Research article

The impact of COVID-19 vaccination on stock market: is there any difference between developed and developing countries?

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ABSTRACT

This study analyzes the impact of COVID-19 vaccination on the stock markets of 77 countries in the period March 11, 2020–October 29, 2021. Using the panel data vector autoregression (PVAR) model, we find that COVID-19 vaccination has a positive impact on stock markets of developing countries and a negative impact on developed countries. Variance decomposition results shows that COVID-19 vaccination explains 0.00022% and 0.00026% of stock market return in developed and developing countries, respectively. Our findings bear important implications: policymakers of developing countries should accelerate mass COVID-19 vaccination programs to recover stock markets, while developed country governments need to combine vaccination with other preventive measures (e.g., mask wearing in indoor public spaces) to limit the spread of the virus, especially when there is a new higher infection variant – Omicron.

1. Introduction

The world has experienced more than 2 years of the COVID-19 pandemic raging with the appearance of new SARS-CoV-2 virus variants and many unsolved problems. The complicated situation of the COVID-19 pandemic has proved the fact that the pandemic is still out of control and will even cause new challenges for people in 2022. The new variant of the SARS-CoV-2 virus, Omicron, is still the main factor potentially delaying the recovery of the global economy returns to normal levels like before the pandemic. Since the first case of COVID-19 was recorded in Wuhan, China in December 2019, up to now, the pandemic has spread globally with more than 280 million cases, of which about 5.4 million deaths (WHO). The worldwide healthcare system remains strained due to the continued increase in the number of COVID-19 new cases. Many studies showed that the pandemic has a negative impact on the stock market (Ashraf, 2020; Al-Awadhi et al., 2020; Okorie and Lin, 2020). In the context that there is no vaccine to prevent the disease, some of the effective measures that countries apply to limit the spread of the pandemic are lockdown and asking people to practice social distancing. This has exacerbated the impact of the pandemic on financial markets (Heyden and Heyden, 2021; Zaremba et al., 2020).

In the face of a rapidly spreading disease with serious consequences for the global economy, it is necessary to develop a vaccine that can stop this spread. However, vaccine development is not easy, even for a leading pharmaceutical company in the world. It takes about 10–15 years to develop a new vaccine as well as to ensure its quality, immunogenicity, safety and efficacy (Scheppler et al., 2021). As a result, some countries has granted emergency-use authorization to certain new vaccines to prevent COVID-19. This means that the vaccine could be available to the general public before it is licensed - even without the completion of ongoing clinical trials. Specifically, after a thorough assessment of the quality, safety and protective efficacy of the vaccine, WHO has approved the emergency use of Pfizer and Moderna on December 31, 2020, and April 30, 2021, respectively. Currently, Pfizer has been licensed for use in 107 countries and territories, while Moderna is being used for vaccination campaigns in 77 countries and territories. Two versions of AstraZeneca produced by Oxford and the Serum Institute of India were approved for emergency use by WHO on February 15, 2021. Oxford's AstraZeneca is being used in vaccination campaigns in 125 countries and territories, while the Indian version is being used in 46 countries and territories. Vero Cell vaccine developed by Sinopharm (China) and Coronavac by Sinovac Biotech Ltd were respectively put on the list of emergency use by WHO on May 7, 2021 and June 1, 2021. The development of COVID-19 vaccines offers hope to reverse the epidemic and stabilize socio-economic conditions. However, one problem hindering pandemic containment is vaccine inequality. According to Mallapaty et al. (2021), in high-income countries, about 83% of the eligible population has received at least one COVID-19 vaccine dose, while in low-income countries, the figure is only 21%. In

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addition, although demand for COVID-19 vaccines is declining in high-income countries, they are stocking up on booster doses. This makes it more difficult for lower-income countries to access vaccines, especially in the current situation of scarcity of vaccine supplies (Torjesen, 2021).

The introduction of the COVID-19 vaccine also raises some questions: Will the COVID-19 vaccine have an impact on the recovery of the economy in general and the stock market in particular? Is this an effect similar in high and low-income countries? In this paper, we apply the PVAR model to examine the impact of COVID-19 vaccination on the stock market, and compare this relationship between developed and developing countries.

2. Literature review

Over the past 2 years of the pandemic, there have been many research papers analyzing the impact of the COVID-19 pandemic on the stock market. Studies by Al-Awadhi et al. (2020), Ashraf (2020), Harjoto et al. (2020), Onali (2020), Uddin (2021), Yilmazkuday (2021) showed that an increase in the number of COVID-19 cases and deaths has a negative impact on the stock market. Cao et al. (2020), Okorie and Lin (2020), Liu et al. (2021), and Chaudhry (2021) also confirmed a negative relationship between the COVID-19 pandemic and the stock market. Research by Ibrahim et al. (2020) at Asia-Pacific developed and developing markets indicated that the relationship between COVID-19 and stock market volatility varies across countries. Besides stocks, other assets are also affected by the pandemic, such as gold (Yousef and Shehadeh, 2020; Chaudhry, 2021; Atri et al., 2021), foreign currencies (Benzid and Chebbi, 2020; Narayan, 2020), real estate (Ling et al., 2020; Tanrıvermiş, 2020; Uchehara et al., 2020), and cryptocurrencies (Corbet et al., 2020; Demir et al., 2020; Iqbal et al., 2021).

Another research orientation that has attracted much attention is the impact of government policies in response to the pandemic. Ashraf (2020) argued that the government's social distancing measures have a direct negative impact on the stock market, but help reduce the number of COVID-19 cases. Meanwhile, policies related to raising public awareness, testing and isolation measures, and income support packages have a positive impact on the market. Similarly, Zaremba et al. (2021) found evidence that closing schools and workplaces can constrain stock market liquidity. Baig et al. (2021) suggested that the implementation lockdowns and mobility restrictions increase the volatility of the stock market.

From the end of 2020, with the development of COVID-19 vaccines, countries began to conduct mass vaccination campaigns, then gradually loosened restrictions. Scientists have begun to study the impact of vaccines on the economy as well as the stock market, but the number of research is still very limited. Rouatbi et al. (2021) investigated the impact of COVID-19 vaccination on stock market volatilities of 66 countries from January 1, 2020 to April 30, 2021. Using pooled OLS estimation, the study showed that mass vaccination programs help stabilize global stock markets. In addition, the impact of vaccination on developed markets is relatively stronger than in emerging markets. Khalfaoui et al. (2021) used multiple wavelet coherence to examine the impact of COVID-19 vaccination on US financial markets during the period of December 20, 2020–April 9, 2021. The results showed that vaccination has a positive effect on the S&P 500 index, implying that the government should intervene in the vaccination strategy as it can be beneficial for the stock market recovery as well as the entire economy. Cong Nguyen To et al. (2021) studied the role of vaccine initiation rates in mitigating international stock market volatility during COVID-19. Using the asymmetric GJR-GARCH model, the research results found a positive effect of the vaccination initiation rate which helps to stabilize the international stock market. This possible effect is stronger for developed markets and countries where vaccination initiation rates are higher than the general average. Demir et al. (2021) studied the role of mass vaccination in energy companies. Applying Pooled OLS and REM estimations on the dataset of 58 countries from January 1, 2020 to April 30, 2021, the article confirmed that vaccination programs help reduce volatility in stocks of energy companies in the international market. Similar to Rouatbi et al. (2021), this study also

showed that the influence of vaccination on energy stocks of developed countries is more pronounced than that of emerging countries. Hartono (2021) examines the effect of the presence of a Covid-19 vaccine on investor sentiment and the performance of global stock markets after being hit by heightened concerns due to the pandemic. The results suggested that each stage of vaccine development receives high praise from stock investors, especially after vaccine candidates pass human clinical trials. Positive investor sentiment towards the vaccine program has boosted stock market performance. Also studied in clinical trials, Chan et al. (2022) examined the stock market's response as human clinical trials of COVID-19 vaccine candidates began. The panel data regression results for 83 COVID-19 vaccine candidates showed that at the start of the vaccine clinical trial, the average global stock market abnormal return increased by 8.08 basis points. Research also indicated that the day-one impact of phase II and III clinical trials is stronger for developed economies than for emerging economies. Table 1 summarizes studies on the impact of COVID-19 vaccination on the stock market. As some vaccines pass clinical trials and begin to be approved, Ho et al. (2022) investigated the Chinese stock market's reaction to Covid-19 vaccine approval announcements. Employing the event study methodology, the results show that the announcement of a Covid-19 vaccine has had a positive impact on overall stock prices. However, stocks in different sectors react differently to the announcements. In particular, companies with poorer performance, smaller size, and older age may benefit more from this type of positive public health announcement. Apergis et al. (2022) also found a positive impact of Covid-19 vaccination programs on stock return in Canada for the period 27 January 2020, to 31 August 2021.

By different approaches, studies have confirmed the positive effect of mass vaccination campaigns on the stock market. However, there are no studies that address vaccine inequality between countries, nor compare the impact of vaccination on stock markets between countries. This is a research gap that we seek to fill through this paper.

Therefore, this study has three important contributions as follows. First, the number of studies on the relationship between vaccinations and the stock market is still limited. Our article provided more evidence on the impact of vaccinations on the stock market. Second, the study was conducted on two groups of developed and developing countries to compare the influence of vaccination on the stock market of these two groups of countries. The findings revealed that vaccination had a varied influence on the stock market in these two categories of countries. Finally, to our best knowledge, this is the first study on this topic to apply the PVAR model with the advantage of being able to explain the direct and indirect effects of COVID-19 vaccination to the stock market.

3. Data and methodology

In this study, we use daily data on the stock market closing prices of 77 countries, including 37 developed and 40 developing countries (as ranked by the United Nations). The list of countries is presented in Table A1 of the Appendix. The study period was from March 11, 2020 (date when WHO declared COVID-19 a pandemic) to October 29, 2021.

Table 2 presents the descriptive statistics. We find that the average vaccination rate in developed countries is 2.838907 (logarithm), 1.22 times higher than that in developing countries. This reflects the fact that there exists COVID-19 vaccine inequality between these two group. To prevent this from happening, the COVAX Scheme was established to accelerate the development and manufacturing COVID-19 vaccines, while ensuring fair and equal access for all countries. But most rich countries have ignored COVAX (WHO). In addition, developed countries have had a higher average COVID-19 infection rate than developing countries (0.0144% vs. 0.0107%). As a result, they are stepping up the vaccination process, stocking up on doses for their populations, and cut direct transactions with low and middle-income countries, leading to difficulties in vaccine access of these countries (WHO). This is also the reason why the death rate from COVID-19 in developing countries is also higher than in developed countries (3.3046% compared to 2.6160%).

Table 1. Review of selected studies on the relationship between stock market and COVID-19 vaccination.

Authors	Method	Variables	Countries	Main results
Rouatbi et al. (2021)	Pooled OLS	Stock return volatility, daily vaccination, Δ Infections to Cases, ΔDeaths to Cases,	66 countries	Mass vaccinations help stabilize global stock markets. The impact of vaccination on developed markets is relatively stronger than in emerging markets.
Khalfaoui et al. (2021)	Multiple wavelet coherence	Stock market return, Infection rate, Vaccination rate, Case Fatality Ratio	USA	COVID-19 vaccination has a positive effect on the S&P 500 index
Cong Nguyen To et al. (2021)	Asymmetrical GJR GARCH	Stock return volatility, Vaccine initiation rate, Daily relative change of COVID-19 total cases and deaths per million individuals	34 countries	Vaccine initiation rates help stabilize international stock markets
Demir et al. (2021)	Pooled OLS, REM	Stock return volatility, daily vaccination, Δ Infections to Cases, ΔDeaths to Cases,	58 countries	Vaccination programs help reduce volatility of energy stocks in international market.
Chan et al. (2022)	Panel data regression	Daily abnormal return, Daily growth rate of COVID-19-confirmed cases, daily growth rate of COVID-19-related death cases, Bull-bear spread, CBOE VIX	23 developed economies and 27 emerging economies	The average global stock market abnormal return increased on the first day of the trials
Ho et al. (2022)	Event study methodology	Cumulative abnormal returns (CARs), return on assets, tangible assets ratio, financial leverage, Age of firm, and Size of firm	China	The announcement of a Covid-19 vaccine has had a positive impact on stock prices

Source: Author's own compilation.

Table 2. Descriptive statistics of variables in the model.

	Developing countries				Developed countries			
	SR	LNVR	IR	CFR	SR	LNVR	IR	CFR
Mean	0.075633	2.335741	0.010667	3.304644	0.090152	2.838907	0.01438	2.61595
Median	0	0	0.003053	1.762905	0.03	0	0.004996	0.667881
Maximum	351.89	7.628057	0.355826	402.7397	11.96	7.695619	0.319729	683.3333
Minimum	−77.29	0	−0.000157	0	−16.92	0	−0.000039	0
Std. Dev.	3.054683	2.716813	0.018764	9.898428	1.371813	2.969643	0.023724	10.99642
Skewness	88.24737	0.452041	4.243141	19.68517	−0.727667	0.182874	3.558521	34.43178
Kurtosis	10304.04	1.420051	38.25282	557.4133	18.68491	1.177819	22.71055	1774.556
Jarque-Bera	75700000000	2363.704	937875	220000000	163727.3	2279.141	289771.1	2070000000
Probability	0	0	0	0	0	0	0	0
Sum	1294.834	39987.89	182.6119	56575.51	1427.65	44956.92	227.7173	41426.18
Sum Sq. Dev.	159738.9	126356.6	6.027519	1677300	29799.41	139645.4	8.912573	1914789
Observations	17120	17120	17120	17120	15836	15836	15836	15836

Source: Data statistics are over the period of March 11, 2020–October 29, 2021.

Table 3. Variable description and source of data.

Signs	Descriptions	Research	Source
SR	Stock market return $$SR_{i,t} = \frac{Index_{i,t} - Index_{i,t-1}}{Index_{i,t-1}}$$ in which $Index_{i,t}$ is the stock price index of country i at the end of day t.	Khalfaoui et al. (2021)	investing.com
LNVR	Vaccination rate in form of logarithm $$VR = \frac{Number\ of\ daily\ COVID\ 19\ vaccinations}{Population\ size} \times 100.000$$	Khalfaoui et al. (2021)	Our world in data
IR	Infection rate $$IR = \frac{Number\ of\ daily\ confirmed\ cases}{Population\ size} \times 100$$	Khalfaoui et al. (2021)	Our world in data
CFR	Case Fatality Ratio $$CFR = \frac{Number\ of\ daily\ deaths}{Number\ of\ daily\ confirmed\ cases} \times 100$$	Khalfaoui et al. (2021)	Our world in data

Source: Author's own compilation.

The variables included in the research model are described in Table 3 below. Since the Vaccination rate (VR) is a highly skewed variable, we used the logarithm of vaccination rate (LNVR) to transform it into one that is more approximately normal.

In this paper, the PVAR model is used, which does not distinguish between exogenous and endogenous variables, but instead considers all variables to be endogenous. Moreover, each variable in PVAR depends on its past data and on all other variables, which show concurrency and equality between variables. Therefore, this is a suitable model for this research. The PVAR model to analyze the relationship between COVID-19 vaccination and the stock market is as follows:

Table 4. Cross-sectional dependence test results.

LM test (Breusch and Pagan, 1980)

Variables	Developing countries	Developed countries
SR	16788.54***	71846.70***
LNVR	270508.0***	246829.1***
IR	34738.52***	37639.11***
CFR	4050.813***	14113.95***

Scaled LM test (Pesaran, 2004)

Variables	Developing countries	Developed countries
SR	405.3119***	1950.339***
LNVR	6829.104***	6744.829***
IR	859.7782***	1013.057***
CFR	82.81203***	368.4715***

Notes: *,**,*** show significance level at 10%, 5% and 1%, respectively. The null hypothesis is no cross-sectional dependence.

$$Y_{i,t} = A_1 Y_{i,t-1} + A_2 Y_{i,t-2} + \ldots + A_k Y_{i,t-k} + u_i + \varepsilon_{i,t} \qquad (1)$$

where $Y_{i,t} = (SR_{i,t}, LNVR_{i,t}, IR_{i,t}, CFR_{i,t})$ donates to a four – dimensional system vector of endogenous variables; $Y_{i,t-p}$ is a 1×4 vector of lagged endogenous variables; $A_1, A_2, \ldots, A_k$ represent the $(k \times k)$ vectors of the estimated coefficients; k is the optimal lag-length; u_i is the dependent variable fixed effect vector; and $\varepsilon_{i,t}$ is a vector of idiosyncratic errors.

After estimating the panel VAR model, we computed the Impulse-Response Functions (IRFs) following the Cholesky decomposition of variance-covariance matrix of residuals. The IRFs describe the reaction of one variable to the innovations in another variable in the system, while holding all other shocks equal to 0. To analyze the IRF, we need an estimate of their confidence intervals using Monte Carlo (MC) simulations. Since the matrix of IRF is constructed from the estimated VAR coefficients, their standard errors need to be taken into account.

Finally, we also present the Variance Decompositions (VDCs), which show the percent of the variation in one variable that is explained by the shock to another variable, accumulated over time. The variance decompositions show the magnitude of the total effect. We report the total effect accumulated over the 1, 5, and 10 years, as longer time horizons produced equivalent results.

4. Research results

To compare the impact of COVID-19 vaccination on stock markets in developed and developing countries, we respectively estimate Eq. (1) on the data sets of the two groups of countries.

4.1. Panel cross-section dependence test

One of the most crucial diagnostics that a researcher should examine before performing a panel data analysis is cross-sectional dependency (Urbain and Westerlund, 2006; Tugcu, 2018). The number of cross-sectional dependency tests that may be employed to discover the problem is limited. These are the Breusch and Pagan (1980) LM test, Pesaran (2004) scaled LM test, Pesaran (2004) CD test, and Baltagi et al. (2012) bias-corrected scaled LM test. Since our data sets have large time dimensions and number of cross-section units, we employ both the Breusch and Pagan (1980) LM test and Pesaran (2004) scaled LM test. Test results are showed in Table 4.

According to LM test and scaled LM test results, the null hypothesis is rejected at 1% level. This findings indicate that countries in each of the study's groups are cross-sectional dependent, which can be explained by the strong economic and financial connections between many of these countries. Furthermore, this result implies that cross-sectional dependence should be taken into account when applying panel unit root tests.

4.2. Panel unit root tests

After detecting cross-sectional dependency, we evaluate the stationarity characteristics of the variables using the second generation CADF unit root test by Pesaran (2003), which takes cross-sectional dependence into account. In addition, we also report first generation Levin – Lin – Chu (LLC), Im-Pesaran-Shin (IPS), and Augmented Dicker Fuller (ADF) unit root tests in Table 5. The results reveal that all the variables are stationary at levels except LNVR, which is stationary at first differences. Therefore, to analyze the dynamics between the research variables, we first transformed the nonstationary variable (LNVR) into the first difference form so that all analyzed variables are stationary. This is important to obtain efficient results in PVAR framework (Tiwari, 2011).

4.3. Empirical results

4.3.1. Optimal lag selection

Before performing PVAR regression, we need to determine the optimal lag to use in the equations. The result in Tables 6 and 7 present that all criteria, including LR (sequential modified LR test statistic), FPE (Final prediction error), AIC (Akaike Information Criterion), SC (Schwarz Information Criterion) and HQ (Hannan-Quinn Information Criterion) suggest that the optimal lag of the variables in the PVAR model in both developed and developing countries is one lag.

4.3.2. Stability condition test

In the next step, we need to examine the stability of PVAR model. Figure 1A and 1B present the Inverse Roots of AR Characteristic

Table 5. Panel unit root test results.

Method		SR	LNVR	D (LNVR)	IR	CFR
Developing countries						
Pesaran's CADF test	constant	−30.580***	−1.646**	−20.695***	−30.580***	−27.122***
	constant & trend	−30.937**	6.136	−19.159***	−30.937***	−26.724***
Levin, Lin & Chu t*		−155.526***	4.30152	−111.367***	−1.92026***	−16.3775***
Im, Pesaran & Shin W-stat		−135.954***	8.47129	−93.3043***	−7.09100***	−35.9041***
ADF - Fisher Chi-square		5900.29***	10.7891	4624.09***	203.342***	1551.94***
Developed countries						
Pesaran's CADF test	constant	−29.411 ***	2.189	−4.502 ***	−28.952 ***	−26.900***
	constant & trend	−29.754***	4.593	−2.426 ***	−29.070 ***	−26.831***
Levin, Lin & Chu t*		−45.9663***	−1.22675	−72.4926***	2.32471***	−13.4349***
Im, Pesaran & Shin W-stat		−69.1011***	4.43114	−62.2332***	−5.86312***	−26.8869***
ADF - Fisher Chi-square		3125.05***	18.4958	2857.79***	175.789***	1140.23***

Note: **, *** means significant at 5% and 1%, respectively.

Table 6. Testing optimal lag selection of PVAR model for developing countries.

Lag	LogL	LR	FPE	AIC	SC	HQ
0	−57046.25	NA	0.009509	6.696038	6.697856	6.696638
1	−46825.58	20435.34*	0.002871*	5.498307*	5.507396*	5.501304*

* indicates lag order selected by the criterion.

Table 7. Testing optimal lag selection of PVAR model for developed countries.

Lag	LogL	LR	FPE	AIC	SC	HQ
0	−44595.73	NA	0.003372	5.659146	5.661091	5.65979
1	−37000.21	15186.22*	0.001289*	4.697400*	4.707127*	4.700619*

* indicates lag order selected by the criterion.
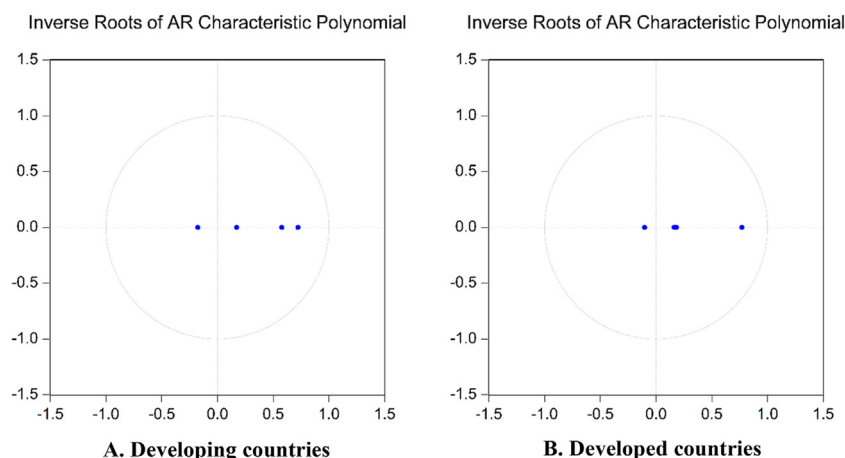
Figure 1. Inverse roots of AR characteristic polynomial.

Polynomial for PVAR model in developing and developed countries, respectively. We can see that no root lies outside the unit circle, that is, both estimated PVAR models satisfy the stability condition.

4.3.3. Result of impulse – response function (IRF)

We continue to analyze the impulse-response function (IRF) to consider the interaction of the variables in the model.

Figure 2 shows the IRF results in developing countries. According to Figure 2A, when there is a LNVR shock, SR responds positively at day 2 with a level of 0.005%. This positive response begins to decrease on days 3 and 4, then converges to zero at day 5 onwards. This implies that the vaccination has made investor sentiment more optimistic in the stock market, contributing to the increase in this market. This result is consistent with Rouatbi et al. (2021), Khalfaoui et al. (2021), Cong Nguyen To et al. (2021), and Demir et al. (2021). This also explains the response of SR to an IR shock in Figure 2B. SR responds positively to an IR shock at day 2 at 0.013% and lasts for the next 9 days. Although this result contrasts with Al-Awadhi et al. (2020), Ashraf (2020), Onali (2020), Yilmazkuday (2021), it makes sense in the context of the development of COVID-19 vaccines and countries conducting mass vaccination programs. However, the case fatality ratio from COVID-19 still somewhat affects investor sentiment. Figure 2C shows that when there is a CFR shock, SR reacts negatively at −0.006% on day 2, but this response only lasted for about 1 week. Figure 2D and 2E describe the response of IR and CFR to the impact of LNVR shock in developing countries. It can be seen that vaccination has a positive effect on the infection rate but has a negative effect on the mortality rate from COVID-19. This is explained that, as countries increase the rate of COVID-19 vaccination, the distancing measures will be gradually eased, causing the infection rate to increase. However, thanks to vaccination strategies, mortality rates in developing countries tend to decrease.

In developed countries, the response of SR to a LNVR shock is in stark contrast to that of developing countries. Figure 3A shows that when there is a LNVR shock, the SR reacts negatively at day 2 with a level of −0.002%. However, this reaction only lasts for day 2 and stops completely from day 3 onwards. Some reasons for the negative response of stock markets to vaccination in developed countries are as follows:

(i) *People's fear and lack of trust about the new COVID-19 vaccine.* It can be seen that, although a vaccine for COVID-19 has been released and countries have begun mass vaccination campaigns, people still have a feeling of fear and lack of confidence in the effectiveness of vaccines in preventing the disease. In particular, anxiety has increased when delta variant was detected in India in late 2020 (Awijen et al., 2022). According to Fadda et al. (2020), one of the reasons which makes people believe in vaccines is the slow and methodical process of developing them, which can take several years before final approval. The rapid approval of a new COVID-19 vaccine could contribute to the backlash, causing people to hesitate because they think the vaccine has been rushed to market without being fully tested in terms of both safety and effectiveness;

(ii) *Misinformation about vaccination increases public hesitation.* This is really a challenge for developed countries, because this group of countries has a high degree of freedom to express their views. The average Voice and Accountability Index in 2020 of this group of countries is 0.88, higher than that of developing countries (−0.06). Thus, in developed countries, the vigorous activity of anti-vaccination campaigners leads to misinformation about vaccination, increasing public hesitation and doubt about the effectiveness as well as the possible side effects of the COVID-19 vaccines. Several studies are demonstrating that COVID-19
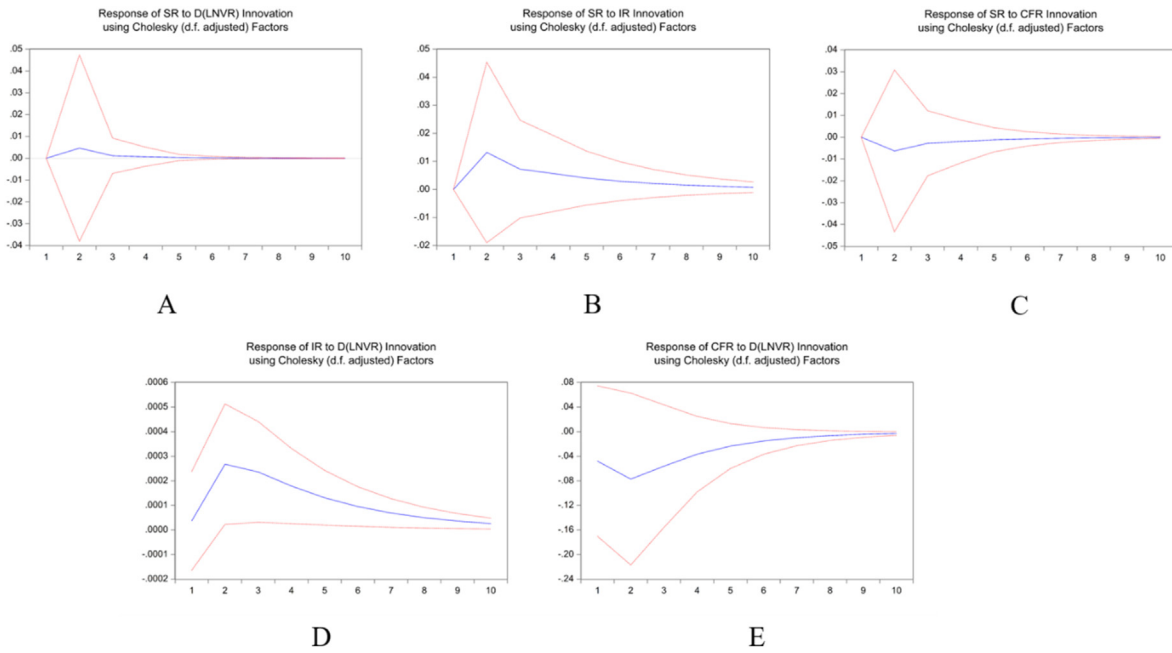
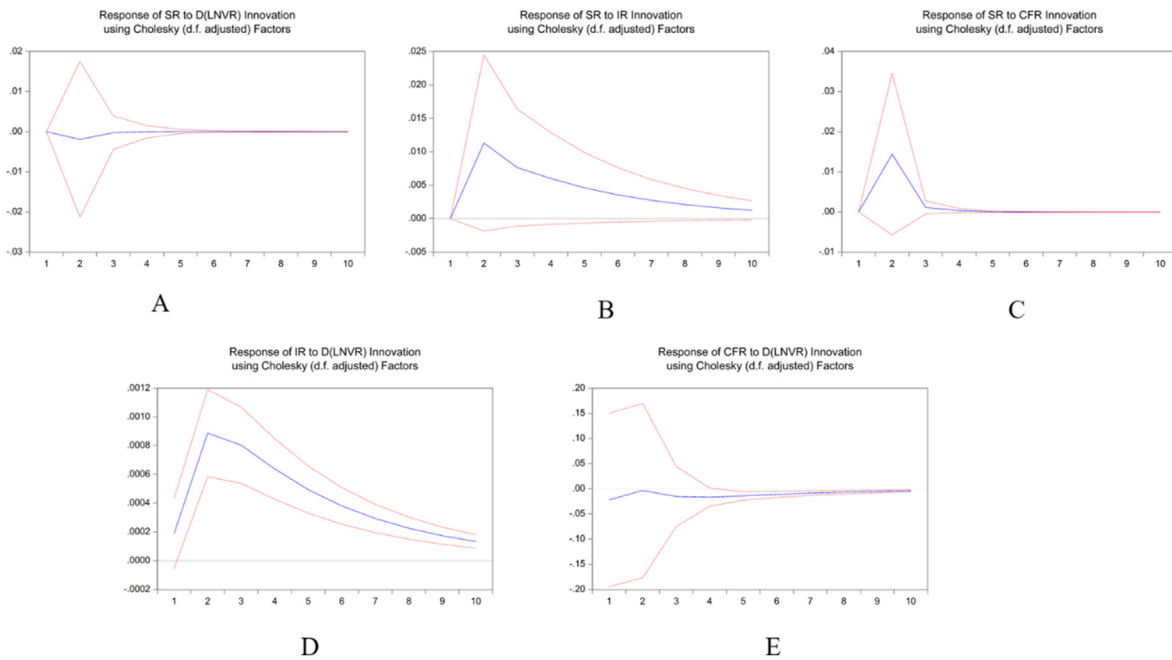**Figure 2.** Impulse-response function in developing countries.

Figure 3. Impulse-response function in developed countries.

vaccine hesitancy varies from low to high, with about 29% of New York residents declaring they would refuse the vaccine, compared with 20% of those in Canada (Latimer 2020) and 6% of those in the United Kingdom (Henley et al. 2020);

(iii) *Investors' confidence in the stock market has not been restored.* Figure 3D and 3E show that IR and CFR also respond positively to a LNVR shock, peaking at day 2 and decreasing in the following days. This means even with an increasing vaccination rate, infection rates and death rates from COVID-19 have also increased in developed countries, leading investors to believe that even with a vaccine, the pandemic is still not completely under control. In that context, they tend to invest in other assets like gold, foreign currencies as a safe haven for stocks (Husnul et al., 2017;

Robiyanto et al., 2017; Wen and Cheng, 2018), which is the reason for the stock market decline.

One bright spot in these results, however, is that stock markets in developed countries have positive responses to COVID-19 infection and death rates. Figure 3B and 3C show that SR responds positively to IR and CFR shocks. Specifically, SR reacts positively to IR shock with the highest level of 0.0114% on day 2, then gradually decreases and lasts for more than 10 next days. SR's response to CFR shock is also positive, but lasts only for 2 days and then stops. According to Auld and Toxvaerd (2021), in countries with a fast vaccination rate, policymakers have relaxed social distancing measures. The reopening policies but not accompanied by strict epidemic control measures such

Table 8. Variance decomposition of SR.

Developing countries					
Period	S.E.	SR	D (LNVR)	IR	CFR
1	2.992204	100.0000	0.000000	0.000000	0.000000
2	3.038773	99.99748	0.000235	0.001856	0.000425
3	3.040232	99.99682	0.000249	0.002426	0.000509
4	3.040283	99.99642	0.000254	0.002778	0.000551
5	3.040288	99.99622	0.000255	0.002958	0.000567
10	3.040291	99.99602	0.000256	0.003150	0.000579
15	3.040291	99.99601	0.000256	0.003157	0.000579
Developed countries					
1	1.283103	100.0000	0.000000	0.000000	0.000000
2	1.289940	99.97946	0.000215	0.007841	0.012483
3	1.290036	99.97586	0.000218	0.011363	0.012555
4	1.290051	99.97369	0.000218	0.013535	0.012562
5	1.290059	99.97241	0.000218	0.014813	0.012562
10	1.290070	99.97069	0.000219	0.016531	0.012562
15	1.290071	99.97056	0.000219	0.016656	0.012561

as wearing masks in public places is the reason for the increasing infection rate and death rate. But on the other hand, reopening makes investors more optimistic about the recovery of the economy, thereby helping the stock market to rise again. Thus, in developed countries, COVID-19 vaccination has a direct negative but indirect positive affect on the stock market.

4.3.4. Variance decomposition results

Finally, we analyze the variance decomposition results to see how SR is explained by LNVR, IR, and CFR. The results of variance decomposition are shown in Table 7 below.

Table 8 shows that in both developed and developing countries, SR was 99% explained by its own shock. Specifically, in developing countries, SR is explained 99.996% by itself, 0.00026% by LNVR, 0.003% by IR, and 0.0005% by CFR. Meanwhile, in developed countries, SR is explained 99.97% by itself, 0.00022% by LNVR, 0.016% by IR, and 0.013% by CFR. We can see that vaccination explains stock market return in developing countries more than in developed countries. In contrast, the rate of infection and mortality from COVID-19 in the developed countries explains the stock market return more than the other. This result is completely consistent with the results of the impulse-response function that we mentioned above.

5. Conclusion

The study uses the PVAR model to analyse the relationship between the stock market and COVID-19 vaccination. Descriptive statistics show that the average COVID-19 vaccination rate in developed countries is 1.22 times higher than that in developing countries (in term of logarithm), confirming the vaccination inequality in 2 group. The results of the impulse-response function analysis suggest that in developing countries, vaccination has a positive effect on the stock market, while in developed countries, this effect is negative. However, the vaccination could have an indirect impact on the stock market through the easing of restrictions after the COVID-19 vaccination. Research also finds that vaccination has caused the market to no longer respond negatively to the pandemic as concluded by previous studies, but even respond positively to the COVID-19 infection rate. The results of the variance decomposition also further emphasize that COVID-19 vaccination explains stock market return in developing countries more than in developed countries. This finding bears the policy implication that developing countries need to step up mass vaccination programs as a measure to recover the stock markets. In developed countries, although vaccination rates are high, governments need to promote public awareness and trust about the effectiveness and role of COVID-19 vaccines. According to the Centres for Disease Control and Prevention (CDC), full vaccination reduces the risk of infection and spread of the virus, and prevents severe symptoms and death, but people must combine vaccination with other preventive measures (e.g., mask wearing in indoor public spaces) to limit the spread of the virus, especially in the context of the emergence of a new coronavirus variant - Omicron - with a higher rate of spread than previous variants, and the effects of current COVID-19 vaccines for this variant are not yet fully established.

In addition to the findings presented above, there are a number of issues that this article has not explored. It is interesting to study the changes in the policies of the countries following the mass vaccination against COVID-19, and how these policies affect the stock markets of the countries. These topics are left for future research.

Appendix

Table A1. Countries covered by the study.

Developed countries						Developing countries					
1	Australia	15	Israel	29	Slovenia	1	Argentina	15	Jamaica	29	Philippines
2	Austria	16	Italy	30	South Korea	2	Botswana	16	Jordan	30	Romania
3	Belgium	17	Japan	31	Spain	3	Brazil	17	Kazakhstan	31	Russia
4	Canada	18	Luxembourg	32	Sweden	4	Bulgaria	18	Kenya	32	Serbia
5	Czech	19	Netherlands	33	Switzerland	5	Chile	19	Latvia	33	South Africa

Table A1 (*continued*)

Developed countries						Developing countries					
6	Denmark	20	New Zealand	34	Taiwan	6	China	20	Lebanon	34	Sri Lanka
7	Estonia	21	Norway	35	UAE	7	Colombia	21	Lithuania	35	Thailand
8	Finland	22	Oman	36	United Kingdom	8	Costa Rica	22	Malaysia	36	Tunisia
9	France	23	Poland	37	United States	9	Croatia	23	Mauritius	37	Turkey
10	Germany	24	Portugal			10	Ecuador	24	Mexico	38	Ukraine
11	Greece	25	Qatar			11	Egypt	25	Morocco	39	Vietnam
12	Hongkong	26	Saudi Arabia			12	Hungary	26	Namibia	40	Zambia
13	Iceland	27	Singapore			13	India	27	Pakistan		
14	Ireland	28	Slovakia			14	Indonesia	28	Peru		

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