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Exploring the Performance of Financial Derivatives in the Context of a Global Public Health Crisis and Their Tole in Risk Management

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Abstract: The worldwide implications of the COVID-19 pandemic had a lot of impact on the markets, identifying the weaknesses of financial instruments, especially the derivatives such as credit default swaps (CDS), futures, and options. These derivative risk management tools have been subjected to extreme volatility, forcing specialists to look into their effectiveness under extremely hazardous conditions. This article highlights the participation of derivatives in the market downturn period amid the pandemic, targeting the VIX index and the Global Interest Rate. Employing both quantitative and qualitative perspectives, such as the estimation of event studies and regression analysis, the research investigates the onset of the pandemic and the derivatives markets and assesses these markets' role in responding to global uncertainty. The study's results illustrated the derivative's dual function in the pandemic, which was capable of efficient risk mitigation, although there were chances of market volatility becoming uncontrollable. This suggests that the regulators' supervision and effective risk management technologies are needed to surmount systemic risk during periods of uncertainty.

Keywords: Financial Derivatives, COVID-19, Risk Management, Multivariate Regression.

1. Introduction

Financial derivatives are financial instruments tailored to deal with the risk inherent in the value of an asset. Derivatives can be categorized based on three key factors: product form, underlying asset, and trading scenario. In the context of trading, there are two types of markets with derivatives: on-exchange and off-exchange transactions. Exchange trading is the place where trading transactions aggregate for all buyers and sellers, so on-exchange trade includes the centralized bidding process[1]. OTC trading is the trading that occurs when two parties exchange the underlying asset(s) as counterparts directly. Financial derivatives are known to be a good coping strategy to the turbulent market and risk hedging in most market situations. It is evident that under a worst-case scenario, financial derivatives, which were initially minted for hedging risk management, have ultimately grown into investment products, both direct and indirect, of extremely complicated structures combined with high risk and high leverage[2]. Unfortunately, lack of systematic research on the leverage and performance of derivatives markets under extreme market conditions, such as the ones caused by the COVID virus, which affected the whole world, has been a bad point. Through this

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incomplete knowledge, the question of financial derivatives market behavioral patterns and mechanics remains today's task. We have today a special and rare opportunity to study the uncertainty and rivalries in the global markets that are conditioned by the New Crown epidemic. The paper focusses on the evolution of the derivatives market from the first year of the coronavirus pandemic using a mixed methodology using statistics and qualitative information. This research will particularly analyze derivatives pricing changes, liquidity risk, and the government-like instruments' effect on the derivative price. This study not only aims at enhancing our understanding of the connection between financial crises and the use of derivatives but it also attempts to impart knowledge on the utility of derivatives in managing risks posed by probable crises in the future.

2. Literature Review

Since the onset of the COVID-19 pandemic, there has been significant research on the impact of the pandemic on global financial markets, mainly focussing on the performance and role of the financial derivatives market during this unique period. The studies can be broadly categorized into the following major areas:

Research on the volatility and liquidity of the derivatives market: At the outset of the epidemic, the global financial market experienced substantial fluctuations, which had a significant impact on the financial derivatives market. Analysis of volatility indices such as the VIX and liquidity indicators in the options and futures markets has revealed that the pandemic heightened market uncertainty and resulted in sharp fluctuations in derivatives prices. According to Qin Long, the COVID-19 pandemic has dramatically impacted global economic development and social operations, intensifying market volatility and prompting countries to implement macro-policy regulations to address the crisis. The domestic bond market yields initially declined and then rose, while interest rate levels and maturity spreads experienced unprecedented fluctuations. Despite this challenging environment, the bond derivatives market has continued proliferate, increasing trading volumes across various derivative types, a diversified participant base, and introducing new derivative products[3]. Xuechan Li found in his empirical study of 48 listed companies that the overseas business income of the sample companies was positively correlated with the willingness to use derivatives, and a more reasonable explanation is that this part of the income needs to be protected against the risk of exchange rate fluctuations through derivatives[4]. Yang Shenggang et al., by combing the existing studies, mainly select the determinants of financial derivatives use from the two levels of the company's financial characteristics and corporate governance, including enterprise size, the number of years of listing, the growth rate, financial leverage, the independence of the board of directors, the combination of the positions of the chairman and the general manager, and the nature of the shareholding[5]. At the same time, the drying up of liquidity in the derivatives market has exacerbated systemic risk.

Analysis of the risk management function of derivatives: Several studies have examined the risk management role of financial derivatives during the COVID-19 pandemic. Although derivatives were designed as a tool to hedge risks, after the outbreak, some studies found that the dramatic volatility in the derivatives market instead amplified the risk exposure of financial institutions. Kong Mingyi suggests that from the global financial derivatives trading data since 2020, it can be seen that by the adverse effects of the impact of the new Crown Pneumonia epidemic, the global financial market fluctuates violently and the risk is significantly amplified, while the financial derivatives market is conducive to stabilizing the investors' mood, especially when the underlying market fluctuates violently, it is an effective measure for the risk prevention tool and keeping the market inflow of funds. In a market crisis, financial futures options can provide market liquidity and release the pressure of market risks[6].

Interaction between policy response and derivatives market: under the influence of the COVID-19 pandemic, although the volatility of the global financial market has increased, the degree of

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openness in China's futures market has deepened, and the derivatives market has become more and more active under the situation that investors' demand for the derivatives market has risen dramatically[7]. Zhongloudong notes that with the advancement and deepening of China's market economic system reform and opening up to the outside world, the continued impact of the three-year pandemic, the influx of overseas risks and the increasing prominence of listed companies of varying quality, China's real industry is faced with more and more market risks, and the demand for more effective and more diversified risk-hedging tools has also increased. As a result, China has progressively introduced various financial derivatives for trading, and the financial derivatives market has slowly begun to grow[8]. Contagion effect of global financial markets: In the context of economic globalization, the deepening of financial openness of countries and regions has led to increasingly close ties between international financial institutions and markets, but at the same time, with the deregulation of financial controls in various countries and the rapid flow of capital and information in international financial markets, the contagion effect of financial risks has been emerging in recent years, and localized financial risk events are more likely to spread through international financial networks and eventually evolve into a global financial crisis. international networks and eventually evolve into a global financial crisis. The global neococcal pneumonia epidemic event in 2020 plunged the global economy into recession, the international financial market was violently shaken, and the international capital market was seriously illiquid, which triggered serious global financial volatility[9]. Tang Yingying new coronavirus pneumonia “(COVID-19) epidemic outbreak, with the rapid development of the epidemic, the global stock market also violent shock. Starting in mid-February, the stock market, as the representative of the global financial markets, suffered heavy setbacks. The U.S. stock market is in just eight trading days, four times the first level of meltdown. Although from the major stock indices in Europe and the United States and the A-share composite index response, the impact of this epidemic impact is global[10]. This groundbreaking study builds on previous research by examining the performance of derivatives in extreme market conditions and their vital role in risk management. Unlike past studies, this paper conducts a comprehensive analysis using quantitative and qualitative methods to investigate the combined impact of VIX and liquidity changes. Furthermore, it introduces a novel approach utilizing multiple regression models to assess derivatives' performance under diverse market conditions and pinpoint the crucial factors influencing their effectiveness.

3. Related Concepts and Theoretical Foundations

The Derivative Pricing Theory: Derivatives pricing theory is vital in financial engineering, encompassing pricing models for options and futures. The renowned Black-Scholes model is widely used, but it is not immune to market upheavals like the recent COVID-19 crisis. During such events, the model's assumptions may no longer be valid, impacting derivative pricing.

Efficient Market Hypothesis(EMH): The concept of market efficiency asserts that in an efficient market, all publicly available information is instantly factored into asset prices. This means market prices are always fair, and investors cannot consistently profit from known information. According to this theory, the cost of a derivative should precisely reflect the market's expectation of the future movement of the underlying asset. However, the sudden and widespread impact of the COVID-19 pandemic has called into question the assumption of market efficiency, resulting in pricing anomalies and market failures in the derivatives market.

The Financial Instability Hypothesis: The financial instability hypothesis, proposed by Hyman Minsky, argues that the stability of financial markets can itself lead to instability. That is, during a period of sustained market prosperity, financial institutions and investors will gradually increase their leverage and take on greater risks, ultimately leading to market bubbles. Once an external shock occurs, such as the COVID-19 pandemic, these accumulated risks could trigger a massive market

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crash. Derivatives markets play a role in amplifying risks in this process, especially in terms of leveraged operations and risk transmission. Thus, rather than attributing the financial crisis largely to cyclical economic turmoil, the inherent instability of the financial sector itself is the most fundamental cause of the crisis[11].

The Risk Contagion Theory: The theory of risk contagion highlights how financial risks can quickly spread through interconnections between markets, creating systemic risks. In a globalized financial market, derivatives are a crucial conduit for risk contagion due to their leverage and intricate trading structure. Throughout the COVID-19 pandemic, global financial market linkages intensified, with the derivatives market accelerating the transmission of risks through the trading chain. This led to heightened market volatility and amplified the instability of the global financial system.

4. An Empirical Analysis of Financial Derivatives Responses to Global Uncertainty in the Context of the New Crown Epidemic

4.1. Data sources and description

(1)The source of data

Chicago Board Options Exchange (CBOE): CBOE is one of the esteemed markets of options. Historical data on VIX, a major factor concerning the market volatility ahead, will be collected. This work will make use of the historical data of the Chicago Board Options Exchange (CBOE) VIX index to explore how volatility has altered the derivatives market and the financial sector at large[12].

Bank for International Settlements (BIS, Bank for International Settlements): Roaming through the Bank for International Settlements (BIS) on a regular basis, we come across statistics regarding the global derivatives market, such as the trade volume, value of open positions, and so on. These data will be the baseline in monitoring the overall dynamics of global derivatives markets and the variations across different regions and derivatives market types triggered by the pandemic[13].

Federal Reserve Economic Data (FRED): FRED plays an essential role in macroeconomic and financial market-related data distribution, such as TED spreads, the VIX index, and US Treasury yields. The worldwide data sourced will assist us in the analysis of the movement and current trends of the global derivatives market and the impending impacts of the pandemic on different zones and types of derivatives markets. Rather, the data matters will also be utilized to examine the issue of market liquidity, the volatility of the market, and its impact on the derivatives market as well[14].

Moreover, it is going to provide data on the ratio of assets of financial institutions which are trading in derivatives and how this influences the management operations of their trading partners.

(2)Data Time Range

This study obtains data for the period between December 2019 and December 2021; this embraces the COVID-19 worldwide pandemic, high diving in commodity market prices, and subsequent policy response and recovery in the economy. The wide range of this interval may be seen as directed both towards the pre- and post-crisis periods of the financial derivatives market, which ultimately results in an empirical dataset with strong statistics.

(3)Data types and descriptions

The data to be collected will include the VIX index based on the mean implied volatility of S&P 500 options, volume, and prices for such stocks. Such data will form the basis for a determination of the volatility and performance of the derivatives market in times of large market swings. Furthermore, we will gather global Credit Default Swap (CDS) spread data, which will focus on the performance of other key companies and financial institutions as well. These listed benchmarks, in turn, stand for the variations in market understanding of credit risks, each being connected with a particular entity, becoming one of the key factors for evaluating credit spread in the time of Coronavirus. Hence, we will also compile the market risk data, particularly involving TEDS spreads, LIBOR, and US Treasury

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yield. It will, therefore, be a timely basis to probe the liquidity structure of the market and its potential effects on the derivatives market, especially while studying liquidity tightening under extreme stress to the markets.

This data pool will include futures market information, with primarily gross trading volume, price adjustments on key commodities, and financial futures contracts. Apart from the case, the question of what happened in April 2020 when prices of WTI crude oil future contracts plummeted into the negative territory is of exceptional importance. It will help to raise awareness of the trading behaviour patterns of the derivatives markets in situations of adverse market nvironments. Ultimately, we wish to acquire the data of financial institutions as a whole, including ratios of leverage, balance sheet information, and other relevant metrics. These data will help constitute an assessment of risk management practices of financial institutions during the spread of the disease and a spread of the derivatives market-related issues.

(4)Data processing and analysis

Data cleaning and normalization are necessary for our analysis process to get on track. We make our data properly cleaned and standardized to let others appreciate the differences and the similarities. In addition, we use outlier statistics and handling methods. By doing this, we take measures to maintain the integrity of our results.

4.2. Multiple Regression Cconstruction

Through doing this study, a multiple regression model aims to provide an insight into the elements that drive volatility and risk pricing within the derivatives sector. The model brought into play two important clues of derivatives markets — VIX and the global interest rate — thus becoming the dependent variable in the multiple regression. It was very important to furnish a basket of indicators suitable for studying and monitoring changes in volatility and main trends of the market's economic structure. On the other hand, they could be determinants of pricing, trading volumes, and risk regulation and management in the financial market of derivatives.

1. VIX equation:

Dependent variable: the VIX (market volatility index)

Independent variables: GLOBAL INTEREST RATE: a measure of activity in the derivatives market. TED spread: a measure of market liquidity. Unemployment rate: a measure of macroeconomic conditions. S&P 500: a measure of overall market movement.

A multiple regression model with the VIX index as a variable can be expressed as:

$$VIX=$$

$$\beta_0 + \beta_1 \times Global\ interest\ rate + \beta_2 \times \text{TED Rate} + \beta_3 \times \text{Unemployment rate} + \beta_4 \times \text{SP500} + \varepsilon$$

2. Global interest rate equation:

Dependent Variable: Global interest rate

Independent variables: VIX (market volatility index): an indicator of expected market volatility. TED spread: an indicator of market liquidity. Unemployment rate: a variable measuring macroeconomic conditions. S&P 500: a measure of the overall market trend.

$$Global\ interest\ rate=$$

$$\beta_0 + \beta_1 \times VIX + \beta_2 \times TED\ Rate + \beta_3 \times \text{Unemployment rate} + \beta_4 \times \text{SP500} + \varepsilon$$

which: Intercept term(β_0): denotes the expected value of the dependent variable when all independent variables are zero.

Coefficient of independent variable(β_1, β_2, β_3, β_4): indicate the degree of influence of the respective variables on the dependent variable, respectively.

error term(ε): denotes the model's unexplained random errors.

Model analysis steps:

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(1) Data collection and preprocessing: relevant data during the epidemic period (December 2019 to December 2021) were collected, cleaned and standardized to ensure consistency and comparability across the independent and dependent variables in the model.

(2) Model estimation and testing: the regression model was estimated using the least squares (OLS) method to calculate the regression coefficients of the respective variables (β_1, β_2, β_3, β_4).

(3) "Interpretation and analysis of results: It is crucial to thoroughly analyze the magnitude and direction of the respective variables' impact on the dependent variable based on the regression results. Special emphasis should be placed on understanding how trading volume, market liquidity, and leverage ratios in the derivatives market collectively shape market volatility and credit risk dynamics during the epidemic. Data encompassing global VIX, SP&500, TED Rate, global interest rate, and the unemployment rate were meticulously collected and cleansed from FRED and BIS, spanning December 2019 to December 2021. These datasets were subsequently structured into tables using STATS to aid in comprehensively evaluating the specific variables' influence on market dynamics during the epidemic."

Table 1: Multiple regression results for the dependent variables, global interest rates and VIX

	(1)	(2)
VARIABLES	GLOBAL	VIX
VIX	656.7	6.28e-07**
	(1,195)	(2.74e-07)
TEDRATE	-1.058e+06**	0.000631
	(489,463)	(0.00165)
UNRATE	5.914e+06	2.889***
	(3.505e+06)	(0.377)
GLOBAL	332,033**	1.607
	(144,609)	(5.140)
Constant	2.265e+06	-2.160
	(5.575e+06)	(7.686)
Observations	25	25
R-squared	0.375	0.898

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

5. Result

The findings reveal significant variations in the impact of different independent variables on GLOBAL and VIX, shedding light on the underlying mechanisms of these economic factors during the COVID-19 pandemic.

(1) : Global Interest Rate (GLOBAL)

In the regression model with the global interest rate (GLOBAL) as the dependent variable, we found that the TED spread (TEDRATE) and GLOBAL wield significant influence, while the remaining variables (VIX, Unemployment) demonstrate statistically. The regression coefficient for VIX is 656.7 with a standard error of 1,195. Although positive, this suggests that the direct effect of market volatility on GLOBAL is not significant, as indicated by the p-value ($p > 0.1$). The regression coefficient of TED spread (TEDRATE) is -1.058e+06 with a standard error of 489,463, which is significant at the 0.05 level ($p < 0.05$), indicating that the effect of TED spread on global interest rates is negative and significant. This implies that an increase in TED spreads is significantly associated

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with a decrease in global interest rates during the epidemic, reflecting that a tightening of market liquidity may lead to this decline.

The regression coefficient for the unemployment rate (UNRATE) is 5.914e+06 with a standard error of 3.505e+06 and a p-value greater than 0.1, suggesting that the effect of the unemployment rate on global interest rates is not statistically significant. Although an increase in the unemployment rate usually brings about an adjustment in monetary policy, the direct effect of the unemployment rate on the global interest rate fails to reach statistical significance in this model.

The regression coefficient of GLOBAL itself is 332,033 with a standard error of 144,609, which is significant at the 0.05 significance level ($p < 0.05$). This result indicates that the movement of global interest rates has a significant positive effect on its own future trend, which may reflect the inertia characteristic of global interest rates. The constant term (Constant) is 2.265e+06 with a standard error of 5.575e+06 and a high p-value, indicating that the benchmark value of GLOBAL is not significant when all independent variables are zero, which suggests that there may be other important factors not included in the model. The R-squared value of 0.375 indicates that the model explains 37.5% of the variability in GLOBAL. While the model explains a portion of the volatility in GLOBAL, the overall explanatory power is limited, suggesting that GLOBAL may be significantly influenced by other factors.

(2): Market Volatility Index (VIX)

In the regression model with Market Volatility Index (VIX) as the dependent variable, the results show that Unemployment Rate (UNRATE) is a significant factor affecting VIX, while the other variables are not significant. The coefficient of VIX is 6.28e-07 with a standard error of 2.74e-07, which is significant at the 0.05 significance level ($p < 0.05$). Although VIX is the dependent variable, the item may be due to regression error or the autoregressive structure of the model and should be interpreted with caution.

The regression coefficient for TED spread (TEDRATE) is 0.000631 with a standard error of 0.00165 and a p-value greater than 0.1, indicating that the effect of TED spread on VIX is weak and insignificant. The regression coefficient of Unemployment Rate (UNRATE) is 2.889 with a standard error of 0.377 which is significant at the 0.01 significance level ($p < 0.01$), indicating that an increase in unemployment rate significantly increases market volatility (VIX). This result is in line with expectations as rising unemployment is usually associated with increased economic uncertainty, leading to a rise in investor panic, which pushes up the VIX. The regression coefficient of Global Interest Rate (GLOBAL) is 1.607 with a standard error of 5.140 and a p-value greater than 0.1, indicating that the direct effect of global interest rate on VIX is insignificant.

The constant term (Constant) is -2.160 with a standard error of 7.686 and a p-value greater than 0.1, indicating that the benchmark value of VIX is insignificant with all independent variables at zero. The R-squared value of 0.898 indicates that the model is able to explain 89.8% of the variability of the VIX, which is a strong explanatory power, suggesting that variables such as the unemployment rate have significant explanatory power on market volatility, especially the impact of the unemployment rate as a key driver.

Combining the analytical results of the two regression models, the study finds that TED spreads have a significant negative impact on global interest rates. In contrast, the unemployment rate substantially and robustly influences market volatility (VIX). The statistically insignificant effects of international interest rates and TED spreads on market volatility suggest that factors such as market sentiment and policy responses may have driven market volatility to a greater extent during the epidemic. These results therefore suggest that careful examination of the latter and the TED spreads and unemployment rates as the major determinants of market risk and uncertainty during the COVID-19 pandemic can go a long way in enhancing economic recoveries.

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6. Discussion

1. TED spreads and derivatives usage in financial markets

Consequently, TED spreads directly influence interest rates in economies and global markets. Thus, TED spreads can be considered as one of the key financial indicators used to measure various risks of treasury debt securities. The current state of the market, shall they admit, presents a challenge; the TED spreads, for instance, would reflect the entailing risks of the instruments, which would dilute the racing liquidity. The mitigation of derivatives market risk stemming from expanding TED spreads is in the process of being scrutinized. In particular, if TED spreads were to widen significantly, financial derivatives, such as interest rate swaps and credit default swaps (CDS), could be endangered with pricing difficulties and liquidity risks. Investors as well as financial institutions may dodge liquidity risk relating to the alteration of the common constellation of their derivative positions, which is likely to add to the CAGR of derivatives markets. Additionally, liquidity pressures may require participants not to close some contracts of their derivatives, resulting in growing uncertainty in the marketplace.

2. The link between unemployment rate and market of financial derivatives

The derivation of the VIX index for unemployment and its positive association with sudden uncertainty in the market is indicative of the extent to which rising unemployment can directly increase market instability. Depending on the response, this increased volatility may lead to a rise in market participants' expectations of future uncertainty, which may lead to the demand and the price of derivatives going up and down.

In a setting with a high rate of unemployment, where volatility follows, options, for example, in the derivatives market, may experience an increase in presumed volatility. It could be that the VIX stock market index growth could make option prices also go up because the implied market volatility is essential in the parameter of option pricing. Investors may step up the use of options as an insurance instrument to manage market uncertainties, which may introduce more transactions in the options market. In addition, joblessness is typically coupled with downward economic pressures, which may trigger an increase in corporate credit risk, and the demand for credit-swap instruments such as credit default swaps (CDS).

3. Global Interest Rates and Financial Derivative Markets

Global interest rates on the VIX index, whereas, though not as directly impactful as the interest rate derivatives market, tend to be altered. Diversions caused by global interest rates ultimately create an impact both on pricing and volume of the interest rate futures, interest rate swaps, and other derivatives. Response of the derivatives market: When prevalent, financial institutions and firms aim to use interest rate derivatives to lock in borrowing costs or hedge the interest rate risks during the excess volatility. In the case when interest rates remain low or vary at short intervals, investors may trade interest rate derivatives with the double aim of hedging the volatility of future rates and securing an advantageous market position.

4. Connecting thematic concepts and practical consequences.

Risk Management Tools: To strengthen our findings, the study shows that the level of economic parameters like TED spread and unemployment also has a significant effect on the market volatility and interests during the epidemic. This type of circumstance compels the participants of the financial derivatives market to cope with the higher risk management level. The new era of the epidemic began with the increased use of financial derivatives, including options and credit derivatives, to manage the unforeseen market conditions. Such instruments can support market actors in avoiding uncommercial unemployment or general freeze risks that usually heighten in the markets, and these instruments can help with maintaining the portfolio's stability. The Extending Role of Derivative Market: Nevertheless, it is appropriate to bear in mind that, on the one hand, the derivatives market

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is an important part of risk management, and may contribute to increasing volatility of financial assets due to the uncertainty, on the other hand. That is, a sudden rise in the VIX index, an index that represents market volatility, may cause disruptions in the options market, while the leverage effect of the derivatives market will further increase the chances of the potential impact of the economic crisis. The amplifying impact of the derivatives market on greater stock volatility is a worthy problem that should be addressed by market regulators and participants. Sensible comprehension of and the susceptibility to these effects is of utmost importance in order to avert an increase in the probability of systemic risks. Based on the above analysis, considerations should be given to fortifying the regulation of the derivatives market, particularly during liquidity constraints and heightened economic uncertainty. Furthermore, future research could explore the risk performance of different derivatives in various economic environments and how financial derivatives can effectively manage global uncertainty in other periods.

7. Conclusion

The study indicates that derivatives served as a critical risk management tool during the crisis but also posed the risk of exacerbating market volatility. An in-depth examination of derivatives pricing mechanisms, liquidity changes, and policy interventions showed that while financial derivatives played an essential role in managing risk, market instability and liquidity challenges caused some derivatives to lose their intended hedging effect. This underscores the vulnerability and uncertainty of the derivatives market under extreme market conditions. However, it is essential to note that this study has some limitations. The data sources primarily focused on the early stage of the pandemic, and future studies should encompass the market's gradual recovery in the later stage of the pandemic. Additionally, while this study adopts quantitative and qualitative methods, the depth of qualitative analysis still requires strengthening. Therefore, future research could benefit from more in-depth analysis of specific cases. Furthermore, further research on the performance of different derivatives in various market environments is imperative to provide effective countermeasures for future global crisis management. Future research should emphasize the more effective utilization of derivatives for risk management during a crisis.

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