SHORT REPORT

The COVID-19 risk in the Chinese option market

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Abstract

The COVID-19 pandemic has increased fear of a financial market crash in China. We use an implied volatility slope measure, which proxies the cost of option protection against and therefore trader's fear of crash risk, using the Shanghai Shenzhen CSI 300 Index options. We show that this measure is positively related to new cases and deaths of the pandemic during the COVID-19 outbreak in China. Option traders are willing to pay more for hedging downside tail risk as the pandemic worsens, and are no longer as concerned by news of cases and deaths after the lift of the lockdown.

KEYWORDS
COVID-19, CSI 300 Index options, implied volatility slopes, tail risk

INTRODUCTION

The COVID-19 outbreak originated in the city of Wuhan, China, in December 2019. The virus had spread to other cities in China and many other countries in less than a month. China instigated the lockdown in Wuhan on January 23, 2020, which had a great effect in containing the spread of the virus (Yuan et al., 2020). On April 8, 2020, when Wuhan had reported zero daily cases of infection and deaths for the most days in 3 weeks, China lifted the lockdown in Wuhan, marking the beginning of China's return to normality. In this article, we explore the Chinese equity option market's sensitivity to the COVID-19 severity during the lockdown of Wuhan, that is, from January 23, 2020 to April 9, 2020 (the lockdown period, hereinafter).

We employ a unique dataset of the Shanghai Shenzhen CSI 300 Stock Index (CSI 300 Index) options to examine the impact of COVID-19 on Chinese option traders', the most sophisticated investors, expectations, and the hedging costs of crash risk. CSI 300 Index options were launched on December 23, 2019 by the China Financial Futures Exchange (CFFEX). It is China's first and only mainland stock index option market. The CSI 300 Index options provide six maturities, including those for the next 3 months and the final month of each of the following three quarters. The

underlying asset of the CSI 300 Index option contract is the CSI 300 Index, which spans 300 large-capitalization stocks with strong liquidity in the Shanghai and Shenzhen stock markets.

An emerging literature studies the detrimental effects of the spread of COVID-19, especially on the equity returns of major economies, including China, where the prevalence of coronavirus is measured by the number of cases and deaths caused by infection (Al-Awadhi et al., 2020; Alber, 2020; Alfaro et al., 2020; Baig et al., 2020; Brodeur et al., 2020; Cao et al., 2020; Rehan et al., 2020; Sansa, 2020; Topcu & Gulal, 2020). Moreover, the COVID-19 outbreak has heavily affected the global economy and increased market volatility expectations. The volatility of stock markets has also been investigated by Albulescu (2020a), Ozili (2020), and Baek et al. (2020) for the US market, and Albulescu (2020b), Baker et al. (2020), Zhang et al. (2020), and Zaremba et al. (2020) for the global stock exchanges among others.

There are only a handful of papers exploring the COVID-19 pandemic in a forward-looking dimension using derivative prices. Hanke et al. (2020) use equity index options and find that the initial reaction in all analyzed markets was late and simultaneous. Gormsen and Koijen (2020) study the reactions of the dividend futures to the outbreak and reports inconsistencies between investors' short- and long-term expectations. Cheng (2020) investigates the COVID-19 impact on the VIX futures and find that trading based on estimated premiums is profitable from the subsequent increase in market volatility. Jackwerth (2020) uses the information from the risk-neutral moments derived from options and gives a comprehensive view of the reaction of the S&P 500 to COVID-19, showing that the index did not reflect the full COVID-19 impact until March 16, 2020. We add to the literature by showing that the implied volatility (IV) slope measure that proxies the hedging costs of downside tail risk, is sensitive to the reported COVID-19 cases and deaths in China. The slope measure is the steepness of a linear function that relates out-of-the-money (OTM) put option IVs to moneyness (with moneyness being measured by the option's delta), which originates from Kelly et al. (2016).

In this article, we test whether the investors' fear of crash risk caused by COVID-19 is priced in the Chinese option market. Specifically, we examine whether the aforementioned IV slope measure representing the fear is more pronounced during the lockdown period when COVID-19 peaks in China. We also try to answer the question of whether the IV slope measure is related to the daily new confirmed cases and daily new deaths during such period.

The remainder of this paper is organized as follows. Our selected hypotheses are summarized in Section 2. In Section 3, we describe the option data sources and sample period. Then in Section 4, we present the dependent variables and regression models. Further, in Section 5, we present and discuss our results. Finally, Section 6 concludes.

HYPOTHESES

We examine two hypotheses in terms of the relationship between COVID-19 and the option investors' fear in China. The disease mitigation measures in control of COVID-19 would likely disrupt the economy by reducing the consumption and production in major industrial sectors. Hence, the investors expect a depression as a result. The investors' confidence would be restored when the Chinese government lifted the lockdown and the cases and deaths decreased thereafter. This leads to our first hypothesis:

Hypothesis 1. *The cost of option protection against downside tail risk that investors are willing to pay, which represents the investors' fear of such risk, is more pronounced in the lockdown period in China.*

In addition, the investors' fear of crash risk should intuitively be magnified with the rising cases of infection and deaths. This leads to our second hypothesis:

Hypothesis 2. *The investors' fear of crash risk is positively related to the COVID-19 severity in China.*

We use the option-based measure, which originates from Kelly et al. (2016) and identifies downside tail risk to test the hypotheses. The measure is the estimated slope of a function that relates OTM put option IVs to deltas. A positive slope indicates that the OTM put options are relatively more expensive, which suggests a higher cost of insurance against downside tail risk. A more positive slope in the lockdown period than in the post-lockdown period suggests that option traders regain confidence in the market after the lift of the lockdown. Furthermore, we regress the slope measure on the pandemic severity measures, namely, the daily new confirmed cases and daily new deaths. Positive coefficients would support that the cost of protection against downside tail risk is more expensive with news of more reported daily cases and deaths.

DATA

We obtain the CSI 300 Index options' daily expiry date, last price, trading volume, open interests, and delta of the options, from the WIND terminal, which is the largest financial data provider in China. We only consider the option contracts with positive open interests. Our study period is from December 23, 2019 to June 19, 2020. We split our sample into three subsamples, pre-lockdown period from December 23, 2019 to January 22, 2020, the lockdown period from January 23, 2020 to April 9, 2020, and the post-lockdown period from April 10, 2020 to June 19, 2020, to examine the COVID-19 effect.[1] We collect the number of the daily new confirmed cases and daily new deaths of the COVID-19 pandemic in China from the Our World In Data database, which provides worldwide daily updated data on the coronavirus pandemic.[2] The daily closing price data for the underlying asset of the options are taken from the WIND terminal. We interpolate the Shanghai Inter-Bank Offer Rate to match the interest rate maturity to the option maturities.

METHODOLOGY

In this section, we first introduce the option market measure. The measure originates from Kelly et al. (2016) and proxies for downside tail risk. Furthermore, we construct an empirical model to examine the relationship between the slope measure and the COVID-19 factors.

Daily IV slope

Kelly et al. (2016) construct the slope by fitting a linear function that relates the left-tail IVs to deltas as follows:

$$IV_{i,\tau} = \alpha + SLOPE_\tau \times \Delta_{i,\tau} + \varepsilon_i, \tag{1}$$

where $IV_{i,\tau}$ is the Black-Scholes IV of an OTM put option whose time to expiry is τ years, and Δ is the option's delta from the Black-Scholes formula provided by the WIND terminal. OTM put options are defined as those whose deltas satisfy the condition $-0.5 < \Delta < -0.1$ (Kelly et al., 2016), and for each maturity, τ, on a given day, we select the option series with at least three such OTM puts. The $SLOPE_t$ with 30 calendar days to expiry on day t is computed using interpolation or extrapolation between the two closest maturity $SLOPE_\tau$ values. An alternative slope measure computed using a quadratic function rather than the linear one in Equation (A1) is presented in the Appendix.

$SLOPE_t$ captures the relative cost of protection against extreme downside tail risk to the cost of protection for less extreme downside risk in a 30-day window. Positive values of $SLOPE_t$ indicate that deep OTM put options are particularly expensive.

Empirical model

We take the log transformation of the independent variables, that is, the daily new cases and deaths, because the log transformation responds to skewness toward large values better than the normalization. It is worth noting that the daily new death numbers are mostly zero in the post-lockdown period. Therefore, $\log(\text{deaths})$ is transformed to $\log(\text{deaths}+1)$ in order to obtain valid variable values.

Our research examines the impact of the COVID-19 severity on the investors' expectation of crash risk in the short-term. The investors' fear of potential crash risk is measured by the expensiveness of the cost of option protection against downside tail risk, that is, the SLOPE_t variable. We therefore estimate the following regression to explore the relationship between the COVID-19 severity in China and the investors' crash fear:

$$\text{SLOPE}_t = \alpha_1 + \beta_1 X_{t-1} + \varepsilon_{1,t}, \tag{2}$$

where X_{t-1} is the COVID-19 measure, that is, the logarithm of the daily new confirmed cases or logarithm of the daily new deaths, on day $t-1$. The log cases and deaths in the pre-lockdown period are not available for most days because the Chinese government imposed the lockdown of the Wuhan city promptly when the authority began to report initial cases. Therefore, we fit the regressions for the lockdown and post-lockdown period.

EMPIRICAL RESULTS

Figure 1 shows the market IV, fitted IV lines and the trading volumes for all available maturities on a random day, February 11, 2020. We can observe that the coefficients are positive for the short-term option contracts, which is consistent with the notion that deeper OTM options are generally more expensive. In addition, SLOPE_ts are more positive for shorter-dated options, and counter-intuitively, the option contracts are cheaper when there is lengthier time left before the expiration. This evidence suggests that, as of the selected random day, the investors are more pessimistic about the equity market in the nearer future and are willing to pay more for the short-term deeper OTM put options to hedge against the potential downside tail risk.

Table 1 tests the first hypothesis and describes the summary statistics of the option measure and the COVID-19 measures in our analysis. Columns 2 shows that, the average SLOPE_t is positive in each panel, and is larger in Panel B (8.87%) than in Panel A (1.32%) and C (2.65%), indicating that the deeper OTM put options are more expensive than those less deep OTM put options on average in each periods, and that the cost of option protection against downside tail risk is the most expensive in the lockdown period, which supports our first hypothesis that the investors' fear of crash risk in the lockdown period is more pronounced than the pre- and post-lockdown periods. The standard deviation in Column 3 shows the similar trend, that is, it is the largest in the lockdown period, because the SLOPE_t measure is more likely to be volatile amid the severe COVID-19 outbreak due to recurrent shocks[3].

Particularly, the mean and the standard deviation of SLOPE_t remain a higher level in the post-lockdown period, comparing to the pre-lockdown period, as shown in Table 1. SLOPE_t did not drop to the same degree as the number of confirmed cases and deaths after the lift of the Wuhan lockdown. This is to be expected for two reasons. First, soft government policies including stay-at-home requirements, restrictions on public gatherings, travel controls, and so forth, remained in place across Mainland China after the Wuhan lockdown. Therefore, the investors believed that the potential market crash risk triggered by COVID-19 was not over despite the significantly declining infection and death rates. Second, while Mainland China was recovering from the COVID-19 crisis and the numbers of new cases and deaths were dropping, some other major economies started to struggle to control COVID-19, which was likely to have a spillover effect on the Chinese equity market and therefore knocked investor confidence.

The option measures as well as the patterns of the COVID-19 measures are presented in Figure 2. Figure 2 illustrates the relationship between the dependent and independent variables of regressions in Equation (2) graphically.
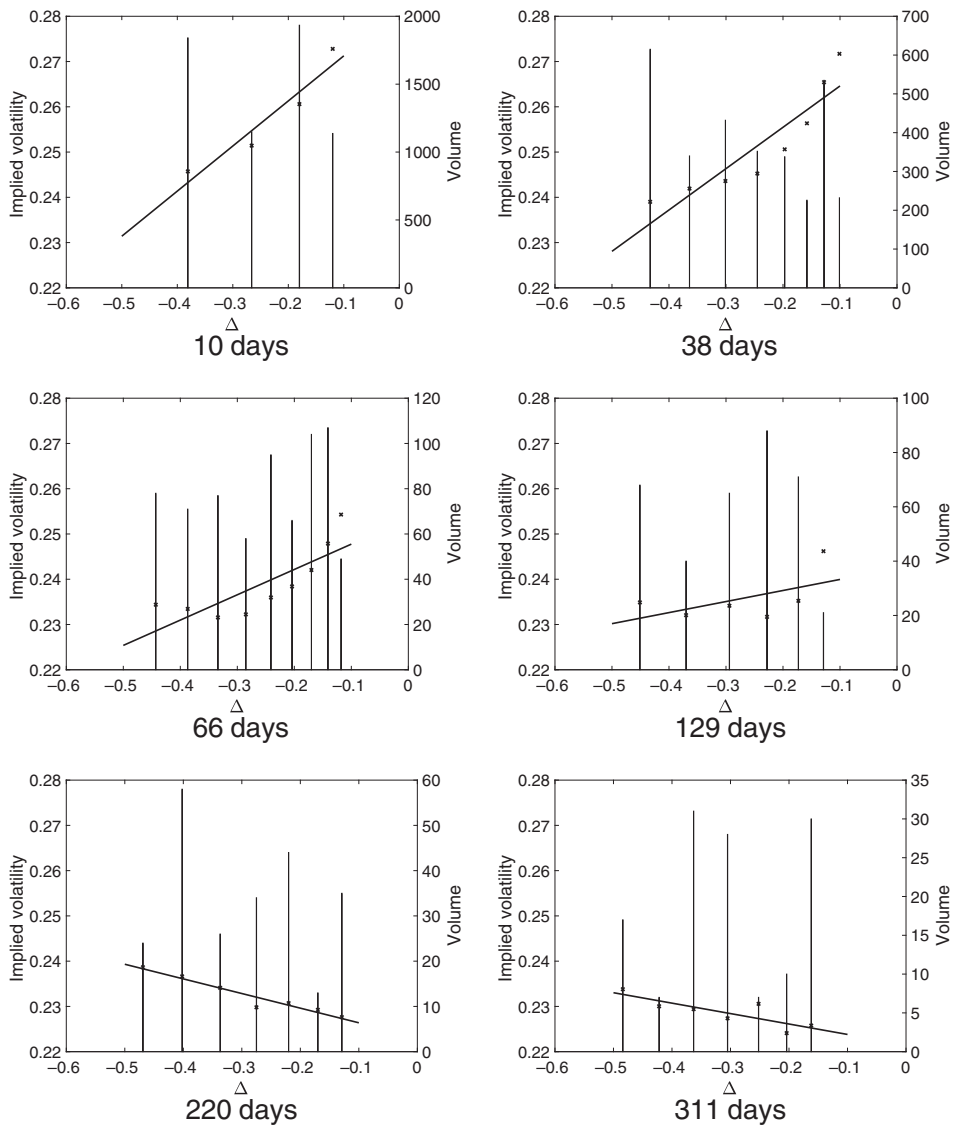
FIGURE 1 IV curves on February 11, 2020. This figure illustrates the market and fitted IV lines for each available time to maturity 10, 38, 66, 129, 220, and 311 days using Kelly et al. (2016) method. Crosses in each graph are the market IVs. The solid lines are fitted IV lines and the bars are the trading volumes

There is a structural break in the correlation between news of the COVID-19 severity and the investors' fear between the lockdown and post-lockdown period. Specifically, the new cases and deaths drop sharply while the $SLOPE_t$ remains higher in the post-lockdown period than in the pre-lockdown period, albeit much lower than the lockdown period, which breaks the correlation between the variables. It suggests that the investors still regard COVID-19 as a potential tail risk despite the greatly reduced COVID-19 cases and deaths and the eased lockdown, which is consistent with the evidence in Table 1. As established previously, it is possibly because there are still government restrictions in place in the whole country after the lift of the Wuhan lockdown and the global spread of COVID-19 also affects the Chinese investment outlook. The patterns in Figure 2 provide initial evidence for the second hypothesis; that is, the investors' fear of crash risk is related to the COVID-19 severity during the lockdown

TABLE 1 Summary statistics

	Obs.	Mean	SD	Min	Median	Max
Panel A: The pre-lockdown period: December 23, 2019–January 22, 2020						
$SLOPE_t\%$	22	1.32	2.67	−5.53	1.89	5.25
Panel B: The lockdown period: January 23, 2020–April 9, 2020						
$SLOPE_t\%$	48	8.87	5.40	−4.88	9.33	20.28
New cases	48	1081.73	2365.42	20	123	15,141
New deaths	48	47.83	53.17	0	28	254
Log cases	48	5.47	1.78	3.00	4.81	9.63
Log deaths	48	3.18	1.35	0.00	3.37	5.54
Panel C: The post-lockdown period: April 10, 2020–June 19, 2020						
$SLOPE_t\%$	48	2.65	3.13	−2.48	1.79	11.24
New cases	48	21.31	27.65	1	10	112
New deaths	48	0.15	0.46	0	0	2
Log cases	48	2.27	1.32	0.00	2.25	4.72
Log deaths	48	0.09	0.27	0.00	0.00	1.10

Note: This table reports summary information of the slope measure, the 30-day IV slope $SLOPE_t$, and the COVID-19 measures, the logarithms of and the original daily new confirmed cases and daily new deaths of COVID-19 in the pre-lockdown (Panel a), lockdown (Panel B), and post-lockdown period (Panel C) in China.
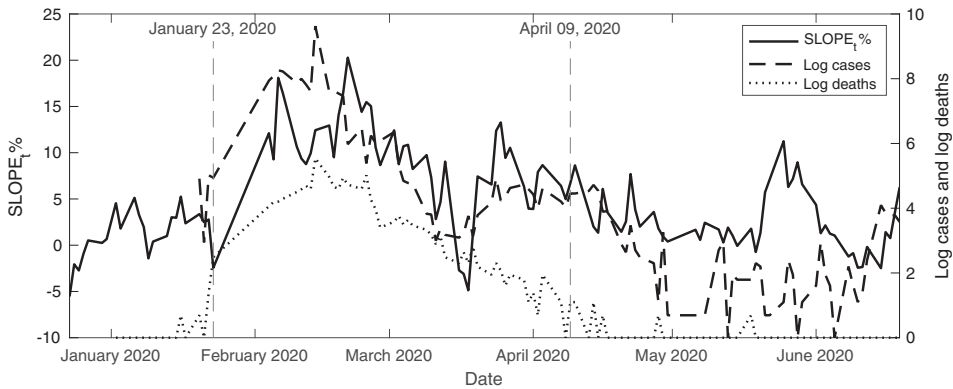

FIGURE 2 Evolution of variables. This figure shows the evolution of the dependent variables, that is, $SLOPE_t$ and the independent variables, that is, the log cases and $\log(\text{deaths} + 1)$ along the full sample period. The vertical dash lines divide the sample period into the pre-lockdown, lockdown, and the post-lockdown period

period but no longer in the post-lockdown period. Furthermore, we apply Equation (2) and report the numerical results for the test of the second hypothesis in Table 2.

Panel A in Table 2 shows that the COVID-19 cases and deaths have a positive and significant effect on $SLOPE_t$ during the lockdown period. The coefficients from regressing $SLOPE_t$ on the log cases and deaths are both positive and significant at the 1% level of significance. In contrast, we cannot detect any notable evidence that the COVID-19 case and death news still affects $SLOPE_t$ in the post-lockdown period, as shown in Panel B of Table 2. The result of the model regressing $SLOPE_t$ on the log cases or deaths in the post-lockdown period is insignificant; suggesting that the COVID-19 severity has little effect on the expensiveness of the OTM put options measured by the Kelly et al. (2016) method after the lockdown is over. We can conclude that the insurance against downside tail risk

TABLE 2 Impact of COVID-19 on the CSI 300 Index option market measures

Independent variable	(1) Log new cases	(2) Log new deaths
Panel A: The lockdown period: January 23, 2020–April 9, 2020		
$SLOPE_t\%$	1.86*	2.24*
	(5.28)	(4.60)
Obs.	48	48
Adj. R^2 (%)	36.34	30.04
Panel B: The post-lockdown period: April 10, 2020–June 19, 2020		
$SLOPE_t\%$	−0.01	2.04
	(−0.04)	(1.22)
Obs.	48	48
Adj. R^2 (%)	−2.17	1.03

Note: This table reports the results of the ordinary least squares regression regarding the impact of COVID-19 on the CSI 300 Index options in China, during the lockdown (Panel A) and the post-lockdown period (Panel B). The dependent variable $SLOPE_t$ is the steepness of the linear function that relates IV to moneyness. The independent variable in the regression model is the log daily new confirmed cases or the log daily new deaths plus one. * denotes significance at the 1% level.

becomes more costly as there are more cases or deaths during the lockdown, but option traders are not concerned by new cases or deaths after the lockdown period.

CONCLUSION

The COVID-19 outbreak caused widespread fear of a stock market crash in China. This study is the first attempt to examine the influence of COVID-19 on option traders' expectations and hedging costs of downside tail risk in Mainland China.

We show that the fear generated by the COVID-19 pandemic in China is priced in China's option market during the lockdown. Specifically, the cost of insurance provided by the CSI 300 Index options against downside tail risk is the most expensive in the lockdown period, and furthermore, it is positively related to the daily new cases and deaths during the COVID-19 lockdown period in China. After the Chinese government officially lifted the lockdown, investors' confidence appeared immune to COVID-19 news in China, for the cost of option protection against downside tail risk was no longer related with the COVID-19 cases or deaths, in the post-lockdown period. Yet it remained higher than in the pre-lockdown period, indicating that the investors' confidence was not restored to the pre-lockdown level shortly after the lift of the lockdown.

In future research, it would be interesting to explore if these results hold for other countries.

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ENDNOTES

[1] The pre-lockdown period is from December 23, 2019 when CFFEX launched the CSI 300 Index options, to the day before the lockdown period starts. The lockdown period starts on the first trading day when the Chinese government imposed the lockdown in Wuhan and ends on the day following the lockdown lift, while the post-lockdown period starts thereafter and has the same sample size as the lockdown period.

[2] Published online at OurWorldInData.org. Retrieved from: "https://ourworldindata.org/coronavirus-data" [Online Resource].

[3] The log cases and deaths in the pre-lockdown period are not available for most days and therefore are not reported in Panel A.

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APPENDIX A: AN ALTERNATIVE SLOPE

An alternative option measure of downside tail risk is the slope factor in a quadratic function that relates out-of-the-money (OTM) put implied volatilities (IVs) to deltas, given by

$$IV_{i,\tau} = \alpha + QSLOPE_\tau \times \Delta_{i,\tau} + QCURV_\tau \times \Delta_{i,\tau}^2 + \varepsilon_i, \tag{A1}$$

where $QSLOPE_\tau$ and $QCURV_\tau$ are the slope and curvature of the regression. $QSLOPE_t$ and $QCURV_t$ with 30 calendar days to expiry on day t are computed using interpolation or extrapolation between the two closest maturity $QSLOPE_\tau$ and $QCURV_\tau$ values. $QCURV_t$ is highly correlated with $QSLOPE_t$ at all times (over 95%), indicating that $QSLOPE_t$ and $QCURV_t$ contain similar information about the movement of future stock prices.

Table A1 report the summary statistics of $SLOPE_t$ constructed by fitting a linear function in Equation (1) with the label "$LSLOPE_t$" and the slope measure derived from a quadratic regression in Equation (A1) with the label "$QSLOPE_t$." It is clear that the quadratic function fits the OTM put IVs better, compared with the linear one, for the R^2s of the regressions based on Equation (A1) are higher than those based on Equation (1) on average in all sample periods. However, $LSLOPE_t$ and $QSLOPE_t$ have the same patterns that the value is the highest in the lockdown period, and dips after the lift of the lockdown, but does not fall back to the pre-lockdown level. In addition, regressing $LSLOPE_t$ and $QSLOPE_t$ on the log new cases and deaths yields significantly positive coefficients in the lockdown period and insignificantly coefficients in the post-lockdown period, as shown in Table A2, suggesting that $QSLOPE_t$ contains the same information as $LSLOPE_t$ does regarding the impact of COVID-19 on the CSI 300 Index options in China.

TABLE A1 Summary statistics

	Obs.	Mean	SD	Min	Median	Max	Mean R^2 (%)
Panel A: The pre-lockdown period: December 23, 2019–January 22, 2020							
$LSLOPE_t$%	22	1.32	2.67	−5.53	1.89	5.25	54
$QSLOPE_t$%	22	6.23	7.06	−8.02	6.76	17.74	74
Panel B: The lockdown period: January 23, 2020–April 9, 2020							
$LSLOPE_t$%	48	8.87	5.40	−4.88	9.33	20.28	75
$QSLOPE_t$%	48	29.83	14.01	−12.81	30.47	57.31	91
Panel C: The post-lockdown period: April 10, 2020–June 19, 2020							
$LSLOPE_t$%	48	2.65	3.13	−2.48	1.79	11.24	37
$QSLOPE_t$%	48	17.95	7.37	5.62	16.89	40.30	84

Note: This table reports summary information of the 30-day IV slope, $LSLOPE_t$, estimated by the regression in Equation (1), and the 30-day IV slope, $QSLOPE_t$, estimated by the regression in Equation (A1), in the pre-lockdown (Panel A) lockdown (Panel B) and post-lockdown period (Panel C) in China.

TABLE A2 Impact of COVID-19 on the CSI 300 Index option market measures

Independent variable	(1) Log new cases	(2) Log new deaths
Panel A: The lockdown period: January 23, 2020–April 9, 2020		
$LSLOPE_t$%	1.86*	2.24*
	(5.28)	(4.60)
$QSLOPE_t$%	4.10*	3.83*
	(4.15)	(2.70)
Panel B: The post-lockdown period: April 10, 2020–June 19, 2020		
$LSLOPE_t$%	−0.01	2.04
	(−0.04)	(1.22)
$QSLOPE_t$%	0.73	4.25
	(0.89)	(1.08)

Note: This table reports the results of the ordinary least squares regression regarding the impact of COVID-19 on the CSI 300 Index options in China, during the lockdown (Panel A) and the post-lockdown period (Panel B). The dependent variable $LSLOPE_t$ and $QSLOPE_t$ are the steepness of the linear and quadratic functions that relate IV to moneyness, respectively. The independent variable in the regression model is the log daily new confirmed cases or the log daily new deaths plus one. * denotes significance at the 1% level.