.68297	0.730868	2.090714	8.883819	7.887350	19.72428
February 2022	1.553067	60.62387	0.730464	2.100195	8.935553	7.901542	19.70837
March 2022	1.553429	60.59581	0.730512	2.108000	8.959092	7.907193	19.69939

Notes: S.E. shows standard error, CFR shows case fatality ratio, CTR shows the case to test ratio, LPI shows logistics performance index, HEXP shows health-care expenditures, CSR shows corporate social responsibility, and CDAM shows carbon damages

is likely to cause increasing more socialization in the corporation and their corporate clients, which exacerbate new emerging coronavirus cases. The inter-temporal relationship suggested that carbon damages, supply chain process, CSR activities, and health-care expenditures will be the primary predictor that causes influencing CFR over a time horizon. Based on the stated results, the study proposed the following policies that help to minimize CFR across countries:

- There is a high need to increase technical and collaborative assistance between the developed and developing countries to build a liaison of transferring knowledge and expertise to control the coronavirus pandemic.
- The countries should need to increase their testing capacities to contain coronavirus cases early that help quarantine the common public and avoid the spread among the masses.
- The health-care logistics services should be expanding to ensure the free flow of protective health-care equipment to the frontline doctors who can treat the susceptible coronavirus patients by giving symptomatic treatments.
- The CSR activities should be responsibly deal with during the wake of the COVID-19 pandemic to take care of their employees and their corporate clients and suggest using all standardized operating procedures to contain coronavirus.
- The economies should have to be concentrated to improve air quality level that helps develop health conditions of the general public and adjust their body's defense mechanism against the coronavirus disease.

These five policy suggestions would be helpful to improve the countries defense mechanism against the coronavirus disease and allow them to contain pandemic crises globally. The study is limited to the case-to-test ratio and its impact on the CFR. This relationship can be expanded by using other vital factors, i.e. coronavirus cases and recovered cases. It determines the capability of coronavirus testing facilities to minimize the pandemic efficiently. Further, the study used CSR and overall LPI as regressors that influenced the CFR. At the same time, this relationship can be more viable by using ease of doing business and supply chain process during the pandemic era. Finally, the study used carbon damages and health-care expenditures related to the CFR, which can be substituted by particulate matter (PM2.5 or PM10) and logistics health-care supply chain to get a more in-depth analysis. Future research would take care of all these limitations and utilize all the stated factors in a large panel of countries to understand the role of coronavirus testing capabilities and vaccines in reducing the CFR worldwide.

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