♣ To Cite: Fizza, S. (2025). Impact of High Frequency Trading on Stock Market's Volatility under COVID-19: Evidence from Selected Asian Economies. Applied Research in Social Sciences, 2(1), 14-29.

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Applied Research in Social Sciences

Pages: 14 – 29
Vol. 2, No. 1 (2025)

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Impact of High Frequency Trading on Stock Market's Volatility under COVID-19: Evidence from Selected Asian Economies

Abstract: Over the last few years, there has been a dramatic shift in how securities are traded in the capital markets globally. By employing, highly complex algorithms and superfast computer technology, Institutions now execute trades within a matter of microseconds or Nanoseconds through a practice known as high-frequency trading. HFT, now a day's widely used trading mechanism that accounts for 80% of the trading volume of the developed markets as well as getting popularity among developing or volatile markets. This study aims to analyze whether the HFT technique will going to help in diluting the concentration of the stock market's volatility or it exacerbate the recent market turmoil situation of COVID-19. We employed the unique dataset of six stock markets those are involved in High-Frequency Trading as well as non-high frequency trading and are affected by a pandemic with different level (in context of financial disaster) from July 2019 July 2020 in order to capture the difference in volatility level of the selected economies in both dimensions i.e. HFT vs non-HFT as well as Pre-COVID vs. Post- COVID. This study concludes that high-frequency traded stocks are positively correlated with market volatility in both the Pre-COVID and Post-COVID periods, but the relation is comparatively weaker in Post-COVID as compared to the Pre-COVID period. Secondly, in comparison with Non-high frequency traded stocks its stock price volatility rate is low. This implies the high-frequency trading is beneficial in the context of presuming stock volatility in the markets.

Keywords: High Frequency Trading; Market Volatility; Global Pandemic; Pre-COVID; Post-COVID

Introduction

The most recent contagious pathogen, corona virus (officially named as COVID-19) has captivated the attention of whole world since its inception from the Wuhan city of China. Within the matter of few weeks, it crossed the boundaries of china and

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outspread globally. So far, the confirmed number of cases around the globe exceeds from 22 million with death toll of more than 7 lacs and it continuously increases (WHO, 2020). This outbreak effect worse the world's most developed economies such as China, UK, US, France, Italy, Germany and others and of course the emerging economies those are always in struggling process. Sharply, with the declaration of COVID-19 as Global pandemic by World Health Organization, world's stock markets plunged double times, more than 20% fall in international Oil prices in a single day(Albulescu, 2020), global GDP drop below average, downfall in firm's profitability and employment ratio with rise in financial obligations, threat of mass unemployment, food shortages, shutting down of major business like aviation, trade and tourism industry.

In a nutshell, this newborn infection disease shook up all the pillars of world i.e. economic, financial, political, social, technological even religious structures. For our concern here is to have a debate on chaos made by COVID-19 with regards to global financial and economic disruption, specifically global financial market's volatility that is skyrocketed around the globe which seem like end up with short run or may have chance of long run financial pandemic (D. Zhang et al., 2020). This or even less burdensome kind of volatility swings last experienced in 2008 global financial crisis. Surprisingly, no previous contagious outbreak impact economy and financial community in such a powerful manner as of COVID-19 outbreak. Thus, current outbreak not only rises up the biological crisis but also triggers forthcoming financial crisis.

This "once in the century" pathogen, not only mobilize the health community worldwide besides financial regulatory and economic policy makers also call to arms with aim to mitigate the severity of "financial pathogenicity" which resulted from current situation of COVID-19 pandemic. Financial experts and regulators thrown number of financial instruments like crypto currencies in order to cope with economic disturbance but fails to make financial markets comeback with that much kind of positivity. Close, yet far more complex, speedy and highly digitalized system of trading (High Frequency Trading) in stock markets that may act as 'life saver' instrument has not been experimented so far. High frequency trading (HFT) is the subset of algorithmic trading, is a recent phenomenon widely used by investment bankers, institutional investors, hedge funds that enhances the momentum and efficiency of trading activities. It accounts majority of the trading volume of the developed markets and in recent year it is becoming popular among emerging

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economies due to its unique features like low latency, cutting down the transaction cost, provide liquidity to the market by administering the unique high frequency trading strategies. HFT catch the attention of academia as well as policy regulator due to its ambiguous impact on market efficiency (in term of volatility, price discovery, liquidity) as well the assumption that HFTrs generate profits at the expense of traditional traders by manipulating market (Caivano, 2015). Apart from debate on its moral standard, the point of consideration is whether HFT has a positive or a negative impact on market's volatility? Weather the relation between variables are remains the same or it will change with the market situations (here COVID-19) and with trading venues (HFT)? And ultimately whether HFT technique will going to help in diluting the concentration of stock market's volatility or it exacerbate the recent market turmoil situation?

The rest of the paper includes: Section 2 composed of background and prior literature. Section 3 includes Data and Statistics whereas; Section 4 depicts the concluding remarks.

Background and prior literature

High Frequency Trading, market volatility and global pandemic 2020 (COVID-19) are three most aggressive present-day terminologies, frequently debated by scholars. There may some kind of direct or indirect connection among these three. But the relation is still ambiguous even after the substantial empirical research. So far research on COVID-19 pandemic with respect to economic and financial perspective concludes this outbreak as an unprecedented impact on global economic community and financial market's quality. Market's quality can be measured in terms of different parameters i.e. financial economic uncertainty, stock's price discovery, oil prices, market's liquidity, market's volatility and many others. For the smooth functioning of financial markets, these parameters must be in right direction towards efficiency and profitability. But unfortunately, recent global health crisis disturbs this framework worse than ever before. Financial regulators as well as academia community burns mid night oil to discover the intensity of COVID-19 consequences and the vaccine (solution) to deal with existing as well as approaching financial pandemic. They induce many financial gadgets into market like bit coin with aim to narrow down the extremity of the consequences like instant shoot up of stock market volatility, but literature proves that these instruments neither act as hedges nor safe haven in current market turmoil situation. Another recent phenomenon that may call financial instrument is still there, as a ray of hope which we aim to experiment in our analysis.

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Our study stands at the crossroad of two strands of literature. One road leads to address the relation between high frequency trading and financial volatility whereas, the other one scrutinize the impact of COVID-19 on market's volatility.

High Frequency Trading: In relation with volatility

Quality of market can be measured in terms of liquidity provided by the market participants; Market volatility, shows the stability of the market and transaction cost and price discovery etc. empirical research shows that HFT improves price discovery, bolster liquidity, narrow down bid-ask spreads and reduce market volatility to some extent. Ultimately, the literature asserts a beneficial impact of HFT on overall market quality matrix. The center of attention of another strand of literature focuses the ambivalent nature of High Frequency Trading towards market quality measures-i.e. stock market volatility, liquidity and price discovery. On one hand, Algo-trading mitigates market frictions by speeding up price discovery and enhance liquidity thus reduces volatility. On other hand, number of researchers concluded with positive association between HFT and volatility-higher the Algo-trading activity, higher the volatility in stock prices which leads to instability in stock exchanges. Many researchers claim that there is no relation between HFT and volatility. These contradictions in literature regarding relationship between HFT and volatility are still inconclusive.

Björkman & Durling (2018) concluded that HFT reduces stock market volatility by applying GMM model on each stock traded at OMXS 30 index. Similarly, (Chaboud et al., 2014) also advocated a negative relation HFT on volatility and stock price discovery by using first level regression model by applying on FOREX market. (Hagströmer & Nordén, 2013) documented the same results for intraday stock price volatility of stock traded on NASDAQ OMX Stockholm by considering Momentum and Arbitrage strategies.

Zhou & Kalev (2014) examine the algorithmic trading (AT) during the most volatile trading days on the Australian Securities Exchange from October 2008 till October 2009 and came up with conclusion of significant negative association between the level of AT activities in a particular stock and the stock's price swings.

Caivano (2015) was among the authors who found positive relation between HFT and stock price volatility by using Panel two stage instrumental variable approaches by considering blue chip companies operated on Borsa Italiana. In the same line,

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(Boehmer et al., 2014) studied the impact of HFT on stock price discovery and volatility by using methodology of instrumental variable approach on 42 markets across the globe and found a positive connotation between considered variables.

Zhang (2010) found high-frequency trading is positively correlated with stock price volatility after controlling for firm fundamental volatility and other exogenous determinants of volatility. The positive correlation is stronger among the top 3,000 stocks in market capitalization.

Stock market volatility: In relation with COVID-19

The center of attention of another strand of research is to figure out the severity of COVID-19 pandemic's impact on market volatility. Academic scholars have demanded with thorough research on different aspects of corona virus with respect to its global financial and economic impact. Volatility is used to calculate the dispersion of returns for a specific security and it dramatically increased in the stock markets during the pandemic of COVID-19.

Albulescu, (2020) investigated the daily COVID-19 reported cases impact on international oil prices by using ARDL on US market and founded a negative impact on long run. Further, Sharif et al., (2020) documented link between COVID-19, economic policy uncertainty, stock market, and volatility in oil prices by using wavelet-based approach on US market and came to know that market effected more with oil prices volatility than EPU and COVID-19.Study by (Akhtaruzzaman et al., 2020) examines how financial contagion occurs through financial and nonfinancial firms between China and G7 countries during the COVID–19 period and experience significant increase in conditional correlations between their stock returns specifically in financial firms. According to study of (Corbet et al., 2020), this pandemic condition of COVID-19 increases volatility dramatically. While, (Baker et al., 2020) investigated the impact of COVID-19 on volatility and EPU in comparison with earlier pandemics on US stock market and documented a remarkable stock market swings on daily basis.

Data and Analysis

Data of 6 stock markets of Asia; China, Pakistan, India, Malaysia, Japan and Singapore is used to conduct the measurement of the level of High Frequency Trading activity in selected markets and its impact on stocks' volatility before and after COVID-19 period separately to make a detailed comparison at its consequences on

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current market situation. We took this sample in order to capture the influence of this pandemic more effectively as the impact of the outbreak has been the highest in Asian emerging markets whereas emerging markets in Europe have experienced the lowest (Topcu & Gulal, 2020). Regression and correlation analysis is conducted to get the true picture of relationship between HFT and volatility. Daily intraday data from 1st July 2019 to 30 July has been taken. Data is gathered through stock market indices available on Thomas Reuter and analysis are run through STATA.

Correlation analysis:

Correlation analysis is conducted to test whether or not there is a relationship running from either of the variables towards the other. The correlation analysis was conducted for all the sample countries and for the purpose of comparison; the data for pre-COVID and Post-COVID period were analyzed separately. The table 4.1 shows results for Singapore in the pre-COVID period and Post-COVID period. We find that there is strong and positive relationship between SV and HFT and the result is consistent for Post-COVID period. This signifies that there is no significant difference in the relationship between HFT and SV with the occurrence of COVID pandemic, i.e. the relationship remained steady.

In the table1, the correlation analysis for Pakistan in the pre-COVID and Post-COVID period is analyzed. We find that there is a slight increase in the strength of positive relationship between SV and HFT. It means that in the Post-COVID period, the practice of HFT lead to increase in SV and vice-versa.

Analyzing the results of table, we find results opposite to that of Pakistan such that the pre-COVID period relationship between HFT and SV is strongly and positively correlated for Malaysian index, whereas, in the Post-COVID period this relationship is slightly weakened compared to pre-COVID period. This suggests that there was/were mediating factors apart from HFT that affected SV in the Post-COVID period. The results of correlation for Japan show that the relationship between HFT and SV in the pre and post COVID period is extremely weak for Japan index. This is the weakest relationship when compared to other sample countries. This clearly shows that the SV is not related to HFT in the Japan region, but there are other factors that could be affecting SV in Japan index. In case of India, the results suggest similar yet weak correlation for both the periods. It could mean that there are other variables that could impact the SV rather than the HFT variable. However, the Chinese index shows a stronger correlation in the Post-COVID period as compared to pre-COVID period. This could mean the increase of HFT in china in the Post-COVID and its impact on

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the SV. This could be due to the downfall of Chinese economy due to COVID and the need for the companies to re-establish their presence in the market. Hence, the increase in HFT trading as well as its impact on SV. For further analysis of the relationship between HFT and SV, we conduct a linear regression analysis for both pre and post COVID periods for each sample country separately. This helps in comparing and contrasting the results in the sample countries.

Table 1. Correlation between SV and HFT

	Pre-COVID	**Post-COVID**
Pakistan	0.484	0.56
India	0.343	0.307
China	0.576	0.647
Malaysia	0.805	0.783
Singapore	0.663	0.674
Japan	0.056	0.032

Regression Analysis

Regression Analysis is utilized to determine whether or not our dependent variable, SV is affected by our independent variable, HFT, before or after the COVID period. For this purpose, we design a model, wherein, SV is our dependent variable and HFT is our main independent variable.

Table 2. Regression Analysis of Considered sample (Pre-COVID)

	coefficient	**Standard error**	**t- statistics**	**p-value**	**R-Squared**	**Adj. R-squared**
Pakistan	0.34 ***	0.027	12.48	0.000	0.267	0.26
India	0.56***	0.021	26.06	0.000	0.153	0.15
China	0.25***	0.006	40.29	0.000	0.496	0.49
Malaysia	0.18***	0.004	38.09	0.000	0.611	0.61
Singapore	0.29***	0.012	23.26	0.000	0.459	0.46
Japan	1.634***	0.141	11.55	0.000	0.034	0.03

Note: ***shows significance at 1%, ** at 5% and * at 10% correlation

From the Regression results, table 2 shows that in Singapore in pre-COVID period, the HFT is statically significant at 5%. The p-value of 0.000 shows strong relationship

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between HFT and SV for the pre-COVID period. Furthermore, the Post-COVID period shows a similar result for Singapore. We also find that the R-squared is 46% approximately, which means that the independent variable significantly helps in explaining the dependent variable. We can say that in the Malaysian context, the HFT affects SV in both, pre and post COVID periods which also means that COVID pandemic does not have any significant impact in affecting this relationship between HFT and SV in Singapore.

Table 3. Regression Analysis of Considered sample (Post-COVID)

	coefficient	Standard error	t- statistics	p-value	R-Squared	Adj. R-squared
Pakistan	0.37***	0.024	15.3	0.000	0.354	0.352
India	0.64***	0.027	23.43	0.000	0.127	0.127
China	0.21***	0.004	44.4	0.000	0.544	0.544
Malaysia	0.21***	0.005	36.7	0.000	0.594	0.593
Singapore	0.36***	0.015	24.02	0.000	0.476	0.475
Japan	2.71***	0.293	9.26	0.000	0.022	0.021

Note: ***shows significance at 1%, ** at 5% and * at 10% correlation

In table 2 and 3, the results of regression in Pakistani context are presented. The pre and post COVID results, both suggest a significant and positive impact of HFT on SV as the p-value is 0.000 which is <0.05. We notice that the r-squared has improved in the Post-COVID period, which means that the relationship between HFT and SV is better explained in the Post-COVID period as compared to pre-COVID period. Same tables show the Malaysian index results for regression. The results suggest that there is significant impact of HFT and SV as the p-value is 0.000. the r-squared suggests that the pre-COVID HFT variable explained the relationship with SV better as compared to Post-COVID period. This differs with that of Pakistan, which could be due to differences in cultural setting of both the countries. From results, we find that similar to the results of correlation, the Japanese index shows a very weak r-squared of only 3% and 2% approximately in the pre and post COVID periods respectively. However, the impact of HFT on SV remains significant, this could suggest lack of proper explanatory variable, hence, the low r-squared. Similarly, Indian index shows a weak HFT variable in explaining SV for both pre and post COVID periods. The HFT impact on SV is significant and the COVID as mediating variable helps little in explaining the HFT impact on SV as there is no significant differences in both the periods. The findings suggest that there is significant and positive relationship between HFT and SV in case of Chinese Index. We further notice that the r-squared has increased drastically from 49.60% in pre-COVID period to 54.45% in the Post-COVID period. We can say

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that the COVID pandemic did play a mediating role in affecting the relationship between HFT and SV. Based on the above correlation and regression analysis results, we can make conclusive remarks on our constructed hypothesis. Our first hypothesis stated that "there is a positive relationship between HFT and SV". This is true for both pre-COVID period and Post-COVID period that HFT and SV are positively related; however, the strength of relationship is significantly weak, specially, for Japan and India in both pre and Post-COVID periods. It suggests us that there are other reasons for volatility in the financial markets of these countries. Whereas this relationship is positive and significant in Singapore, Malaysia, Pakistan and China. Therefore, we accept the first hypothesis as HFT and SV are positively related and simultaneously, we reject the second hypothesis which states that there is negative relationship between HFT and SV. Our third hypothesis states that financial stocks with HFT involvement are more vulnerable to SV during pre-COVID period as compared to those not involved in HFT. Our fourth hypothesis states that companies with HFT activity are less vulnerable to SV in the Post-COVID period. From our results, we find opposite result. It suggests that compared to Post-COVID period, the relationship between HFT and SV is stronger than pre-COVID period. This is the case in Singapore, Pakistan and China, but in Malaysia, the relationship is stronger in pre-COVID as compared to Post-COVID period. From the above regression analysis, the relationship between SV and HFT are clear as our findings suggested that in the pre-COVID period SV depends on HFT, however, the causal relation between these two main variables is unclear. It means that we are unsure of whether HFT causes SV and vice-versa or both. For this purpose, we conduct a Granger causality test which helps us in understanding which variable causes which variable and whether or not if there is a bi-directional relationship between both the variables.

Granger Causality test

Granger Causality test determines the causal relationship between each variable and further depicts the direction of the relationship of the concerned variables. In order to test for causality, we have to conduct a co integration test like Vector Auto regression (VAR) that helps to determine the direction of causality. VAR is essential as it tests the past values of other variables to the past values of the variable itself.

For instance, as we test for casual relationship between SV and HFT, then VAR determines the past values of HFT and SV to find correlation between current values of HFT and past values of SV. Thus, if past values of HFT can predict SV, then we can conclude that HFT Granger-cause SV. Conversely, if we find that past values of SV

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predict HFT, then we can conclude that SV Granger-cause HFT. This relationship is also called unidirectional causality as one variable granger-cause another variable. However, if both HFT's and SV's past values predict each other's present values then such causal relationship is bidirectional causality. The past values of each variable are also known as the lagged values (hereby, we use the term lagged values for better technical understanding of the results). Following are the results generated for Granger-causality after running tests for VAR (not included in results) using STATA analytical tool.

Table 4 Results of Granger Causality Test

		Pre-COVID		Post-COVID	
		SV	**HFT**	**SV**	**HFT**
Pakistan	Chi 2	269.6	2.148	237.5	0.00
	Prob>Chi 2	0.00	0.34	4.019	O.13
India	Chi 2	335	6.606	335	0.609
	Prob>Chi 2	0.88	0.96	0.00	0.738
China	Chi 2	0.237	0.379	139.4	2.875
	Prob>Chi 2	0.88	0.82	0.00	0.237
Malaysia	Chi 2	25.12	42.11	72.19	24.09
	Prob>Chi 2	0.00	0.00	0.00	0.00
Singapore	Chi 2	48.14	8.46	21.78	16.21
	Prob>Chi 2	0.00	0.01	0.00	0.00
Japan	Chi 2	3.656	0.006	1.156	0.025
	Prob>Chi 2	0.561	0.987	0.561	0.98

Table 4 illustrates the results of Granger-Causality for the Singapore index for pre-COVID and Post-COVID periods respectively. The results suggest that there is a bi-directional causal relationship between HFT and SV in both the periods as p-value < 0.05. However, this relationship is strongest in the Post-COVID period as compared to pre-COVID period. Subsequently, from results, we find that in Pakistan, the causal relationship runs from SV to HFT as p-value is 0.000 and p-value for HFT to SV is 0.342 i.e., >0.05. Hence, there is one-way causal relationship from SV to HFT in Pakistan, as result is consistent for both pre-COVID and Post-COVID periods. In case of Malaysia, the findings suggest that in both, pre-COVID period and Post-COVID period, the causal relation is bi-directional i.e., SV causes HFT and simultaneously HFT causes SV in Malaysia. However, in Japan the findings are different. We find that there is no causal relationship between SV and HFT as p-value for SV to HFT is 0.161 and for HFT to SV is 1.000. Similar result is found in the Post-COVID period as p-values are 0.561 and 0.987 for SV to HFT and HFT to SV respectively.

Furthermore, the granger causality for Indian index is presented. The results suggest that in the pre-COVID period, there is a causal relationship running from SV to HFT

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(as p-value is 0.000), but not from HFT to SV (as p-value is 0.969). The results are consistent for Post-COVID period as the relationship is running from SV to HFT (p-value is 0.000) and not from HFT to SV (as p-value is 0.738). This suggests that there is no significant mediating effect by COVID pandemic on the relationship between HFT and SV in India.

The results for Chinese index are depicted. The findings for China show some interesting relationship pattern. In the pre-COVID period the p-values are quite high at 0.888 and 0.827 for SV to HFT and HFT to SV respectively. Hence, no causal relationship is flowing from either of the variables. However, in contrast, in the Post-COVID period, there is significant causal relationship flowing from SV to HFT as p-value is 0.000. But there is no causal relationship flowing from HFT to SV in the post COVID period as p-value is 0.237. Thus, COVID pandemic plays a mediating role for Chinese index as SV causes HFT.

Based on the above results of Granger-Causality between HFT and SV for pre-COVID period and Post-COVID period, we can make conclusive remarks on our premised hypothesis. Our hypothesis suggested that "there is causal relationship from Algorithmic trading activity to stock volatility", and, we found that causal relationship in Singapore and Malaysia but not in other sample countries. However, in other sample countries (except Japan) we found SV causes HFT. It means that stocks with high volatility tend to involve in Algorithmic trading activity in the case of selected Asian sample countries (except Japan). Therefore, we reject the hypothesis H5.

Further, our hypothesis suggested that "there is no bi-directional relationship between HFT and SV", and this is evident from our results as we found no bidirectional relationship between the two variables except in the case of Malaysia. However, as mentioned earlier, only SV causes HFT whereas, HFT does not cause SV. Therefore, we accept the hypothesis H6 of no bidirectional relationship among HFT and SV.

Conclusion

The aim of this research study is to find the relationship between HFT and volatility in turbulent period of COVID-19. To find the relationship between HFT and volatility we use SV as measure of volatility and HFT as measure of Algorithmic trading activity. We use statistical tools to determine positive or negative relation namely, correlation analysis and we find that the relationship between HFT and SV, as predicted, is positive and significant for Singapore, Malaysia and China (Post-COVID period) and insignificant for Japan, Pakistan and India. We further conduct a

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regression analysis to find if SV is dependent on HFT in both pre- and Post-COVID period. Our findings suggest that as predicted, in the pre-COVID period the SV depends on HFT significantly and this relationship is consistent in the Post-COVID period possibly due to some other factors that have affected the stock market presumably the financial effects of COVID outbreak. As per study of (Mamtha & Srinivasan, 2016) factors like information flow, trading volume, economical aspects and investor's behavior are may the cause of volatility in the stock markets. Furthermore, in order to determine the causal relationship between HFT and SV we adopted the use of Granger-causality test. In contrast to our predictions, we found that SV causes HFT and not the other way around except in Singapore and Malaysia. Finally, we also found that there is no bi-directional relationship between HFT and SV except in case of Singapore and Malaysia. Our study is subject to certain limitations, such as, results are subject to data availability and some firms did not disclose their data. The results cannot be generalized for other countries, as there could be other factors affecting the financial market volatility. However, we suggest future studies can include more variables and determine the cause of differences in the Post-COVID period as the effect of HFT on SV is steady. The study is useful for government regulators and policy makers to monitor the HFT activities and regulate the stock markets accordingly.

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