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Response of stock market volatility to COVID-19 announcements and stringency measures: A comparison of developed and emerging markets

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ABSTRACT

We investigate the relationship between the daily release of COVID-19 related announcements, defensive government interventions, and stock market volatility, drawing upon an extended time period of one year, to independently test, confirm and iteratively improve on previous research findings. We categorize stock markets into emerging and developed markets and consider differences and similarities utilizing an asymmetric measure of volatility. We find that there are major differences between these markets with respect to investors' interpretation of risk in response to daily new confirmed cases, death rates, recovery rates, and different defensive government interventions. We suggest explanations for these differences, in terms of national culture, and the quality of governance. Moreover, the development of Pfizer-BioNTech's vaccine is of immense importance to both markets. The findings have implications for tailoring government responses to crises in country-specific contexts.

1. Introduction

The emergence of the Coronavirus pandemic (COVID-19) has generated numerous strands of academic research. Of great interest are studies that focus on the pandemic and its impact on stock market volatility (Albulescu, 2021; Baig et al., 2021; Cheng, 2020; Haldar and Sethi, 2021; Li et al, 2020; Mazur et al., 2021; Sharma, 2020; Tripathi and Pandey, 2021; Zaremba et al., 2020, 2021; Zhang et al., 2020). The selection of variables for estimation in these important studies are drawn from, but not limited to, announcements of new COVID-19 infections, either fatality ratios or death rates, recovery rates, liquidity in financial markets, government stringency measures, macroeconomic announcements, and economic policy uncertainty.

The existing studies are mostly focused on particular geographic areas like the United States (Albulescu, 2021; Baek et al., 2020; Choi, 2020; Onali, 2020), while others also include Europe (Mirza et al., 2020), Australia (Gunay et al., 2021), and the Asia Pacific Region (Ibrahim et al., 2020). Other studies concentrate on a mix of developed and emerging market countries around the globe

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(Ashraf, 2020; Zaremba, 2020). Harjoto et al., (2020) conducted multivariate regressions, while Uddin et al. (2021) applied an EGARCH model, to test the impact of daily COVID-19 cases and deaths on the volatility of stock markets in emerging and developed markets separately. Others have focused their studies solely on emerging markets or developed markets. Both include a comparison of similarities and differences between the two markets. Uddin et al. (2021) further explore the effects of capital market and country-level variables on stock market volatility.

The primary objective of our paper is to explore the effect of COVID-19 announcements and government stringency measures on stock market volatility particularly focusing on emerging and developed market contexts. Moreover, we seek to test, confirm and address gaps in knowledge, on the relationship between stock market volatility and its potential drivers in the COVID-19 environment. Thus, we are able to iteratively improve, and build confidence in studies both current and previous.

Considering, that the good and bad announcements have an asymmetric impact on stock market volatility (Onan et al., 2014), our study fits within this strand of literature by exploring the impact of, COVID-19 announcements that include daily new confirmed cases, deaths and recovered cases, and government stringency measures (in aggregate and individually), on stock market volatility in our investigation of differences and similarities between emerging and developed markets.

Zaremba et al. (2020), pioneered the investigation into the impact of government imposed social restrictions on COVID-19 related stock market volatility. They explored the impact of the aggregate stringency index and the individual impact of seven government policy actions on stock market volatility. Although their sample includes both developed and emerging markets, unlike our investigation, they do not separately investigate the differences and similarities in the impact on stock market volatility in the two markets. Thus, their focus was only on the impact of the stringency of government policy responses and stock market volatility, included in our model.

Both, Harjoto et al., (2020) and Uddin et al. (2021) focus only on the adverse effects of COVID-19 cases and deaths on stock market volatility. In addition, we consider the differences and similarities in the impact of COVID-19 recoveries, government stringency measures, and the announcement of the successful Pfizer-BioNTech's vaccine trials on volatility in the two markets. Thus, we build considerably on previous works by focusing on a particular now established field of interest, the volatility of stock markets in the midst of a pandemic, in emerging and developed markets.

We contribute to the existing literature by extending our investigation over a period of approximately one year, from January 22, 2020, to February 10, 2021, in contrast to Zaremba et al. (2020), who focus on the period January to April 2020, Harjoto et al., (2020) from January 14 to August 20, 2020, and Uddin et al (2021) from July 19, 2019, to August 14, 2020, all of whom focus on approximately a 4 - 7 month period. Thus, our findings will have greater power in justifying epistemic confidence.

Ultimately, we seek explanations for the differences in stock volatility in these markets, resulting from the interpretations of risk and subsequent investor behavior, by considering the impact of culture (Ashraf, 2020; Chiah and Zhong, 2020; Wang, 2021) on uncertainty avoidance and individualism (Fernandez-Perez et al., 2021) and the level of trust in national governments and fellow citizens (Engelhardt et al., 2021).

Our findings reveal critical differences between developed and emerging markets with important implications for global investors and policy makers. The rest of this paper proceeds as follows: Section 2 describes the data and outlines the methodology. Section 3 reports the empirical results. Finally, Section 4 concludes the study.

2. Data and methodology

2.1. Data description

In this study, our choice between emerging and developed markets was based on the Morgan Stanley Capital International (MSCI) classification[1] which includes 27 emerging and 23 developed financial markets. This paper compiles data for COVID-19 announcements (including confirmed cases, death, and recovered cases), an overall Government Response Stringency Index and its underlying nine indicators or sub-indices[2], and the major stock market index from each financial market. The data for analysis was compiled by utilizing the data from three databases, namely, the John Hopkins University Coronavirus Resource Centre, the Oxford COVID-19 government Response Tracker (OxCGRT) (Hale et al., 2020), and the Refinitiv Datastream database. The data was refined by excluding countries for which daily death and/or confirmed cases were either not available or constant over a substantial period. Our final dataset consists of 24 emerging and 15 developed countries. The data sample commencement date corresponds to the commencement date of the John Hopkins University COVID-19 data, with non-trading days being omitted. Table 1 lists the emerging and developed countries covered in this study and the stock market index used for each country. Lastly, daily country-level data was collected for each of the countries considered in this study.

[1] (https://www.msci.com/market-classification)

[2] Data source: Https://www.bsg.ox.ac.uk/research/research-projects/coronavirus-government-response-tracker (accessed 12 February 2021). For more details on the *methodology used to calculate the government response Stringency index and its underlying indicators' sub-indices scores, please visit* https://github.com/OxCGRT/covid-policy-tracker/blob/master/documentation/index_methodology.md#calculating-sub-index-scores-for-each-indicator

Table 1
Sample information This table reports the countries used in this study and the main stock market index used for each country. Panel a. Emerging markets as classified by MSCI and Panel b. Developed markets as classified by MSCI. Indices data is sourced from the Refinitiv Datastream database.

No	Country Panel a. Emerging Markets	Stock Index	No	Country Panel b. Developed Markets	Stock Index
1	Argentina	S&P Merval	1	Australia	S&P_ASX 200
2	Brazil	BOVESPA	2	Austria	ATX
3	Chile	S&P_CLX IGPA CLP	3	Belgium	BEL 20
4	China*	Shanghai Composite	4	Canada	S&P_TSX
5	Colombia	COLCAP	5	Denmark	OMX Copenhagen 20
6	Czech Republic	PX	6	France	CAC 40
7	Egypt	Egypt Hermes Financial	7	Germany	DAX30
8	Greece	Athex Composite	8	Israel	TA125
9	Hungary	Budapest SE	9	Italy	FTSE MIB
10	India	NIFTY 500	10	Japan	Nikkei 225
11	Indonesia	IDX Composite	11	Netherlands	AEX
12	Malaysia	FTSE KLCI	12	Portugal	PSI
13	Mexico	S&P_BMV IPC	13	Switzerland	SMI
14	Pakistan	Karachi 100	14	United Kingdom	FTSE 100
15	Peru	S&P_BVL General	15	United States	S&P 500
16	Philippines	PSEi Composite			
17	Poland	WIG 30			
18	Qatar	QE General			
19	Russia	MOEX			
20	Saudi Arabia	Tadawul All Share			
21	South Africa	FTSE_JSE All Share			
22	South Korea	KOSPI Composite			
23	Turkey	BIST 100			
24	United Arab Emirates	ADX General			

*Although the study uses data starting from Jan 22, 2020 (John Hopkins COVID-19 reported data starting date), COVID-19 cases and Stringency Government Response index for China starts well before that date.

2.2. Estimating volatility: the asymmetric Glosten–Jagannathan–Runkle (GJR)-GARCH model

Although traditional GARCH models can capture volatility clustering and leptokurtosis, they all assume that financial data consists of asymmetric distribution. This means that they do not account for the sign of past error values and are, therefore, unable to capture the asymmetric response of volatility to market shocks caused by good and bad news (i.e., leverage effects).[3] The GJR-GARCH model (Glosten et al., 1993) captures the leverage effects by examining the impulse of negative shocks, which are larger than the impulse of positive shocks (Dutta, 2014).

We investigate how the daily COVID-19 announcements and government stringency responses relate to the volatility of stock market indices in emerging and developed markets. To achieve this, we employed the GJR-GARCH (1,1) model and obtained the conditional variance of the market indices. The GJR-GARCH (1,1) is given by:

$$r_t = \mu + \varepsilon_t \tag{1}$$

$$h_t = \omega + \alpha\varepsilon_{t-1}^2 + \gamma\varepsilon_{t-1}^2 d_{t-1} + \beta_j h_{t-1} \tag{2}$$

where r_t is the returns of each country's stock market price index calculated as $\ln(P_t/P_{t-1})$, h_t which is the conditional forecasted variance at time t; γ denotes the asymmetric parameter; d_{t-1} is a dummy variable where $d_{t-1} = 1$ if $\varepsilon_{t-1} < 0$ (bad news) and $d_{t-1} = 0$ if $\varepsilon_{t-1} \geq 0$ (good news).

2.3. Research model

To examine the time-varying impact of COVID-19 announcements and governments stringency responses on stock market volatility in emerging and developed markets, we utilized panel data analysis to estimate the following model:[4]

$$VOL_{i,t} = \beta_0 + \beta_1 CC_{i,t} + \beta_2 DR_{i,t} + \beta_3 RR_{i,t} + \beta_4 GSI_{i,t} + \sum_{c=1}^{C} \beta_c X_{c,i,t} + \delta_t + \varepsilon_{i,t} \tag{3}$$

[3] Volatility asymmetry is a phenomenon commonly observed in financial time series data where levels of market volatility tend to be higher during market downtrends and lower during market uptrends.

[4] The study employs the Levin, Lin, and Chu (2002) and the Im, Pesaran, and Shin (2003) panel unit root tests to confirm whether the data is stationary in levels I(0) or first differences I(1). The results are available from authors on request.

where i and t refer to country and time, respectively. $\beta_0$is a constant term. The dependent variable $VOL_{i,t}$ is the conditional variance extracted from the asymmetric GJR-GARCH (1,1) for country i on day t. The main independent variables are the COVID-19 announcements proxies, which includes the daily COVID-19 confirmed cases rate ($CC_{i,t}$), the COVID-19 death rate ($DR_{i,t}$), COVID-19 recovery rates ($RR_{i,t}$), and the change in the overall government response stringency index ($GSI_{i,t}$). $X_{c,i,t}$ is a set of control variables which include country-level control variables and dummies for Pfizer-BioNTech vaccine announcement and administration days[5], US election day and Short-selling ban. δ_t is a dummy variable to account for time-invariant country unobserved daily fixed-effects of the error term. $\varepsilon_{i,t}$is an error term. Table 2 provides a detailed description of the variables stated above.

In addition to examining the general effect of the overall government Stringency Response Index (GSI), the study also measured the effect of each of the nine individual government response sub-indices on the volatility of emerging and developed markets. To achieve that, we re-estimated Eq. (3) by replacing the GSI variable with nine separate government response indicators:

$$VOL_{i,t} = \beta_0 + \beta_1 CC_{i,t} + \beta_2 DR_{i,t} + \beta_3 RR_{i,t} + \sum_{j=1}^{J} \beta_j GSI_{j,i,t} + \sum_{c=1}^{C} \beta_c X_{c,i,t} + \delta_t + \varepsilon_{i,t} \quad (4)$$

where $GSI_{j,i,\ t}$is a set of nine sub-indices representing the different government stringency policy responses for country i on day t. A detailed description for each of these nine variables is presented in Table 2. Eqn 3 and 4 can be estimated using regular static panel regressions such as pooled ordinary least squares (OLS), panel fixed effects, and panel random effects regressions. However, to decide the most efficient and reliable model, the study used two post-estimation tests: The Hausman, (1978) test, which tests whether the errors are correlated with the regressors and thus helps in choosing between panel fixed and panel random effects, and the Breusch-Pagan Lagrange Multiplier (LM) test to assess the existence of non-observed individual effects and therefore the appropriateness of using the pooled OLS regression.

Finally, to ensure our results are robust, re-estimation of the conditional variance was carried out after adding more specifications to the mean equation of our estimated GJR-GARCH (1,1) model. Specifically, AR (1), MA (1), and ARMA (1,1) processes were each added to Equation (1) and the most suitable mean specifications for each stock market was found based on the Akaike's information criterion (AIC) and the Bayesian information criterion (BIC).

2.4. Descriptive statistics

Table 3 displays the statistical properties of all the variables employed in this study. The mean value of stock market volatility is 0.0033 and 0.0036 for emerging and developed markets, respectively. Minimum and maximum values of daily volatility for both markets suggest that these markets experienced wide fluctuations. Although COVID-19 confirmed cases and death rates are slightly higher in developed markets, recovery rates are much higher in emerging markets. Moreover, there are differences in the average levels of stringency of government policy implemented in each market. For example, emerging markets on average experienced more school closures and more cancelations of public events, whereas developed markets had more international travel restrictions on average. Online Appendices A and B (Tables A.1 and B.1) show the correlation matrices between all variables for emerging and developed markets, respectively. The correlation matrices show no high correlation between independent variables which implies that there is no multicollinearity concern.

3. Results and discussion

Table 4 presents the empirical results of our analysis. We find that there are important differences between emerging and developed markets markets in how investors' risk perceptions change upon hearing such announcements. Table 4 columns (1) and (3) show the main results for Eq. (3). In both markets, there is a positive and significant relationship between volatility and COVID-19 confirmed cases. An increase in COVID-19 cases may trigger increased uncertainty about how critical the pandemic may get, the severity of financial implications for businesses (including how long the crisis will last), the nature and stringency of possible government actions, and public responses to these actions (Wagner, 2020). This is consistent with the findings of previous studies (Harjoto et al., 2020; Uddin et al. 2021). The death rate has a positive and significant impact on volatility only in the emerging markets. It is likely that investors in developed markets place greater importance on the information content in confirmed cases than death rates when assessing the outlook on the economy and businesses - a result consistent with Harjoto et al., (2020). The heightened risk perception of investors in the emerging market when the death rate rises, may be related to the lack of confidence in the number of reported confirmed cases and in the effectiveness of government interventions in weak governance settings (Uddin et al., 2021), implying more economic pain and stringency to follow. Higher uncertainty avoidance in the national cultures of emerging markets may also amplify investors' concerns about increasing death rates (Ashraf, 2020). Moreover, the improvement in the recovery rates is found to dampen volatility only in emerging markets. Since it is only in the emerging markets that the investors are concerned by the information

[5] From all the potential vaccine announcements during 2020, Pfizer-BioNTech's vaccine announcement on November 9, 2020 was, by far, the most exciting since it was the first announcement that showed promising results regarding their Phase III clinical trials with their vaccine showing a 90 percent effectiveness in protecting people from transmission of the virus (Badiani et al. 2020). In response to this news, global stock markets witnessed a surge to record highs as hope that economies returning to normal is becoming a possibility. Moreover, global stock markets witnessed gains as the first round of Pfizer-BioNTech's vaccine was administered.

Table 2
Variables and definitions The table displays the detailed definition of the variables used in this study.

Variable	Definition
VOL	daily stock return volatility for country i at time t. Measured as the unconditional variance of the GJR-GARCH (1,1) model.
CC	confirmed cases rate measured as the number of confirmed cases for country i at time t divided by the cumulative number of confirmed for country *i* at time *t*.
DR	death rate measured as the number of deaths for country i at time t divided by the cumulative number of confirmed cases for country *i* at time *t*.
RR	recovery rate number of recoveries for country i at time t divided by the cumulative number of confirmed cases for country *i* at time *t*.
GSI	change in the overall government Stringency Response Index for country i between time t and time *t-1*.
SI1	level of restrictions on school closures for country *i* at time *t*.
SI2	level of restrictions on workplaces closures for country *i* at time *t*.
SI3	level of restrictions on public events for country *i* at time *t*.
SI4	level of restrictions on cut-off size of public gathering for country *i* at time *t*.
SI5	level of restriction on public transport closures for country *i* at time *t*.
SI6	level of restrictions on "stay-at-home" requirements for country *i* at time *t*.
SI7	level of restriction on internal travel between regions/cities for country *i* at time *t*.
SI8	level of restrictions on international travel for country *i* at time *t*.
SI9	level of public information campaigns for country *i* at time *t*.
Ln(MV)	the natural logarithm of the total market capitalization in USD for country *i* at time *t*.
Ln(PE)	the natural logarithm of the market-wide Price to Earnings ratio for country *i* at time *t*.
DY	the market-wide Dividend yield for country *i* at time *t*.
ER	The daily percentage change in the exchange rate for country *i* at time *t*.
PfizerAnn	is a dummy variable that takes 1 on the day Pfizer-BioNTech announced the development of a COVID-19 vaccination which is 90 per cent effective in stopping the virus and 0 otherwise.
PfizerVAC	is a dummy variable that takes 1 on the day Pfizer-BioNTech administered the first COVID-19 vaccine and 0 otherwise.
USelec	is a dummy variable that takes 1 on the United States 2020 election day and 0 otherwise.
ShortSban	is a dummy variable that takes 1 on the day(s) short-selling transactions were banned in country *i* and 0 otherwise.

Table 3
Summary statistics This table reports the summary statistics for the dependent and the independent variables for each market.

	Emerging Markets					Developed Markets				
Variable	**Obs**	**Mean**	**SD**	**Min**	**Max**	**Obs**	**Mean**	**SD**	**Min**	**Max**
VOL	6504	0.0033	0.0061	0.0001	0.1424	4065	0.0036	0.0794	0.0001	0.2207
CC	6504	0.0325	0.0902	0.0000	1.0000	4065	0.0335	0.0906	0.0000	1.0000
DR	6504	0.0007	0.0020	0.0000	0.0617	4065	0.0008	0.0028	0.0000	0.0909
RR	6504	0.0097	0.0278	0.0000	1.0000	4065	0.0077	0.0260	0.0000	1.0000
GSI	6504	0.0024	0.0310	-0.3890	0.4720	4065	0.0025	0.0304	-0.3890	0.4440
SI1	6504	0.0089	0.0022	-0.0200	0.0300	4065	0.0076	0.0024	-0.0300	0.0300
SI2	6504	0.0077	0.0020	-0.0200	0.0300	4065	0.0081	0.0020	-0.0200	0.0300
SI3	6504	0.0072	0.0015	-0.0200	0.0200	4065	0.0064	0.0017	-0.0200	0.0200
SI4	6504	0.0137	0.0025	-0.0400	0.0400	4065	0.0138	0.0024	-0.0400	0.0400
SI5	6504	0.0034	0.0015	-0.0200	0.0200	4065	0.0027	0.0008	-0.0200	0.0100
SI6	6504	0.0066	0.0018	-0.0300	0.0300	4065	0.0057	0.0020	-0.0200	0.0200
SI7	6504	0.0045	0.0017	-0.0200	0.0200	4065	0.0047	0.0017	-0.0200	0.0200
Si8	6504	0.0097	0.0023	-0.0400	0.0400	4065	0.0121	0.0020	-0.0300	0.0300
SI9	6504	0.0074	0.0011	0.0000	0.0200	4065	0.0074	0.0011	0.0000	0.0200
Ln(MV)	6504	12.130	1.4641	9.6520	15.978	4605	13.798	1.5819	10.633	17.534
Ln(PE)	6504	2.6401	0.3879	1.3350	3.5115	4605	2.9486	0.2866	1.9169	3.5695
DY	6504	0.0354	0.0179	0.0060	0.1006	4605	0.0282	0.0108	0.0115	0.0652
ER	6504	-0.0001	0.0070	-0.0782	0.0548	4605	0.0003	0.0048	-0.0344	0.0376

content in death rates, it is logical that they would be more likely to respond positively to recovery rates.

We also find major differences between emerging and developed markets in how investors interpret risk based on government responses to COVID-19. There is a strong positive relationship between volatility and the stringency of government actions in emerging markets, but a negative relationship between these variables in developed markets. An early study by Zaremba et al. (2020) used a combined sample of both developed and emerging markets and found that non-pharmaceutical interventions increase volatility. Our finding that the investors in the emerging markets have a heightened sense of uncertainty to announcements of government actions can be seen as a reflection of the higher fragility of these markets to bad economic outcomes inherent in these actions. It can also be explained by the possible low level of trust in governments' actions during the pandemic as well as in fellow citizens obeying the government's orders in emerging markets (Engelhardt et al., 2021). This fear of weaker compliance with the governments' responses, worsening the effects of the pandemic, may trigger a further tightening of the policies (Zaremba et al., 2020).

To explore whether national culture plays any role in explaining the observed differences in the extent of the relationship between volatility and the stringency index, we compare the median individualism scores and uncertainty avoidance scores of emerging and developed markets (see Table 5). We find that individualism scores are lower and uncertainty avoidance scores are higher for the emerging markets. This finding is consistent with Fernandez-Perez et al. (2021) that the higher stock market volatility is associated

Table 4
The effect of COVID-19 confirmed cases, death, recovery and the stringency of policy government response on emerging and developed stock markets volatility.

Market	Emerging Markets		Developed Markets	
	(1)	(2)	(3)	(4)
Model Specifications	Fixed Effects	Fixed Effects with SI government intervention indicators	Random Effects	Fixed Effects with SI government intervention Indicators
Variables	*VOL*	*VOL*	*VOL*	*VOL*
CC	0.0030***	0.0029***	0.0024*	0.0019*
	(0.001)	(0.001)	(0.001)	(0.001)
DR	0.1406***	0.1424***	-0.0235	-0.0223
	(0.032)	(0.032)	(0.039)	(0.039)
RR	-0.0040**	-0.0041**	-0.0023	-0.0027
	(0.002)	(0.002)	(0.004)	(0.004)
GSI	0.0068***		-0.0059*	
	(0.000)		(0.003)	
SI1		0.0509*		-0.0003
		(0.027)		(0.043)
SI2		0.1204***		0.0216
		(0.033)		(0.055)
SI3		-0.1460***		-0.0951*
		(0.042)		(0.058)
SI4		0.0000		-0.0840*
		(0.024)		(0.045)
SI5		-0.0135		0.3506***
		(0.041)		(0.116)
SI6		-0.0135		-0.0338
		(0.035)		(0.057)
SI7		0.0971***		-0.0584
		(0.037)		(0.060)
SI8		0.0743***		-0.1251**
		(0.025)		(0.050)
SI9		0.0451		0.0933
		(0.052)		(0.090)
ln(MV)	0.0013***	0.0013***	0.0002	0.0022
	(0.000)	(0.000)	(0.000)	(0.002)
ln(PE)	-0.0029***	-0.0029***	-0.0055***	-0.0061***
	(0.000)	(0.001)	(0.001)	(0.001)
DY	0.0473***	0.0470***	-0.0530***	-0.0581***
	(0.012)	(0.012)	(0.018)	(0.019)
ER	0.0118	0.0111	0.1365***	0.1363***
	(0.009)	(0.009)	(0.029)	(0.029)
PfizerAnn	0.0024*	0.0024*	0.0047**	0.0047**
	(0.001)	(0.001)	(0.002)	(0.002)
PfizerVAC	0.0017	0.0017	0.0020	0.0020
	(0.001)	(0.001)	(0.002)	(0.002)
USelec	0.0016	0.0015	0.0007	0.0004
	(0.001)	(0.001)	(0.002)	(0.002)
ShortSban	0.0003	0.0004	-0.0013**	-0.0013**
	(0.000)	(0.000)	(0.001)	(0.001)
Day dummy	Yes	Yes	Yes	Yes
Constant	-0.0089*	-0.0088*	0.0161***	0.0522*
	(0.005)	(0.005)	(0.005)	(0.029)
Observations	6,504	6,504	4,065	4,065
R^2	0.4413	0.4447	0.4796	0.4827
Prob > F	0.0000	0.0000		0.0000
Prob > chi2			0.0000	
Hausman test	36.28***	50.01***	8.26	149.53***
LM test			593.26***	

The table presents the results of panel data regressions over the period 22/01/2020-10/02/2021. The dependent variable is the GJR-GARCH (1,1) daily conditional volatility (*VOL*) for emerging and developed stock markets' indices. The independent variables are the COVID-19 daily new confirmed cases rate (*CC*), daily death rate (*DR*), daily recovery rate (*RR*), COVID-19 Government Response Stringency Index (*SI*), the natural logarithm of daily total market value in USD (*ln(MV)*), the natural logarithm of daily market-wide PE ratio (*ln(PE)*), daily market- wide Dividend yield (*DY*), daily percentage change in the exchange rate (*ER)*. Pfizer-BioNTech's COVID-19 Vaccine Announcement day *(PfizerAnn),* Pfizer-BioNTech's COVID-19 Vaccine administered day *(PfizerVAC),* 2020 US election day *(USelec)* and short-selling ban *(ShortSban)* are dummy variables that equals 1 for the event day and 0 otherwise. *SI1* to *SI9* are the different stringency Index government intervention indicators in country *i* on day *t.* Detailed definitions of the variables are given in Table 2. The numbers in the parentheses are the robust standard errors. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Table 5

Comparison of Individualism and Uncertainty Avoidance scores for emerging markets and developed markets This table reports the Individualism scores and the Uncertainty Avoidance scores for countries included in our sample of emerging markets and developed markets are given below. Each of these two dimensions are scored in the range 0-100.

No	Country- Emerging Market	Individualism Score	Uncertainty Avoidance Score	No	Country- Developed Market	Individualism Score	Uncertainty Avoidance Score
1	Argentina	46	86	1	Australia	90	51
2	Brazil	38	76	2	Austria	55	70
3	Chile	23	86	3	Belgium	75	94
4	China	20	30	4	Canada	80	48
5	Colombia	13	80	5	Denmark	74	23
6	Czech Republic	58	74	6	France	71	86
7	Egypt	25	80	7	Germany	67	65
8	Greece	35	100	8	Israel	54	81
9	Hungary	80	82	9	Italy	76	75
10	India	48	40	10	Japan	46	92
11	Indonesia	14	48	11	Netherlands	80	53
12	Malaysia	26	36	12	Portugal	27	99
13	Mexico	30	82	13	Switzerland	68	58
14	Pakistan	14	70	14	United Kingdom	89	35
15	Peru	16	87	15	United States	91	46
16	Philippines	32	44				
17	Poland	60	93				
18	Qatar	25	80				
19	Russia	39	95				
20	Saudi Arabia	25	80				
21	South Africa	65	49				
22	South Korea	18	85				
23	Turkey	37	85				
24	United Arab Emirates	25	80				
Median		28.0	80.0		74.0	74.0	65.0
Mean		33.8	72.8		69.5	69.5	65.1

Source: Hofstede Insights, accessed on 22 April 2021, https://www.hofstede-insights.com/country-comparison/

with the countries displaying lower individualism and higher uncertainty avoidance.

Table 4 columns (2) and (4) show the results for Eq. (4). There are major differences between both markets in how volatility responds to changes in the sub-indices constituting the Stringency Index. In emerging markets, school closures, workplaces closures, restrictions on internal movements, and restrictions on international travel have a positive and significant impact on volatility. In developed markets, none of these sub-indices has any positive relationship with volatility. These findings highlighting the increased risk sensitivity of emerging markets reflect their vulnerability to financial crises (Neaime, 2016), particularly due to the structural weaknesses in these economies and the prominence of herding behavior of investors in these markets during periods of market losses (Demirer et al., 2010). Cancellation of public events is the only government intervention associated with decreased volatility in the emerging markets - a result shared with developed markets, albeit at a lower level of significance. Restrictions on public gatherings and international travel also decreased volatility in developed markets. Closure of public transport is the only policy response that contributed to higher volatility in developed markets, which is consistent with Zaremba et al. (2020).

The results also suggest that the announcement of the successful development of a COVID-19 vaccine by Pfizer-BioNTech increased volatility in both markets, indicating the immense significance of this positive development. A short-selling ban, though, seems to have decreased volatility only in developed markets. We note that such bans were imposed predominantly in developed countries.

Table 6 demonstrates that our results are robust after adding AR (1), MA (1), or ARMA (1,1) specifications to the mean equation of our estimated GJR-GARCH (1,1) regression. The results and the overall conclusions are consistent with our previous findings.

4. Conclusions

In this study, we explore how COVID-19 announcements and stringent government actions impacted stock market volatility. Our hypothesis was based on a belief that the context in which information is introduced is relevant to the informational impact on volatility. By differentiating developed and emerging market contexts, we found strong empirical evidence supporting our hypothesis, i.e., similar announcements had a different impact on volatility depending on whether they were made in developed or emerging market contexts. Further, by introducing an asymmetric measure of volatility and extending the range of our observations to approximately one year of the pandemic, we differentiate our study from previous COVID-19 related studies on volatility which can further help to understand the impact of COVID-19 announcements on stock market volatility.

Moreover, our results offer novel and imperative investment and policy implications. First, the relationship of stock market volatility and COVID-19 information being conditioned differently by the contexts of developed and emerging markets will provide useful insights into risk assessment to managers of global portfolios. Second, given that the fortunes of major financial institutions (including citizens' pension funds) are greatly affected by stock market performance, our findings suggest that governments,

Table 6
Robustness test - The effect of COVID-19 confirmed cases, death, recovery and the stringency of policy government response on emerging and developed stock markets volatility.

Market	Emerging Market		Developed Market	
	(1)	(2)	(3)	(4)
Model Specifications	Fixed Effects:AR(1), MA(1) or ARMA(1,1)–GJR–GARCH (1,1) models	Fixed Effects:AR(1), MA(1) or ARMA(1,1)–GJR–GARCH (1,1) models	Random Effects:AR(1), MA(1) or ARMA(1,1–GJR–GARCH (1,1) models	Fixed Effects:AR(1), MA(1) or ARMA(1,1)–GJR–GARCH (1,1) models
Variables	*VOL*	*VOL*	*VOL*	*VOL*
CC	0.0023***	0.0023***	0.0031**	0.0027*
	(0.001)	(0.001)	(0.001)	(0.002)
DR	0.1632***	0.1656***	-0.0044	-0.0073
	(0.033)	(0.033)	(0.042)	(0.042)
RR	-0.0034*	-0.0035**	-0.0020	-0.0024
	(0.002)	(0.002)	(0.004)	(0.004)
GSI	0.0087***		-0.0102***	
	(0.002)		(0.004)	
SI1		0.0152		-0.059
		(0.027)		(0.046)
SI2		0.1317***		-0.0610
		(0.034)		(0.059)
SI3		-0.1305***		-0.1683***
		(0.042)		(0.062)
SI4		-0.0035		-0.1046**
		(0.025)		(0.048)
SI5		-0.0550		0.4829 ***
		(0.042)		(0.124)
SI6		0.0343		0.0930
		(0.036)		(0.061)
SI7		0.1012***		-0.0209
		(0.037)		(0.064)
SI8		0.1138***		-0.1975***
		(0.025)		(0.054)
SI9		0.0701		0.0139
		(0.053)		(0.097)
ln(MV)	0.0014***	0.0014***	0.0002	0.0003
	(0.000)	(0.000)	(0.000)	(0.002)
ln(PE)	-0.0031***	-0.0031***	-0.0038***	-0.0046***
	(0.001)	(0.001)	(0.001)	(0.001)
DY	0.0411***	0.0407***	-0.0377**	-0.0462**
	(0.012)	(0.012)	(0.019)	(0.020)
ER	0.0332***	0.0325***	0.0999***	0.1022***
	(0.009)	(0.009)	(0.031)	(0.031)
PfizerAnn	0.0024*	0.0026*	0.0034	0.0035
	(0.001)	(0.001)	(0.002)	(0.002)
PfizerVAC	0.0015	0.00167	0.0019	0.0018
	(0.001)	(0.001)	(0.002)	(0.002)
USelec	0.0009	0.0009	0.0009	0.0008
	(0.001)	(0.001)	(0.002)	(0.002)
ShortSban	0.0004	0.0004	-0.0013**	-0.0013**
	(0.000)	(0.000)	(0.001)	(0.001)
Day dummy	Yes	Yes	Yes	Yes
Constant	- 0.0215***	-0.0084*	0.0102**	0.0116
	(0.005)	(0.005)	(0.005)	(0.003)
Observations	6,504	6,504	4,065	4,065
R^2	0.4475	0.4516	0.5683	0.5681
Prob > F	0.0000	0.0000		0.0000
Prob > chi2			0.0000	
Hausman test	34.51***	48.66***	5.29	134.61***
LM test			507.25***	

This table reports the results of robustness test regarding the stock markets' reaction to COVID-19 news and government response policies. Stock return volatility (*VOL*), with AR(1), MA(1) or ARMA(1,1) restrictions on the mean equation of the GJR–GARCH (1,1) model, is the dependent variable in all models and is measured as the daily unconditional variance of the GJR–GARCH (1,1) model of major stock market indices of emerging and developed countries. The independent variables are the COVID-19 daily new confirmed cases rate (*CC*), daily death rate (*DR*), daily recovery rate (*RR*), COVID-19 Government Response Stringency Index (*SI*), the natural logarithm of daily total market value in USD (*ln(MV)*), the natural logarithm of daily market-wide PE ratio (*ln(PE)*), daily market- wide Dividend yield (*DY*), daily percentage change in the exchange rate *(ER*). Pfizer-BioNTech's COVID-19 Vaccine Announcement day (*PfizerAnn*), Pfizer-BioNTech's COVID-19 Vaccine administered day (*PfizerVAC*), 2020 US election day (*USelec*) and short-selling ban (ShortSban) are dummy variables that equals 1 for the event day and 0 otherwise. SI1 to SI9 are the different Stringency Index government intervention indicators in country *i* on day *t*. Detailed definitions of the variables are given in Table 2. The numbers in the parentheses are the robust standard errors. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

particularly in emerging markets, should carefully consider tailoring regulatory responses to pandemics to their specific national contexts to minimize its adverse financial impact. And lastly, long-term reforms to improve institutional quality of governance in emerging economies would mitigate the negative impact of stock market volatility, especially with respect to exogenous shocks, such as pandemics.

Based on previous literature we suggested that factors such as dependence on government, quality of governance, trust in fellow citizens as well as the government, and degrees of individualism and uncertainty avoidance embedded in the national culture could possibly explain why investor behavior differred in these two categories of markets. Furthermore, the empirical exploration and corroboration of these factors, especially when differentiating between emerging and developed market contexts, is warranted and likely to yield yet more comprehensive understanding of stock market volatility. Given the use of COVID-19 vaccines in recent months in many countries, the impact of vaccine popularity in different countries on stock market volatility is an area for future research as well. In addition to stringency response measures, exploring the impact of government containment and health, and economic support policy responses on volatility, may also prove beneficial in future studies.

Author Statement

CRediT authorship contribution statement:

Walid Bakry: Conceptualization, Data curation, Methodology, Software, Formal analysis, Project administration, Writing - original draft, Writing - review & editing. **Peter Kavalamthara**: Conceptualization, Project administration, Writing - original draft, Writing - review & editing. **Vivienne Saverimuttu**: Conceptualization, Project administration, Writing - original draft, Writing - review & editing. **Yiyang Liu**: Conceptualization, Writing - review & editing. **Sajan Cyril**: Conceptualization, Writing - review & editing.

Declarations of Competing Interest

None.

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Supplementary materials

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