The study has attempted to study the impact of COVID-19 on downside stock market risk in the G-20 nations using Value-at-Risk models. The findings of the study suggest that all the G-20 nations have experienced very high level of risk during Global Financial Crisis and COVID-19 as all the countries’ stock markets are critical during these two periods, but the magnitude of risk is found to be highest during COVID-19 period compared to other regimes in most of the countries. However, one shocking revelation is that China is found to be on safe zone having very less market risk, whereas all other countries are found to be critical.

1.1 Pandemics and stock market

Stock market is considered to be an important pillar of the financial sector. Pearce (1983) stated that variation in stock prices impacts aggregate spending and thus direction of the economy can be predicted. Rising stock market leads to larger spending followed by higher economic growth and vice versa. Comincioli (1995) added...
that the stock prices mirror potential about profitability, thus directly linked to economic activity. However, As per Carp (2012), sometimes stock market is also seen as an agent who hurts economic development due to their susceptibility market failure. Creeping up of crisis (unpredictable risk) leads to market failure. Liu, Manzoor, Wang, Zhang, and Manzoor (2020) consider pandemic as a hindrance to economic development for the investors. Delisle (2003) observed that SARS outbreak in 2003 has resulted in losses approximate to financial crisis of Asia, $2 trillion value in financial markets equity. The SARS epidemic also fabricated depressing growing negative returns in the chemicals, construction, department stores, food, hotels, textiles, and automobile sectors in Taiwan (Chen, Kim, & Kim, 2005). However, not every time markets crash due to epidemic and pandemic. In case of Zika virus, Macciocchi et al. (2016) found that the market indices of three Latin American and Caribbean Countries (LCR) did not show large negative returns the day after each shock except Brazil. Velde (2020) too noticed that the negative stock market impact of the Spanish flu was not too daunting even over time spans of several months. On similar note, Capital Partners (2020) informed that the S&P 500 Index fell by 24.7% in 1918 and rose by 8.9% in 1919 during Spanish fl u, 1918; the S&P 500 Index rose by 24.0% in 1957 and by 2.9% in 1958 during Asian fl u, 1957; and the S&P 500 Index rose by 12.5% in 1968 and by 7.4% in 1969 during Hongkong influenza, 1968. Wang Yang, and Chen. (2013) have found the stocks of biotechnology industry reacting positively to the pandemics. The difference in different crises can be linked to investors’ mood, which also directly influences the stock market behavior (Shu, 2010).

With regard to COVID-19, significant adverse impact on major stock indices performances is observed, with Asian countries reacting rapidly; although recovering slightly in the later stage of the pandemic (Liu et al., 2020). Hartl, Klaus, and Weber (2020) are concerned about the stock market impact as it is more temporally concentrated and more probable to generate high stock market volatility than Spanish fl u. As per Kumar (Kumar, 2020, April 6), COVID-19 has crashed 30 and 32% of the stock markets of India and United States, respectively, within a few days. Baker et al. (2020) observed that 18 jumps were there in 22 trading days, which is more than any other time in history in U.S. stock market. Anil Sarin 2020, CIO-Equities of Centrum Broking communicated that with Indian stock market has dropped more than 20% added by unpredictability in other markets due to crude oil war between Saudi Arabia and Russia; thus investors must plan carefully (Nathan, 2020, March 16). McKibbin and Fernando (2020) observed investors to be shifting their funds to other assets and countries that they perceive to be safe. Liu et al. (2020) established that indices for France, Germany, Russia, Italy, Thailand, the United Kingdom, Canada, Japan, the United States, India, Abu Dhabi, and Australia decreased the most in mean return, by 0.01 approximately, while those for Singapore, Thailand, Korea, Indonesia, and Hong Kong cut down the most by 325.245%, 274.619%, 115.163%, 64.345%, and 49.086%, respectively, by percentage. However, investors must be persistent as Valigra (2020, March 9) by expressed that the stock market usually corrects itself after such outbreaks.

1.2 | Inter-linkage of economies

The world today is interconnected with each other. News in a market not only impacts that market in particular but also other which are linked to it. Chiang, Jeon, and Li (2007), Sun and Hou (2018), Morales and Andreossos (2012) noted that volatility in one market is significantly correlated with other markets due to the interlinked characteristics of global markets after globalization. Positive news is not detrimental, but the negative news is. Study of In, Kim, and Yoon (2002) too showed that the markets became more closely linked during pandemic. It can be therefore, understood that higher the inter-linkage, higher is the risk in times of crisis.

We therefore planned to test the impact of COVID-19 on the stock markets of G-20 nations. Crippling up of financial crises in number of emerging economies, especially that took motion in Asia in 1997 together with the idea of recognizing some important countries in global discussion led to the formation of G20 group. In September 1999, the finance ministers and central bank governors of the G-7 countries planned to widen the discussion on key economic and financial policy issues and to encourage co-operation, stability, and sustainable world economic growth of the systemically significant economies. In December 1999, the Finance Ministers and Central Bank Governors of systematically important advanced and emerging countries met for the first time in Berlin, Germany and it is a continuous journey since then. It was raised to the Summit level in 2008 to tackle the global financial crisis (GFC) of 2008.

On the given backdrop, it is well understood that different types of crises critically affect the stock markets due to the herd behavior of the investors. Further, the stock market also affects the functioning of an economy, financial, and economic integration. Therefore, provided the seriousness of the COVI-19 pandemic compared to other health and economic and health crises, we want to examine its impact on the stock market, especially the experience of the G-20 nations. Precisely, the primary objective of the study is to assess the downside stock market risk of the G-20 nations during the outbreak of COVID-19 and compare it with other regimes of high volatile periods. The results of this study would help the investors to understand the short-run behavior of the stock markets during different types of crisis and thus help to take decisions in similar period. Further, it would also help the investors to estimate approximately, the maximum value they might lose on their present investment and accordingly plan for the future.

The rest of the paper is organized into three sections. We have discussed the methodology in Section 2. Section 3 presents the empirical analysis and Section 4 concludes the study.

2 | METHODOLOGY

2.1 | Data

For our study, we have considered data of the G-20 countries (list is provided in Table A1) from January 1, 1998 to June 30, 2020. As per
Department of Foreign Affairs and Trade, Australia, the G20 members account for 85% of the world economy, 75% of global trade, and two-thirds of the world’s population, including more than half of the world's poor. Therefore, considering G-20 nations to represent the impact of COVID-19 is justified. In other words, assessing the stock markets of these countries would provide us roughly an idea about other markets true, assuming other factors constant. On the other hand, COVI-19 has also affected most of the countries in G-20 group at worst. Further, we have chosen the period of study based on availability and uniformity of data for all the countries. All the relevant data are collected from Bloomberg database.

2.2 | Division of regimes

As shown in Table A2, we have identified four time periods within the overall time period which showed high volatility in the stock market prices in order to compare the volatility of stock prices during COVID-19 with other regimes. The regimes are:

2.2.1 | Asian financial crisis (Regime I)

The 1997–1998 Asian financial crises started in Thailand, which occurred due to the collapse of the Thai baht in July 1997, when Bangkok unpegged the Thai baht from U.S. dollar, followed by currency devaluations of other countries. In the first 6 months, the value of the Indonesian rupiah, Thai baht, South Korean won, Malaysian ringgit was depreciated by 80%, 50%, 50%, and 45%, respectively (Ba, 2019). The stocks prices fell seriously by 40%-60% (Moreno, 1998). The MSCI emerging markets index dropped 56% from August 1997 to August 1998 and other promising markets fell by 40%. However, U.S. markets rose by 21% during that period (Carlson, 2016). In a report of IMF (1998), accumulation of overheating pressures, the long-standing continuance of pegged exchange rates, lack of enforcement of prudential guidelines, insufficient administration of financial systems, lack of transparency, trouble of governance and political uncertainties, underestimation of the risks in search of higher yield are cited as some of the major reasons of the crisis. Apart from the Asian countries, the crisis had hurt Russia and Brazil.

2.2.2 | Internet bubble bursting (Regime II)

The stock price downturn in 2002 is also popularly known as Internet Bubble Bursting. It has affected United States, Canada, Asia, and Europe. No specific event happened in 2002, but this crisis was recognized with different events happened before the downfall. The terrorist attack of September 11, bursting of dot.com bubble, continuous bull market since 1995, accounting scandals by Arthur Anderson, Adelphia, Enron and WorldCom, all these factors led to damage in investors' confidence and led to the crash in 2002 (Young Guys, 2016, July 28). Ofek and Richardson (2003) linked the crisis to unprecedented level of lockup expirations and insider trading. Further, in the late 1990s, Argentina’s hard currency peg to the U.S. dollar, procyclical fiscal policies, and widespread foreign borrowing left the country unable to deal with a number of economic shocks and confronted severe currency, sovereign debt, and banking crisis (Wiel, 2013).

2.2.3 | Global financial crisis (Regime III)

The GFC is considered to be the most horrible financial crisis since the Great depression. It began in the United States in 2007. In the beginning, it affected the OECD countries, which transmitted to other prospering economies gradually. As per the report, global GDP has down trended by 5.8% in 2009. GDP growth rates of countries constituting the Commonwealth of Independent States and those of Central and Eastern Europe were down by an average of 15.2 percentage points between 2007 and 2009 (Dullien, Kotte, Marquez, & Priewe, 2010). As pointed out by Merrouche and Nier (2010), excessively loose monetary policy, global imbalances due to widespread moral hazard, inadequate prudential policies, and inability of capita regulation in preventing excessive leverage are the reasons which led to the sub-prime crisis. Mustafa, Samsudin, Shahadan, and Yi (2015) added that the recession has adversely affected the stock markets in United States and other countries and investors shifted to the bond market.

2.2.4 | COVID-19 (Regime IV)

In Regime IV, the study has considered the time period of COVID-19 outbreak, which have affected 213 countries over the globe. Overall, it has affected 15,947,431 people and caused 6,42,827 deaths as of July 25, 2020.

2.3 | Models for risk measurement

2.3.1 | VaR models

As our prime objective is to identify and compare the downside risk of stock markets, we have used Value-at-Risk (VaR) models to estimate the risk of different countries in different regimes as VaR is considered to be the best model to capture the downside risk. The largely used method of VaR is Variance–Covariance approach, also known as (Parametric VaR) or PVaR. PVaR is defined as:

$$VaR_p = \mu - z^{-1}\sigma$$

where at 99% confidence interval, $\mu$ and $\sigma$ are the mean and standard deviations of the time series, and $z^{-1}$ is the inverse of normal distribution function.
Nevertheless, return series are frequently noticed to be containing high peaks and flat tails. Therefore, we have also computed VaR with Student t-distribution, which works better for such distribution. TVaR is given by:

$$\text{VaR}_{ST} = \sqrt{v^{-1}(v-2)\mu^2} \text{ST}$$

(2)

where VaRST stands for TVaR, v explains the degrees of freedom for Student’s T distributions. Likewise, for $t_{0.01} + 0.99$ per cent i – day Student’ T VaR for Bank’s equity return is,

$$\text{VaR}_{ST} = \sqrt{v^{-1}(v-2)\mu^2} \text{ST}$$

(3)

where $\mu_i$ explains the m x m covariance matrix of the risk factor $\mu_1$ and $\mu_i$ denotes m x 1 vector of mean excess returns over the i – day risk horizon.

We have also computed Monte-Carlo simulation method to cross-check the estimates as the stock market returns are normally found to be non-normal. The VaR using Monte-Carlo simulation can be defined as:

$$l_{t+1} = l_t \exp \left[ r - \frac{\sigma^2}{2} + \sigma \gamma \right]$$

(4)

where $l_t$ is the current price of the indices at time t, $r$ is the risk free rate of return, $\sigma$ denotes the standard deviation of the indices return, and $\gamma$ is a normally distributed random variable with zero mean and one standard deviation. We have followed arithmetic variate method by Boyle (1977). We have randomly generated one lakh simulated equity indices prices. 

On the other hand, financial data series consists stylized facts namely volatility clustering, long memory, leptokurtic, and leverage effect. Therefore, we have also computed the VaR estimates using GARCH.

GARCH VaR model helps to check the presence of persistence, volatility clustering. The GARCH VaR model is given as follows:

$$\ln(\gamma_t^2) = a_0 + a_1 \left( \frac{\gamma_{t-1}^2}{\gamma_t} \right) + b_1 \ln(\gamma_{t-1}^2)$$

(5)

$$\ln(\gamma_{0,t}^2) = \tilde{c}_b + \gamma_b \left( \frac{\gamma_{t-1}^2}{\gamma_t} - \sqrt{2/\pi} \right) + b_0 \ln(\gamma_{t-1}^2)$$

(6)

where the stochastic error term is $\epsilon_t$ as $\epsilon_{t-1}$ at time t – 1, $\gamma_t^2$ is the conditional variance and the standardized residual $\epsilon_t/\gamma_t$. The white noise term $\epsilon_t$ is assumed to be distributed normally with zero mean and conditional variance.

2.3.2 | Expected shortfall

We have also computed ES of the stock market returns of all the nations in order to know the tail risk. It calculates the riskiness of a position by allowing for both size and the possibilities of losses ahead of a confidence level. The sum of all losses further than the VaR quantile $\alpha$, is likely a shortfall accounts for losses which is more than the confidence interval.

$$\text{VaRE}_S = E(x \mid x > \text{VaR}_\alpha)$$

(7)

Equivalently,

$$\text{VaRE}_S = \text{VaR}_\alpha + E(x - \text{VaR}_\alpha \mid x > \text{VaR}_\alpha)$$

(8)

2.3.3 | Backtesting

Backtesting of the VaR results are very pertinent to assess the validity or accuracy of the models. We have used Kupiec Likelihood Ratio Test is used for backtesting the results. It checks the frequency of loss beyond VaR. Let the number of observations be N, number of violations be V, & confidence interval be $\alpha$, then the proportion of failure (POF) will be $\rho$ and it should be such that, $\alpha = \rho = V/N$, then the likelihood ratio is computed as:

$$LR_r = -2\ln \left( \frac{1 - \frac{V - 1}{N} \text{VaR}^\alpha}{\left(1 - \frac{V - 1}{N} \right)^{\frac{V - 1}{2}}} \right)$$

(9)

3 | RESULTS AND DISCUSSION

3.1 | Model validity

As mentioned in the methodology, it is very important to check the validity of the models before making any comment on the downside risk as different models may provide different results depending on the distribution of the data. From the results of Kupiec’s Likelihood Ratio results as presented in Tables A3–A7, it is observed that SVaR is the most suitable VaR model for all the countries in all the regimes and GVaR is the inefficient model for most of the countries in every regime (also visible from Figure 2, as GVaR estimates differ significantly from other VaR models). Figure 2 also shows that SVaR and TVaR are closer to each other. But, PVaR and GVaR are not. Especially for the overall period, PVaR is not suitable at all. This is well justified as PVaR is unable to capture the fat tails. However, in the shorter regimes, the PVaR is also found to be efficient except in some specific countries (Table A8). TVaR is found to be working better than PVaR and GVaR models. Overall, the SVaR is found to be the best. Therefore, we consider mainly the results of SVaR for the further analysis to check the market risk of the countries in all the regimes.

3.2 | Market risk in the overall period

We have observed from the results of VaR model (especially SVaR) as reflected in Table A9 that risk of Asian countries in the overall period is in the range of 3.90 to 4.90% SVaR. Risk is almost in the same range
in all the Asian countries. South America is comparatively riskier than North America, VaR ranging from 5.20 to 6.40% against 3.50–3.80% in North America. On the other hand, Russia is observed to be having higher risk compared to other European nations where the countries are bearing market risk in the range of 3.50–4.50%. Africa is also found to be having lesser risk compared to Asian, European, Middle-East, and American countries. Australia stock markets are found to be least risky in the whole period. Further, the tail risk or ES of 15 countries in the period ranges between 4.50 and 6.40%. The exceptions with higher risk are Argentina, Brazil, Russia, Turkey, and Saudi Arabia.

### 3.3 Market risk in Regime I

Table A10 presents the results of different VaR models in Regime I. The risk of most of the countries ranges between 3 and 6%. The outliers are Republic of Korea, Indonesia, Argentina, Brazil, Mexico, Russia, and turkey whose risk is found to be very high. While, stock market risk of Australia is lowest relative to the other countries, risk of Russia turned out to be highest in this regime. While we compare risk between continents, the European countries had risk in the range of 3–6% except Russia; where risk was very high. Similar to the overall regime, risk of South American countries is higher than North America. In Asian region, the risk is between 3 and 7%, except Indonesia where risk is found to be 9.29%. In Middle-East, Turkey is found to having 11.27% of downside market risk, and Saudi Arab is having 3.64%.

### 3.4 Market risk in Regime II

As per the result of SVaR in Table A11, it can be clearly identified that the European and American countries were riskier than the countries in other regions in this period. This is apparent as the internet bubble majorly affected the American, European countries, and Asian countries. Among the American countries, Argentina is observed to be the highest risk bearer, which can be connected to the currency, sovereign debt and banking crises faced by them apart from the internet bubble bursting. Brazil followed Argentina with respect to downside risk in America. In Europe, the range of risk is between 3.75 and 5.69%, where Germany and France are at the top and Russia is at the bottom. Australia is found be having lowest risk amongst all the countries. In the Middle-East too, Saudi Arabia had lesser risk, but Turkey’s stock market is much riskier. The ES of the stock market indices also reflects the same phenomenon except in case of Indonesia, where tail risk is much higher compared to VaR. Majority of the countries are found to having tail risk between three and 6 %. Korea, Indonesia, Argentina, Turkey, and Brazil are outliers having ES more than 6 %. On the other hand, Saudi Arabia and Australia are outliers having risk less than 3 %.

**FIGURE 1** Regime wise VaR
3.5 | Market risk in Regime III

The downside risk in the regime as per the results presented in Table A12 revolves around seven to 8%. The risk of stock markets of Japan, Saudi Arabia, Russia, Brazil, and Argentina are found to higher relative to the risk of other countries in this period. On the other hand, stock markets of South Africa and Mexico are observed to be having lower risk comparatively in this period. Another important fact is that, the effect of the crisis is almost similar for all the continents except American countries as the crisis originated in United States. However, higher variability is observed among the Asian countries as per the ES results. The range of Asian ES is 7.78–11.13. ES of countries in America is between 6.95 and 12.29%. The European countries maintained ES at 7.39–9.05% except Russia, where, ES is 19.90%. Australia maintained ES at 8%, approximately parallel to other countries. In the Middle-East, Saudi Arabia is seen to be having higher risk as per VaR and ES of Turkey and the countries of other continents on average.

3.6 | Market risk in Regime IV

From Table A13, it can be understood that South American Countries are worst hit due to COVID-19 where the range of risk 14.79–14.99% and the tail risk is between 15.63 and 15.99%. Highest risk is America is quite apparent as it is on the top with regard to infection and deaths due to COVID-19. America is the Australian markets are also suffering very high level of risk as per the estimates of SVaR and SES. As per Chao (2020, June 30), the Australian market is worst hit in the last three decades, even more than the GFC. The risk of European countries is between 8 and 11%, where Italy is the worst affected country. However, the ES of the European countries are much higher compared to VaR estimates and ES estimates of other regions. In Asian region, the risk ranges from 5 to 6%, where India is the worst hit by the pandemic (8.53% VaR and 14.10% ES) and China is found to be the least affected country (3.78% S VaR and 8.04% ES). The ES of India is also very high. China, even turned out to be least affected among the countries of all the continents which is very surprising as the virus first started there itself. The pandemic’s impact on the Indian stock market among the other Asian countries is justified as India is the top affected countries after USA and Brazil as of July 26, 2020. Moreover, the economy of India was on downturn even before COVID-19 due to various other macro-economic factors. However, the risk is lesser than the American countries, which might be due to the strict preventive measures undertaken by the Government, which reduces the investors woes. Thus, if we ranked the continents (among G-20 countries) risk-wise excepting the outliers, FIGURE 2 | Comparison of different VaR models
America stands first, followed by Australia, Europe, South Africa, Middle-East, and Asia.

If we compare the market risk during COVID-19 with other pandemics, which have been theoretically discussed in the literature, this has worst hit the markets. This might be due to the fact that, information transmits faster in this ever-increasing world of linkage. During other pandemics, markets grew at a faster pace when the pandemics are over. At present also, it is observed that market corrects itself on getting favorable news like, invention of vaccine, release of funds for economic activities, and so on.

3.7 | Comparison of market risk in different regimes

Figure 1 presents the VaR and ES estimates of all the results in a graphical way. From all the values of VaR, on an average, it is inferred that the VaR is higher in the period of COVID-19 compared to the other crises. The result of VaR and ES is not similar for all the models. As it is already discussed that the results of Kupiec test tell us that SVaR is suitable for the regimes and all the countries, better is to compare with the help of SVaR results for uniformity. Major observations are:

- Risk is higher in the COVID-19 period for most of the countries compared to other regimes. Although, the markets fluctuated in other periods, the economic activities did not stop. As the virus has led the countries to total shutdown, increase in unemployment, decrease in production, and spending, and so on, it points toward lower economic growth. This has definitely caused panic and uncertainty among the investors, which has led to such high risk. However, as per earlier studies, it is observed that government strategies viz. lockdown, shutdown, budget, and so on plays important role in stabilizing the markets. Further technology namely news of vaccine, tracing mechanism, and so on could also help in gaining momentum in the markets as established by some movements observed in the stock markets.
- Among Asian countries, China suffered more negative volatility during global recession than in other regimes. Similar is the case of Japan. Again, Korean stock markets are found to be riskier in Regimes I and II compared to Regime IV. Whereas, Indonesia suffered more risk in Regime I. India is the only Asian country (included in G-20 group) which is experiencing very high risk which is even greater than the global recession of 2007–2008.
- Downside risk is found to be highest in the COVID-19 period for all American countries except Mexico, where the risk appetite is similar in Regimes I, III, and IV.
Australian stock markets were very less risky in Regimes I and II, risk increased to an extending Regime III, and the risk is highest during the COVID-19 outbreak.

Among the European countries, risk is found to be higher relative to other periods. However, Russia is an outlier and had greater risk during Regime I and Regime III. In Regime I, the Asian crisis was heavily transmitted to Russia coupled with the shock from disintegration from Soviet Union, followed by transformation from communist economy to capitalist economy. These might be the reasons of volatile market of Russia during the 1990s.

In the Middle-East, Turkey was worst hit in Regime I, and Saudi Arabia was worst hit during the GFC. For Turkey, the risk during COVID-19 and global crisis are approximately similar.

South Africa is also worst hit by COVID-19 followed by global crisis and Asian crisis, then internet bubble bursting.

Overall, the ES is also highest in Regime IV, except for some Asian countries.

### 3.8 Robustness check

For checking the consistency of the results, the average SVaR value of the overall regime is considered and compared it with the values of VaR and ES of different regimes for all the countries. The average SVaR for the whole period turns out to be 4.52%. If the SVaR or ES of particular country crosses above 4.52, we consider it as critical, otherwise safe. The pattern as per the criteria is shown in Figure 3. Overall, it is clearly visible from all the models, except GVaR, the market risk of all the countries is higher than the overall average during the GFC and COVID-19. This is also evident from the pattern of ES in all the regimes. This unmistakably implies towards high level of risk during these two regimes. This was also evident from the VaR estimates, which are already discussed. However, the most interesting and surprising fact is that, all the countries are critical from the point of view of stock market downside risk, however, China is found to be safe even after the COVID-19 outbreak started in China. This might be because of the fact that China has been able to contain the virus within a short period of time and restarted their economic activities. However, some countries term it as biological war by China. After COVID-19 and GFC, Regime I is found to be having serious impact on the stock markets. The stocks are found to be critical for 8, 11, and 13 countries as per PVaR, TVaR, and SVaR, respectively. On the other hand, in Regime II, 7, 8, 8 countries are found to be critical. In Regime I, mostly South Africa, Asian, and European countries are mainly affected. Brazil, Argentina from American region, Korea from Asia, Spain from Europe, and Turkey from Middle East are countries, which were found to be risky in all the regimes. The risk during the COVID-19 is highest may be because in other regimes, even
though crisis took place, people did not require to stop working. But, this pandemic has brought the economies to halt.

4 CONCLUSION AND IMPLICATIONS

With respect to the gravity of the COVID-19 outbreak, the present study was directed to assess the impact of the COVID-19 on the stock market risk of the G-20 nations. Comparison of risk was also made between the G-20 nations and different regimes. From the results of different VaR models and their backtesting, it is found that SVaR is the best suited model for all the countries in all the regimes. As per the SVaR estimates and graphical representation of the deviations from average VaR (overall period), it can be concluded that all the G-20 nations have experienced very high level of risk during Regime III and IV, that is, GFC and COVID-19 as all the countries stock markets are critical during these two periods. But, the magnitude of risk is varied from country to country. However, for most of the countries, it is found to be highest during COVID-19 period compared to other regimes. However, one shocking revelation is that China is found to be on safe zone having very less market risk, where all other countries are found to be critical.

The results of this study would help the investors to understand the short-run behavior of the stock markets during different types of crisis and thus help to take decisions in similar period. Further, it would also help the investors to estimate approximately, the maximum value they might lose on their present investment and accordingly plan for the future. Moreover, it is observed that although COVID-19 has affected all the countries; however, the magnitude is different from country to country and continent to continent. G-20 nations may together make effort to diversify the risk among them and maintain stability. Again, highly affected countries must learn from the locally affected countries to maintain stability in the stock market. However, as the outbreak of COVID-19 is not yet curable and increasing in an alarming rate, the results of our study are applicable for short-run. The long-run impact can be assessed only after overcoming this crisis. This could be an interesting area to be research for the benefits of the markets, investors, and public as a whole. The researchers may also examine other macro-economic parameters with respect to COVID-19.

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## APPENDIX

### TABLE A1 Countries and their stock exchanges

| Countries             | Abbreviation   |
|-----------------------|----------------|
| Argentina             | MERVAL         |
| Australia             | AS51           |
| Brazil                | IBOV           |
| Canada                | SPTSX60        |
| China                 | SHCOMP         |
| France                | CAC            |
| Germany               | DAX            |
| India                 | SENSEX         |
| Indonesia             | JKSE           |
| Italy                 | FTSEMIB        |
| Japan                 | NKY            |
| Republic of Korea     | KOSPI          |
| Mexico                | MEXBOL         |
| Russia                | IMOEX          |
| Saudi Arabia          | SASEIDEX       |
| South Africa          | JALSH          |
| Turkey                | XU100          |
| United Kingdom        | UKX            |
| United States         | INDU           |
| European Union (represented by Spain) | IBEX |

Note: Collection from official websites of respective countries.

### TABLE A2 Regimes of volatile market

| Regimes           | Time period                | Explanation of volatility |
|-------------------|----------------------------|---------------------------|
| Regime I          | January 1, 1998–December 31, 1998 | Asian financial crisis    |
| Regime II         | January 1, 2002–December 31, 2002 | Internet bubble           |
| Regime III        | January 1, 2008–December 31, 2008 | Global financial crisis   |
| Regime IV         | January 1, 2020–June 30, 2020 | COVID-19                  |
| Overall regime    | January 1, 1998–June 30, 2020 | Overall period            |

Note: Own identification.
### TABLE A3  Overall regime

| Estimation/countries | Percentage of violation | Kuepic test |
|----------------------|-------------------------|-------------|
|                      | PVaR | TVaR | SVaR | GVaR | PVaR | TVaR | SVaR | GVaR |
| SENSEX               | 2.12 | 0.99 | 0.92 | 0.80 | 55.89 | 0.007 | 0.37 | 2.48 |
| MERVAL               | 1.76 | 0.89 | 1.01 | 0.10 | 27.78 | 0.77 | 0.003 | 78.27 |
| AS51                 | 1.84 | 1.13 | 0.94 | 0.24 | 33.73 | 0.91 | 0.33 | 49.41 |
| SPTSX60              | 1.81 | 1.14 | 1.02 | 0.43 | 31.29 | 1.17 | 0.03 | 24.77 |
| SHCOMP               | 2.08 | 1.01 | 0.96 | 4.39 | 52.88 | 0.003 | 0.12 | 25.33 |
| CAC                  | 2.08 | 1.11 | 0.94 | 0.24 | 52.88 | 0.69 | 0.22 | 49.41 |
| DAX                  | 2.10 | 1.13 | 1.01 | 0.32 | 54.38 | 0.91 | 0.003 | 36.62 |
| KOSPI                | 2.08 | 0.73 | 1.04 | 1.95 | 52.88 | 4.61 | 0.12 | 41.51 |
| NKY                  | 1.66 | 1.11 | 1.11 | 1.42 | 21.27 | 0.69 | 0.69 | 9.11 |
| MEXBOL               | 1.90 | 1.09 | 0.24 | 37.54 | 37.54 | 0.49 | 49.41 |
| SASEIDX              | 2.37 | 1.50 | 0.99 | 1.69 | 80.52 | 12.94 | 0.005 | 25.35 |
| XU100                | 1.93 | 0.96 | 1.04 | 6.90 | 40.17 | 0.14 | 0.10 | 34.32 |
| UKX                  | 1.86 | 1.69 | 0.92 | 0.34 | 34.99 | 23.35 | 0.36 | 34.42 |
| INDU                 | 1.78 | 0.99 | 0.94 | 0.12 | 28.92 | 0.006 | 0.22 | 73.86 |
| IBEX                 | 1.88 | 1.09 | 1.04 | 0.19 | 36.25 | 0.49 | 0.06 | 58.73 |
| IBOV                 | 1.55 | 1.06 | 1.01 | 1.23 | 15.52 | 0.19 | 0.003 | 2.89 |
| JALSH                | 1.95 | 1.20 | 0.99 | 0.31 | 41.51 | 2.12 | 0.005 | 38.94 |
| IMOEX                | 1.88 | 0.97 | 0.94 | 4.75 | 36.25 | 0.04 | 0.22 | 21.34 |
| FTSEMIB              | 1.96 | 0.14 | 1.04 | 0.34 | 42.87 | 69.72 | 0.1 | 34.42 |
| JKSE                 | 1.88 | 1.13 | 0.92 | 1.02 | 36.25 | 0.91 | 0.37 | 0.03 |

Note: Authors' estimation.
*Indicates significance at 99% confidence.

### TABLE A4  Regime I

| Estimation/countries | % of violation | Kuepic test |
|----------------------|---------------|-------------|
|                      | PVaR | TVaR | SVaR | GVaR | PVaR | TVaR | SVaR | GVaR |
| SENSEX               | 1.53 | 0.77 | 0.77 | 1.53 | 0.64 | 0.16 | 0.16 | 0.64 |
| MERVAL               | 1.92 | 0.77 | 1.15 | 3.45 | 1.74 | 0.16 | 0.06 | 9.67 |
| AS51                 | 1.15 | 0.00 | 1.15 | 1.92 | 0.06 | 0.00 | 0.06 | 1.74 |
| SPTSX60              | 3.45 | 1.53 | 0.77 | 3.83 | 9.67 | 0.64 | 0.16 | 12.29 |
| SHCOMP               | 1.15 | 0.77 | 1.15 | 1.15 | 0.06 | 0.16 | 0.06 | 0.06 |
| CAC                  | 2.68 | 2.68 | 1.15 | 3.45 | 5.11 | 5.11 | 0.06 | 9.67 |
| DAX                  | 2.30 | 4.21 | 0.77 | 3.07 | 3.25 | 15.14 | 0.16 | 7.25 |
| KOSPI                | 0.77 | 0.38 | 0.77 | 1.15 | 0.16 | 1.31 | 0.16 | 0.06 |
| NKY                  | 0.77 | 0.77 | 1.15 | 3.07 | 0.16 | 0.16 | 0.06 | 7.25 |
| MEXBOL               | 1.92 | 0.38 | 1.15 | 2.68 | 1.74 | 1.31 | 0.06 | 5.11 |
| SASEIDX              | 1.92 | 0.00 | 1.15 | 0.77 | 1.74 | 0.00 | 0.06 | 0.16 |
| XU100                | 1.53 | 1.15 | 1.15 | 2.30 | 0.64 | 0.06 | 0.06 | 3.25 |
| UKX                  | 2.68 | 1.15 | 0.77 | 3.45 | 5.11 | 0.06 | 0.16 | 9.67 |
| INDU                 | 2.30 | 2.30 | 1.15 | 3.07 | 3.25 | 3.25 | 0.06 | 7.25 |
| IBEX                 | 2.68 | 4.21 | 0.77 | 4.98 | 5.11 | 15.14 | 0.16 | 21.39 |
| IBOV                 | 2.30 | 1.15 | 0.77 | 0.77 | 3.21 | 0.06 | 0.16 | 0.16 |
| JALSH                | 2.30 | 1.92 | 0.77 | 2.30 | 3.25 | 1.74 | 0.16 | 3.25 |
| IMOEX                | 1.92 | 0.38 | 1.15 | 9.20 | 1.74 | 1.31 | 0.06 | 65.54 |
| FTSEMIB              | 2.30 | 1.53 | 0.77 | 7.66 | 3.25 | 0.64 | 0.16 | 47.87 |
| JKSE                 | 1.92 | 0.77 | 1.15 | 2.68 | 1.74 | 0.16 | 0.06 | 5.11 |

Note: Authors' estimation.
*Indicates significance at 99% confidence.
### TABLE A5  Regime II

| Estimation/countries | Percentage of violation | Kuepic test |
|----------------------|-------------------------|-------------|
|                      | PVaR  | TVaR  | SVaR  | GVaR  | PVaR  | TVaR  | SVaR  | GVaR  |
| SENSEX               | 1.15  | 1.15  | 0.77  | 2.30  | 0.06* | 0.06* | 0.16* | 3.25* |
| MERVAL               | 2.30  | 0.38  | 0.77  | 3.83  | 3.25* | 1.31* | 0.16* | 12.29 |
| AS51                 | 1.15  | 0.38  | 1.15  | 1.15  | 0.06* | 1.31* | 0.16* | 0.06* |
| SPTSX60              | 6.90  | 0.77  | 1.15  | 5.36  | 39.67 | 0.16* | 0.06* | 24.76 |
| SHCOMP               | 0.77  | 1.53  | 1.15  | 1.15  | 0.16* | 0.64* | 0.06* | 0.06* |
| CAC                  | 1.53  | 0.38  | 0.77  | 8.43  | 0.64* | 1.31* | 0.16* | 56.51 |
| DAX                  | 0.38  | 0.00  | 1.15  | 1.53  | 1.31* | 0.00* | 0.06* | 0.64* |
| KOSPI                | 1.15  | 0.77  | 1.15  | 0.77  | 0.06* | 0.16* | 0.06* | 0.16* |
| NKY                  | 0.77  | 0.38  | 1.15  | 2.30  | 0.16* | 1.31* | 0.06* | 0.16* |
| MEXBOL               | 1.53  | 0.77  | 0.77  | 1.15  | 0.06* | 0.64* | 0.06* | 0.06* |
| SASEIDX              | 2.68  | 0.00  | 0.77  | 0.77  | 5.11* | 0.00* | 0.16* | 0.16* |
| XU100                | 0.38  | 0.38  | 1.15  | 0.38  | 1.31* | 0.05* | 0.05* | 31.95 |
| UKX                  | 2.30  | 2.30  | 0.77  | 3.45  | 3.25* | 3.25* | 0.16* | 9.67  |
| INDU                 | 1.15  | 0.77  | 1.15  | 3.07  | 0.06* | 0.16* | 0.06* | 7.25  |
| IBEX                 | 1.15  | 0.77  | 1.15  | 4.21  | 0.06* | 0.16* | 0.06* | 15.14 |
| IBOV                 | 1.53  | 1.15  | 1.15  | 0.06* | 0.16* | 0.06* | 0.06* | 7.25  |
| JALSH                | 1.15  | 0.77  | 1.15  | 2.67  | 0.06* | 0.16* | 0.06* | 5.07* |
| IMOEX                | 1.15  | 0.77  | 0.77  | 2.30  | 0.06* | 0.16* | 0.06* | 3.25* |
| FTSEMIB              | 1.15  | 0.38  | 1.15  | 3.45  | 0.06* | 1.31* | 0.05* | 9.67  |
| JKSE                 | 0.77  | 0.38  | 0.77  | 2.68  | 0.16* | 1.31* | 0.16* | 5.11* |

Note: Authors’ estimation.  
*Indicates significance at 99% confidence.

### TABLE A6  Regime III

| Estimation/countries | % of violation | Kuepic test |
|----------------------|----------------|-------------|
|                      | PVaR  | TVaR  | SVaR  | GVaR  | PVaR  | TVaR  | SVaR  | GVaR  |
| SENSEX               | 1.53  | 0.76  | 0.76  | 3.05  | 0.63* | 0.16* | 0.16* | 7.21  |
| MERVAL               | 2.67  | 1.15  | 0.76  | 6.49  | 5.07* | 0.05* | 0.16* | 38.63 |
| AS51                 | 1.53  | 1.53  | 0.76  | 4.58  | 0.63* | 0.63* | 0.16* | 18.1  |
| SPTSX60              | 2.29  | 1.15  | 1.15  | 2.29  | 3.23* | 0.05* | 0.05* | 3.23* |
| SHCOMP               | 1.15  | 0.38  | 1.15  | 0.38  | 0.05* | 1.32* | 0.05* | 1.32* |
| CAC                  | 2.67  | 0.76  | 1.15  | 4.58  | 5.07* | 0.16* | 0.05* | 18.1  |
| DAX                  | 2.67  | 0.38  | 1.15  | 3.05  | 5.07* | 0.16* | 0.05* | 7.21  |
| KOSPI                | 2.67  | 1.53  | 1.15  | 2.67  | 5.07* | 0.63* | 0.05* | 5.07* |
| NKY                  | 2.29  | 1.53  | 0.76  | 5.73  | 3.23* | 0.63* | 0.16* | 28.19 |
| MEXBOL               | 1.91  | 2.67  | 1.15  | 4.58  | 1.72* | 5.07* | 0.05* | 18.1  |
| SASEIDX              | 3.05  | 4.58  | 1.15  | 1.91  | 7.21  | 18.1  | 0.05* | 1.72* |
| XU100                | 2.29  | 1.15  | 0.76  | 4.96  | 3.23* | 0.05* | 0.16* | 21.31 |
| UKX                  | 1.91  | 1.15  | 1.15  | 4.58  | 1.72* | 0.05* | 0.05* | 18.1  |
| INDU                 | 2.29  | 1.15  | 0.76  | 3.82  | 0.63* | 0.05* | 0.16* | 12.24 |
| IBEX                 | 1.91  | 1.15  | 1.15  | 7.63  | 1.72* | 0.05* | 0.05* | 47.73 |
| IBOV                 | 1.91  | 0.76  | 0.76  | 5.73  | 1.72* | 0.16* | 0.16* | 28.19 |
| JALSH                | 1.53  | 0.76  | 0.76  | 1.91  | 0.63* | 0.16* | 0.16* | 1.72* |
| IMOEX                | 1.91  | 1.53  | 0.76  | 3.05  | 1.72* | 0.63* | 0.16* | 7.21  |
| FTSEMIB              | 2.67  | 0.00  | 0.76  | 6.49  | 5.07* | 0.00* | 0.16* | 35.63 |
| JKSE                 | 1.91  | 0.76  | 1.15  | 1.91  | 5.07* | 0.16* | 0.05* | 5.07* |

Note: Authors’ estimation.  
*Indicates significance at 99% confidence.
### TABLE A7  Regime IV

| Estimation/countries | Percentage of violation | Kuepic test |
|----------------------|-------------------------|-------------|
|                      | PVaR | TVaR | SVaR | GVaR | PVaR | TVaR | SVaR | GVaR |
| SENSEX               | 2.54 | 0.85 | 0.85 | 3.39 | 1.99a | 0.03a | 0.03a | 4.19a |
| MERVAL               | 3.39 | 1.69 | 1.69 | 1.69 | 4.19a | 0.48a | 0.48a | 0.48a |
| ASS1                 | 3.39 | 0.00 | 0.00 | 2.54 | 4.19a | 0.00a | 0.00a | 1.99a |
| SPTSX60             | 3.39 | 1.69 | 0.85 | 2.54 | 4.19a | 0.48a | 0.03a | 1.99a |
| SHCOMP               | 2.54 | 0.85 | 1.69 | 3.39 | 1.99a | 0.03a | 0.48a | 4.19a |
| CAC                  | 1.69 | 1.69 | 0.85 | 0.85 | 0.48a | 0.48a | 0.03a | 0.03a |
| DAX                  | 1.69 | 1.69 | 0.85 | 0.85 | 0.48a | 0.48a | 0.03a | 0.03a |
| KOSPI                | 1.69 | 0.85 | 0.85 | 2.54 | 0.48a | 0.02a | 0.03a | 1.99a |
| NKY                  | 1.69 | 1.69 | 0.85 | 4.24 | 0.48a | 0.48a | 0.03a | 6.93  |
| MEXBOL              | 2.54 | 2.54 | 0.85 | 2.54 | 1.99a | 1.99a | 0.03a | 1.99a |
| SASEIDX             | 2.54 | 0.00 | 1.69 | 1.69 | 1.99a | 0.00a | 0.48a | 0.48a |
| XU100                | 2.54 | 1.69 | 1.69 | 7.63 | 1.99a | 0.48a | 1.99a | 21.47 |
| UKX                  | 1.69 | 1.69 | 0.85 | 1.69 | 0.48a | 0.48a | 0.03a | 0.48a |
| INDO                 | 2.54 | 0.85 | 1.69 | 0.85 | 1.99a | 0.03a | 0.48a | 0.03a |
| IBEX                | 2.54 | 2.54 | 1.69 | 0.85 | 1.99a | 1.99a | 0.48a | 0.03a |
| IBOV                 | 3.39 | 2.54 | 0.85 | 6.78 | 4.19a | 1.99a | 0.03a | 17.39 |
| JALSH               | 3.39 | 1.69 | 1.69 | 3.39 | 4.19a | 0.48a | 0.48a | 4.19a |
| IMOEX               | 3.39 | 0.00 | 0.85 | 4.24 | 4.19a | 0.00a | 0.03a | 6.93  |
| FTSEMIIB            | 1.69 | 1.69 | 0.85 | 1.69 | 0.48a | 0.48a | 0.03a | 0.48a |
| JKSE                | 3.39 | 0.00 | 1.69 | 16.10 | 4.19a | 0.00a | 0.48a | 72.82 |

Note: Authors’ estimation.
*Indicates significance at 99% confidence.

### TABLE A8  Model validation

| Regimes           | PVaR              | TVaR              | SVaR              | GVaR              |
|-------------------|-------------------|-------------------|-------------------|-------------------|
| Regime I          | Fit except for Canada | Germany and Spain | Fit for all       | Unfit for most of the countries |
| Regime II         | Fit except for Canada | Fit for all       | Fit for all       | Unfit for most of the countries |
| Regime III        | Fit except Saudi Arabia | Fit except for Saudi Arabia | Fit for all       | Unfit for most of the countries |
| Regime IV         | Fit for all       | Fit for all       | Fit for all       | Unfit for most of the countries |
| Overall period    | Not fit for any country | Fit except for United Kingdom, Mexico, Italy, and Saudi Arabia | Fit for all       | Unfit for most of the countries |

Note: Authors’ findings.
| Region   | PVaR  | PES  | TVaR  | TES  | SVaR  | SES  | GARCH-VaR | GES  |
|----------|-------|------|-------|------|-------|------|------------|------|
| Africa   |       |      |       |      |       |      |            |      |
| JALSH    | −2.80%| −3.20%| −3.20%| −4.60%| −3.40%| −4.80%| −4.80%     | −6.20%|
| Asia     |       |      |       |      |       |      |            |      |
| SHCOMP   | −3.50%| −4.00%| −4.70%| −7.90%| −4.90%| −6.40%| −2.50%     | −3.20%|
| SENSEX   | −3.40%| −3.90%| −4.30%| −6.90%| −4.40%| −6.00%| −4.70%     | −5.80%|
| KOSPI    | −3.80%| −4.30%| −5.40%| −11.30%| −4.70%| −6.40%| −3.90%     | −4.90%|
| JKSE     | −3.40%| −4.00%| −4.20%| −6.80%| −4.40%| −6.10%| −4.30%     | −6.00%|
| NKY      | −3.40%| −3.90%| −3.90%| −5.80%| −3.90%| −5.70%| −3.60%     | −4.70%|
| South America | |      |       |      |       |      |            |      |
| MERVAL   | −5.20%| −6.00%| −6.60%| −10.60%| −6.40%| −9.40%| −11.90%    | −16.00%|
| IBOV     | −4.50%| −5.20%| −5.10%| −7.50%| −5.20%| −7.70%| −4.80%     | −6.20%|
| North America | |      |       |      |       |      |            |      |
| INDU     | −2.70%| −3.10%| −3.40%| −5.80%| −3.50%| −5.20%| −7.30%     | −9.40%|
| SPTSX60  | −2.80%| −3.20%| −3.30%| −5.40%| −3.50%| −5.30%| −4.50%     | −5.70%|
| MEXBOL   | −3.10%| −3.60%| −3.10%| −4.10%| −3.80%| −5.10%| −5.60%     | −7.10%|
| Australia |       |      |       |      |       |      |            |      |
| AS51     | −2.30%| −2.70%| −2.70%| −4.00%| −2.80%| −4.10%| −4.50%     | −5.60%|
| Europe   |       |      |       |      |       |      |            |      |
| CAC      | −3.30%| −3.80%| −4.10%| −6.10%| −4.30%| −5.70%| −5.90%     | −7.60%|
| DAX      | −3.40%| −3.90%| −4.30%| −7.00%| −4.50%| −5.70%| −5.90%     | −7.30%|
| IMOEX    | −5.50%| −6.30%| −7.10%| −13.20%| −7.30%| −10.70%| −3.50%     | −4.80%|
| FTSEIMIB | −3.60%| −4.10%| −6.90%| −13.30%| −4.50%| −6.10%| −6.00%     | −7.60%|
| IBEX     | −3.40%| −3.90%| −4.00%| −6.00%| −4.10%| −5.80%| −6.60%     | −8.30%|
| UKX      | −2.80%| −3.20%| −2.90%| −3.90%| −3.50%| −4.70%| −4.90%     | −6.10%|
| Mid east |       |      |       |      |       |      |            |      |
| XU100    | −5.10%| −5.90%| −6.60%| −10.90%| −6.40%| −8.80%| −2.80%     | −3.80%|
| SASEIDEX | −3.20%| −3.70%| −4.10%| −6.10%| −4.80%| −7.50%| −3.80%     | −5.60%|

Note: Authors' estimation.
|           | PVaR  | PES   | TVaR  | TES   | SVaR  | SES   | GARCH-VaR | GES   |
|-----------|-------|-------|-------|-------|-------|-------|------------|-------|
| **Africa**|       |       |       |       |       |       |            |       |
| JALSH     | −4.08%| −4.67%| −4.57%| −6.34%| −5.56%| −6.99%| −4.43%     | −5.61%|
| **Asia**  |       |       |       |       |       |       |            |       |
| SHCOMP    | −3.02%| −3.45%| −3.32%| −4.54%| −3.05%| −6.89%| −2.94%     | −4.09%|
| SENSEX    | −4.35%| −4.97%| −4.82%| −6.12%| −4.64%| −6.79%| −4.58%     | −6.80%|
| KOSPI     | −7.18%| −8.25%| −8.40%| −11.06%| −6.69%| −7.84%| −6.42%     | −7.57%|
| JKSE      | −6.75%| −7.73%| −9.59%| −17.12%| −5.69%| −11.33%| −5.50%     | −8.25%|
| NKY       | −3.91%| −4.47%| −4.34%| −5.67%| −3.52%| −5.61%| −2.82%     | −3.51%|
| **South America** | | | | | | | |
| MERVAL    | −6.65%| −7.60%| −9.32%| −17.31%| −8.16%| −12.71%| −5.99%     | −6.26%|
| IBOV      | −8.36%| −9.55%| −10.03%| −15.21%| −10.09%| −13.91%| −10.17%    | −10.43%|
| **North America** | | | | | | | |
| INDU      | −2.81%| −3.22%| −2.73%| −3.35%| −3.47%| −5.40%| −2.70%     | −3.12%|
| SPTSX60   | −3.18%| −3.64%| −3.91%| −5.87%| −3.95%| −5.55%| −2.76%     | −3.27%|
| MEXBOL    | −5.35%| −6.11%| −6.38%| −9.44%| −6.17%| −8.36%| −4.25%     | −4.64%|
| **Australia** | | | | | | | |
| AS51      | −2.22%| −2.54%| −9.41%| −17.36%| −2.38%| −2.52%| −1.99%     | −2.10%|
| **Europe** |       |       |       |       |       |       |            |       |
| CAC       | −3.66%| −4.21%| −3.82%| −4.83%| −4.70%| −5.37%| −2.94%     | −4.10%|
| DAX       | −4.14%| −4.75%| −3.30%| −4.46%| −6.00%| −6.28%| −3.82%     | −4.31%|
| IMOEX     | −14.08%| −16.09%| −18.34%| −30.68%| −17.47%| −18.53%| −7.59%     | −8.36%|
| FTSEMIIB  | −4.67%| −5.37%| −5.03%| −6.41%| −5.59%| −6.07%| −3.14%     | −3.36%|
| IBEX      | −4.34%| −4.99%| −3.35%| −4.37%| −6.03%| −7.33%| −3.16%     | −3.80%|
| UKX       | −2.99%| −3.44%| −3.31%| −4.34%| −3.35%| −3.53%| −2.70%     | −3.11%|
| **Mid east** | | | | | | | |
| XU100     | −9.49%| −10.86%| −11.54%| −16.82%| −11.97%| −13.05%| −8.60%     | −9.77%|
| SASEIDX   | −2.49%| −2.83%| −6.31%| −9.37%| −3.64%| −4.50%| −3.94%     | −5.46%|

*Note: Authors' estimation.*
| Table A11 | Regime II |
|----------|----------|
|          | PVaR     | PES      | TVaR     | TES      | SVaR     | SES      | GARCH-VaR | GES       |
| Africa   |          |          |          |          |          |          |          |           |
| JALSH    | −2.75%   | −3.15%   | −2.91%   | −3.50%   | −2.89%   | −3.07%   | −2.96%    | −3.15%    |
| Asia     |          |          |          |          |          |          |          |           |
| SHCOMP   | −3.49%   | −3.99%   | −3.23%   | −4.05%   | −3.48%   | −5.31%   | −3.47%    | −3.56%    |
| SENSEX   | −2.50%   | −2.87%   | −2.72%   | −3.43%   | −2.98%   | −3.47%   | −2.19%    | −2.64%    |
| KOSPI    | −4.63%   | −5.30%   | −4.84%   | −5.94%   | −4.82%   | −6.70%   | −4.83%    | −6.70%    |
| JKSE     | −3.35%   | −3.84%   | −3.69%   | −5.10%   | −2.97%   | −7.24%   | −2.58%    | −4.48%    |
| NKY      | −3.76%   | −4.29%   | −4.09%   | −4.87%   | −3.47%   | −3.97%   | −3.22%    | −3.54%    |
| South America |      |          |          |          |          |          |          |           |
| INDU     | −3.74%   | −4.27%   | −4.02%   | −4.91%   | −3.77%   | −4.49%   | −2.73%    | −3.46%    |
| Merval   | −6.80%   | −7.82%   | −10.09%  | −17.45%  | −8.75%   | −10.13%  | −4.87%    | −5.42%    |
| IBOV     | −4.78%   | −5.47%   | −5.06%   | −6.15%   | −5.22%   | −6.09%   | −4.35%    | −5.04%    |
| North America |    |          |          |          |          |          |          |           |
| SPTSX60  | −1.71%   | −1.95%   | −3.00%   | −3.67%   | −2.87%   | −3.33%   | −1.89%    | −2.44%    |
| MEXBOL   | −3.22%   | −3.68%   | −3.88%   | −5.25%   | −3.69%   | −4.97%   | −2.66%    | −3.24%    |
| Australia |          |          |          |          |          |          |          |           |
| AS51     | −1.69%   | −1.93%   | −1.85%   | −2.22%   | −1.74%   | −2.04%   | −1.66%    | −1.88%    |
| Europe   |          |          |          |          |          |          |          |           |
| CAC      | −5.27%   | −6.01%   | −5.65%   | −6.95%   | −5.55%   | −5.81%   | −2.95%    | −4.10%    |
| DAX      | −5.99%   | −6.83%   | −6.42%   | −7.78%   | −5.69%   | −5.92%   | −5.43%    | −6.50%    |
| IMOX     | −3.66%   | −4.21%   | −3.90%   | −4.68%   | −3.75%   | −4.73%   | −2.53%    | −3.05%    |
| FTSEMB   | −4.30%   | −4.91%   | −4.58%   | −5.59%   | −4.42%   | −4.80%   | −3.31%    | −3.46%    |
| IBEX     | −4.54%   | −5.18%   | −4.91%   | −5.95%   | −4.62%   | −5.12%   | −3.23%    | −3.66%    |
| UKX      | −4.07%   | −4.65%   | −4.32%   | −5.40%   | −4.87%   | −5.33%   | −3.77%    | −4.10%    |
| Mid East |          |          |          |          |          |          |          |           |
| XU100    | −6.46%   | −7.38%   | −7.01%   | −8.71%   | −5.58%   | −6.61%   | −5.80%    | −6.45%    |
| SASEIDX  | −1.65%   | −1.89%   | −3.28%   | −10.46%  | −1.95%   | −2.39%   | −2.03%    | −2.43%    |

Note: Authors' estimation.
| Regime III | PVaR | PES | TVaR | TES | SVaR | SES | GARCH-VaR | GES |
|------------|------|-----|------|-----|------|-----|-----------|-----|
| Africa     |      |     |      |     |      |     |           |     |
| JALSH      | −5.33% | −6.09% | −6.24% | −8.22% | −5.99% | −7.41% | −4.98% | −5.31% |
| Asia       |      |     |      |     |      |     |           |     |
| SHCOMP     | −6.84% | −7.78% | −7.71% | −10.13% | −7.46% | −7.78% | −7.50% | −7.80% |
| SENSEX     | −6.72% | −7.65% | −7.58% | −9.71% | −7.33% | −9.81% | −5.57% | −7.50% |
| KOSPI      | −5.78% | −6.59% | −7.22% | −12.27% | −7.86% | −10.54% | −5.43% | −6.08% |
| JKSE       | −6.14% | −6.99% | −8.12% | −14.61% | −8.01% | −11.13% | −6.17% | −8.40% |
| NKY        | −6.80% | −7.76% | −8.86% | −14.39% | −10.09% | −11.12% | −4.64% | −6.17% |
| South America |    |     |      |     |      |     |           |     |
| MERVAL     | −6.73% | −7.68% | −9.59% | −18.17% | −10.66% | −12.29% | −4.67% | −5.44% |
| IBOV       | −7.68% | −8.76% | −10.18% | −16.52% | −9.83% | −11.42% | −4.78% | −5.65% |
| North America |   |     |      |     |      |     |           |     |
| INDU       | −5.60% | −6.39% | −7.32% | −12.43% | −7.62% | −8.10% | −4.86% | −5.32% |
| SPTSX60    | −6.14% | −7.01% | −8.85% | −17.44% | −8.97% | −10.22% | −6.49% | −6.62% |
| MEXBOL     | −5.32% | −6.08% | −5.12% | −6.25% | −5.55% | −6.95% | −4.53% | −4.90% |
| Australia  |      |     |      |     |      |     |           |     |
| AS51       | −5.13% | −5.84% | −5.93% | −8.15% | −6.90% | −8.00% | −3.55% | −5.24% |
| Europe     |      |     |      |     |      |     |           |     |
| CAC        | −6.06% | −6.91% | −7.72% | −13.32% | −7.08% | −8.75% | −4.58% | −7.57% |
| DAX        | −5.65% | −6.44% | −7.41% | −13.34% | −7.27% | −7.39% | −5.15% | −7.65% |
| IMOEX      | −10.62% | −12.11% | −14.90% | −33.61% | −15.49% | −19.90% | −9.41% | −10.24% |
| FTSEI50B   | −5.71% | −6.51% | −10.04% | −16.25% | −7.02% | −7.97% | −3.54% | −5.63% |
| IBEX       | −5.93% | −6.77% | −7.32% | −12.42% | −7.84% | −9.05% | −3.81% | −6.26% |
| UKX        | −5.55% | −6.33% | −7.14% | −11.40% | −7.43% | −8.74% | −4.48% | −5.49% |
| Mid east   |      |     |      |     |      |     |           |     |
| XU100      | −6.47% | −7.37% | −7.52% | −10.26% | −7.75% | −8.52% | −4.88% | −5.79% |
| SASEIDIX   | −6.19% | −7.05% | −5.10% | −6.26% | −10.87% | −12.88% | −8.82% | −12.57% |

Note: Authors' estimation.
| Region      | Table A13 | PVaR | PES | TVaR | TES | SVaR | SES | GARCH-VaR | GES |
|------------|-----------|------|-----|------|-----|------|-----|-----------|-----|
| Africa     |           |      |     |      |     |      |     |           |     |
| JALSH      | −5.86%    | −6.71% | −8.51% | −16.95% | −8.69% | −10.23% | −5.57% | −7.50%    |
| Asia       |           |      |     |      |     |      |     |           |     |
| SHCOMP     | −3.21%    | −3.67% | −4.25% | −8.09% | −3.78% | −8.04% | −3.12% | −6.32%    |
| SENSEX     | −6.60%    | −7.60% | −11.97% | −32.27% | −8.53% | −14.10% | −5.86% | −6.82%    |
| KOSPI      | −5.16%    | −5.91% | −6.86% | −11.73% | −5.49% | −8.77% | −4.56% | −4.62%    |
| JKSE       | −5.03%    | −5.73% | −7.07% | −13.63% | −5.34% | −6.81% | −1.70% | −1.84%    |
| NKY        | −4.78%    | −5.47% | −4.75% | −5.73% | −5.20% | −6.27% | −4.25% | −4.74%    |
| South America |        |      |     |      |     |      |     |           |     |
| MERVAL     | −9.14%    | −10.47% | −12.02% | −19.05% | −14.79% | −15.63% | −11.85% | −19.48%   |
| IBOV       | −9.16%    | −10.47% | −12.67% | −25.11% | −14.99% | −15.99% | −5.57% | −7.50%    |
| North America |        |      |     |      |     |      |     |           |     |
| INDU       | −7.55%    | −8.64% | −12.82% | −30.92% | −10.52% | −13.84% | −12.02% | −15.46%   |
| SPTSX60    | −7.07%    | −8.08% | −11.08% | −12.28% | −11.19% | −13.37% | −7.49% | −10.14%   |
| MEXBOL     | −4.66%    | −5.32% | −5.11% | −6.49% | −5.49% | −6.64% | −5.22% | −7.25%    |
| Australia  |           |      |     |      |     |      |     |           |     |
| AS51       | −5.93%    | −6.77% | −11.61% | −19.18% | −14.79% | −15.63% | −6.83% | −7.46%    |
| Europe     |           |      |     |      |     |      |     |           |     |
| CAC        | −6.38%    | −7.28% | −8.68% | −16.91% | −8.76% | −13.10% | −8.99% | −9.14%    |
| DAX        | −6.33%    | −7.24% | −8.18% | −14.79% | −8.28% | −13.06% | −8.59% | −9.31%    |
| IMOEX      | −5.09%    | −5.82% | −12.99% | −28.10% | −8.46% | −8.65% | −4.04% | −5.06%    |
| FTSEIB     | −7.08%    | −8.08% | −8.18% | −14.38% | −11.85% | −18.54% | −10.04% | −11.74%   |
| IBEX       | −6.54%    | −7.46% | −5.96% | −7.49% | −8.30% | −15.15% | −9.55% | −11.03%   |
| UKX        | −5.73%    | −6.53% | −7.32% | −12.41% | −8.00% | −11.51% | −7.43% | −7.56%    |
| Mid east   |           |      |     |      |     |      |     |           |     |
| XU100      | −4.49%    | −5.14% | −7.21% | −17.95% | −7.53% | −8.42% | −2.32% | −2.42%    |
| SASEIDX    | −5.57%    | −6.37% | −23.94% | −11.03% | −7.55% | −16.76% | −7.20% | −16.00%   |

Note: Authors' estimation.