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ABSTRACT: This paper investigates the effect of COVID-19 uncertainty on corporate default risk using an international sample of firms from 71 countries. We document that corporate default risk increases with higher COVID-19 uncertainty, even after controlling for a wide range of firm-level and country-level characteristics. The effect is weaker for firms in highly religious adherence countries, stronger for firms in developed countries, and for firms geographically closer to China and Italy. Further, the effect is weaker for highly innovative firms and less financially constrained firms. Our findings are robust to propensity score matching and entropy balancing methods to address selection bias, diagnostic tests regarding omitted variable bias, and alternative measures of COVID-19 uncertainty and default risk.

Keywords: COVID-19 Stringency policy, COVID-19 uncertainty, default risk, financially unconstrained.

JEL classification: G15; G18; I10; M14

1. Introduction

The impact of COVID-19 pandemic crisis has been among the most important topics in the traditional finance literature in the last few years.[1] Anecdotal evidence shows that the COVID-19 pandemic crisis negatively affects the global economy and the financial system. World Bank reports that the global GDP growth rate declined by 3.3% in 2020.[2] The human loss has been horrific, and the economic and social costs are severe.[3] In addition to substantial economic and societal loss, the COVID-19 crisis disrupted many business operations, resulting in dropping production, revenues, and cash flows. The COVID-19 pandemic crisis is not like of 2008/2009 financial crisis, but it is more severe than any other pandemics in the past, such as the Spanish Flu in 1918 and Ebola in 2014, because of its unique evolutionary volatile characteristics and uncertain economic impacts (McKibbin & Fernando, 2021; Szczygielski et al., 2022).

From early 2020 to early 2022, COVID-19 developed great uncertainty associated with a range of sequential events related to the emergency declaration as a pandemic. We include as follows: discovery of the transmission mechanism of the disease, imposing of social distance, lockdowns, quarantine, personal protective equipment (PPE), vaccine trials, the discovery of the effective vaccine, evolution of new variants, effectiveness of the existing vaccine, etc.[4,5] These events led governments and central banks to formulate policies and the use of tools on how to impose effective and timely fiscal and monetary policies in response (Pagano & Zechner, 2022).

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[1] The World Health Organization (WHO) announced the outbreak of the Covid-19 virus as a pandemic on March 11, 2020. Globally, as of December 15, 2022, WHO reported about 646 million confirmed cases, including 6.6 million deaths.
[2] https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?most_recent_year_desc=false
[3] https://theindependentpanel.org/wp-content/uploads/2021/05/Background-paper-9-Social-impact.pdf
[4] https://www.cdc.gov/museum/timeline/covid19.html
5https://www.ajmc.com/view/a-timeline-of-covid19-developments-in-2020

The COVID-19 pandemic crisis has created uncertainty that affects all types of assets in all countries. In this study, we propose a new measure of COVID-19 uncertainty based on the country-level daily number of new COVID-19 cases and examine the concurrent impact of COVID-19 uncertainty on firm-level default risk. To the best of our knowledge, no study has investigated the concurrent effect of uncertainty due to the volatility of the country-level daily number of COVID-19 cases on firm-level default risk.

There is a growing body of work on the COVID-19 pandemic and financial markets. For example, using data from more than 6,700 firms across 61 economies, Ding et al. (2021) examine the relationship between pre-pandemic corporate characteristics and the reaction of stock returns to COVID-19 cases. They show that firms with stronger pre-2020 finances (more cash and undrawn credit, less total debt, and larger profits) suffered a milder drop in stock returns during the COVID-19 pandemic crisis. Suardi et al. (2022) demonstrate that stock market liquidity decreases, but liquidity commonality among U.S., UK, Germany, and China increased when the pandemic began and worsened. Hoang et al. (2022) examine whether performance on the stock market reflects the built-up capacity of a startup pre-COVID-19, which would allow it to withstand the impact of the COVID-19 pandemic. Most of these papers focus on the stock market reaction and liquidity impact of the COVID-19 pandemic crisis. It has yet to be established whether COVID-19 uncertainty affects credit risk experience, i.e., default behavior. We seek to fill this gap by examining the impact of the COVID-19 uncertainty on corporate default risk in an international setting.

COVID-19 uncertainty could influence corporate default risk, either positively or negatively. On the one hand, higher uncertainty appears to increase firms' default risk. It is more likely for a firm to experience cash flow shortfalls in a volatile economic environment, resulting in default (Tang & Yan, 2010). During uncertainty, firms with financial constraints are inherently more vulnerable to default risk than firms with financially unconstrained due to insufficient cash flow and lack of access to external capital. On the other hand, the literature indicates that corporate default risk does not necessarily rise with uncertainty. Firms operating activities may be disrupted during uncertainty, but firms may avoid default by adopting a risk-averse strategy (Tran, 2019). The uncertainty caused by COVID-19 may also cause firms to make prudent financial decisions, such as increasing cash holdings (Goodell et al., 2021).

We investigate the relationship between COVID-19 uncertainty and corporate default risk using a large sample of 187,920 firm-quarter observations and 25,944 unique firms from 71 countries from January 2020 to June 2022. We use two alternative proxies to measure COVID-19 uncertainty. The first measure, COVID19_VOL, is the quarterly standard deviation of daily COVID-19 case growth rates. The second measure, STRINGENCY_POLICY, is the COVID-19 stringency index that measures how strict the response to COVID-19 is based on nine response indicators, including school closures, workplace closures, and travel bans. We follow previous literature (Mackie-Mason, 1990) and use a modified Altman Z-score score as a proxy of default risk.

Consistent with our expectations, we find strong evidence that COVID-19 uncertainty increases the corporate default risk. This result is also economically meaningful. When we add an extensive set of firm-level and country-level characteristics as control variables in the regression specification, a 1-standard-deviation increase in COVID19_VOL will augment the default risk value by 0.011 (=0.015 × 0.75), representing 2.34% (=0.011 /0.48) of its mean. To validate the impact of COVID-19 uncertainty on corporate default risk in our baseline regression, we conduct a series of tests to mitigate the concern about self-selection bias and endogeneity due to omitted bias. First, we perform an Oster (2019) test to ensure our results do not suffer from omitted variable bias. The results of this test indicate that to drive away our results, the effect of omitted variables must be 1.05 to 3.50 times greater than that of observed variables in the models with the most standard restrictive criteria. These estimates of Delta (δ) are significantly higher than 1, which is the threshold suggested by Oster (2019), indicating that our results are unlikely to be driven by omitted variable bias. Second, we address a possible endogeneity issue due to the self-selection bias, using propensity score matching (PSM) and an entropy balancing (EB) method. Moreover, our results are robust to use of alternative measures of COVID-19 uncertainty, including: realized volatility of COVID-19 (RV) and standard deviation of COVID-19 spread (STD_SPREAD), use of distance-to-default (DTD) as an alternative measure of default risk, use of alternative samples by excluding observations from large countries in the sample, use of alternative fixed effects (firm and country), and use of additional controls (possible influential omitted) variables, including tangibility, market-to-book, cash holding, and creditors' rights.

We further investigate cross-sectional variations in the effect of COVID-19 uncertainty on default risk. We find that the effect of COVID-19 uncertainty is weaker for firms in religious-adherent countries. The result is consistent with the intuition that firms prefer to take less risk in a highly religious adherent country than in less religious adherent countries, subsequently translating into lower default risk. On the other hand, the effect is stronger for firms in developed countries than in developing countries. Moreover, the effect of COVID-19 uncertainty on default risk is stronger for firms geographically closer to China than for those geographically far away from China. Furthermore, investment in innovation plays a vital role in the relationship between COVID-19 uncertainty and default risk, in line with the argument that highly innovative firms are more adaptable to changing environments and bring long-term growth and success. The relation between COVID-19 uncertainty and default risk is weaker when firms are financially unconstrained, consistent with the argument that firms with healthy financial resources are better positioned to absorb the pandemic shock. Finally, industry analysis reveals that the industries most impacted by COVID-19 uncertainty are chemicals and allied products and the industry least impacted by COVID-19 uncertainty is finance.

This study contributes to literature in several ways. First, contrary to corporate default risk studies focusing on a single country, our study investigates cross-country and time-varying effects of COVID-19 uncertainty on corporate default risk. As COVID-19 has affected every country at varying intensities and speeds, we have a unique opportunity to assess the relevance of firm characteristics across countries and government policies to the COVID-19 impact on firms to examine the COVID-19 uncertainty-corporate default risk relationship. Unlike the earlier studies using data on COVID-19 one or two quarters from the earlier COVID period, our study spans almost the entire COVID-19 period (from January 2020 to June 2022) to explore the relationship between COVID-19 uncertainty and corporate default risk.

Second, we add to a growing stream of literature that examines the economic consequences of the COVID-19 pandemic crisis to the credit risk. The studies that are most relevant to ours are Liu et al. (2021), Apergis et al. (2022), and Hasan et al. (2023), who examine the effect of the COVID-19 pandemic crisis on CDS spreads. In the first wave of COVID-19, Liu et al. (2021) show a significant increase in CDS spreads for U.S. firms. Apergis et al. (2022) show that the CDS spreads are positively influenced by the severity of the pandemic, as measured by the number of COVID-19 cases and deaths worldwide from February 2020 to September 2020. Hasan et al. (2023) investigate the reaction of global corporate CDS spreads to the COVID-19 pandemic for 655 firms from 27 countries and show a pandemic-induced increase in corporate CDS spreads.

Our study differs from them in three aspects. First, in their interesting settings of Hasan et al. (2023), conducting an empirical study on less developed economies are challenging because CDS information is limited to large firms in developed markets. We build on these studies, but we improve on firm/country coverage and methodology by investigating the effect of COVID-19 uncertainty on corporate default risk measured by modified Altman Z-score using a very large sample of 187,925 firm-quarter observations and 25,940 unique firms from 71 countries (20 developed and 51 developing). Second, the expanded country and firm coverage, not only in quarters but also over the cross section, yields a novel result in this paper. While Ding et al. (2021) use data from 61 countries with a focus on stock market data, they note that the U.S. and Japan account for more than 69% of the firms in their sample. Our study seeks to strike a balance between industrial and emerging markets with 25,940 firms resulting in coefficients of the effects of COVID19 on default risk varying from 0.035 (industrial) vs. 0.012 (developing) by splitting the sample. We reject the null of the same COVID19 coefficients and observe a coefficient of 0.022 in our baseline model. This suggests the effect of COVID19 on default risk, estimated to be positive and statistically significant, varies across levels of income, a result robust to various controls entering separately or jointly. Third and most important, our measure of COVID19 (quarterly standard deviation of COVID19 infections growth rates) differs from theirs (weekly changes of COVID19 infections) and therefore indicates volatility effects on default risk. Our study also differs in its specifications, as Hasan et al. (2023) use interactions between pre-pandemic firm and country characteristics and COVID19, whereas we estimate the (positive) effect of COVID19 on DEFAULT1 by controlling for firm and country characteristics. For example, we document in this paper for our international sample of firms that size and ROA have negative effects on default risk, while leverage and CAPX have higher (positive) effects.

Furthermore, our sample period is longer than Hasan et al. (2023), who interact 2020 COVID-19 data with 2019 financial accounting data.

Following this Introduction, section 2 discusses the literature review and empirical predictions, and section 3 reports the sample selection process and data properties. Section 4 reviews the research methods used herein, section 5 discusses the empirical results, and section 6 concludes the paper.

2. Literature review and empirical prediction

Lawson (1985) argues that during uncertain periods, economic agents may make irrational decisions. This is because uncertainty makes it difficult for economic agents to accurately predict future outcomes and evaluate risks. From the economic point of view, Bloom (2014) suggests that uncertainty can adversely affect firms' incentives to hire, invest and innovate, as well as consumers' willingness to spend. Uncertainty can make firms hesitant to invest in long-term projects or hire new employees, while consumers may delay major purchases or cut back on discretionary spending. The impact of uncertainty on asset prices (Brogaard et al., 2017), corporate policies (Goodell et al., 2021) and financial intermediaries (Berger et al., 2020), as well as household economic behavior (Li et al., 2018), have been studied from a finance perspective.

With the onset of the COVID-19 pandemic, there has been a renewed interest in studying the impact of uncertainty on corporate risk. The pandemic has created unprecedented levels of uncertainty, leading to disruptions in global supply chains, changes in consumer behavior, and fluctuations in financial markets. As a result, researchers are increasingly examining how the uncertainty triggered by the pandemic is affecting firms' financial decisions and overall risk profile.

Previous literature explains that uncertainty may induce corporate risk-taking behavior, subsequently translating into higher default risk. For example, Zhang et al. (2021) find that uncertainty led to increased corporate risk-taking in Chinese A-share firms listed on the Shanghai and Shenzhen stock exchanges between 2013 and 2019. Liu and Zhong (2017) suggest that political uncertainty increases the credit risk of firms. More recently, Hasan et al. (2023) show that COVID-19 pandemic crisis increases CDS spreads. Based on the above discussion, COVID-19 uncertainty is expected to have a positive association with credit risk. This assumption leads to our first hypothesis:

H1: Higher COVID-19 uncertainty is associated with higher corporate default risk.

However, the high COVID-19 uncertainty may not necessarily translate into a high default risk for firms. According to Tran (2019), EPU negatively correlates with firm risk-taking in 18 countries from 2005 to 2016. Firms may adopt a risk-averse strategy during times of uncertainty since they are more cautious in adverse conditions. Therefore, uncertainty may not have a significant impact on corporate default risk. Furthermore, firms may make prudent financial decisions in response to uncertainty, such as increasing cash holdings. A recent study by Goodell et al. (2021) indicates that firms hold more cash during greater uncertainty and volatility.

Next, we develop four hypotheses that investigate cross-sectional variations of the effect of COVID-19 uncertainty on default risk (if any). First, we predict that the effect of COVID-19 uncertainty on default risk is weaker when the firm's headquarters is in a highly religious-dominated country. Several research studies (e.g., Hilary & Hui, 2009; McGuire et al., 2012) indicate local religious adherence influences corporate decisions. Individuals connect to others with similar values and beliefs through religious activity (Parboteeah et al., 2008). Adhikari and Agrawal (2016) find that banks in religious counties take less risk than those in less religious counties. Hilary and Hui (2009) provide evidence that firms headquartered in counties with many religious adherents are less likely to take risks than those headquartered in areas with fewer religious adherents. As a result, religiosity induces firms to take more conservative risk-taking behavior during uncertainty (i.e., the COVID-19 pandemic), subsequently translating into lower default risk. Based on these arguments, we propose the following hypothesis:

H2: The effect of COVID-19 uncertainty on default risk is weaker for firms in highly dominated religious countries relative to less dominated religious countries.

Our second cross-sectional test is based on the firm's headquarters' geographic proximity to China and Italy. These two large countries on different continents experienced many cases early in the pandemic (Ding et al., 2021). We expect the relationship between COVID-19 uncertainty and default risk to be stronger for firms geographically closer to China and Italy than those far from China and Italy because China and Italy were among the first and largest countries to face a severe outbreak of COVID-19 in early 2020. As a result, geographically closer firms in these countries might have more exposure to the COVID-19 pandemic, more disruption to their operations, more difficulty accessing markets and resources, and more uncertainty about their prospects. Based on these analyses, we propose our third hypothesis:

H3: The effect of COVID-19 uncertainty on default risk is stronger for firms closer to China and Italy than those far away from China and Italy.

Our third cross-sectional prediction is based on investment in innovation. In today's corporate world, innovation can catalyze growth and success (Porter, 1992; Hall et al., 2005). In contrast to conventional investments such as capital expenditures and mergers and acquisitions, innovation involves a long-term and risky process that entails both high risks and the possibility of extraordinary positive returns (Holmstrom, 1989). Li et al. (2021) state that highly innovative firms are more adaptable to changing environments. They reveal that during a pandemic crisis, firms with a strong culture, which includes innovation, are more likely to focus on digital technology and new product development. Based on these analyses, we have come up with a third hypothesis:

H4: The effect of COVID-19 uncertainty on default risk is weaker when firms invest more in innovation.

Finally, we also consider the financial resources of the firm. Firms must have enough financial resources to face challenging business environments like pandemic crises. Firms with financial constraints cannot raise additional funds through external debt or equity markets. The cost of debt and equity financing increases for firms with financial constraints. The severity of these situations increases during times of economic uncertainty. Recent COVID-19 uncertainty has adversely affected regular business operations, supply chain and deliveries, production, and revenue streams worldwide. Due to the adverse impact of the COVID-19 pandemic, firms with healthy financial resources are in a better position to absorb the pandemic shock (Ding et al., 2021). Despite the negative consequences of COVID-19 uncertainty, financially unconstrained firms may be able to endure declining business revenue and operations for a long time. As a result, we predict that the effect of COVID-19 uncertainty on default risk is weaker if firms are financially unconstrained:

H5: The effect of COVID-19 uncertainty on default risk is weaker when firms are financially unconstrained.

3. Sample and Variables

We extract COVID-19 information from the Center for Systems Science and Engineering at Johns Hopkins University[4], which covers COVID-19 data for 213 countries since January 2020. Data on the government policy response to COVID-19 obtain from Oxford COVID-19 Government Response Tracker.[5] Several studies (Ding et al., 2021; Liu et al. (2021) use these data sets as a primary source of COVID-19 pandemic crisis research.

We collect data on financial accounting from Worldscope's quarterly file. Our initial sample includes publicly traded firms in Worldscope between January 1, 2020, and June 30, 2022. This choice is motivated by the discovery of COVID-19 in Wuhan, China, in December 2019. We exclude firm-quarter observations with the missing value of necessary accounting information. We further exclude countries with less than 20 country-quarter observations. After combining all data sets, our final sample used in the baseline regressions consists of 187,925 firm-quarter observations with 25,940 unique firms from 71 countries between January 1, 2020, and June 30, 2022.

3.1 Corporate Default risk measure

Shareholders, investors, creditors, and business partners bear heavy penalties when a corporate default occurs (Warner, 1977). Because of corporate default, the supply chain hinders, the customer retention rate reduces, and legal and administrative expenses increase (Nguyen et al., 2022). Therefore, understanding the forces leading to higher corporate default risk deserves considerable attention from academics and policymakers alike.

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[4] Data are available at https://systems.jhu.edu/research/public-health/ncov/
[5] Data are available at https://www.bsg.ox.ac.uk/research/covid-19-government-response-tracker

The existing literature uses accounting-based and market-based measures to determine whether a firm is in default. Accounting-based measures incorporate financial statement data to construct indicators for predicting corporate default risk. This paper uses a modified Altman Z-score developed by Mackie-Mason (1990) to calculate the default risk for a firm in each quarter. We calculate Altman Z-score as follows:

$$Z - score = 3.3 \times \frac{EBIT}{BA} + 1.0 * \frac{SALES}{BA} + 1.4 \times \frac{RE}{BA} + 1.2 \times \frac{WCAP}{BA} \quad (1),$$

where EBIT is earnings before interest and taxes, SALES is the net sales, RE is the retained earnings, WCAP is the working capital, and BA is the book value of assets. Since the Z-score has a highly skewed distribution, we use the natural logarithm to calculate its value. To make interpretation easier, we set $\text{DEFAULT1} = -Ln(Z - score)$. The higher the value of DEFAULT1, the greater the corporate default risk.

For robustness checks, we further utilize two alternative measures of default risk. We follow Nadarajah et al. (2021) and Islam et al. (2022) and obtain data on DTD from the Credit Research Initiative (CRI) database[6]. CRI database calculates DTD as follows:

$$DTD_{i,t} = \frac{ln(\frac{V_t}{L}) + (\mu - \frac{\sigma^2}{2})(T - t)}{\sigma\sqrt{T - t}} \quad (2),$$

where $\mathrm{V_t}$ denotes assets value following a geometric Brownian motion with drift μ and volatility σ; L represents the default point which is the sum of short-term liabilities and half of long-term liabilities. The parameters are estimated applying the maximum likelihood model recommended in Duan (2000). We calculate the quarterly average of DTD since the CRI provides data with high

[6] CRI is a non-profit project that belongs to the Asian Institute of Digital Finance (AIDF) at the National University of Singapore (NUS). It provides data and analysis on corporate default risk. See more detail at: https://nuscri.org/

frequency. For ease of interpretation, we calculate DEFAULT2 = –1 × DTD, which means that higher DEFAULT2 values indicate higher default risk, and vice versa. We further follow previous studies that use Merton's (1974) model (Brogaard et al., 2017; Trinh et al., 2021) and measure firm risk with the expected default frequency (EDF). The EDF is the probability that the firm's assets will be worth less than its debt, based on DTD. We measure EDF by inserting DTD in a cumulative standard normal distribution. For example, EDF = N(–DTD), where N(.) is the cumulative standard normal distribution function. We use DEFAULT3 = EDF to measure default risk, suggesting that higher DEFAULT3 values mean higher default risk.

3.2 COVID-19 Uncertainty Measure

We primarily use two measures of COVID-19 uncertainty. The first measure, COVID19_VOL, is the quarterly standard deviation of daily growth rates of COVID-19 pandemic new cases. Following the approach used by Phan et al. (2020), we calculate COVID19_VOL as follows:

$$\mathrm{COVID19\_VOL}(\sigma_t) = \sqrt{\frac{1}{N-1}\sum_{t=1}^{N}\left[r_t^{COVID19} - E(r_t^{COVID19})\right]^2 . \sqrt{N}} \qquad (3),$$

where $r_t^{COVID19}$ is the daily growth rate of COVID-19 new cases and N is the number of days in a quarter.

Our second measure of COVID-19 uncertainty is the COVID-19 stringency policy index, which is constructed by Ashraf et al. (2022). This index is a composite measure that averages nine response indicators, such as school closures, workplace closures, public event cancellations, public gathering restrictions, public transport closures, stay-at-home policies, public information campaigns, internal movement restrictions, and international travel restrictions. The index ranges from 0 to 100 on any given day. The higher the score, the stricter the policy (100 = strictest).

For robustness checks, we also employ two alternative proxies of COVID-19 uncertainty. First, we calculate the realized volatility of COVID-19 pandemic crisis by following the approach used by Xiao et al. (2022). The specific form of realized volatility is as follows:

$$COVID19_{c,t} = ln(1 + Cumulative\ Cases_{c,t}) - ln(1 + Cumulative\ Cases_{c,t-1}) \quad (4)$$

$$RV_t = \sum_{i=1}^{N} COVID19_{c,t}^2 \quad (5),$$

where c and t index economy and a quarter, respectively. In Eq. (4), $Cumulative\ Cases_{c,t}$ represents the cumulative number of confirmed cases in economy c in quarter t. $COVID19_{c,t}$ measures the quarterly growth of confirmed cases over quarter t in economy c. In Eq. (5), N represents the number of observations of $COVID19_{c,t}$ available during a quarter.

Second, we calculate the standard deviation of COVID-19 spread per thousands of people in an economy (STD_SPREAD) as follows:

$$\text{STD\_SPREAD}(\sigma_t) = \sqrt{\frac{1}{N-1} \sum_{t=1}^{N} [r_t^{COVID19\ spread} - E(r_t^{COVID19\ spread})]^2 . \sqrt{N}} \quad (6),$$

where $r_t^{COVID19\ spread} = ((Daily\ new\ Cases_t * 1000) / (\#\ of\ population))$. N represents the number of observations of $COVID19_{c,t}$ available during a quarter.

3.3 Control variables:

We follow extant literature to select our control variables (Jiang et al., 2020; Nadarajah et al., 2021). We utilize the natural logarithms of total assets to capture firm size. Nguyen, Nguyen, & Dang (2022) provide evidence that firm size is significantly negatively associated with default risk in the studies of emerging countries. Larger firms have more net profit and cash flow than small firms, thus allowing them to repay a debt on time. Therefore, we expect a negative relationship between firm size and corporate default risk. We employ LEVERAGE to represent corporate financial leverage, defined as the total debt scale by total assets. The higher the amount of debt relative to total assets, the higher the firm's risk-taking, increasing default risk. Therefore, we assume that the relationship between leverage and corporate default risk is positive.

We also include profitability to control for firm's performance. Profitability (ROA) is calculated as earnings before interest and taxes scaled by total assets Market-to-book (MTB), which captures firms' growth opportunities, is the market value of equity divided by the book value of equity. CAPX is the ratio of capital expenditures to book value of assets. TANGIBILITY is the ratio of property, plant, and equipment to the book value of assets.

Moreover, we also control for two country-level characteristics that may affect corporate default risk: DEMOCRACY and COMMON_LAW. These variables capture the institutional quality and legal conditions of a country that can influence credit behavior. DEMOCRACY is a dummy variable that equals one if the firm's headquarters is in a democratic country and zero otherwise. COMMON_LAW is a dummy variable that equals one if the commercial law of a country originates from Common Law and zero otherwise.

Table 1 introduces the sample distribution by quarters and country. Panel A illustrates sample distribution by quarters. The firm-quarters observations vary from 17,041 in 2020Q1 to

21,837 in 2021Q4. During the sample period, around 10% of the firm-quarter observations are present in every quarter, suggesting a reasonable distribution of data over the sample period.

<INSERT TABLE 1>

In Table 1, Panel B shows the distribution of samples by country. Our empirical analysis is based on 187,925 firm-quarter observations and 25,944 unique firms drawn from 71 countries (20 developed and 51 developing) spanning January 2020 to June 2022, which makes it a comprehensive sample coverage. This group comprises firms from diverse social and economic development levels and is geographically dispersed. While firms from advanced countries represent most of the sample (52.08%), firms from developing and transitional economies are also fairly represented (47.92%). Panel B also shows that 37.77% of the firm-quarter observations come from U.S. and Japanese firms.

3.4 Descriptive statistics

Table 2 presents summary statistics for the variables used in the empirical analysis. Over the sample period, the mean (median) of the DEFAULT1 is -0.48(-0.58), with a standard deviation of 0.54. In addition, COVID19_VOL has a mean of 1.04 and a standard deviation of 0.75. Furthermore, we find that STRINGENCY_POLICY varies significantly across countries in our sample, with an average value of 51.32 and a standard deviation of 17.40. Our figures are close to Liu et al. (2021), who report a STRINGENCY_POLICY mean of 54.45 and a standard deviation of 20.10. We also use two alternative measures of the COVID-19 pandemic crisis: realized volatility of COVID-19 (RV) and standard deviation of COVID-19 spread (STD_SPREAD). The average values of RV and STD_SPREAD are 8.18 and 0.13, respectively.

<INSERT TABLE 2>

Our sample firms are moderately leveraged, with an average value of 0.24. This figure is consistent with those of Nguyen et al. (2022), who reported an average leverage of 0.25 in 26 emerging markets over the 1991-2019 period. The average firm in our sample has a CAPX of 0.01, return on assets (ROA) of 0.02, cost of debt of 0.02, and cash holdings (CASH) of 0.19. Around 8% of the sample firms paid cash dividends during the sample period. Overall, the recorded statistics are consistent with literature. Among the country-level characteristics, COMMON_LAW shows a mean of 0.66 and DEMOCRACY of 0.90.

Table 3 presents the pairwise correlation between variables used in this study. We find that COVID19_VOL correlates positively and slightly with the default risk (DAFAULT1). Firm size has a negative correlation with the default risk. However, leverage and CAPX have a positive correlation with default risk. Overall, the correlation coefficients between the COVID19_VOL and firm's default risk align with expectations. The multivariate analysis below will present evidence that COVID19_VOL leads to increased corporate default risk.

<INSERT TABLE 3>

4. Econometric Strategy

Initially, we develop an empirical model to investigate the relationship between corporate default risk and COVID-19 uncertainty at the firm-quarter level. Our empirical model is motivated by previous studies (Baghdadi, Nguyen, and Podolski, 2020) augmented with COVID-19 uncertainty, whose specification is as follows:

$$DEFAULT\_RISK_{i,t} = \alpha + \beta COVID19_{c,t} + \gamma X'_{i,t} + \delta_{j,t} + \theta_t + \varepsilon_{i,t} \quad (9),$$

where c,i, j, and t index economy, firm, industry, and time, respectively. $DEFAULT\_RISK_{i,t}$ represents each of the measures of default risk for firm i at period t. $COVID19_{c,t}$ is one of the measures of COVID19 uncertainty in economy c in period t. Assume that the coefficient estimates for $COVID19_{c,t}$ is positive. Hence, firms in high COVID-19 uncertainty countries are more likely to experience corporate default risk than those in low COVID-19 uncertainty countries, and vice versa. $X'_{i,t}$ denotes a vector of firms and country-level control variables. Following contemporary COVID-19 uncertainty research, we estimate Eq. (9) incorporating industry ($\delta_{j,t}$) and time θ_t) fixed effects. These fixed effects account for unobserved heterogeneity across quarters and industries. All standard errors are robust to heteroskedasticity and corrected for industry and economy clustering, yielding more robust coefficients and standard errors than in the traditional Fama-MacBeth framework.[7]

5. Empirical Results

5.1 The effect of COVID-19 uncertainty on corporate default risk: Baseline model

Table 4 presents the regression results for the COVID19 uncertainty and default risk. In Panel A of Table 4, the primary research variable is COVID19_VOL. In column 1, we only include COVID19_VOL in the regression. In columns (2) to (5), we separately add firm characteristics, including the firm's size, return on assets, leverage, and CAPX. In columns 6 and 7, we add country-level factors, including democracy and common law. Finally, COVID19_VOL and a complete set of control variables are incorporated in column 8. All regression specifications include time and industry-fixed effects.

[7] Our conclusions remain unchanged when we cluster standard errors at the country level, at the country and quarters level, and at the firm and quarters.

<INSERT TABLE 4>

We find that all adjusted R-squared values are increased to different degrees, indicating the incremental explanatory power of COVID19_VOL on corporate default risk. The estimated coefficient of COVID19_VOL is positive and statistically significant regardless of the specifications. In terms of statistical significance, COVID19_VOL is significant at the 1% level (*t*-statistics = 6.81) in column 8 with the full set of control variables. Regarding economic significance, the estimated effect is sizable. In column 8 a 1-standard-deviation improvement in COVID19_VOL will increase the default risk value by 0.011 (=0.015 × 0.75, the COVID19_VOL-coefficient of column 8 versus its standard deviation from Table 2), representing a change of 2.34% in its mean (=0.011 /0.48). We find that the estimated coefficients of firm-level characteristics are significantly related to corporate default risk in columns (2) to (8). As column 8 shows, default risk is negatively affected by firm size and ROA but positively related to the leverage and CAPX, consistent with the prior studies (e.g., Nguyen et al. 2022). Among country-level characteristics, default risk has a negative and statistically significant relation with democracy but positive and significant relation with COMMON_LAW.

In Panel B of Table 4, our primary variable of interest is the COVID-19 stringency policy. In column 1, we only add STRINGENCY_POLICY in the regression model. In columns (2) to (5), we separately include firm characteristics, including the firm's size, return on assets, leverage, and CAPX. In columns (6) and (7), we have country-level factors, consisting of democracy and common law. Finally, the STRINGENCY_POLICY and a comprehensive set of control variables are included in column 8. All regression specifications include time and industry-fixed effects.

Similar to the results of Panel A, we find that all adjusted R-squared values are increased to different levels, suggesting the incremental explanatory power of STRINGENCY_POLICY on corporate default risk. The estimated coefficient of STRINGENCY_POLICY is positive and statistically significant regardless of the specifications. We find the same estimated coefficient (0.003) of STRINGENCY_POLICY in all columns except in column 7 (0.004); their *t* statistics and adjusted R-squared values are different in all specifications. Specifically, in column (8), the magnitude of the significant coefficient of STRINGENCY_POLICY indicates that a one standard deviation increases in STRINGENCY_POLICY increases default risk by 0.052 ($= 0.003 \times 17.40$), which represents a change of 0.102% (=0.052/51.32) in its mean.

Consistent with Panel A of Table 4, we find that the estimated coefficients of the complete set of firm-level control variables are significantly linked to corporate default risk. As in column 8, default risk is negatively related to the firm size and ROA but positively related to the leverage and CAPX. Among country-level characteristics, the estimated coefficient of DEMOCRACY has a negative and statistically significant effect on default risk. Overall, we find compelling evidence that the COVID-19 uncertainty affects corporate default risk in the international setting, with comparable economic significance. This result supports our first hypothesis. Among the above specifications in Panel A and B, we select column 8 in panel A as our preferred specification because it includes the full set of control variables and fixed effects. We will use this specification for further analysis below.

In Internet Appendix B, we conduct a battery of robustness checks of the baseline results. First, we use two alternative measures of COVID-19 uncertainty: realized volatility (RV) and standard deviation of COVID-19 cases spread per thousands of people in an economy (STD_SPREAD). Second, we construct two alternative measures of default risk (Distance-to-default or expected default frequency). Third, we re-estimate baseline regressions models by excluding observations from large countries in the sample, namely USA, Japan, and Taiwan, which account for approximately 47% of the sample. Fourth, we add additional controls, including tangibility, market-to-book, cash holding, and creditors' rights. Finally, we use alternative fixed effects models (firm and country fixed effects). Our results are consistent across all these tests.

5.2 Endogeneity

In our baseline model the effect of COVID-19 uncertainty on corporate default risk might be endogenous due to omitted variable bias, and self-selection bias. In this section, we perform a variety of tests to address endogeneity issues.

5.2.1 Omitted variable Test

The relationship between COVID-19 uncertainty and corporate default risk may be affected by unobservable omitted variables that are not fully captured by the fixed effects in our baseline models. Following Oster (2019), we assess the potential bias caused by unobservable or omitted variables relative to observed controls by estimating the value of delta (δ) or by constructing an identifiable set of research variables β. Delta (δ) can be defined as the degree of selection on unobservable relative to observables necessary to explain away the results (i.e., to make Bias-adjusted β = 0). The suggested cutoff $\delta = 1$ means that omitted variables need to be equally important as the observables to erase the research coefficient or make Bias-adjusted β=0. According to the rule of thumb suggested by Oster (2019) and later implemented by Lin et al. (2021), if delta (δ) is greater than one or smaller than zero, unobservables are unlikely to explain away the effect of the treatment variable. Alternatively, if the bound of this identifiable set of β does not include a 0, one can reject the null hypothesis that the omitted variable drives the result. Following Oster (2019), by using the common $R_{max} = 1.3R^2$, results in Table 5 indicate that, to explain away the significant association between COVID-19 uncertainty and corporate default risk in the baseline models of Table 4, the effect of omitted variables must be 3.501 times greater than that of observed variables in the models. With the same specification omitted variables must be 6.96 times greater than that of observed variables in the models of association between STRINGENT_POLICY and corporate default risk. Alternatively, with the same specifications the bound of the identifiable set of Beta does not contain zero which also confirms that unobservable are unlikely to explain away the effect of the treatment variable. If we impose more restrictive criteria (for instance, R_{max} = $1.8R^2$ and R_{max} = $2R^2$), the results remain unchanged. Overall, the evidence in this omitted variable bias diagnostic test suggests that our results do not suffer from endogeneity due to omitted variable bias.

<INSERT TABLE 5>

5.2.2 Propensity Score Matching and Entropy Balancing

Our study employs OLS regression methods in the baseline regression model, which may lead to model misspecification issues if the linearity between dependent and independent variables is violated. However, with a Propensity Score Matching (PSM) sample this issue can be largely mitigated, as it ensures no pre-existing relationship between the dependent variable and the covariates (Rosenbaum & Rubin, 1983; Jha & Chen, 2015). Moreover, using a PSM sample helps mitigate sample selection bias concerns (Fang et al., 2014). To perform the PSM analysis, we define Treatment group as the sub-sample of firms with a COVID19_VOL that is above or equal to the top quartile, while control group as the sub-sample of firms with a COVID19_VOL that is below the bottom quartile. To ensure that our treated and control firms are comparable, we match treatment and control firms using propensity score matching. The matching is based on all the control variables that are used in the baseline regressions in Table 4. The results are presented in Panels A and B of Table 6.

Panel A of Table 6 presents the univariate mean comparisons between treatment and control firms' characteristics and their corresponding t-statistics. The results show that the average values of the matching variables are qualitatively similar across the treatment and control firms, suggesting that the two groups of firms are indistinguishable in those aspects. Next, we perform PSM regressions using the post-matched sample in Panel B of Table 6. Consistent with the baseline regression results, we find that COVID19_VOL significantly increases default risk.

<INSERT TABLE 6>

We also employ entropy balancing (EB) to further address the possible selection bias in our baseline results.[8] Specifically, we divide firm-quarter observations into treatment group for firms with a COVID19_VOL that is above or equal to the top quartile and control group for firms with a COVID19_VOL that is below to the bottom quartile. The entropy balancing method then assigns different weights to each observation of the control group so that the mean, variance, and skewness of all covariates are balanced across the treatment and control groups. This technique thus controls for random and systematic differences in the variable distributions between the treatment and control groups to mitigate the risk that design choices could influence our results (Hainmueller, 2012). We then re-estimate the regressions using the entropy balanced sample and present the results in Panel C of Table 6. The coefficient of COVID19_VOL remains positive and statistically significant, consistent with the baseline regressions results.

5.3 Cross-Sectional Analysis

[8] Moreover, the PSM tends to discard observations, reducing the test's power (Hossain et al., 2023).

In this section, we execute the relation between COVID-19 uncertainty and default risk in four cross-sectional analyses.

5.3.1 Local Religiosity

First, we test the effect of cultural traits (i.e., local religiosity) on the relation relationship between COVID19 uncertainty and default risk. The intuition is that if firms' headquarters are in a highly religious adherence country, they take a conservative risk-taking strategy, subsequently translating into lower default risk. Hilary and Hui (2009) show that firms located in counties with numerous religious adherents are less likely to take risks than firms located in counties with fewer religious adherents. Therefore, we assume that the effect of COVID-19 uncertainty on default risk is weaker if the firm's headquarters are in a highly religious adherence country.

<INSERT TABLE 7>

We employ in Table 7 three alternative proxies to examine the influence of religiosity on the relationship between COVID-19 uncertainty and corporate default risk. First, religiosity at the country level comes from the 2009 Gallup survey. Respondents in each country are asked whether religion plays a significant role in their daily lives. The percentage of respondents who answer "yes" (0-100%) determines a country's religiosity (REL_ARGNDT). Second, REL_DUMMY is a dummy variable equal to one if the percent of respondents are above the median who answer "yes." Third, CATHOLIC is an indicator variable equal to one when the largest proportion of the population of country c practicing catholic religion and zero otherwise.[9] In column 1,

[9] Data are available at https://www.cia.gov/the-world-factbook/

COVID_VOL interacts with REL_ARGNDT; in column 2, COVID_VOL interacts with REL_DUMMY; and in column 3, COVID_VOL interacts with CATHOLIC. As shown in Table 7, the estimated coefficients of interaction term are negative and statistically significant at the 1% level regardless of the specifications, suggesting that the relationship between COVID-19 uncertainty and default risk has weakened for firms in countries with a larger proportion of the population practicing religiosity. Overall, the relation between COVID-19 uncertainty and default risk is weaker for firms in a highly religious adherent country, consistent with H2.

5.2.2 Firms headquarters geographic proximity to China and Italy

In this paper, we focus on China and Italy because these two large countries on different continents experienced many COVID-19 cases in the early phases of the pandemic crisis. Hence, we calculate COVID19(CHINA)-DISTANCE-WGT for each country c by applying the COVID-19 uncertainty in China in quarter t weighted by the inverse distance between country c and China. In the same way, we calculate COVID19(ITALY)-DISTANCE-WGT for Italy.

<INSERT TABLE 8>

In Table 8, we present the results of the regression estimate. The results show that the default risk of firms in country c has a positive relationship with COVID19_VOL and COVID19(CHINA)-DISTANCE-WGT, suggesting that the default risk of a firm outside of China increase due to COVID-19 uncertainty in China. This relationship is stronger for firms geographically closer to China than for those geographically far away from China. We do find similar results on the relationship between default risk and COVID uncertainty for firms outside of Italy.

5.2.3 Investment in innovation

In this section, we test the effect of investment in innovation. Our prediction is that the impact of COVID-19 uncertainty on corporate default risk is weakened for highly innovative firms. Li et al. (2021) show that firms with high innovation are more adaptable to changing environments. We therefore assume that highly innovative firms will make more investment in innovation during the uncertainty than slightly innovative firms.

Following Chang et al. (2015), we use R &D expenditure as a proxy of investment in innovation. Hence, we construct the dummy variable HIGH_R&D, which is equal to one if the firm's R & D expenditure to assets is 90 percentile and 0 otherwise. We interact HIGH_R&D with COVID19_VOL and reexamine our baseline regressions by including the interaction term COVID19_VOL × HIGH_R&D and HIGH_R&D. Table 9 presents the estimation results of the role of investment in innovation.

<INSERT TABLE 9>

Consistent with the prediction of Hypothesis 4, Table 9 demonstrates that the coefficient on the interaction term between COVID19_VOL × HIGH_R&D is negative and significant at the 5% level, suggesting that the relation between COVID-19 uncertainty and corporate default risk is weaker for highly innovative firms compared to low innovative firms. The results are also economically significant. The coefficient estimates suggest that for firms with high investment in innovation (i.e., HIGH_R&D=1), a one-standard-deviation increase in COVID-19_VOL is associated with a total reduction of 0.002 bps in corporate default risk.[10]

5.2.4 Financial constraints

[10] This is calculated as $(0.017 - 0.015) \times 0.75$, where 0.017 and -0.015 are the coefficients on COVID19_VOL and COVID19_VOL × HIGH_R&D, respectively, and 0.75 is the standard deviation of COVID19_VOL.

In this section, we investigate the potential effect of financial constraints on the relationship between COVID-19 uncertainty and corporate default risk. We posit that firms more financially unconstrained will negatively moderate the relationship between COVID-19 uncertainty and corporate default risk. To test this conjecture, we proxy for financial unconstrained using dividend policy (Fazzari et al., 1987; Agrawal & Matsa, 2013) and cash flow to assets. DIV_DUM is an indicator variable that equals one if firms pay a cash dividend each quarter and zero otherwise. HIGH_CASHFLOW is an indicator variable equal to one for firms with 75 percentile cash flow to assets and zero otherwise. Firms with DIV_DUM=1 or HIGH_CASHFLOW=1 are more likely to have less financial constraints (financially unconstrained firms). We expand the regression model in Eq. (1) by including the proxy of financial unconstraint and the interaction between COVID-19 uncertainty and financial constraints. The results are reported in Table 10.

<INSERT TABLE 10>

As column 2 of Table 10 shows, the estimated coefficient of COVID19_VOL × HIGH_CASHFLOW is negative and statistically significant at a 5% level, indicating that firms with high cash flow to assets have the positive relationship between COVID-19 uncertainty and corporate default risk weakened. Regarding economic significance, 1-standard-deviation increases in COVID19_VOL decrease the corporate default risk by 0.008, or 1.56% of its mean.[11] We obtain similar results when using DIV_DUM as a proxy of financial unconstraint. We find that the coefficient of COVID19_VOL is positive and statistically significant. More importantly, the coefficient of COVID19_VOL × DIV_DUM is -0.026, which is significant at the 1% level, suggesting that firms with cash dividends payer weaken the positive relationship between COVID-

[11] This is calculated as $(0.018 - 0.008) \times 0.75$, where 0.018 and -0.008 are the coefficients on COVID19_VOL and COVID19_VOL × HIGH_CASHFLOW, respectively, and 0.75 is the standard deviation of COVID19_VOL.

19 uncertainty and corporate default risk. Economically, an increase of one standard deviation in COVID19_VOL will decrease the corporate default risk by 0.005, or 0.94 % of its mean.[12]. Overall, the results suggest that the relation between COVID-19 uncertainty and default risk is weaker when firms are financially unconstrained, consistent with H5.

5.3 Further Analysis

5.3.1 Industry Analysis

This section examines the effect of COVID-19 uncertainty on corporate default risk across industries. As capital markets have become more integrated in recent decades, global industries play an increasingly significant role in financial markets rather than country-specific risks. In addition, firm-specific analysis can miss important relationships between default risk and COVID-19 uncertainty since sectors can be heterogeneous across countries. Furthermore, COVID-19 uncertainty has been more prevalent in certain industries than in others. Social distancing interventions strongly impact firms where face-to-face communication or close physical proximity are required for manufacturing products or rendering services. Therefore, we investigate how COVID-19 uncertainty affects corporate default risk in different industries.

<INSERT TABLE 11>

We re-estimate our baseline regression using the Fama and French 12 industry classifications and present the results in Table 11. The results show that the estimated coefficients of COVID19_VOL are positive and significant at 1%, 5%, or 10% levels for all industries except for firms in the energy (column 4), utilities (column 6), and healthcare, medical equipment, and drugs industries (column 8), suggesting that the COVID-19 uncertainty is associated with

[12] This is calculated as $(0.020 - 0.026) \times 0.75$, where 0.020 and -0.026 are the coefficients on COVID19_VOL and COVID19_VOL × DIV_DUM, respectively, and 0.75 is the standard deviation of COVID19_VOL.

increased default risk across most of the sectors. The industries most impacted by COVID-19 uncertainty are chemicals and allied products (column 5) followed by consumer durables (column 2) and wholesale, retail, and some services such as Laundries, Repair Shops (column 7). The industry least impacted by COVID-19 uncertainty is finance. This is followed by manufacturing and others industry including mines, construction, transportation, hotels, Business Services, and entertainment.

5.3.2 Economy Size

Next, we run the baseline regression separately for the firms in the developed and developing countries, including all control variables used in columns 8 of Panel A in Table 4. The results are reported in Table 12. The estimated coefficient of COVID19_VOL is positive and highly significant, with *t* -statistics of 8.83 in the firm in developed countries subsample compared to a *t*-statistics of 3.92 in the firms in developing countries subsample.

<INSERT TABLE 12>

The Chi-square test shows that the estimated coefficient of COVID19_VOL is significantly different in the two subsamples, with chi-square statistics of 20.19 (*p*-value=0.000) for firms in the developed countries subsample compared to a t-statistics of 2.58 for firms in the developing countries subsample. Based on these results, the positive relationship between the COVID19_VOL and default risk is more pronounced in firms of developed countries than in firms of developing countries.

6. Conclusions

In this paper, we investigate the impact of the unprecedented COVID-19 pandemic on corporate default risk in an international context, using a comprehensive dataset comprising

187,925 firm-quarter observations and 25,944 unique firms from 71 countries, spanning January 2020 to June 2022. Our findings indicate that COVID-19 uncertainty causes an increase corporate default risk. Furthermore, we investigate several moderating factors that affect the association between COVID-19 uncertainty and corporate default risk, including religious adherence, geographical proximity to China and Italy, economic size, investment in innovation, financial constraints, and industry.

We observe that the effect of COVID-19 uncertainty on corporate default risk is attenuated for firms situated in countries with higher religious adherence, highly innovative firms, and financially unconstrained firms. Conversely, the effect is exacerbated for firms geographically closer to China and Italy and firms in developed countries. We expand upon firm and country coverage and refine the methodology by scrutinizing the effect of COVID-19 uncertainty on corporate default risk, as gauged by the modified Altman Z-score, employing a sizeable sample of 20 developed and 51 developing countries. This paper highlights the volatility effects of COVID-19 infections on default risk, with a specific emphasis on accounting for underrepresented developing economies. Our baseline model produces a coefficient of 0.022 for firms spanning all countries, whereas partitioning the sample results in coefficients of 0.035 for industrial countries and 0.012 for developing countries. We robustly reject the null hypothesis of identical COVID-19 coefficients and observe a more pronounced effect on default risk in industrial countries, accompanied by a comparatively reduced impact on developing economies. Furthermore, our industry analysis reveals that chemicals and allied products are the most affected by the uncertainty caused by COVID-19, while finance is the least affected.

To address potential omitted variables concerns, we adopt rigorous research design strategies that encompass alternative series of dependent and test variables, a comprehensive set of firm and country-level control variables, a highly restrictive fixed effects design, alternative sample, propensity score matching, entropy balancing, and Oster (2019) test. While our findings are consistent across these tests, we recognize that the likelihood of unidentified time-varying omitted variables influencing our results can not be completely ruled out.

This study contributes to the rapidly expanding body of literature on the tangible consequences of COVID-19 uncertainty and the determinants of corporate default risk, a topic that is both pertinent and timely given the extensive economic repercussions of the ongoing global pandemic. Our results have significant policy implications, as policymakers may contemplate offering targeted support to firms within these categories to alleviate the detrimental effects of COVID-19 uncertainty on their default risk. A promising direction for future research involves delving deeper into the sources of this differential impact, extending beyond democracy and common law regimes. Although monetary easing and expansionary fiscal policies have been executed worldwide, the response of default risk to a major health crisis remains diverse across countries.

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APPENDIX-A
Variable definition and sources

Variable name	Definition	Sources
DEFAULT1	The natural logarithm of modified Altman Z-score. Z-score is the distance from insolvency and is calculated as: $Z - score = 3.3 \times \frac{EBIT}{BA} + 1.0 * \frac{SALES}{BA} + 1.4 \times \frac{RE}{BA} + 1.2 \times \frac{WCAP}{BA}$, where EBIT is earnings before interest and taxes, SALES is net sales or revenue, BA is the book value of assets, RE is the retained earnings, WCAP is working capital, which is the difference between current assets and current liabilities.	Author's calculation using Worldscope data
DEFAULT2	Distance-to-default, which is the quarterly average of Merton (1974) distance-to-default (DTD)	Credit Research Initiative (CRI)
DEFAULT3	Expected default frequency, which is the cumulative standard normal distribution of DTD.	Credit Research Initiative (CRI)
COVID19_VOL	The quarterly standard deviation of daily COVID-19 growth rates	Author's calculation based on data from Center for Systems Science and Engineering at Johns Hopkins University
STRINGENCY_POLICY	The stringency index is rescaled to a value from 0 and 100 (100 = strictest) using nine response indicators, such as school closures; workplace closures; cancellation of public events; restrictions on public gatherings; closures of public transport; stay-at-home requirements; public information campaigns; restrictions on internal movements; and international travel controls.	Oxford Coronavirus Government Response Tracker
RV	The realized volatility of COVID-19 pandemic crisis	Author's calculation based on data from Center for Systems Science and Engineering at Johns Hopkins University
STD_SPREAD	The standard deviation of COVID-19 spread per thousands of people in country c.	As above
COVID19(CHINA)-	the COVID-19 uncertainty in China in quarter t weighted by the	Author's own calculation

DISTANCE-WGT	inverse distance between country c and China	
COVID19(ITALY)-DISTANCE-WGT	the COVID-19 uncertainty in Italy in quarter t weighted by the inverse distance between country c and Italy	Author's own calculation
SIZE	The natural logarithm of the book value of total assets (in US$ million) at the end of quarter t.	Author's calculation using Worldscope data
LEVERAGE	Ratio of book value of total debt to book value of assets.	As above
MTB	Market value of assets scaled by book value of assets.	As above
TANGIBILITY	Net property, plant, and equipment divided by book value of assets.	As above
CASH	Cash and short-term investment to assets	As above
CAPX	Ratio of capital expenditures to book value of assets.	As above
ROA	Ratio of earnings before interest and taxes to book value of assets.	As above
DIV_DUM	A dummy variable that equals 1 if a firm pays cash dividend in quarter t, and 0 otherwise.	As above
DEMOCRACY	An indicator variable that equals 1 if firm's headquarters is in a democratic country, and 0 otherwise.	Polity, Freedom speech
COMMON_LAW	An indicator variable that equals 1 if a firm's headquarters is in a common law tradition, and 0 otherwise.	La Porta et al. (1998)
REL_ARGNDT	A country's religiosity is the fraction of people who say religion is important in their daily lives, based on a survey question in each country.	Gallup Survey
REL_DUMMY	A dummy variable that is one when the fraction of people who say "yes" to a religious question in the Gallup survey is higher than the median, and zero otherwise.	Gallup Survey
CATHOLIC	An indicator variable equal to one when the largest proportion of the population of country c practicing catholic religion and zero otherwise.	Gallup Survey
CR	Creditor rights index. The overall index ranges from 0 to 4 with higher values indicating more powerful creditor rights.	Djankov et al. (2007), La Porta et al. (1998)

Table1. Sample distribution.

Table 1 presents the sample breakdown by quarters (Panel A) and by country (Panel B).

Panel A: Sample distributions by quarters

Year	Quarters	Frequency	Percent	Cumulative Frequency	Cumulative Percent
2020	1	17,041	9.07	17,041	9.07
2020	2	18,693	9.95	35,734	19.02
2020	3	17,022	9.06	52,756	28.07
2020	4	21,476	11.43	74,232	39.5
2021	1	17,388	9.25	91,620	48.75
2021	2	19,772	10.52	111,392	59.27
2021	3	17,458	9.29	128,850	68.56
2021	4	21,837	11.62	150,687	80.18
2022	1	17,666	9.4	168,353	89.59
2022	2	19,572	10.41	187,925	100

Panel B: Sample Distribution by country

S.N.	Country	Frequency	Percent	S.N.	Country	Frequency	Percent	S.N.	Country	Frequency	Percent
	Developed Countries			24	Bangladesh	625	0.33	50	Malaysia	7,536	4.01
1	Australia	84	0.04	25	Bolivia	44	0.02	51	Mexico	1,271	0.68
2	Belgium	136	0.07	26	Bosnia and	98	0.05	52	Montenegro	69	0.04
3	Canada	12,983	6.91	27	Brazil	2,970	1.58	53	Nigeria	765	0.41
4	Denmark	705	0.38	28	Bulgaria	901	0.48	54	Oman	755	0.4
5	Finland	849	0.45	29	Chile	1,527	0.81	55	Pakistan	3,187	1.7
6	France	199	0.11	30	China	768	0.41	56	Panama	63	0.03

7	Germany	2,436	1.3	31	Colombia	528	0.28	57	Peru	1,079	0.57
8	Hong Kong	1,510	0.8	32	Costa Rica	24	0.01	58	Philippines	1,799	0.96
9	Ireland	61	0.03	33	Croatia	554	0.29	59	Poland	3,907	2.08
10	Israel	2,938	1.56	34	Czechia	38	0.02	60	Qatar	293	0.16
11	Italy	1,027	0.55	35	Ecuador	70	0.04	61	Romania	451	0.24
12	Japan	31,581	16.81	36	Egypt	1,307	0.7	62	Saudi Arabi	1,397	0.74
13	Luxembourg	119	0.06	37	Estonia	146	0.08	63	Slovenia	106	0.06
14	Norway	1,731	0.92	38	Greece	269	0.14	64	South Africa	25	0.01
15	Portugal	182	0.1	39	Hungary	125	0.07	65	Sri Lanka	1,814	0.97
16	Singapore	820	0.44	40	Iceland	186	0.1	66	Taiwan	16,848	8.97
17	Spain	555	0.3	41	India	10,338	5.5	67	Thailand	7,093	3.77
18	Switzerland	165	0.09	42	Indonesia	5,421	2.88	68	T&T	28	0.01
19	United Kingdom	376	0.2	43	Jamaica	279	0.15	69	Turkey	3,159	1.68
20	United States	39,389	20.96	44	Jordan	956	0.51	70	UAE	724	0.39
	Total	**97,846**	**52.08**	45	Kazakhstan	293	0.16	71	Vietnam	7,933	4.22
	Developing Countries			46	Kenya	23	0.01		**Total**	**90,079**	**47.92**

21	Argentina	675	0.36	47	Kuwait	1,109	0.59
22	Bahamas	43	0.02	48	Latvia	111	0.06
23	Bahrain	150	0.08	49	Lithuania	199	0.11

Table 2. Summary Statistics for the sample

Table 2 presents the number of observations (N), mean, median, standard deviation (Std. Dev.), minimum, maximum, first quartile (p25), and third quartile (p75) for the 187,925 firm-quarter observations of the sample. The sample period covers from January 1, 2020, to June 30, 2022. All continuous variables are winsorized at the 1st and 99th percentile. All variables are defined in Appendix A.

	N	Mean	Median	Std. Dev.	Minimum	Maximum	p25	p75
DEFAULT1	150,590	-0.48	-0.58	0.54	-3.46	9.51	-0.79	-0.31
COVID19_VOL	187,925	1.04	0.78	0.75	0.12	5.59	0.58	1.2
STRINGENCY_POLICY	187,925	51.32	51.21	17.4	8.85	93.78	38.54	67.07
RV	187,925	8.18	8.66	1.32	2.21	9.48	7.65	9.15
STD_SPREAD	187,925	0.13	0.02	0.29	0	4.58	0	0.15
SIZE	187,925	5.76	5.55	2.31	1.03	11.74	4.07	7.31
CAPX	187,925	0.01	0	0.01	0	0.08	0	0.01
LEVERAGE	187,925	0.24	0.21	0.2	0	0.79	0.07	0.37
ROA	187,925	0.02	0.01	0.05	-0.31	0.11	0	0.03
COMMON LAW	187,925	0.66	1	0.48	0	1	0	1
DEMOCRACY	187,925	0.90	1	0.3	0	1	1	1

Table 3. Correlation matrix

Table 3 presents pair-wise correlations coefficients between dependent variables and independent variables. The sample comprises 187,925 firm-quarter observations covering the period from January 1, 2020, to June 30, 2022. All variables are defined in Appendix A. ***, **, and * indicates statistical significance at 1%, 5%, and 10% level, respectively.

Variables	1	2	3	4	5	6	7	8	9
1.DEFAULT1	1								
2.COVID19_VOL	0.03***	1							
3.STRINGENCY_POLICY	0.08***	-0.39***	1						
4.SIZE	-0.02***	0.03***	-0.05***	1					
5.CAPX	0.08***	0.03***	-0.00*	0.01***	1				
6.LEVERAGE	0.29***	0.04***	0.01***	0.20***	0.03***	1			
7.ROA	-0.43***	0.00**	-0.03***	0.22***	0.02***	0	1		
8.COMMON LAW	-0.01**	-0.14***	0.09***	0.08***	-0.08***	-0.02***	-0.13***	1	
9.DEMOCRACY	-0.03***	-0.07***	-0.12***	0.12***	-0.02***	0	-0.08***	0.46***	1

Table 4. COVID-19 Uncertainty and Corporate Default risk: Baseline Regressions

Table 4 reports the results of the corporate default risk regressions. The dependent variable is the DEFAULT1 (-1 times the natural logarithm of modified Altman Z-score). COVID19_VOL is the quarterly standard deviation of daily growth rates of COVID-19 pandemic cases. STRINGENCY_POLICY is the quarterly average of COVID-19 stringency policy index. All firm-level continuous variables are winsorized at the 1% and 99% levels, and all variables are defined in detail in Appendix A. *t*-statistics based on heteroscedasticity-robust standard errors clustered by industry and country are reported in parentheses. The sample period is from January 1, 2020, to June 30, 2022. In Panel A, the effects of COVID19_VOL on default risk are presented, and In Panel B, the effects of COVID-19 stringency on default risk are reported. The symbols ***, **, and * indicate statistical significance at 1%, 5%, and 10% level, respectively.

Panel A: COVID-19 Volatility and Corporate Default Risk

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	DEFAULT1	DEFAULT1	DEFAULT1	DEFAULT1	DEFAULT1	DEFAULT1	DEFAULT1	DEFAULT1
COVID19_VOL	0.022***	0.023***	0.028***	0.013***	0.020***	0.020***	0.022***	0.015***
	(8.42)	(8.61)	(12.10)	(4.96)	(7.38)	(7.71)	(8.57)	(6.81)
SIZE		-0.010***						-0.019***
		(-6.20)						(-13.54)
ROA			-7.486***					-7.212***
			(-68.39)					(-67.78)
LEVERAGE				0.819***				0.783***
				(47.05)				(47.72)
CAPX					3.029***			3.883***
					(13.54)			(19.89)
DEMOCRACY						-0.057***		-0.084***
						(-5.65)		(-8.97)
COMMON_LAW							0.001	0.016***
							(0.08)	(2.64)
Constant	-0.500***	-0.444***	-0.429***	-0.688***	-0.518***	-0.446***	-0.500***	-0.460***
	(-116.78)	(-42.12)	(-102.39)	(-120.09)	(-115.90)	(-45.11)	(-86.89)	(-41.25)
Observations	150,590	150,590	150,589	150,590	150,590	150,559	150,590	150,558
Adjusted R-squared	0.019	0.021	0.200	0.098	0.024	0.020	0.019	0.278
Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Panel B: COVID-19 Stringency Policy and Corporate Default Risk

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	DEFAULT1	DEFAULT1	DEFAULT1	DEFAULT1	DEFAULT1	DEFAULT1	DEFAULT1	DEFAULT1
STRINGENCY_POLICY	0.003***	0.003***	0.003***	0.003***	0.003***	0.003***	0.004***	0.003***
	(21.72)	(21.37)	(23.96)	(22.09)	(21.61)	(20.60)	(22.27)	(21.84)
SIZE		-0.008***						-0.018***
		(-5.40)						(-12.78)
ROA			-7.467***					-7.209***
			(-68.58)					(-67.93)
LEVERAGE				0.818***				0.778***
				(47.37)				(47.83)
CAPX					3.033***			3.809***
					(13.73)			(19.70)
DEMOCRACY						-0.035***		-0.050***
						(-3.44)		(-5.23)
COMMON_LAW							-0.016**	-0.007
							(-2.53)	(-1.21)
Constant	-0.652***	-0.601***	-0.571***	-0.841***	-0.672***	-0.614***	-0.645***	-0.611***
	(-81.44)	(-47.05)	(-79.10)	(-104.46)	(-81.46)	(-46.32)	(-75.39)	(-46.53)
Observations	150,534	150,534	150,533	150,534	150,534	150,503	150,534	150,502
Adjusted R-squared	0.027	0.028	0.206	0.105	0.031	0.027	0.027	0.283
Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 5. Test for Omitted Variable Bias Using Oster (2019).

Table 5 presents the importance of omitted variable bias, measured using Oster (2019)'s bound of identified set and δ of the association between COVID-19 pandemic crisis and corporate default risk from the baseline OLS model with all controls from column (8) of Panel A and Panel B of Table 4. Oster (2019) developed an idea that the research coefficients' stability combined with R-squared of the regression with controls and without any controls can be used to construct an identifiable set of the research variable's Beta. If the bound of this set does not include a 0, one can reject the null hypothesis that the omitted variable drives the result. At the same time the same findings can be interpreted by the value of the parameter δ. The parameter δ captures the degree of proportional bias of the omitted variables relative to the observed variables. The suggested cutoff $\delta = 1$ means that omitted variables need to be equally important as the observables to erase the research coefficient or make Bias-adjusted β=0. Oster δ is calculated assuming on R_{max} = $1.3R^2$, and Bias-adjusted β=0, we also impose more restriction by assuming R_{max} = $1.8R^2$, and Bias-adjusted β=0, and R_{max} = $2R^2$, and Bias-adjusted β=0.

	COVID19_VOL			STRINGENCY_POLICY		
R_{max}, δ	Lower bound	Upper bound	δ for β=0	Lower bound	Upper bound	δ for β=0
$1.3R^2$, 1	0.013	0.015	3.501	0.0029	0.003	6.960
$1.8R^2$, 1	0.011	0.015	1.320	0.0029	0.0033	2.670
$2R^2$, 1	0.010	0.015	1.052	0.0029	0.0033	2.144

Table 6. Propensity Score Matching (PSM) and Entropy balancing.

Table 6 presents the results of tests examining the relationship between COVID-19 pandemic crisis and corporate default risk in a propensity score matched sample as well as entropy balancing sample. Panels A reports the diagnostic statistical differences in means for firm, and country level covariates. *Treatment* denotes sub-sample of firms with an above or equal value of COVID19_VOL top quartile, while *Control* refers sub-sample of firms with a below value of COVID19_VOL bottom quartile. Panel B presents OLS regression models of COVID-19 pandemic crisis and corporate default risk for the PSM sample, while Panel C reports for the entropy balancing sample. We report robust *t*-Statistics that are clustered at the industry and country level in parentheses. All firm-level continuous variables are winsorized at the 1% and 99% levels, and all variables are defined in detail in Appendix A. *, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Panel A. Before and after matching covariate mean comparison: treatment vs. control groups.

	Before				After			
	Treated	Control	Diff	T-stat	Treated	Control	Diff	t-stat
SIZE	5.611	6.035	-0.424	-27.42	5.611	5.676	-0.065	-1.44
ROA	0.012	0.009	0.003	9.86	0.012	0.012	0.000	-0.58
LEVERAGE	0.256	0.243	0.013	9.41	0.256	0.256	0.000	-0.02
CAPX	0.007	0 .006	0.001	12.16	0 .007	0.007	0.000	0.03
DEMOCRACY	0.825	0.942	-0.117	-51.60	0.825	0.891	-0.066	-1.54
COMMON_LAW	0.512	0.714	-0.202	-58.82	0.512	0.553	-0.041	-1.12

Panel B. Effect of COVID-19_UNCERTAINTY on corporate default risk for PSM sample.

	DEFAULT1
COVID19_VOL	0.031***
	(9.12)
Controls	Yes
Observations	76,893
Adjusted R-squared	0.283
Quarter FE	Yes
Industry FE	Yes

Panel C. Effect of COVID-19_UNCERTAINTY on corporate default risk for entropy balancing sample.

	DEFAULT1
COVID19_VOL	0.026***
	(9.63)
Controls	Yes
Observations	76,913
Adjusted R-squared	0.280
Quarter FE	Yes
Industry FE	Yes

Table 7: COVID-19 Uncertainty, Religiosity, Corporate Default Risk

Table 7 presents the results of the corporate default risk regressions augmented with religiosity. The dependent variable is the DEFAULT1 (-1 times the natural logarithm of modified Altman Z-score). COVID19_VOL is the quarterly standard deviation of daily growth rates of COVID-19 pandemic cases. REL_ARGNDT is the fraction of people who say religion is important in their daily lives, based on a survey question (Gallup Survey) in each country. REL_DUMMY is a dummy variable that is one when the fraction of people who say "yes" to a religious question in the Gallup survey is higher than the median, and zero otherwise. CATHOLIC is an indicator variable equal to one when the largest proportion of the population of country c practicing catholic religion and zero otherwise. All firm-level continuous variables are winsorized at the 1% and 99% levels, and all variables are defined in detail in Appendix A. t-statistics based on heteroscedasticity-robust standard errors clustered by industry and country are reported in parentheses. The sample period is from January 1, 2020, to June 30, 2022. The symbols ***, **, and * indicate statistical significance at 1%, 5%, and 10% level, respectively.

	(1)	(2)	(3)
VARIABLES	DEFAULT1	DEFAULT1	DEFAULT1
COVID19_VOL	0.082***	0.022***	0.015***
	(11.02)	(8.05)	(6.35)
REL_ARGNDT	0.273***		
	(19.94)		
COVID19_VOL* REL_ARGNDT	-0.099***		
	(-9.56)		
REL_DUMMY		0.069***	
		(6.89)	
COVID19_VOL* REL_DUMMY		-0.022***	
		(-3.37)	
CATHOLIC			0.234***
			(18.40)
COVID19_VOL* CATHOLIC			-0.028***
			(-6.02)
SIZE	-0.016***	-0.017***	-0.019***
	(-10.42)	(-11.07)	(-13.32)
ROA	-7.420***	-7.331***	-7.157***
	(-65.00)	(-64.59)	(-68.04)
LEVERAGE	0.767***	0.779***	0.780***
	(42.74)	(42.97)	(48.03)
CAPX	4.202***	4.583***	3.332***
	(17.63)	(19.34)	(18.13)
DEMOCRACY	-0.107***	-0.077***	-0.148***
	(-9.51)	(-6.92)	(-15.05)
COMMON_LAW	0.039***	0.016*	0.060***
	(4.55)	(1.93)	(8.97)
Constant	-0.641***	-0.497***	-0.456***
	(-44.59)	(-40.82)	(-40.81)
Observations	126,814	126,814	150,145
Adjusted R-squared	0.282	0.275	0.293

Quarter FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes

Table 8: COVID-19 Uncertainty, Country factor (Distance from China and Italy to country c), and Corporate Default Risk

Table 8 presents the results of the corporate default risk regressions augmented with country factor (Distance from China and Italy). The dependent variable is the DEFAULT1 (-1 times the natural logarithm of modified Altman Z-score). COVID19_VOL is the quarterly standard deviation of daily growth rates of COVID-19 pandemic. COVID19(CHINA)-DISTANCE-WGT is the growth rate of COVID-19 cases in China in quarter t weighted by the inverse distance between country c and China. COVID19(ITALY)-DISTANCE-WGT is the growth rate of COVID-19 cases in China in quarter t weighted by the inverse distance between country c and Italy. All firm-level continuous variables are winsorized at the 1% and 99% levels, and all variables are defined in detail in Appendix A. t-statistics based on heteroscedasticity-robust standard errors clustered by industry and country are reported in parentheses. The sample period is from January 1, 2020, to June 30, 2022. The symbols ***, **, and * indicate statistical significance at 1%, 5%, and 10% level, respectively.

	(Excluding China)	(Excluding China)	(Excluding Italy)	(Excluding Italy)
	(1)	(2)	(3)	(4)
VARIABLES	DEFAULT1	DEFAULT1	DEFAULT1	DEFAULT1
COVID19_VOL		0.002*		0.014***
		(1.70)		(6.62)
COVID19(CHINA)-DISTANCE-WGT	0.503***	0.447***		
	(3.27)	(2.85)		
COVID19(ITALY)-DISTANCE-WGT			0.312**	0.270***
			(2.23)	(2.93)
SIZE	-0.032***	-0.032***	-0.019***	-0.019***
	(-18.82)	(-18.82)	(-13.36)	(-13.45)
ROA	-6.854***	-6.854***	-7.209***	-7.209***
	(-66.62)	(-66.62)	(-67.56)	(-67.58)
LEVERAGE	0.782***	0.782***	0.784***	0.783***
	(49.75)	(49.75)	(47.64)	(47.54)
CAPX	0.715***	0.716***	3.902***	3.889***
	(3.94)	(3.95)	(19.92)	(19.85)
DEMOCRACY	-0.034***	-0.032***	-0.085***	-0.084***
	(-8.92)	(-8.92)	(-9.06)	(-9.01)
COMMON_LAW	0.080**	0.080**	0.016***	0.018***
	(2.42)	(2.41)	(2.60)	(3.00)
Constant	-0.481***	-0.472***	-0.484***	-0.495***

	(-21.84)	(-20.77)	(-23.35)	(-23.78)
Observations	149,900	149,900	149,696	149,696
Adjusted R-squared	0.357	0.357	0.278	0.278
Quarter FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes

Table 9: COVID-19 Uncertainty, Investment in Innovation, and Corporate Default Risk

Table 9 reports the results of the corporate default risk regressions augmented with investment in innovation. The dependent variable is the DEFAULT1 (-1 times the natural logarithm of modified Altman Z-score). COVID19_VOL is the quarterly standard deviation of daily growth rates of COVID-19 pandemic. HIGH_R&D is an indicator variable that equals 1 firm's research and development expenses to book value of assets is above the 90th percentile in quarter t and 0 otherwise. All firm-level continuous variables are winsorized at the 1% and 99% levels, and all variables are defined in detail in Appendix A. t-statistics based on heteroscedasticity-robust standard errors clustered by industry and country are reported in parentheses. The sample period is from January 1, 2020, to June 30, 2022. The symbols ***, **, and * indicate statistical significance at 1%, 5%, and 10% level, respectively.

VARIABLES	(1) DEFAULT1
COVID19_VOL	0.017***
	(7.33)
HIGH_R&D	0.140***
	(10.43)
COVID19_VOL* HIGH_R&D	-0.015**
	(-2.39)
SIZE	-0.021***
	(-14.90)
ROA	-7.120***
	(-67.92)
LEVERAGE	0.809***
	(48.79)
CAPX	3.894***
	(19.89)
DEMOCRACY	-0.091***
	(-9.74)
COMMON_LAW	0.020***
	(3.38)
Constant	-0.465***
	(-41.61)
Observations	150,558
Adjusted R-squared	0.282
Quarter FE	Yes
Industry FE	Yes

Table 10. COVID-19 Uncertainty, Financial Unconstrained, and Corporate Default Risk

Table 10 reports the results of the corporate default risk regressions augmented with financial unconstrained. The dependent variable is the DEFAULT1 (-1 times the natural logarithm of modified Altman Z-score). COVID19_VOL is the quarterly standard deviation of daily growth rates of COVID-19 pandemic cases. HIGH_CASHFLOW is a dummy variable that equals 1 if cash flow to book value of assets is above the median in quarter t and 0 otherwise. DIV_DUM is a dummy variable that takes the value of 1 if a firm pays a common dividend in quarter t, and 0 otherwise. All firm-level continuous variables are winsorized at the 1% and 99% levels, and all variables are defined in detail in Appendix A. t-statistics based on heteroscedasticity-robust standard errors clustered by industry and country are reported in parentheses. The sample period is from January 1, 2020, to June 30, 2022. The symbols ***, **, and * indicate statistical significance at 1%, 5%, and 10% level, respectively.

	(1)	(2)
VARIABLES	DEFAULT1	DEFAULT1
COVID19_VOL	0.018***	0.020***
	(6.61)	(8.22)
HIGH_CASHFLOW	-0.043***	
	(-7.05)	
COVID19_VOL* HIGH_CASHFLOW	-0.008**	
	(-2.43)	
DIV_DUM		-0.002
		(-0.26)
COVID19_VOL*DIV_DUM		-0.026***
		(-6.83)
SIZE	-0.020***	-0.018***
	(-13.93)	(-12.78)
ROA	-6.788***	-7.197***
	(-53.67)	(-67.71)
LEVERAGE	0.771***	0.783***
	(46.84)	(47.71)
CAPX	3.970***	3.914***
	(20.38)	(20.03)
DEMOCRACY	-0.082***	-0.085***
	(-8.89)	(-9.17)
COMMON_LAW	0.016***	0.018***
	(2.61)	(3.07)
Constant	-0.447***	-0.468***
	(-39.72)	(-41.84)
Observations	150,558	150,558
Adjusted R-squared	0.279	0.279
Quarter FE	Yes	Yes
Industry FE	Yes	Yes

Table 11: COVID-19 Uncertainty and Corporate Default Risk: Industry analysis

Table 11 presents the results of the corporate default risk for a subsample of industries. The dependent variable is the DEFAULT1 (-1 times the natural logarithm of modified Altman Z-score). COVID19_VOL is the quarterly standard deviation of daily growth rates of COVID-19 pandemic. Column 1 shows the results for consumer non-durable industries, column 2 for consumer durable, column 3 for manufacturing, column 4 for energy, column 5 for chemicals and allied products, column 6 for utilities, column 7 for wholesale, retail, and some services (Laundries, Repair Shops), column 8 for healthcare, medical equipment, and drugs, column 9 for finance, and column 10 for others industry including mines, construction, transportation, hotels, Business Services, and entertainment. Due to data limitations, we drop business equipment and telephone and television transmission industries from the analysis. All firm-level continuous variables are winsorized at the 1% and 99% levels, and all variables are defined in detail in Appendix A. t-statistics based on heteroscedasticity-robust standard errors clustered by industry and country are reported in parentheses. The sample period is from January 1, 2020, to June 30, 2022. The symbols ***, **, and * indicate statistical significance at 1%, 5%, and 10% level, respectively.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
COVID19_VOL	0.017*	0.021**	0.011*	-0.117	0.023***	-0.010	0.021**	-0.011	0.009*	0.012***
	(1.74)	(1.98)	(1.66)	(-1.04)	(3.43)	(-0.89)	(2.52)	(-0.55)	(1.68)	(4.38)
SIZE	-0.020**	-0.016*	-0.018***	-0.064	-0.029***	-0.040***	-0.048***	-0.006	-0.023***	-0.013***
	(-2.45)	(-1.89)	(-4.58)	(-1.39)	(-6.01)	(-2.86)	(-9.75)	(-0.34)	(-4.03)	(-7.08)
ROA	-5.876***	-6.256***	-7.671***	-11.195***	-7.261***	-5.522***	-7.146***	-3.492***	-6.001***	-7.103***
	(-8.83)	(-9.95)	(-20.85)	(-4.85)	(-20.91)	(-6.30)	(-24.48)	(-6.98)	(-18.55)	(-53.06)
LEVERAGE	0.865***	0.809***	0.867***	1.249*	0.646***	0.977***	0.634***	0.851***	1.149***	0.798***
	(6.96)	(7.11)	(15.75)	(1.85)	(14.67)	(4.97)	(9.49)	(4.81)	(18.17)	(39.74)
CAPX	0.158	0.702	1.489***	1.869	0.722	1.412	9.102***	-0.987	-0.499	2.450***
	(0.17)	(0.72)	(3.26)	(0.54)	(1.62)	(1.12)	(14.44)	(-0.55)	(-0.78)	(11.40)
DEMOCRACY	-0.114*	-0.081	-0.048*	0.078	-0.114***	-0.044	0.045	-0.075	-0.014	-0.098***
	(-1.67)	(-1.55)	(-1.85)	(0.49)	(-4.73)	(-0.65)	(1.38)	(-0.72)	(-0.30)	(-7.65)
COMMON_LAW	-0.020	-0.027	0.049***	-0.106	-0.073***	0.007	0.129***	-0.231***	-0.055**	-0.001
	(-0.48)	(-0.65)	(2.70)	(-0.70)	(-3.83)	(0.13)	(5.60)	(-4.08)	(-2.07)	(-0.20)
Constant	-0.422***	-0.525***	-0.519***	-0.119	-0.317***	-0.524***	-0.389***	-0.533***	-0.531***	-0.475***
	(-5.52)	(-7.19)	(-16.29)	(-0.46)	(-10.39)	(-6.56)	(-9.16)	(-3.85)	(-11.04)	(-32.11)
Observations	3,120	2,547	15,521	436	14,717	1,325	15,082	200	8,574	89,036
Adjusted R-squared	0.260	0.238	0.344	0.266	0.281	0.306	0.251	0.830	0.366	0.287
Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 12. Covid-19 uncertainty and Corporate Default Risk: Economy Size

Table 12 presents the results of the corporate default risk for a subsample of firms incorporated in developed and developing countries. The dependent variable is the DEFAULT1 (-1 times the natural logarithm of modified Altman *Z*-score). COVID19_VOL is the quarterly standard deviation of daily growth rates of COVID-19 pandemic. *t*-statistics based on heteroscedasticity-robust standard errors clustered by industry and country are presented in parentheses. The sample period is from January 1, 2020, to June 30, 2022. Column 1 reports regression results for developed countries and column 2 reports regression results for developing countries. All firm-level continuous variables are winsorized at the 1% and 99% levels, and all variables are defined in detail in Appendix A. The symbols ***, **, and * indicate statistical significance at 1%, 5%, and 10% level, respectively.

	(1)	(2)
	Developed	Developing
VARIABLES	DEFAULT1	DEFAULT1
COVID19_VOL	0.035***	0.012***
	(8.83)	(3.92)
SIZE	-0.025***	-0.020***
	(-10.87)	(-9.65)
ROA	-7.108***	-6.826***
	(-46.05)	(-52.62)
LEVERAGE	0.727***	0.865***
	(30.14)	(40.27)
CAPX	8.910***	0.162
	(22.83)	(1.04)
DEMOCRACY		-0.066***
		(-7.02)
COMMON_LAW	0.063***	-0.024***
	(4.87)	(-3.14)
Constant	-0.573***	-0.459***
	(-27.49)	(-33.63)
Observations	72,718	77,840
Adjusted R-squared	0.283	0.321
Quarter FE	Yes	Yes
Industry FE	Yes	Yes

Null: The effect of Covid-19 uncertainty in both developed & undeveloped economy is the same

$\hat{\beta}$(developed)= $\hat{\beta}$(undeveloped))

P-value =0.000 (Chi-square=20.19)

Internet Appendix for "**The Effect of COVID-19 Uncertainty on Corporate Default Risk: International evidence**"

OA: Robustness Checks of the Baseline Results

OA1: Alternative measure of COVID-19_UNCERTAINTY

We have hitherto employed COVID19_VOL to measure the COVID-19 uncertainty. We now investigate whether the baseline regression results hold when the primary research variable is one of the measures of alternative measures described in section 3. We do this for two reasons. First, we want to ensure that the relationship between default risk and the COVID-19 uncertainty is robust to include other COVID-19 uncertainty proxies. Second, we want to compare the effect on default risk across different COVID-19 uncertainty proxies. The results are reported in Table A.1. The estimated coefficient of COVID-19 uncertainty remains significantly positive for all alternative COVID-19 uncertainty measures.

OA2: Alternative measure of default risk

To check the robustness of our results, we further use an alternative measure of default risk. The first measure is distance-to-default, which is based on Merton's (1974) method to estimate the probability of a firm defaulting on its debt. The second measure is expected default frequency, which is the cumulative standard normal distribution of distance-to-default. Data on distance to default collected from Credit Research Initiative (CRI). Results using distance-to-default expected default frequency as alternative measure of default risk are presented in Table A.2. Due to the data requirements, the sample size decreased to 7,639. We continue to find that COVID-19 uncertainty positively and significantly related to corporate default risk using the alternative measures of default risk.

OA3: Alternative sample

In this section, we test the robustness of our results by excluding observations from large countries in the sample, namely USA, Japan, and Taiwan, which account for approximately 47% of the sample (87,554 firm-quarter observations in Panel B of Table 1 divided by the final sample of 187,925). These countries account for a big share of our initial sample. As columns 1 and 2 of Table A.3 show, the coefficients for COVID19_VOL and STRINGENCY_POLICY remain positive and highly significant statistically. This indicates that our findings do not depend on the firms from these countries.

OA4: Additional controls

In Table A.4, we repeat our analysis by including additional controls: tangibility, market-to-book, cash holding, and creditors' rights. The results remain positive and statistically significant. The economic magnitudes are also similar.

OA 5: Alternative fixed effects:

Although our baseline regression model includes firm-level and county-level control variables, it might still omit some unknown firm or county characteristics that affect COVID-19 uncertainty and default risk. We use firm and country fixed effects in our baseline regression models to address this concern. These fixed effects capture the effects of any time-invariant factors at the firm level and the country level, respectively. The results reported in Table A.5 show that the estimate on COVID-19 uncertainty remains positive and statistically significant.

Table A1: Alternative measure of Covid-19 uncertainty

This table reports regression results on the relationship between COVID-19 uncertainty and corporate default risk using alternative measure of COVID-19 uncertainty. The dependent variable is the default risk. t-statistics based on heteroscedasticity-robust standard errors clustered by industry and country are presented in parentheses. The sample period is January 1, 2020, to June 30, 2021. All variables are defined in Appendix A. The symbols ***, **, and * indicates statistical significance at 1%, 5%, and 10% level, respectively.

	(1)	(2)
VARIABLES	DEFAULT1	DEFAULT1
RV	0.017**	
	(2.24)	
STD_SPREAD		0.072***
		(2.87)
Observations	150,558	150,558
Adjusted R-squared	0.292	0.293
Baseline controls	Yes	Yes
Quarter FE	Yes	Yes
Industry FE	Yes	Yes

Table A2. Alternative measure of Default risk

This table reports regression results on the relationship between COVID-19 uncertainty and corporate default risk using alternative measure of default risk. The dependent variable is the default risk (either distance-to-default or expected default frequency). *t*-statistics based on heteroscedasticity-robust standard errors clustered by industry and country are presented in parentheses. The sample period is January 1, 2020, to June 30, 2021. All variables are defined in Appendix A. The symbols ***, **, and * indicates statistical significance at 1%, 5%, and 10% level, respectively.

	(1)	(2)
VARIABLES	DEFAULT2	DEFAULT3
COVID19_VOL	0.015**	0.013**
	(2.44)	(2.33)
Observations	7639	7639
Adjusted R-squared	0.292	0.293
Baseline controls	Yes	Yes
Quarter FE	Yes	Yes
Industry FE	Yes	Yes

Table A3. Alternative sample (Excluding observations from USA, JAPAN, and TAIWAN)

This table reports the baseline regression results on the relationship between COVID-19 pandemic crisis and corporate default risk for a sub-sample that does not contain the data for USA, JAPAN, and TAIWAN. The dependent variable is the default risk. t-statistics based on heteroscedasticity-robust standard errors clustered by industry and country are presented in parentheses. The sample period is January 1, 2020, to June 30, 2021. All firm-level continuous variables are winsorized at the 1% and 99% levels, and all variables are defined in detail in Appendix A. [*], [**], [†] indicate significance at the 10%, 5%, and 1% levels, respectively.

VARIABLES	DEFAULT1
COVID19_VOL	0.008***
	(2.93)
Observations	78,994
Adjusted R-squared	0.263
Baseline controls	Yes
Quarter FE	Yes
Industry FE	Yes

A4: Additional Control Variables

This table reports regression results on the relationship between COVID-19 uncertainty and corporate default risk using additional control variables. The dependent variable is the default risk. *t*-statistics based on heteroscedasticity-robust standard errors clustered by industry and country are presented in parentheses. The sample period is January 1, 2020, to June 30, 2021. All variables are defined in Appendix A. The symbols ***, **, and * indicate statistical significance at 1%, 5%, and 10% level, respectively.

	Controlling for tangibility	Controlling for growth opportunities	Controlling for cash holding	Controlling for creditor's right
	(1)	(2)	(3)	(4)
VARIABLES	DEFAULT1	DEFAULT1	DEFAULT1	DEFAULT1
COVID19_VOL	0.018***	0.012***	0.021***	0.008***
	(3.68)	(2.90)	(2.90)	(3.33)
TANGIBILITY	-0.093***			
	(2.82)			
MTB		-0.0548*		
		(-1.76)		
CASH			-0.069***	
			(-4.31)	
CR				-0.042**
				(-2.21)
Observations	150,590	150,590	150,590	135,548
Adjusted R^2	0.274	0.287	0.272	0.262
Baseline controls	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes

A5: Alternative Fixed Effects

This table reports the baseline regression results on the relationship between COVID-19 pandemic crisis and corporate default risk using alternative fixed effects. The dependent variable is the default risk. t-statistics based on heteroscedasticity-robust standard errors clustered by industry and country are presented in parentheses. The sample period is January 1, 2020, to June 30, 2021. All firm-level continuous variables are winsorized at the 1% and 99% levels, and all variables are defined in detail in Appendix A. *, **, † indicate significance at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)
	Firm-fixed-effect	Country-fixed-effect
VARIABLES	DEFAULT1	$DEFAULT1$
STRUST	0.008**	0.071***
	(2.37)	(2.92)
Observations	150,590	150,590
Adjusted R-squared	0.707	0.394
Baseline controls	Yes	Yes
Quarter FE	Yes	Yes
Industry FE	No	Yes
Firm FE	Yes	No
Country FE	No	Yes

References

Merton, R. C. (1974). On the pricing of corporate debt: The risk structure of interest rates. *The Journal of Finance*, *29*(2), 449-470.