The impact of government response's policy to COVID-19 on stock market volatility

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ผลกระทบของนโยบายของรัฐบาลต่อสถานการณ์ COVID-19 ต่อความผันผวนของตลาดหุ้น

นายชัยวัฒน์ ราชวัตร

สารนิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
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ชัยวัฒน์ ราชวัตร : ผลกระทบของนโยบายของรัฐบาลต่อสถานการณ์ COVID-19 ต่อความผันผวนของตลาดหุ้น. (The impact of government response’s policy to COVID-19 on stock market volatility) อ.ที่ปรึกษาหลัก : อ. ดร.นราพงศ์ ศรีวิศาล

สารนิพนธ์นี้สำรวจผลกระทบของนโยบายต่อ COVID-19 ของรัฐบาลที่มีต่อความผันผวนของตลาดหุ้น โดยที่สารนิพนธ์นี้อธิบายความผันผวนของตลาดหุ้นผ่านดัชนีที่วัดระดับนโยบายความเข้มงวดของการตอบสนองของรัฐบาลต่อ COVID-19 และใช้แบบจำลอง EGARCH (1,1) เพื่อระบุความผันผวนของตลาดหุ้นจากผลตอบแทนของตลาดหุ้นรายวันของ 68 ประเทศ และใช้การวิเคราะห์แบบ Generalized Method of Moment (GMM) two-step system ของ Arellano–Bond สำหรับการวิเคราะห์ข้อมูลสารนิพนธ์นี้ หลังจากการวิเคราะห์ข้อมูลพบว่า ความผันผวนของตลาดหุ้นในช่วง COVID-19 สามารถลดลงได้จากการตอบสนองต่อนโยบายของรัฐบาลต่อ COVID-19 ที่เข้มงวดมากขึ้น นอกจากนี้ หลังจากที่แบ่งดัชนีออกเป็น 3 ประเภทตามประเภทของนโยบายต่างๆแล้ว นโยบายทุกประเภทยังช่วยลดความผันผวนของตลาดหุ้นและนโยบายสนับสนุนทางเศรษฐกิจมีผลกระทบสูงสุดในการลดความผันผวนของตลาดหุ้น

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This research explores the effect of government's COVID-19 response policy on stock market volatility. We explain the stock market volatility dynamics via the index that measures the strict level of government response's policy to COVID-19. Using EGARCH (1,1) model to identify stock market volatility from daily stock market return of 68 countries and apply the Arellano–Bond two-step system GMM estimator for dynamic panel data analysis, we found that the stock market volatility in the COVID-19 period can be reduced by the government policy response to COVID-19. Furthermore, after dividing the index into 3 types, all types of policy also reduce the stock market volatility and the economic support policy has the highest impact on the stock market volatility.

Field of Study:	Finance	Student's Signature ....
Academic Year:	2021	Advisor's Signature ....

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Chaiwat Ratchawat

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Introduction

Background and Motivation

In December of 2019, the coronavirus epidemic (COVID-19) originated in Wuhan, China, and spread globally (WHO, 2020). The World Health Organization announced a worldwide outbreak on March 11, 2020 (C. O. WHO, 2020). The outbreak of COVID-19 has had a direct effect on the economic and financial markets. (Harjoto et al., 2021; Szczygielski, 2021; Topcu, 2020; Uddin, 2021), as well as generating several unexpected government interventions. COVID-19, especially the announcement number of infected and dead people, impacted negatively on financial markets by causing widespread economic uncertainty. Although numerous diseases and pandemics have occurred since the 1980s, none have had the same worldwide economic impact as COVID-19 (Gössling, 2020).

To manage the pandemic and control infection, the government in every country have been implementing many policies in term of lockdown, health, economics, fiscal support to reduce the effect of this crisis (Narayan et al., 2021). Workplace closures, travel restrictions, new kinds of social support assistance, school closures, contact tracing, prohibitions on public meetings, spending on the healthcare system, vaccination drives, and other policy implementation are all common strategies used to stop the virus from spreading COVID-19. Government decisions may indicate to investors that the outbreak problem is under control in the scenario of a pandemic. For example, the closing of the place or restriction of travel policy has been issued by the government and the investor may realize from this policy that the COVID-19 case will reduce in the future by this kind of government policy. Most of the policy is related to lockdown measurement because it can minimize the infection of COVID-19 by reducing transportation, Work From Home to avoid gathering of people, or even close someplace or event to prevent the transmission of the COVID-19 virus too. However, the government policy itself also significantly impacted the financial market and economy. The rising stringency of government regulations has a negative impact on the stock returns of tourism and travel enterprises in the United States (Ming-Hsiang, 2020).

There are several types of the literature showed that the coronavirus disease (COVID-19) had affected every financial market in terms of return, trading volume, liquidity, or volatility. Most studies mentioned that the announcement number of infected and dead people could impact the financial market. Negative influence on global industry returns and increasing in return volatility in all industries created by the COVID-19, but some sector has fewer effects in both return and volatility (Szczygielski, 2021). When the volume of COVID-19 cases reported rises, the exchange rate becomes more volatile, but government policy can reduce exchange rate volatility (Feng & Hao-Chang, 2021). However, the bond market has a significant positive impact due to the COVID-19 outbreak, and the volatility of bond market got spillover from the volatility of the stock market (Chen et al., 2021). These literature showed that the COVID-19 really has the impact on every financial market and affect to the world economy directly.

Financial markets are affected by liquidity and stability, and it relies heavily on the market's volatility. It offers a measurement of stress, financial risk, or ambiguity for considering the investment. Existing research about the effect of

COVID-19 factors such as Confirmed case, Death case on the volatility of stock market is primarily focused on specific geographic areas such as Asia-Pacific, Europe (Ibrahim et al., 2020; Mirza & Birjees, 2020) or focus in country such as the United States and Australia (Albulescu, 2021; Baek et al., 2020; Gunay et al., 2021). However, the government policy reaction during COVID-19 is still not included in the interesting variable for doing research in these. Only some of them have been included in the study but not be the focus of the study. The stock market, one of the most major financial markets, plays a significant position in transmission of policy mechanisms and it's a main market for many related parties to invest in the company. As a result, it's helpful to look at how the stock market responds to changes in policy.

<u>Objective</u>

Finding the effect of COVID-19 response policy on stock market volatility is the purpose of this Special Problem. The main question is the government policy will reduce stock market's volatility or not. The government response policy will include 3 indexes from the source of data and 3 indexes from recalculated by method from the source of data which it provides the calculation method of the index. Moreover, this study aims to test the different impacts on stock market volatility from increasing and decreasing policy changes. If it has the same or different effects, which variable has more impact? The data also categorized the type of government policy into 3 main categories and find whether each policy has the same effect on stock market volatility or not and which policy has the highest impact?

Concerning to the COVID-19 response policy, there is a huge amount of ambiguity, including issues about whether they will boost the economy effectively or not. Consequently, it is essential and really important to analyze the reaction of financial market especially stock market to policy changes because the stock market, one of the most significant financial markets, has many replated parties invest in the market and the market itself plays a very crucial role for transmission of government policy. The research will add to the current amount of evidence in several ways. First, this paper will extend the effect of the COVID-19 factor on market volatility, not only announcement of the case and death information but also extent to government response policy to COVID-19. As the literatures show many studies done the research related with COVID-19, the study from Harjoto et al. (2021) and Uddin (2021) are primarily concerned with the negative effect of COVID-19 confirmed cases and confirmed deaths on the stock market volatility. Moreover, this paper will focus on the government policy response variable, which the Oxford COVID-19 government Response Tracker (OxCGRT) has provided the index to measure government Response policy (Hale et al., 2020). Moreover, this paper will use the EGARCH model to capture volatility and use panel data analysis to find the impact, unlike Uddin (2021) find the result by set up EGARCH model equation and Harjoto et al. (2021) using multivariate regressions and use VIX to capture it. Second, Ming-Hsiang (2020) used the index to explore the negative impact on stock return, but our paper extends to find stock market volatility. Third, this paper will develop to see the different types of policy changes on stock market volatility and which policy has more impact?

Literature review and Hypothesis

There is empirical evidence that COVID-19 information influences the financial market around the world, especially the stock market. Szczygielski (2021) studied COVID-19-related uncertainty's effect on global industry returns, and all industries got negative impacts, but some sectors are more resilient. Harjoto et al. (2021) found that the number of COVID-19 confirmed cases and death has affected the stock market differently between emerging and developed countries. The study showed that only confirmed cases of COVID-19 affected stock return, trading volume, and volatility in developed countries. Still, in emerging countries, both confirmed case and death of COVID-19 impact stock return, trading volume, and volatility which show that the effect was differently affected between 2 types of country. Moreover, it has the study that focuses more on emerging countries group. The Asian emerging market has affected more than European emerging market, including the impact of policy response will depend on the size of the stimulus package (Topcu, 2020).

This study has been focused more on the volatility of the stock market since it’s having a few studies compared with the studies related with the stock market's return. One of the factors that investors cannot overlook while investing in the financial market is volatility. It can represent a measuring tool of financial risk, uncertainty, or market stress. COVID-19 has inject the uncertainty, stress or concern to the market which affected directly to the investors, not only individual but also including major investors such as financial institution. COVID-19 situation has affected to financial market’s volatility which has been studied in many markets, including Commodity markets (Tauhidul & Ashutosh, 2021), Cryptocurrency markets (Afees & Ahamuefula, 2021; Yousaf & Shoaib, 2020), Exchange rate market (Feng &

Hao-Chang, 2021) or even stock market in each country or group of countries (Albulescu, 2021; Baig et al., 2021; Harjoto et al., 2021; Ibrahim et al., 2020). People were affected by a pandemic's anxiety, which has resulted into the market volatility (Chen & Liu, 2020). However, since the financial market has been fluctuated by the COVID-19 factor, the government also set up the policy to stop or slow down this pandemic too. Since the government implement many policies in different areas, people believe that the lockdown strategy as a remedy for spreading because it decreases adverse mood by reducing spreading and instability (Capelle-Blancard & Desroziers, 2020).

Harjoto et al. (2021) explores the volatility of stock market and found that it has been affected by different COVID-19 factors between developed and emerging countries. In emerging markets, the number of infected and dead people can increase the stock market's volatility. In contrast, only the number of infected people can be affected in developed markets. Baig et al. (2021) also find the same result in increasing the stock market's volatility from the number of infected and dead people in the US stock market. Moreover, it also results in other factors impacting the stock market's volatility, such as US mobility, Lockdowns, Reduces Nobility, or even the google search trend of COVID-19. Albulescu (2021) looked at the impact of official releases information for the COVID-19 announcement on the volatility of the US financial markets and concluded that both worldwide and US COVID-19 data to show that the health issue increases S&P 500 realized volatility.

Many studies have researched the impact of government’s policy implements on the financial market during COVID-19. The policy and regulation ideas to the

COVID-19 are filled with doubt, concentrating on whether and how they would efficiently stimulate the market (Altig et al., 2020). The exchange rate's volatility can be reduced by government policy response to COVID-19 (Feng & Hao-Chang, 2021). The stock price is reduced when the strictness of government policy responses grows (Ming-Hsiang, 2020) especially economic responses and fiscal measures include income assistance, debt restructuring, and agreement alleviation (Demir, 2021). Deng (2021) examined the effect of policy response of COVID-19 to stock market return among 11 countries and found that both lockdown and cutting interest rate has a positive and strong response to the stock market. Moreover, cutting policy interest rate has more effect on the market than stay-at-home policy. The same result as Narayan et al. (2021) was the effects of government responses (travel bans, lockdown, and economic stimulus package) of G7 countries positively affected the stock market. Deng (2021) suggested that regulators are confronted with tremendous difficulties. The decision between "a healthy economy" and "a healthy nation" is a severe challenge. It's very difficult that the government will issue policy to stabilize the economy or control the pandemic or achieve both targets, and policies may be incompatible with one another. However, this is the challenge that every country will face and the stake of this challenge is important to affect the life of people in the country.

Many kinds of literature have researched the return of the market, so this paper will extend the effect of the COVID-19 factor on market volatility, not only announcement of the case and death but also government response policy COVID-19. Numerous variables may influence the volatility of the financial market, but one of the main factors is government policy announcements. Onan et al. (2014) investigate the macroeconomic announcement has a substantial influence on the volatility of the stock market, good and bad announcements have asymmetry impact too. When comparing the pandemic announcements and travel restrictions, the news of lockdown received the most favorable results from its markets. This shows that lockdowns, not travel bans, were the single most significant boost to the stock market's trust (Phan & Narayan, 2020).

COVID-19, especially the announcement number of infected and dead people, impacted negatively on financial markets by causing widespread economic uncertainty (Altig et al., 2020). A business cycle downturn and a financial meltdown are expected to result from the COVID-19. Investors can bear the risk of investment when they believe in the market, or they have trust in the market that they invested. However, the uncertainty that created by COVID-19 factors or its environment make the investors feel uncomfortable to stay in the market or increase the risk of investment in the market which can be over the accepted level of investors. The outcome of the increasing uncertainty surrounding the financial and economic system, stockholders have resorted to selling risky assets in huge volumes, which may show in “flights to safety” (Baele et al., 2020) especially during the crisis. Shareholders tend to imitate their peers' judgments in times of financial market volatility and high uncertainty (Kurz & Kurz-Kim, 2013), i.e., follow trends. The uncertainty motivates responses from governments and businesses, and Government intervention can help lower the tension and minimize the risks from COVID-19. COVID-19 has caused much uncertainty, and effective policy measures can help to alleviate it (Kizys et al., 2021).

Government decisions to the spread of the COVID-19 pandemic may indicate to investors that the outbreak problem is under control in the scenario of a pandemic. For example, the closing of the place or restriction of travel policy has been issued by the government and the investor may realize from this policy that the COVID-19 case will reduce in the future by these kind of government policy. Sharif et al. (2020) stated that the concern in the market may be reduced by governments implementing prompt action that restores investor trust in international stock markets. Haldar and Sethi (2020) also stated that the lockdown policy and related government intervention can significantly the spread of COVID-19. If government policy can reduce general uncertainty and improve corporate expectations, investors may accept the risk and stay investing in the stock market. Moreover, government policy that are announced in a timely manner increase the quality of information accessible to the investors and reduce investor's concerns. Thus, it has been concluded to be the first hypothesis of this paper is as follow:

The tighter government policy response decreases stock market volatility.

This paper will follow Hale et al. (2020) data category, which can divide government response index into two categories: 1) Containment and health and 2) Economic support, and find which policy has a greater impact on market's volatility. Moreover, we recategorized the government policy index indicator and created the index based on the three main categories of the indicator: Containment and closure policies index, Economic support index, and Health system policies index. Zaremba et al. (2021) has done two research to search the effect of the COVID-19 factor on the financial market, especially government policy effect during COVID-19 period. In

April 2021, he researched the effect of government policy on stock market liquidity during COVID-19 period. He found that the market's liquidity in developed country stock markets is not affected by policy interventions issued by government. However, workplace and school closures cause a slight drop in liquidity in emerging markets. The scale and range of governmental policies are constrained. In November 2021, he studied the effect of government policy on bond market volatility during COVID-19 period. Government policy significantly minimizes the volatility of local sovereign bonds. Economic support policies are primarily likely to have an effect, but containment and closure policy and healthcare system reforms have no significant influence. They suggest that the impact of economic immediately affect the market due to the policy no need a long time to respond and directly support the investor. However, containment and closure policy need time to see the impact of the procedure, and the time period also not clear how much the policy needed and investor cannot see it clearly when policy is announced.

Direct economic injections allow citizens to purchase important things while being under lockdown especially low-income people. Lower-income populations are less likely to cooperate with lockdown restrictions and are more likely to get infected with the disease since they do not have enough money and rely on day-to-day revenue from their jobs (Lou et al., 2020; Wright et al., 2020). Many countries faced the problem related with the people are not complied with the regulation or not co-operated with the restriction policy due to the financial problem. These poor people will accept the risk of infection for going to work outside instead of waiting at their home and didn't do anything to support their life. Financial assistance is primarily offered to the poor, so effective financial government assistance may reduce infection rates by encouraging lower-income persons to remain at home and it will support other government policies to be more effective. Hence, it came up with a second hypothesis as follow:

Economic support policy has a higher impact than Containment and closure policies index, and Health system policies index on stock market volatility.

Data and Methodology

Data

COVID-19 information

COVID-19-related information is collected from Hale et al. (2020), COVID-19 Government Response Tracker and Hannah Ritchie (2020), Coronavirus Pandemic (COVID-19) online resource. In response to the COVID-19 epidemic, governments are adopting various steps. This tool seeks carefully and continuously record and compare policy responses throughout the nation. This paper extracted data of confirmed cases and confirmed death numbers from 01 January 2020, when the COVID-19 outbreak began to spread worldwide, to 31 December 2021. The number will be used in the daily announcement and calculated as the percentage of the daily increase as the daily new cases or deaths divided by the total cases or deaths. Other data related to COVID-19, this paper collects from Hannah Ritchie (2020), which is an online database and provides the statistics on the coronavirus pandemic for every country in the world.

COVID-19 government response index

The Government Response Tracker keeps track of how the government responds to COVID-19 (Hale et al., 2020). An overall index score is derived from these replies. A multinational group of over one hundred students and staff from Oxford University gathered publicly accessible data. The information is compiled from various online sites, including official press releases, news, publications, and briefings from across the world. The team documents both the data and its source into the database and the database will update daily on the website. As a result, the information may be coded, examined, and confirmed. Because the same standards are used by all nations worldwide, the statistics can be trusted.

This paper uses three indexes including Government Response Index, Containment health index, and Economic support index. Each index measuring the government policy response to COVID-19 will varies from 0 to 100 and will be generated using a simple average of each policy variables where n is the amount of policy variable in index and I_j is the individually index number for a specific measure. The higher index number means higher intensity, more strictly policy to response COVID-19.

$$index = \frac{1}{n}\sum_{j=1}^{n} I_j$$

The dataset is organized into three categories with 16 indicators as shown in Table 1.

Hale et al. (2020) has calculation method of sub-index by calculating a score for each indication by using the numerical value of each indicator and deducting a half-point if the policy is implemented to a non-targeted population or it didn’t have a specific target group for this indicator. Then, to obtain a index score which it will vary between 0 and 100, we rescale each of them by its highest value. Any sub-index number (I) for just any given indication (j) on any particular day (t) will use the below equation to calculate the sub-index score for each indicator.

$$I_{j,t} = 100\,\frac{V_{j,t} - 0.5(F_j - f_{j,t})}{N_j}$$

N_j is the maximum possible indication value, F_j is a dummy whether that indicator has a focused target group policy or not (F_j = 1 if the indicator has a specific target group policy, or 0 if the indicator does not have a specific target group policy or apply only in general), $V_{j,t}$ is the policy value reported on the interval level and if that indicator has applied specific target policy, $f_{j,t}$ will be the recorded target policy for specific indicator.

Moreover, this paper will attempt to describe the consequences of different government policies, by the index provided by Hale et al. (2020). The study has separated the Government response index into two indexes but these indexes didn't categorize by the dataset categories. However, the indicator of the study has categorized into three categories (economic policies, containment and closure policies, health system policies), so this paper will follow the calculation index method for creating each category index and show in Table 1 and use it to compare the impact of each policy.

Table 1: Component indicator of each index

Indicator	Government response index	Containment and health index	Economic support index	Containment and closure policies index	Health system policies index

C1: School closing	✓	✓		✓	
C2: Workplace closing	✓	✓		✓	
C3: Cancel public events	✓	✓		✓	
C4: Restrictions on gatherings	✓	✓		✓	
C5: Close public transport	✓	✓		✓	
C6: Stay at home requirements	✓	✓		✓	
C7: Restrictions on internal movement	✓	✓		✓	
C8: International travel controls	✓	✓		✓	
E1: Income support	✓		✓		
E2: Debt/contract relief	✓		✓		
H1: Public information campaigns	✓	✓			✓
H2: Testing policy	✓	✓			✓
H3: Contact tracing	✓	✓			✓
H4: Facial Coverings	✓	✓			✓
H5: Vaccination Policy	✓	✓			✓
H6: Protection of elderly people	✓	✓			✓

Note: C - containment and closure policies, E - economic policies, H - health system policies

Stock market information

The stock market index collects from the Refinitiv Datastream and Bloomberg database. The research phase starts the first day after the World Health Organization (WHO) obtained details concerning an unidentified cluster in Wuhan, China which started from 1 January 2020 until 31 December 2021. The research focuses on all available market data in each country and can be collected from the Refinitiv Datastream database and Bloomberg database. This paper also collects other control variables from the Refinitiv Datastream database and Bloomberg database, and the research period is the same as other variables. Table 2 show the list of the countries and the stock index market to be our sample data.

Table 2: Countries and Stock index included in the sample data

No.	Country	Stock Index	No.	Country	Stock Index	No.	Country	Stock Index
1	Argentina	MERVAL Index	24	Iceland	ICEXI Index	47	Poland	WIG Index
2	Australia	ASX Index	25	India	NIFTY Index	48	Portugal	PSI20 Index
3	Austria	ATX Index	26	Indonesia	JCI Index	49	Romania	BET Index
4	Belgium	BEL20 Index	27	Ireland	ISEQ Index	50	Russia	RTSI$ Index
5	Brazil	IBOV Index	28	Italy	FTSEMIB Index	51	Serbia	BELEX15 Index
6	Bulgaria	SOFIX Index	29	Jamaica	JMSMX Index	52	Singapore	STI Index
7	Canada	SPTSX Index	30	Japan	TPX Index	53	Slovenia	SBITOP Index
8	Chile	IGPA Index	31	Kazakhstan	KZKAK Index	54	South Africa	JALSH Index
9	China	SHCOMP Index	32	Kuwait	KWSEAS Index	55	South Korea	KOSPI Index
10	Colombia	COLCAP Index	33	Laos	LSXC Index	56	Spain	IBEX Index
11	Croatia	CRO Index	34	Latvia	RIGSE Index	57	Sri Lanka	CSEALL Index
12	Cyprus	CYSMMAPA Index	35	Lebanon	BLOM Index	58	Sweden	SAX Index
13	Czech Republic	PX Index	36	Lithuania	VILSE Index	59	Switzerland	SMI Index
14	Denmark	OMXC25 Index	37	Malaysia	FBMKLCI Index	60	Taiwan	TWSE Index
15	Egypt	HERMES Index	38	Malta	MALTEX Index	61	Thailand	SET Index
16	Estonia	TALSE Index	39	Mexico	MEXBOL Index	62	Tunisia	TUSISE Index
17	Finland	HEX25 Index	40	Netherlands	AEX Index	63	Turkey	XU100 Index
18	France	CAC Index	41	New Zealand	NZSE50FG Index	64	Ukraine	WIGUKR Index

19	Germany	DAX Index	42	Norway	OBX Index	65	United Kingdom	UKX Index
20	Ghana	GGSECI Index	43	Oman	MSM30 Index	66	United States	SPX Index
21	Greece	ASE Index	44	Pakistan	KSE100 Index	67	Vietnam	VNINDEX Index
22	Hong Kong	HSI Index	45	Peru	BVL Index	68	Zambia	LUSEIDX Index
23	Hungary	BUX Index	46	Philippines	PCOMP Index			

Methodology

EGARCH model

The GARCH model is a Generalized Autoregressive Conditional Heteroscedasticity model. Bollerslev (1986) has extended the work of Engle (1982) and created an methodology that incorporates both autoregressive (AR) and moving average (MA) parts in the heteroskedastic variance. The different impacts of positive and negative fluctuations influence conditional volatility, as well as other forms of asymmetry, are reflected by the GARCH models. The objective of this sort of model is to provide a measurement of volatility which could be used in judgment call, especially financial or investment decisions. Negative and Positive effects show varied impacts on conditional volatility, and GARCH models reflect multiple forms of asymmetry (Aliyev et al., 2020). The variable in a standard GARCH model is expressed as below equation:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i \, \varepsilon_{t-1}^2 + \sum_{i=1}^{p} \beta_j \, \sigma_{t-1}^2$$

where σ_t^2 stands for conditional variance, ε_t for return residual, and $\alpha_0, \alpha_i, \beta_j$ for estimated parameters. The nonnegative number of $\alpha_0, \alpha_i, \beta_j$ variables is necessary to be positive in variance, and $\alpha_i + \beta_j$ is expected to be lower than 1 for the model which it will be acceptable. Greater values of the α_i coefficient in the financial dataset reflect a larger sensitivity of volatility to market shocks, while higher values of the β_j coefficient imply market disaster persistence. The GARCH model does not take into account the leverage impact.

In regular GARCH models, positive and negative error factors have asymmetric impact on volatility but in practical, arbitrage constraints, market frictions, financial time series, and transaction costs reveal asymmetrical non-linear patterns due to several reasons. This will indicate that adverse shocks could have a more substantial impact on conditional variance. There is a statistical fact that the EGARCH model could capture but the GARCH model couldn't. The Exponential GARCH (EGARCH) model developed by Nelson (1991) includes the asymmetric effect of the shocks, so this paper will use the EGARCH model for finding the stock market volatility or conditional variance. To explore the relationship between government policy responses and stock market volatility as the objective of this study, we calculated the conditional variance of the market index using EGARCH (1,1) model.

The conditional mean equation is written by the formula (1) as below:

$$r_t = \mu + \beta_1 r_{t-1} + \varepsilon_t \ (1)$$

Where r_t is the return on the stock market index in time t and ε_t is is a normally distributed, zero-mean stochastic error term representing the unusual return.

The conditional variance equation is written by the formula (2) as below:

$$\ln(\sigma_t^2) = \alpha_0 + \beta_1 \ln(\sigma_{t-1}^2) + \alpha_1 \left(\frac{|\varepsilon_{t-1}|}{\sqrt{\sigma_{t-1}^2}} - \sqrt{2/\pi} \right) + \gamma \frac{\varepsilon_{t-1}}{\sqrt{\sigma_{t-1}^2}}$$

Where σ_t^2 is conditional variance (volatility), α_0 is constant term, ε_{t-1}^2 is volatility information in the previous period, σ_{t-1}^2 is the variance at the previous period. For the estimated variable " γ ", this coefficient stands for leverage effects and captures the models asymmetric. If γ is positive and statistically significant, it suggests that the positive impacts can raise variance more than negatives impacts. At the same time, estimated variables "β_1" and "α_1" coefficients represent the GARCH and ARCH effects on the variance equation, respectively. These variables can be implied that the information on variance from the previous period influences present variance.

Research Model

We used dynamic panel data analysis to build the following approach to evaluate the time-varying impact of governments' policy response to COVID-19 on stock market volatility and using Arellano-Bond estimator (Arellano & Bond, 1991) to regress the model after it has lagged of conditional variance to be one of the explanatory variable. Lillo and Torrecillas (2018) showed that a lagged dependent variable can have a strongly affected on the coefficients of the remaining variables. We estimate our model utilizing the Arellano–Bover/ Blundell–Bond two-step system GMM estimator. This estimator can solves problems including the presence of fixed effects and endogeneity of control variables (undescribed nation-specific results), heteroskedasticity and autocorrelation within individuals, heteroskedasticity and autocorrelation between individuals, the correlation of between independent variable and it’s past and potentially present of the error and the potential bias of omitted variables that persist over time (Roodman, 2009). Moreover, we select to use two-step system GMM estimator due to it's the augmented two-step difference, more efficient and robust to heteroscedasticity and autocorrelation (Roodman, 2009). To test the first hypothesis, we construct the model as follow:

First equation: $\hat{\sigma}_{i,t}^2 = \beta_i + \beta_1 GRI_{i,t} + \beta_2 \hat{\sigma}_{i,t-1}^2 + \sum_{c=1}^{C} \beta_c X_{c,i,t} + \varepsilon_{i,t}$

Where i imply to the country and t imply to the period of time, β_0 is a constant term. The conditional variance, $\hat{\sigma}_{t,i}^2$ obtained from the EGARCH (1,1) for country i on day t is the dependent variable. The independent variable is the overall government response index ($GRI_{i,t}$) and $\varepsilon_{i,t}$ is an error term. We also add the lagged of conditional variance, $\hat{\sigma}_{i,t-1}^2$ to be one of an explanatory variable. This describes the different market participants' differing reaction times to the receipt of information. It enables something to refer volatility patterns over longer intervals to those over shorter intervals, which gives the model an intuitive interpretation. Other than that, the control variable includes country-level factor: daily COVID-19 confirmed cases rate, COVID-19 Death rate, Vaccinated people rate, total market value of stock market, Market Price to Earnings ratio, Trading Volume, and Market Yield.

In addition to studying the impact of governments' policy response to COVID-19, this paper also explores the impact of different types of policy which are categorized into 3 types (Hale et al., 2020). To test the second hypothesis, we recalculated the model by substituting the overall government response index for Containment and health and Economic support indices in the equation.

Second equation: $\hat{\sigma}_{i,t}^2 = \beta_i + \beta_1 CH_{i,t} + \beta_2 ES_{i,t} + \beta_3 \hat{\sigma}_{i,t-1}^2 + \sum_{c=1}^{C} \beta_c X_{c,i,t} + \varepsilon_{i,t}$

where $CH_{i,t}$ is the overall Containment and health index, and $ES_{i,t}$ is the overall Economic support index.

Hale et al. (2020) divide the type of indicator into 3 groups which is Containment and closure policies, Economic support, and Health system policies but they created only 2 indexes. We would like to find the impact of each policy separately, so we recategorized the indicator of government policy index and create the index based on the 3 main categories of indicator.

Third equation: $\hat{\sigma}^2_{t,i} = \beta_i + \beta_1 CT_{i,t} + \beta_2 ES_{i,t} + \beta_3 HS_{i,t} + \beta_4 \hat{\sigma}^2_{i,t-1} + \sum_{c=1}^{C} \beta_c X_{c,i,t} + \varepsilon_{i,t}$

where $CT_{i,t}$ is the overall Containment and closure policies index, $ES_{i,t}$ is the overall Economic support index and $HS_{i,t}$ is the overall Health system policies index.

Empirical results

Descriptive statistic and correlation

Table 3 presents the comprehensive description of the variables utilized in this research.

Table 3: Variables and definitions

Variable	Definition
VOL	conditional variance, obtained from the EGARCH (1,1) calculated by daily percentage stock return volatility
GRI	the overall government response index
CHI	the overall containment and health index
ESI	the overall Economic support index
CTI	the overall containment and closure policies index
HSI	the overall Health system policies index
CC	confirmed cases rate
DR	death rate

VC	vaccine rate
Ln(CAP)	the natural logarithm of the total market value of stock market
Ln(PE)	the natural logarithm of the market Price to Earnings ratio
Ln(VOLUM)	the natural logarithm of the daily trading volume
DY	the market Dividend yield

Table 4 present the descriptive statistic of the variables in 68 countries, during the specific period (01 January 2020 – 31 December 2021)

Table 4: Descriptive statistic of sample data

Variable	Observation	Mean	Std. Dev.	Min.	Max.
Dependent variable					
VOL	35,564	2.3908	32.7783	0.0429	4806.847
Independent variables					
GRI	35,564	55.1077	19.4153	0	91.15
CHI	35,564	55.5002	19.7553	0	93.45
ESI	35,564	52.3608	32.3361	0	100
CTI	35,564	53.3092	26.0278	0	100
HSI	35,564	64.1377	21.4118	0	100
Control variables					
CC	35,564	0.0237	0.0774	0	1
DR	35,564	0.0005	0.0066	0	1
VC	35,564	0.0180	0.674	0	1
Ln(CAP)	35,564	13.7250	3.5047	6.1654	22.8416
Ln(PE)	35,564	2.9329	0.8626	0.0114	10.1219
Ln(VOLUM)	35,564	17.1791	3.8442	3.1780	26.7642
DY	35,564	0.0297	0.0192	0.0007	0.2807

The means value of stock market volatility during sample period is 2.3908 with standard deviation at 32.7783. For the minimum and maximum values of stock market volatility suggest that these markets found a significant increase volatility. During the study period, the daily average confirmed case rate and mortality rate related to COVID-19 are 2.37 percent and 0.05 percent, respectively. The descriptive statistics for the sample period reveal that the conditional variance variable derived from the EGARCH (1,1) has the largest standard deviation of 32.7783, while the variable with the lowest standard deviation is the death rate, which has a value of 0.0066. The indexes consist of 5 types provided and calculated by the method of Hale et al. (2020). Moreover, there seem to be disparities in the average rates of each market-implemented government policy. The mean of the indexes during sample period are 55.1077, 55.5002, 52.3608, 53.3092 and 64.1377, respectively for the overall government response index, the overall containment and health index, the overall Economic support index, the overall containment and closure policies index and the overall Health system policies index.

Table 5 shows the correlation matrix of all variables for first and second model. Table 6 shows the correlation matrix of all variables for third model. Calkins (2005) has criteria the level of correlation's coefficient into 5 levels which show the level of correlation between variable in the research. From both table, we observe a moderately correlation from only 1 pair which is the natural logarithm of the total market value of stock market [Ln(CAP)] and the natural logarithm of the daily trading volume [Ln(VOLUM)] at 0.6321. Due to the unanticipated impact of multicollinearity problem between the variables in the study, the parameter estimations may be inconsistent with the theory (Agung, 2009; Hamsal, 2006). However, some of the research argued that the multicollinearity problem between the independent variables only exists when the correlation coefficient between factors is more than 0.95 (Iyoha, 2004). Moreover, Allison (2012) also stated that if the collinear variables are considered only for control variables and are not collinear with the interested variables in the research, there is no issue with a high correlation.

Table 5 Correlation matrix of first and second model

	VOL	Lagged VOL	GRI	CHI	ESI	CC	DR	VC	Ln(CAP)	Ln(PE)	Ln(VOLUM)	DY
VOL	1											
Lagged VOL	0.0312	1										
GRI	-0.0231	-0.0177	1									
CHI	-0.0194	-0.0147	-	1								
ESI	-0.0281	-0.0222	-	0.4427	1							
CC	0.0576	0.0857	-0.1404	-0.1207	-0.1585	1						
DR	0.0057	0.0505	-0.0050	0.0015	-0.0306	0.1891	1					
VC	-0.0069	-0.0079	0.1178	0.1165	-0.0677	-0.0449	-0.0132	1				
Ln(CAP)	-0.0117	-0.0119	0.0501	0.0669	-0.0459	-0.0046	-0.0016	0.0168	1			
Ln(PE)	-0.0116	-0.0122	0.1452	0.1159	0.2017	-0.0856	-0.0193	0.0837	0.0706	1		
Ln(VOLUM)	0.0098	0.0083	0.0966	0.1101	-0.0070	0.0192	0.0150	0.0187	0.6321	0.2046	1	
DY	-0.0044	-0.0044	-0.0575	-0.0304	-0.1463	-0.0139	-0.0052	-0.0065	-0.0764	-0.0667	-0.1056	1

Table 6 Correlation matrix of third model

	VOL	Lagged VOL	CTI	ESI	HSI	CC	DR	VC	Ln(CAP)	Ln(PE)	Ln(VOLUM)	DY
VOL	1											
Lagged VOL	0.0312	1										
CTI	-0.0058	-0.0009	1									
ESI	-0.0281	-0.0222	0.3079	1								
HSI	-0.0351	-0.0327	0.4192	0.4417	1							
CC	0.0576	0.0857	-0.0466	-0.1585	-0.2048	1						
DR	0.0057	0.0505	0.0278	-0.0306	-0.0446	-0.1585	1					
VC	-0.0069	-0.0079	0.0984	0.0677	0.1048	-0.0449	-0.0132	1				
Ln(CAP)	-0.0117	-0.0119	0.1662	-0.0459	0.0084	-0.0046	-0.0016	0.0168	1			
Ln(PE)	-0.0116	-0.0122	0.0830	0.2017	0.1483	-0.0856	-0.0193	0.0837	0.0706	1		
Ln(VOLUM)	0.0098	0.0083	0.2159	-0.0070	0.0257	0.0192	0.0150	0.0187	0.6321	0.2046	1	
DY	-0.0044	-0.0044	-0.0528	-0.1463	0.0020	-0.0139	-0.0052	-0.0065	-0.0764	-0.0667	-0.1056	1

<u>Estimation results</u>

Table 7 System GMM estimation results

	VOL	VOL	VOL
Lagged VOL	0.0262**	0.0257*	0.0284*
	(0.0228)	(0.0226)	(0.0199)
GRI	-0.0304*	-	-
	(0.0180)		
CHI	-	-0.1470***	-
		(0.0531)	
ESI	-	-0.2806***	-0.0896**
		(0.0140)	(0.0189)
CTI	-	-	-0.0151***
			(0.0229)
HSI	-	-	-0.0694*
			(0.0380)
CC	7.0035**	4.6020*	4.0194**
	(10.84)	(10.70)	(69.02)
DR	86.4057	91.5412	95.2894
	(91.33)	(94.33)	(163.2)
VC	-1.1731**	-1.1060**	-1.3816*
	(0.786)	(0.755)	(0.977)
Ln(CAP)	-0.2768**	-0.3041**	-0.2657*
	(0.142)	(0.146)	(0.109)
Ln(PE)	-0.4054	-0.1520	-0.0475
	(0.235)	(0.246)	(0.435)
Ln(VOLUM)	0.2678**	0.2173*	0.2215*
	(0.118)	(0.113)	(0.106)
DY	-0.0001***	-0.0001***	-0.0001***
	(4.33e-05)	(7.92e-05)	(0.00415)
Observations	35,496	35,496	35,496
Number of N	68	68	68
Arellano-Bond Test AR(1)	0.012	0.038	0.045
Arellano-Bond Test AR(2)	0.419	0.411	0.317
Hansen J - test	0.320	0.237	0.372
Diff-in-Hansen test	0.389	0.334	0.414

The asterisks *, **, and *** reflect statistically significant at 10%, 5% and 1% level, respectively. Coefficient of variable are reported in table and Standard errors in parentheses. The p-values related with the null hypothesis that instruments are valid can be shown by Hansen J -test. The p-values for the feasibility of the required additional moment restrictions for system GMM can be shown by Diff-in-Hansen test.

The AR(1) and AR(2) p-values are shown for first and second order autocorrelated disturbances in the difference equations.

Table 7 shows the result of our system GMM estimation using first to third equation model in the dynamic panel data analysis regression. We use conditional variance, obtained from the EGARCH (1,1) calculated by daily percentage stock return volatility to be dependent variable in each regression. The lagged variable of conditional variance is positive and it's statistically significant at 5% in first equation and 10% in second and third equation. This implies that the conditional variance of previous period plays an essential effect in the conditional variance of the next period. The outcome is in line with the studies of Harjoto et al. (2021).

From first equation, the overall government response index has a negative coefficient and statistically significant at 10% which means that when index increases 1 point, stock market volatility decreases 0.0304. This result is in line with our hypothesis which is the government policy can reduce general uncertainty and improve corporate expectations, investors may accept the risk and stay investing in the stock market which lowers the market volatility. Investors can bear the risk of investment when they believe in the market, or they have trust in the market that they invested. We found the evidence to support our first hypothesis that the stock market volatility can be reduced by the tighter government policy response. This result is also consistent with the research conducted by Kizys et al. (2021), Sharif et al. (2020), and Zaremba et al. (2021) showed that effective policy measures can help alleviate the uncertainty in the market. Moreover, government policy that are announced in a timely manner increase the quality of information accessible to the investors and reduce investor's concerns.

From second equation, the overall containment and health index and economic support index have a negative coefficient and statistically significant at 1% which is consistent with our first hypothesis. The results indicate that containment and health policy and economic support policy can reduce the stock market volatility. A 1-point increase in containment and health index and Economic support index, the stock market volatility decreases 0.1470 and 0.2806 respectively. From third equation, the overall Economic support index, the overall containment and closure policies index and the overall Health system policies index have a negative coefficient in every index and statistically significant at 5%, 1% and 10% respectively. The results indicate that economic support policy, containment and closure policies and health system policies can reduce the stock market volatility. Therefore, a 1-point increase in each index, the stock market volatility decreases 0.0896 for Economic support policy, 0.0151 for Containment and closure policies and 0.0694 for Health system policies. After we got the result from second and third equation, we also compare the impact of each policy by using posted estimation in STATA program to test the second hypothesis. According to second hypothesis, we need to compare the impact of each type of policy and see whether which type of policy has the most impact to stock market volatility.

Based on second equation, we test the hypothesis as below:

$$H_0: \beta_2 - \beta_1 \geq 0 \; VS \; H_1: \beta_2 - \beta_1 < 0 \; ; P - value = \; 0.0471$$

Based on third equation, we test the hypothesis as below:

$$H_0: \beta_2 - \beta_1 \geq 0 \; VS \; H_1: \beta_2 - \beta_1 < 0 \; ; P - value = \; 0.0363$$

$$H_0: \beta_2 - \beta_3 \geq 0 \; VS \; H_1: \beta_2 - \beta_3 < 0 \; ; P - value = \; 0.0155$$

Based on the hypothesis of each equation, we compare the economic support policy with other policy and all of results statistically rejected the null hypothesis which means the economic support policy has coefficient lower than other policy. The significant results of hypothesis of each equation show that Economic support policy is the most effective policy to reduce stock market volatility.

The result from second and third equation support with our second hypothesis that Economic support policy has a higher impact than other policies on stock market volatility. This results also follow with Phan and Narayan (2020) and Zaremba et al. (2021) that the Economic support policy has highest impact to the stock market volatility since the policy no need a long time to respond and directly support the corporate and investor in the market. Moreover, direct economic injections allow citizens to purchase important things while being under lockdown especially low-income people. The result also supported by the research conducted by Lou et al. (2020) and (Wright et al., 2020) which showed that lower-income populations are less likely to cooperate with lockdown restrictions and are more likely to get infected with the disease since they do not have enough money and rely on day-to-day revenue from their jobs. Financial assistance is primarily offered to the poor, so effective financial government assistance may reduce confirmed case rates by encouraging poor persons to remain at their resident and it will support other government policies to be more effective too.

All the index's coefficients are negative and significant, implying that the tighter government policy response can decrease and reduce stock market volatility. Moreover, these imply that all types of government policy can reduce the stock market volatility and economic support policy has a higher effect than another index. These outcomes explain understanding of the stabilization impact of government responses to COVID-19 on stock market volatility.

For control variables related to COVID-19, the result is significant for confirmed cases and vaccine rates. The confirmed cases rate coefficient is strongly positive and statistically significant at 5% in the first and third equation and statistically significant at 10% in the second equation. These imply that the stock market volatility could increase if the confirmed cases rate increases. A 1% increase in the confirmed case rate will increase stock market volatility in the range of 4.0194 – 7.0035. This result is consistent with Albulescu (2021), Baig et al. (2021), and Harjoto et al. (2021). However, the vaccine rate coefficient is negative and significant at 5% in the first and second equation and 10% in the third equation. These imply that the stock market volatility could decrease if the vaccine rate increase. A 1% increase in vaccine rate will decrease stock market volatility in the range of 1.1060 – 1.3816. The result is in line with other research which indicated that the COVID-19 vaccination contributes to the equities market's stability (Rouatbi et al., 2021).

The regression results of total market value of stock market, daily trading volume, and market-wide dividend yield are significant for other control variables. The coefficient of total market value of stock market is negative, but the coefficient of daily trading volume is positive. The coefficients are statistically significant at 5%

and 10% in both results. These results align with Baig et al. (2021), which showed the connection among volatility, trading volume, and market value in the stock market. Moreover, the coefficient' of market-wide dividend yield is negative and it's statistically significant at 1%, which in line with the research from Hoffmann and Marriott (2019), and Sörensen and Deboi (2020). The estimated results of this regression indicate that these variables affect the stock market volatility.

The statistics in below of table 8 is utilized to evaluate the validity of the system-GMM technique's instruments. The system-GMM estimator does not require normality and permits for heteroskedasticity in the information, unlike the OLS model. Regardless of the type of methodology, dynamic panels analysis are recognized for the problem of heteroskedasticity of data that can be addressed (Baltagi & Baltagi, 2008). Moreover, the system-GMM method implies linearity and doesn't show the autocorrelation in the error terms. Thus, testing for the existence of second-order autocorrelation in the error term is the most important step in evaluating the statistical characteristics of this model, which requires checking for the validity of the instruments. Based on the research of Arellano and Bond (1991), the GMM estimator needs to reject for first-order serial correlation [AR(1)] hypothesis which means that there're existing of first-order serial correlation but it's requires to accept for second-order serial correlation [AR(2)] hypothesis with in the residual. The null hypothesis of these test is no first-order and second-order serial correlation in the model, so when we use this estimator, it requires to reject the null hypothesis for the first-order serial correlation and it requires to accept the null hypothesis for the second-order serial correlation to receive proper regression results. Based on our result in Table 8, the null hypothesis for the first-order serial correlation rejects at 5%

significance level (0.012, 0.038, 0.045) in every equation which implied that there is existing of first-order serial correlation. Moreover, the null hypothesis for the second-order serial correlation is not reject at any significant level (0.419, 0.411, 0.317) in every equation which means the result has no second-order serial correlation. These findings supported our model's definition which require for system-GMM estimator.

Moreover, the Hansen J-statistic test is necessary to confirm the null hypothesis of a valid overidentified constraint, such as instrument validity, and a good model formulation. The p-values for the extra moment limitations required for system GMM are provided by the Diff-in-Hansen test. Baum et al. (2007) stated that the Hansen J-statistic test is the most often used test in GMM estimate for determining the model's suitability, so it requires to accept the null hypothesis for both Hansen J – test and Diff-in-Hansen test. Another point that we should take care is the P-Value that we need to accept the null hypothesis in second-order serial correlation and Hansen J – test, it cannot accept when we got P-value at 1.00 since it’s have too many instruments and create implausibly good p-value at 1.00 (Roodman, 2009). The result shows that the Hansen J-statistic and the Diff-in-Hansen test doesn’t reject the null hypothesis at any significance level (P-value > 0.10) in every equation model. These imply that the models have valid instrument and additional moment restrictions necessary for system GMM. The P-value of the Hansen J-statistic and the Diff-in-Hansen test record in range between 0.237 – 0.414

<u>Conclusion</u>

This study investigates the impact of government response’s policy to COVID-19 on stock market volatility, whether government response’s policy to

COVID-19 really has impact to the volatility of stock market. We use dynamic panel data analysis and Arellano–Bover/ Blundell–Bond system GMM to be model's estimator. The sample data includes stock market index, COVID-19 information (Confirm case, Death case, Vaccine people) and COVID-19 government response index provided by Hale et al. (2020) from 68 countries with the period 01 January 2020 – 31 December 2021.

The results indicate that the government policy response to COVID-19 lower the stock market volatility during the COVID-19 outbreak period. This result is consistent with our first hypothesis that the government policy can reduce general uncertainty and improve corporate expectations, investors may accept the risk and stay investing in the stock market which lowers the market volatility. This is also compatible with the findings of Kizys et al. (2021), Sharif et al. (2020) and Zaremba et al. (2021) investigation which showed that effective policy measures can help alleviate the uncertainty in the market. We categorized the index based on type of policy into 2 types and follow calculation method by Hale et al. (2020) to recategorized the type of policy into 3 types. All types of indexes seem to have the same direction of effect after all of coefficient from the result show negative value and it also has statistically significant. Moreover, the policy that has the highest effect for reduce stock market volatility is Economic support policy which in line with the results from Phan and Narayan (2020) and Zaremba et al. (2021). These results still follow with our first hypothesis after we divided the index into 3 categories but all of policy still reduce the volatility of stock market.

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