Credit Risk in a Pandemic

Byström, Hans

2021

Document Version:
Other version

Citation for published version (APA):
Byström, H. (2021). *Credit Risk in a Pandemic*. (Working Papers; No. 2021:1).

Total number of authors:
1

Working Paper 2021:1

Department of Economics
School of Economics and Management

Credit Risk in a Pandemic

Hans Byström

January 2021

LUND UNIVERSITY

Credit Risk in a Pandemic

Hans Byström*

Using different measures of how the Covid-19 pandemic progresses we find that the level of credit risk among US blue chip companies increases in tandem with the Covid-19 virus spreading. The credit risk increases dramatically during the pandemic, but we find it to be short of the levels seen during the 2008–2009 financial crisis. Furthermore, we find weekly ups and downs in credit risk and virus impact to be significantly positively correlated throughout the pandemic. Finally, Basel II capital requirements increase drastically when the pandemic strikes but, again, not to the levels seen during the financial crisis.

Keywords: credit risk; Covid-19; equity market; debt market; CDS; Merton model; Basel II
JEL classification codes: G10; G33; I18

* Hans Byström is from the Department of Economics, Lund University, Box 7082, 22007 Lund, Sweden (hans.bystrom@nek.lu.se). Disclosure: The author reports no conflicts of interest. The views expressed in this article are those of the author in his personal capacity and do not reflect the views of Lund University.

Our aim is to investigate how, when and to what extent the credit risk in the economy has changed as a consequence of the Covid-19 pandemic. We focus on the US market, more exactly the companies in the Dow Jones Industrial Average (DJIA) index. These companies are all large blue chip companies from various industry sectors.

The Covid-19 coronavirus pandemic hit the economy very suddenly and, at the time of writing this, the pandemic has lasted for less than a year. As a result, we cannot rely on slow-moving traditional credit measures such as credit ratings, credit scores or the number of bankruptcy filings to assess the extent to which corporate credit health has been affected by the virus. Instead, we will let the market talk, and use daily updated market-based measures of credit risk to investigate the link between the credit risk and the spread of Covid-19 throughout the economy. Of course, market-based credit risk measures are not "actual" measures of companies' de facto credit health, but rather market assessments, or perceptions, of the companies' credit health.

We turn to two separate markets to assess the level of credit risk; the equity market and the credit (derivatives) market. We limit our study to the companies in the DJIA index. One reason for this is that all the companies in the DJIA index are major blue chip companies with stocks and credit derivatives that are traded on deep and liquid markets. At least for credit derivatives, illiquidity can otherwise be an issue for many smaller companies, with illiquidity premiums contaminating credit risk estimates. Our choice leaves us with a relatively small sample of companies. However, as many studies have shown (Fisher et al. (1970), Alexeev et al. (2013)), a portfolio is well diversified already at a portfolio size of around 20-30 stocks. As a result, the size and behavior of the credit risk of the portfolio of 30 companies making up the DJIA index can probably be considered a good representation of the size and behavior of the credit risk of a typical portfolio of blue chip US stocks held by a random investor. Consequently, we believe our results on the link between the pandemic and the credit health in the corporate sector to be representative of the broader US market.

We also use various measures to assess the seriousness of the Covid-19 pandemic, on a daily basis, and whether we look at domestic- or international numbers, and whether we look at the number of infected persons, the number of deaths or the stringency of government-induced economic restrictions due to Covid-19, we find that the level of credit risk in the US moves in tandem with the seriousness of the pandemic. However, we find the credit risk to peak long before the pandemic is peaking. Credit risk appears to peak when the rate of virus spreading is increasing at its maximum rate, not when the virus count reaches its highest absolute daily numbers. Also, while we see a dramatic increase in credit risk due to the pandemic, we find the level of credit risk in 2020 to be short of the levels seen during the 2008–2009 financial crisis. When we look at the (short-term) credit risk–virus co-movements we find a significant positive relationship between weekly changes (as well as levels) in credit risk and corresponding weekly changes (as well as levels) in virus impact (infected/deaths/restrictions) throughout the pandemic.

Turning to the extreme tails of the credit risk distributions, we find that the weeks with the largest percentage increase in credit risk are all in March and late February, i.e. in the initial dramatic episode of the pandemic. Over these five extreme weeks the credit risk levels for the individual DJIA companies increase every week for almost every firm. Moreover, both the equity- and the debt-market considers these particular weeks in the pandemic to be the weeks with the worst deterioration in creditworthiness for the companies in the DJIA index. In other words, both the stock market and the credit derivatives market are significantly affected by the pandemic, and when one of the two markets is spooked, in a credit risk sense, the other one is typically spooked as well. Looking at the most extreme weeks of the pandemic we also find an industry pattern, with the creditworthiness of the financial- and petroleum industry companies doing much worse than the health- and pharmaceutical industry companies, both according to the stock market and the credit market. This strengthens our conclusion that the deterioration in credit health in the US corporate sector in the first half of 2020 goes hand in hand with

the deterioration in the pandemic situation, and that the pandemic is the main determinant of creditworthiness during this period.

As a final assessment of the economical relevance of the virus pandemic we look at how the Basel II capital charge of our fairly typical portfolio of US corporate credits is affected. Looking at the full sample period 2008–2020, the general picture is of a capital charge (portfolio credit risk) that, after an extreme start in 2008, is steadily falling except for smaller bursts of risk during the Eurozone crisis. This steady decrease in capital charges, from double-digit levels in 2008 to low single digits at the end of 2019, drastically changes with the onset of the pandemic in early 2020. A month or two later, in March, the Basel II capital charges peak at historically high levels, albeit still not close to the levels seen during the financial crisis in 2008 and 2009.

While alarming, neither the stock market nor the credit default swap (CDS) market seems to consider the increase in credit risk in the US corporate sector due to the Covid-19 pandemic to be as alarming as the situation during the 2008–2009 crisis, at least not for large blue chip companies. Nevertheless, one conclusion that we draw from our empirical findings is that the Covid-19 pandemic is likely to lead to an increased number of bankruptcies in the economy. At least that is the verdict of the market.[1] This pattern of increased credit risk, and likely associated increases in bankruptcies down the line, should be an important lesson for any possible second or third wave of the Covid-19 pandemic, as well as for other pandemics that might strike in the future. Furthermore, our results show that while the severity of the pandemic when it comes to the number of human casualties and the number of people infected is important for the economy and for the levels of credit risk, the restrictions on the economy implemented by governments fighting the disease seem to be even more critical. The market response in the first half

[1] As for actual bankruptcies, among smaller companies in the US one can already see an increase in the number of bankruptcies. As of August 17, a record 45 companies with more than $1bn in liabilities, as well as 157 companies with more than $50m in liabilities had filed for Chapter 11 bankruptcy in 2020 (Financial Times (2020a)). This can be compared to 18 companies with more than $1bn in liabilities filing for Chapter 11 bankruptcy in 2019 over the comparable period.

of 2020 clearly shows the close link between the virus spreading, the stringency of government-initiated economic restrictions and credit risk.

We believe that we contribute to the literature in several ways. As far as we can tell there are no previous studies looking at the intertemporal developments of credit risk during the pandemic. There are, however, some recent studies looking at the market-response to the Covid-19 pandemic, as well as a few studies linking the pandemic to financial instability. Albelescu (2020), for example, shows that the number of infected/deaths due to Covid-19 has had a positive impact on the S&P 500 volatility. They only look at a 2-month long sample, March 11 to May 15, though, and they also only look at an index, not at individual stocks. Baker et al. (2020), in turn, use text-based methods to demonstrate that no other pandemic has had such a forceful impact on the (US) stock market. They argue that restrictions on economic activity are the main reasons for the unprecedented turbulence in the stock market, and they find news related to Covid-19 to be the main driver of the heightened volatility in the US stock market in early 2020. Baker et al. (2020) look at a very short sample ending in April, however. Similar to Baker et al. (2020), we also find the government-induced restrictions on the economy to have an outsized effect on market behavior, in our case the market's perception of the credit risk level in the economy.

As for the issue of corporate solvency and financial stability, there are a few studies available. None of them links market reactions to actual Covid-19 data, though. Mirza et al. (2020), for example, use simulated stress scenarios to investigate the potential effect of the Covid-19 pandemic on the solvency of companies in the EU. It is the first study on the impact of the pandemic on the solvency of EU companies, and it finds the deterioration in solvency to be, potentially, significant. The paper is written early in the pandemic, though, and no data from the pandemic is used. In a similar spirit, Reinders et al. (2020) look at the financial stability in the euro area banking sector, and estimate potential credit losses due to Covid-19 in the banks' corporate loan portfolios to be over 1 trillion Euros. They only use market data up until April, however, and no Covid-19 data is used. Liu et al. (2020), in turn, look at CDS

spreads and find the pandemic to have a positive effect on CDS spreads, i.e. the credit risk, of US companies, particularly those with high debt-rollover-risk. Again, the time period is very short, less than two months (January to March) and only covers the initial phase of the pandemic.

To sum up, compared to previous Covid-19 related studies in finance, including those on credit risk and financial stability, we believe we contribute by explicitly looking at the dynamics of credit risk (including Basel II capital charges) during the pandemic, by computing and comparing credit risk estimates based on the equity market and the debt market, by carefully pairing daily and weekly estimates on credit risk with daily and weekly data on the seriousness of the pandemic (including the stringency of the government response), by looking at individual companies from different industry sectors rather than just stock indexes and, finally, by looking at a longer time period (9 months) than previous studies.

Credit Risk Modeling

Throughout this study we focus on the creditworthiness of companies. More exactly, we try to estimate the market's assessment of the risk of a company defaulting on its debt. The credit risk of a firm, and ultimately the company's default probability, can be inferred either from the debt market or from the equity market. For the debt market's opinion on the creditworthiness of a company we turn to the credit derivatives market, more specifically the credit default swap market, and the link between credit spreads and default probabilities. We simply assume that the expected loss (*EL*), in percentages, on a bond issued by the company is equal to the CDS spread, and then solve for the probability in

$$spread_{CDS} = EL = PD \cdot LGD \tag{1}$$

where *PD* is the default probability and *LGD*, the loss given default, is chosen to be 45% as suggested in the Basel II framework. Solving for *PD* in this equation gives us the debt market's estimate of a company's default probability, PD_{debt}.

For the equity market's creditworthiness opinion, on the other hand, we rely on a structural model called the Merton model (Merton (1974)). This model views a company's equity and debt as contingent claims issued against the company's underlying assets. A company's default probability is computed by backing out asset values and volatilities from the company's stock price and balance sheet information (leverage). The Merton model uses the Black and Scholes (1973) framework to solve for the asset value and volatility which can then be combined into a risk measure called distance to default (*DD*) that is inversely related to the default probability (*PD*) of the firm. In the Merton model

$$V_E = V_A N(d_1) - e^{-r(T-t)} DN(d_2) \tag{2}$$

where $N(\ )$ is the cumulative normal distribution, and

V_E is the company's market value of equity,

V_A is the company's market value of assets,

D is the total amount of company liabilities,

T-t is the time to maturity of the company's liabilities,

r is the risk-free interest rate,

$$d_1 = \frac{\ln\left(\frac{V_A}{D}\right) + \left(r + \frac{\sigma_A{}^2}{2}\right)(T-t)}{\sigma_A\sqrt{T-t}},$$

$$d_2 = d_1 - \sigma_A\sqrt{T-t}\,.$$

Moreover, the equity volatility σ_E and the asset volatility σ_A are related through the equation

$$\sigma_E = \frac{V_A N(d_1)\sigma_A}{V_E} \tag{3}$$

and one can solve the nonlinear system of equations (2) and (3) for V_A and σ_A. The distance to default is then defined as

$$DD = \frac{\ln\left(\frac{V_A}{D}\right) + \left(r - \frac{\sigma_A^{\,2}}{2}\right)(T-t)}{\sigma_A\sqrt{T-t}} \tag{4}$$

and the larger the value of *DD* the smaller the probability that the company will default on its debt. In the original Merton model the default probability is computed by mapping the distance to default to a default probability using the standard normal distribution. Due to the highly non-linear relationship between *PD*s and *DD*s, however, this process is well known to produce unrealistic probabilities, and in this paper we therefore choose a different path. While it is beyond the aim and scope of this paper to estimate fully realistic default probabilities (there is a reason why companies such as Moody´s|KMV that commercialize the Merton model can charge good money for this service) we will at least try to produce a reasonably accurate description of the dynamics of the default probability, i.e. we will focus more on the relative properties of the probabilities across time and across companies rather than on the absolute levels of the probabilities. Nonetheless, in our mapping we will i) acknowledge the non-linearity between *PDs* and *DDs* and ii) anchor the *PD* level to that of Moody´s|KMV. In Moody´s|KMV (2004), on page 28, the relationship between *PD* and *DD* is shown, but only one point on the curve is pin-pointed – a *DD* equal to 4 corresponds to a *PD* equal to 0.43%. This fact together with the most basic non-linear mathematical function (y=1/x) resembling, approximately, the non-linear relationship in Moody´s|KMV (2004) leads us to the mapping function

$$PD = \frac{1.72}{DD} \tag{5}$$

This is the relationship that we use in this paper to get the equity market's estimate of a company's default probability, PD_{equity}.

In the final part of the paper we turn to portfolio credit risk and capital charges and to how these have evolved up until, and throughout, the pandemic. In order to compute the credit risk of our DJIA portfolio we turn to Basel II and the capital requirement (capital charge) formula in the Internal Ratings-Based (IRB) Basel II framework (BIS (2006)). While this formula was first intended for regulatory capital calculations, it has since earned acceptance in the industry as a way of computing portfolio credit risk more generally.

The capital requirement for a credit portfolio exposure under the Basel II IRB framework is given by

$$Capital = LGD \cdot N\left(N^{-1}(PD) \cdot \sqrt{\frac{1}{1-\rho}} + N^{-1}(0.999) \cdot \sqrt{\frac{\rho}{1-\rho}} \right) - LGD \cdot PD \tag{6}$$

where $N(\ )$ is the cumulative normal distribution, $N^{-1}(\ )$ is the inverse of the cumulative normal distribution and ρ is the average pair-wise asset correlation (BIS; 2006, Zhang et al.; 2008, Lee et al., 2009). The size of the capital charge depends on the default probability, *PD*, as well as the loss given default, *LGD*, of the typical company in the portfolio. As described above, the default probability is calculated using either the CDS market together with a simple model based on credit spreads and expected losses, or the stock market and the structural Merton (1974) model. As for the loss given default we, again, choose the 45% value required under the foundation approach in the Basel II framework. To get an estimate of the asset correlation ρ, we also follow the Basel II framework (see below).

Empirical Study

We start this section with a description of the data and the empirical setup, and then proceed to the empirical study which is divided into four subsections; one subsection looking at the overall (longer run)

level of credit risk and its relationship with the Covid-19 virus spreading in the economy, a second subsection looking at (shorter run) weekly changes in credit risk and ditto weekly changes in Covid-19 levels and on how the two are linked to each other, a third subsection focusing on the most extreme changes in credit risk as well as on different industry sectors, and a final subsection where portfolio credit risk and Basel II capital charges are computed for the entire time period 2008–2020.

Data and Empirical Setup

We focus on the companies in the Dow Jones Industrial Average (DJIA) index, a widely followed stock index that has been around for more than a century. The DJIA index is made up of 30 large US blue chip companies from a range of different sectors. We collect daily stock prices and CDS spreads for the companies in the DJIA index for the time period June 18, 2008 to September 30, 2020. The CDS contracts are all 5-year senior USD contracts (except for one company where the reference loan is denominated in Euros) and the stock prices are all quoted in USD. The rather ad-hoc starting point (June 18, 2008) is chosen based on a trade-off where we, on the one hand, want to include as much as possible of the 2008–2009 financial crisis but, on the other hand, also want to keep as many of the 30 DJIA companies as possible in our sample. In the end, the equity-market based credit risk measure is calculated for 27 companies, 3 companies were excluded because of the low quality of the data on company leverage, while the debt-market based credit risk measure is calculated for 23 companies, 7 companies were excluded because of a lack of CDS data spanning the entire time period.[2] In the Merton model, the stock return volatility is computed using daily data from the past 12 months, and the risk-free interest rate is set equal to the US 3-month treasury-bill rate.

The Covid-19 measures are also downloaded on a daily basis and there are five different measures; the number of Covid-19 infections in the world, the number of Covid-19 infections in the US, the number of

Covid-19 deaths in the world, the number of Covid-19 deaths in the US, and the Covid-19 government response stringency index.[3] All data except the leverage-data was downloaded from Datastream. Leverage-data was downloaded from Yahoo Finance and is from December 2019 (or in a few cases the last possible reporting dates before that).

Credit Risk from the Financial Crisis to the Covid-19 Pandemic

In this subsection we look at the development of individual companies' credit risk in the US over the period 2008 to 2020. Each of the two measures of corporate credit risk, i.e. the distance to default and the credit default swap spread, are plotted on a day-to-day basis, year-by-year (January–December), in Figure 1.[4] The panels on the left show the average-company distance to default and the panels on the right show the corresponding average-company CDS spread. There are five panels, and in addition to showing identical credit risk graphs, each panel is also showing one of the five different Covid-19 measures. The dashed line shows the Covid-19 measure (5-day moving average, normalized, January–September 2020) and the bold black line shows the credit risk over the same January–September 2020 time period.

If we focus on the year 2020, it is quite clear that the level of credit risk at the beginning of the year, before the pandemic struck, was close to its lowest level since the financial crisis. Both the equity- and the debt-market considered the level of credit risk among blue chip US companies to be very low at this point. This situation changes drastically with the onset of the Covid-19 pandemic, and regardless of whether we look at the number of infected, the number of deaths or the stringency of government-induced economic restrictions (the five different panels) it is clear that the level of perceived credit risk increases pretty much in tandem with the virus developments. Interestingly, however, the credit risk

[2] For some of the companies we were not able to compute the distance to default measure for shorter periods. None of these periods were in 2020 though. That is, the Covid-19 period was not affected.
[3] The latter is a composite measure based on nine response indicators including school closures, workplace closures, and travel bans.
[4] For now, we will focus on distance to defaults and credit spreads. Default probabilities will not be computed until we estimate Basel II capital charges.

peaks long before the pandemic peaks. While there is a pretty consistent time lag between the credit risk peak and the Covid-19 peak, regardless of how the seriousness of the pandemic is measured, the equity- and the debt-markets signal a peak in credit risk levels at almost exactly the same time (the average DJIA company CDS spread peaks on March 20 and the corresponding distance to default peaks a few days later). Figure 2 is identical to Figure 1 but with the level of Covid-19 impact replaced by changes. The dashed line is now the day-to-day percentage change in the number of Covid-19 deaths/infections/stringency and the message in Figure 2 is basically that the credit risk appears to peak exactly those days/weeks when the virus is multiplying at its maximum rate, not the days/weeks when the virus count reaches its highest absolute numbers.

While the (perceived) credit risk goes from very low to very high in just a month's time due to the virus pandemic, Figures 1 and 2 clearly show how the level of credit risk in 2020 still is far short of the levels during the 2008–2009 financial crisis. According to both markets the credit risk situation was roughly twice as bad during the financial crisis. We are not trying to explain these differences here but the, relatively, much lower credit risk levels during the pandemic, compared to the financial crisis, is most likely a result of massive Covid-19 related fiscal- and monetary policy support from governments around the world and the extent to which this support is perceived to limit (corporate) credit losses in the economy.

Returning to the virus levels (i.e. the actual daily numbers, not the daily percentage change), in Figure 3 we look at the time lag between the peaks of the Covid-19 induced credit risk levels for individual companies in the DJIA and the peak of the actual Covid-19 pandemic (i.e. the peak of the first wave of the pandemic). While Figures 1 and 2 focus on the average company, we now turn to individual companies, and Figure 3 shows the distribution of the number of individual DJIA companies' credit risk levels peaking a certain day. The higher the fat (red) bars in Figure 3, the more common it is that the credit risk of a company peaks this particular day, and while the peak-dates in the various companies'

credit risk are very close to each other according to the credit (derivatives) market, the dates of maximum firm-level credit risk according to the stock market is more spread out. In fact, the latter measure never really peaks. It rather reaches a plateau and stays at that new riskier level throughout the pandemic.[5] The dates for the distance to default peak are therefore approximate dates estimated through a subjective eyeballing of the individual graphs, picking the dates when the plateau is reached.

The thin (black) vertical bars in Figure 3 indicate the dates when the different Covid-19 measures peak. They are, from left to right; the government response stringency index, the number of world deaths, the number of US deaths, the number of US infected and the number of world infected. It is clear that for every single DJIA company, both of the two market-based credit risk measures peak long before the number of Covid-19 infected/deaths peaks. The credit risk instead seems to reach its peak around the time the economic restrictions reaches its peak; the CDS market signals a perceived credit risk-peak a week or so before the economic lockdown reaches its peak, while the stock market signals a peak in perceived credit risk on days quite evenly distributed around the day the severity of the global economy lockdown peaks.

How are we to interpret this time lag between peak-credit risk and peak-Covid deaths/infections? After all, the time lag is found for every company in the DJIA index. One possibility is that the market is more concerned with the immediate economic costs of the government restrictions than with the human/economic costs of large numbers of Covid-induced deaths. Another possibility is that the market was better at predicting the economic and political dimension of the virus, i.e. government restrictions, than the human dimension, i.e. death- and infection rates. It could also be an indication of how intertwined governments and investors are. They both have access to similar information and they react in tandem to the virus spreading. And while they both attempt at being forward-looking, they probably make similar (correct or incorrect) forecasts of restrictions, deaths or both. It is also important to

[5] The reason for this is at least partly the ghost effect caused by the 12-month long estimation window used for the stock return volatility when the distance

remember that in addition to government actions affecting the markets, the causality also goes in the other direction, and the serious deterioration in the markets in mid-March 2020 probably limited the government appetite for more drastic limitations to economic activity. This could also explain some of the close intertemporal links between the government response stringency index and the (perceived) credit risk levels in the economy.

Correlations between Weekly Movements in Credit Risk and Covid-19 Measures

While the previous subsection focused on the longer term movements in US companies' credit risk from the financial crisis up to and including the pandemic, this subsection will instead focus on the short run co-movements between credit risk and Covid-19 measures. We will use weekly data over the 9-month time period January–September 2020 and primarily look at (percentage) changes, rather than levels. We choose a weekly sampling frequency since a monthly analysis gives us too few observations and since an analysis of daily changes seems a bit unrealistic considering the rather long-term nature of both credit risk (and related default probabilities and bankruptcies) and the development of a pandemic such as Covid-19. Another reason for using weekly data, rather than daily data, is the strong weekly seasonality in the Covid-data. The number of dead/infected is much higher on Mondays (due to the accumulation over the weekend).

Before we turn to changes, however, we will look at the levels of average weekly CDS spreads and distance to defaults and their relationship to the corresponding weekly Covid-19 measures from January to September. In the upper panel of Table 1 we present average correlations (ordinary Pearson correlation coefficients) between the various risk- and virus-measures, and they are all either positive or non-significant. For level-data, the equity-based distance to default measure is clearly more correlated to the severity of Covid-19 than the credit-based measure is. Moreover, credit risk seems to be particularly

to default is calculated.

strongly related to the government response stringency index, i.e. the amount of economic restrictions in place around the world. This confirms the results from the previous subsection where we saw the credit risk of individual companies peaking close to the peak in government restrictions. Next, Figure 4 looks at individual companies' credit risk correlations with Covid-19, rather than just averages, and reveals a fairly consistent pattern across the companies in the DJIA index. For the distance to default, all the correlations are large and positive, and for the CDS spread the positive correlations are both more frequent and larger than the negative ones.

As for the changes, the lower panel of Table 1 shows that all the (average) correlations are positive, regardless of Covid-19 measure and regardless of credit risk measure. Most of these correlations are also statistically significant and, again, the co-movements are stronger for the stock market-based credit risk estimates as well as for the stringency index. Furthermore, the individual correlations in Figure 5 are again overwhelmingly positive, particularly for the distance to default measure where every DJIA company's weekly credit risk change has a positive correlation with the weekly changes in every one of the five Covid-19 measures. The correlations for the CDS spreads are mostly positive as well, even more so than for the levels, and there is clearly a significant positive relationship between weekly changes in perceived credit risk and corresponding weekly changes in virus impact (infected/deaths/restrictions) across the pandemic.

Extreme Changes in Credit Risk and Different Industry Sectors

In this subsection we will continue to look at weekly changes in credit risk during the peak of the pandemic. Rather than studying the entire distribution of credit risk changes, however, we will look solely at the most extreme distance to default- and CDS spread changes. When we sort on credit risk, we find that the weeks with the largest percentage increase in perceived credit risk are almost all in March (and late February), i.e. the initial dramatic episode of the pandemic.

In Table 2 we list the five largest average weekly percentage distance to default decreases (five weeks sums up to about one month of pandemic in total) together with the percentage CDS spread changes the very same weeks (the date March 18 in the list indicates a weekly change from the week starting on Monday March 9 to the week starting on Monday March 16, etc.). Out of these five weeks with the largest average-company distance to default decreases we also find four of the five largest weekly CDS spread increases of the entire pandemic. In other words, both the equity- and the debt-market considers these particular weeks of the pandemic to be the weeks with the largest deterioration in creditworthiness. Moreover, the list of dates in Table 2 shows that the deterioration in credit risk sentiment most likely is caused by the Covid-19 virus and not by other credit-related events. Both the stock market and the credit derivatives market clearly agree on the strong impact of the virus on the credit health of US companies; the two markets "freak out" more or less at the same time. Also during slightly less extreme episodes of stress we find this similarity between the two markets. Among the nine largest weekly average-company CDS spread increases (nine weeks sums up to about two months of pandemic in total), all corresponding distance to default changes are negative (credit risk increases) and, vice versa, among the nine largest weekly average-company distance to default decreases, two thirds of the corresponding credit spread changes are positive. So, when one of the two markets is spooked, in a credit risk sense, the other one is often spooked as well.

If we turn to individual companies, the conclusion is the same. Over the five extreme weeks in Table 2, the credit risk as perceived by the stock market, increases every week for every individual company (100%). The credit risk as perceived by the debt market, meanwhile, decreases just 16 times (i.e. it increases in 86% of the cases). This strengthens the results found for the average company above. When we look at individual companies, we can also draw some (preliminary and limited) conclusions regarding industry sectors, and how different industries have been affected differently during the most extreme phase of the crisis when it comes to credit health and default probabilities. During the most

extreme weeks, i.e. the weeks when the credit risk increased the most, there is a clear pattern, with some of the most pandemic-relevant sectors fairing very differently. The credit health of the financial sector can be expected to be particularly badly affected by a pandemic coupled with a severe economic lockdown, and the same holds for the petroleum sector. The credit health of the health- and pharmaceutical sector, on the other hand, can be expected to be much less affected. This pattern is, indeed, found in Table 3 where the week with the largest average credit deterioration (the one labeled March 18 in Table 2) is singled out, and where the creditworthiness of both the financial- and the petroleum-industry companies fares much worse than that of the health- and the pharmaceutical-industry companies, both according to the stock market and the credit derivatives market. The former two sectors are represented in Table 3 by some of the worst affected companies that week and the latter two sectors are represented by some of the least affected companies in the DJIA index that week.[6]

Portfolio Credit Risk and Basel II Capital Requirements

As we have seen in previous subsections, the market deemed the credit risk of the average company in the DJIA index to have increased significantly during the peak of the pandemic. The two measures that we have used to indicate heightened credit risk in our empirical analysis this far are Merton's distance to default and the credit default swap spread. In order to go from these two measures to actual interpretable risk measures that can be used by risk managers or government supervisory agencies, we use the methods described earlier in the paper to calculate default probabilities, i.e. the probability that a company will default on its debt within a year. These probabilities can then be used to calculate the capital charge of a portfolio of credits. To calculate these capital charges we have chosen the Internal Ratings-Based (IRB) Basel II framework; a modeling framework that can be used both for calculating

[6] The results are very similar for March 11, the second most extreme week (not presented in the paper).

capital requirements and to compute portfolio credit risk more generally. As described above, the capital requirement for a credit portfolio exposure under the Basel II IRB framework is given by[7]

$$Capital = LGD \cdot N\left(N^{-1}(PD) \cdot \sqrt{\frac{1}{1-\rho}} + N^{-1}(0.999) \cdot \sqrt{\frac{\rho}{1-\rho}} \right) - LGD \cdot PD$$

To get an estimate of the average pair-wise asset correlation ρ, we follow BIS (2006) and use the formula

$$\rho = 0.12 \cdot \frac{\left(1-e^{-50 \cdot PD}\right)}{\left(1-e^{-50}\right)} + 0.24 \cdot \left[1 - \frac{\left(1-e^{-50 \cdot PD}\right)}{\left(1-e^{-50}\right)}\right] \tag{7}$$

where the default probability *PD* is computed using the formulas described earlier and, again, *LGD* is set equal to 0.45.

The Basel II capital charge (i.e. the DJIA portfolio credit risk) according to the equity- and debt market, respectively, is plotted on a day-to-day basis in Figure 6. The upper panels show the entire sample period 2008–2020 while the lower panels show the development of the capital charge during the Covid-19 pandemic (the dashed curve is the number of daily world deaths). The picture is quite similar for the two credit risk measures even though the absolute capital levels differ somewhat, at least during stress periods (the capital charge peaks in 2009 at around 5-6% according to the equity market and at around 15-20% according to the debt market). In the calmer period in between the financial crisis and the pandemic, the level of capital is quite similar for the two markets (around 2-4%) and any discrepancy can easily be explained by the default probability calculation(s) and the inherent approximations involved. The general picture, however, is of a capital charge (portfolio credit risk) that, after an extreme start in 2008, steadily falls except for smaller bursts of capital requirement during the Eurozone crisis. This steady decrease in Basel II capital charges, from double-digit levels in 2008 to low single digits at the end of 2019, changes drastically with the start of the pandemic in early 2020. The two

[7] No firm-size adjustment is needed for the blue chip companies in DJIA.

sets of capital charges (see the lower panels of Figure 6) are at more or less the exact same level, 2.5%, when the pandemic strikes. This was close to an all-time low. Towards the end of March, on the other hand, the capital charge peaks somewhere around 4-8% depending on if you ask the stock market or the CDS market.[8] These are historically high levels but not close to the levels seen during the financial crisis in 2008 and 2009. Neither stock- nor CDS market participants seem to consider the increase in credit risk in the US corporate sector caused by the Covid-19 pandemic to be alarming, at least not for large blue chip companies.

Conclusions

We investigate how the credit risk in the corporate sector has changed as a consequence of the Covid-19 pandemic. In the empirical analysis, we focus on large US blue chip companies from various industry sectors, and rely on market-based measures of credit risk extracted from the equity market as well as the debt market. Using different measures of how the Covid-19 pandemic progresses, we find that the level of perceived credit risk in the US corporate sector increases in tandem with the Covid-19 virus developments, in the US as well as globally. Credit risk appears to peak when the virus levels multiply at its maximum pace, but while the credit risk increases dramatically as a consequence of the pandemic, we find the level to be short of the levels seen during the 2008–2009 financial crisis. Further, we find weekly changes in credit risk and virus impact to be significantly positively correlated with each other throughout the pandemic, and during the most extreme period of the pandemic we find the creditworthiness of financial- and petroleum industry companies to deteriorate much more than health- and pharmaceutical industry companies. Finally, Basel II capital charges for our US blue chip portfolio of credits increases drastically during the pandemic, but not to the extreme levels seen during the

[8] These numbers can be compared to actual reported loan loss reserves of 2.2% in US banks since the pandemic began (Financial Times (2020b)). The same reserves peaked at around 4% during the financial crisis. Of course, the reserves are for the total loan portfolio of all US banks and are therefore not directly

financial crisis. All through the study, our results are essentially the same whether we estimate the credit risk using information from the equity- or the debt market.

References

Albulescu, C.T. 2020. "Covid-19 and the United States Financial Market Volatility." *Finance Research Letters* 101699, In Press.

Alexeev, V., and Tapon, F. 2013. "Equity Portfolio Diversification: How Many Stocks are Enough? Evidence from Five Developed Markets." University of Tasmania Discussion Paper N 2013-16.

Baker, S. R., Bloom, N. and Davis, S. J., Kost, K., Sammon, M. and Viratyosin, T. 2020. "The Unprecedented Stock Market Impact of Covid-19." NBER Working Paper No. w26945.

BIS. 2006. International Convergence of Capital Measurement and Capital Standards. Technical Document, Basel Committee on Banking Supervision.

Black, F., Scholes, M. 1973. "The Pricing of Options and Corporate Liabilities." *Journal of Political Economy* 81**:** 637–659.

Financial Times. 2020a. "Under the Hood: Bankruptcy "A Growth Industry" in the US amid Mounting Distress". *Financial Times,* August 21, 2020.

Financial Times. 2020b. "Upbeat Bond Traders at Odds with Banks over Covid Risks". *Financial Times,* September 30, 2020.

Fisher, L., Lorie, J.H. 1970. "Some Studies of Variability of Returns on Investments in Common Stocks." *Journal of Business* 43 (2)**:** 99-134.

Lee, J., Wang, J, & Zhang, J. 2009. "The Relationship Between Average Asset Correlation and Default Probability. Working Paper, Moody´s|KMV.

comparable to our portfolio of 30 US corporate exposures. For one thing, the reported loan loss reserves are for a much more diverse and much more diversified loan portfolio, with exposures not only to corporate issuers and not limited to US borrowers.

Liu, Y., Qiu, B. and Wang, T. 2020. “Debt Rollover Risk, Credit Default Swap Spread and Stock Returns: Evidence from the Covid-19 Crisis.” Working Paper, Sydney University.

Merton, R. 1974. “On the Pricing of Corporate Debt: The Risk Structure of Interest Rates. *Journal of Finance* 29 (2): 449-470.

Mirza, N., Rahat, B., Naqvi, B. and S.K.A. Rizvi. 2020. “Impact of Covid-19 on Corporate Solvency and Possible Policy Responses in the EU.” *The Quarterly Review of Economics and Finance*, In Press.

Moody´s|KMV. 2004. “Measuring & Managing Credit Risk: Understanding the EDF™ Credit Measure for Public Companies.” PowerPoint Presentation, Moody´s|KMV.

Reinders, J.H., Schoenmaker, D. and van Dijk, M. 2020. “Is Covid-19 a Threat to Financial Stability in Europe?” Working Paper, Erasmus University.

Zhang, J., Zhu, F., and Lee, J. 2008. “Asset Correlation, Realized Default Correlation, and Portfolio Credit Risk.” Working Paper, Moody´s|KMV.

Table 1. Correlations between Corporate Credit Risk and Covid-19 Measures In the upper panel of the table we present average correlations (ordinary Pearson correlation coefficients, averaged across the firms) between weekly credit risk- and virus-measure levels for the individual DJIA firms from January to September 2020. In the lower panel we present the same thing but for weekly changes.

		Distance to Default	CDS Spread
	Stringency Index	0.98	0.30
	World Deaths	0.91	0.08
LEVELS	**World Infected**	0.73	-0.12
	US Deaths	0.71	0.14
	US Infected	0.78	-0.05
	Stringency Index	0.74	0.36
	World Deaths	0.46	0.16
CHANGES	**World Infected**	0.28	0.11
	US Deaths	0.77	0.13
	US Infected	0.44	0.44

Table 2. Corporate Credit Risk Increases - The Most Extreme Weeks The five weeks with the largest percentage increase in perceived credit risk, measured as distance to default. The corresponding CDS spread changes the very same weeks are also presented. The date March 18, 2020 in the list indicates a change in weekly credit risk from the week starting on Monday March 9 to the week starting on Monday March 16, etc.

	Distance to Default % Weekly Change	**CDS Spread** % Weekly Change
March 18, 2020	-24.3	19.2
March 11, 2020	-13.2	25.7
March 25, 2020	-9.7	-6.1
March 4, 2020	-6.9	11.0
February 26, 2020	-4.5	22.0

Table 3. Corporate Credit Risk Increases during the Most Extreme Week – Different Sectors The percentage increase in perceived credit risk during the week with the largest average credit deterioration (the week labeled March 18, 2020 in Table 2). The firms are ranked from worst- to least affected this particular bad week (a decrease in distance to default is an increase in credit risk) and the financial-, petroleum-, and **health/pharmaceutical** sectors are marked in different shades of grey/black.

Distance to Default		CDS Spread	
Firm Ranking	**Weekly Change**	**Firm Ranking**	**Weekly Change**
TRAVELERS	-40%	JP MORGAN CHASE	74%
AMERICAN EXPRESS	-36%	VERIZON	62%
CHEVRON	-36%	CHEVRON	56%
JP MORGAN CHASE	-31%	GOLDMAN SACHS	53%
HONEYWELL	-30%	DOW CHEMICAL	42%
INTEL	-30%	MICROSOFT	33%
GOLDMAN SACHS	-30%	HONEYWELL	16%
MICROSOFT	-29%	HOME DEPOT	16%
WALMART	-28%	**MERCK**	16%
VISA	-26%	PROCTER & GAMBLE	15%
PROCTER & GAMBLE	-26%	IBM	11%
UNITEDHEALTH	-25%	NIKE	10%
WALT DISNEY	-23%	CATERPILLAR	10%
NIKE	-23%	**AMGEN**	7%
SALESFORCE	-22%	WALMART	7%
DOW CHEMICAL	-22%	TRAVELERS	6%
CISCO	-21%	**JOHNSON & JOHNSON**	4%
APPLE	-21%	COCA COLA	4%
COCA COLA	-20%	BOEING	4%
IBM	-20%	INTEL	2%
JOHNSON & JOHNSON	-18%	3M	0%
AMGEN	-18%	**UNITEDHEALTH**	0%
MERCK	-16%	CISCO	-4%
VERIZON	-16%		
WALGREENS BOOTS	-15%		
CATERPILLAR	-13%		
3M	-12%		

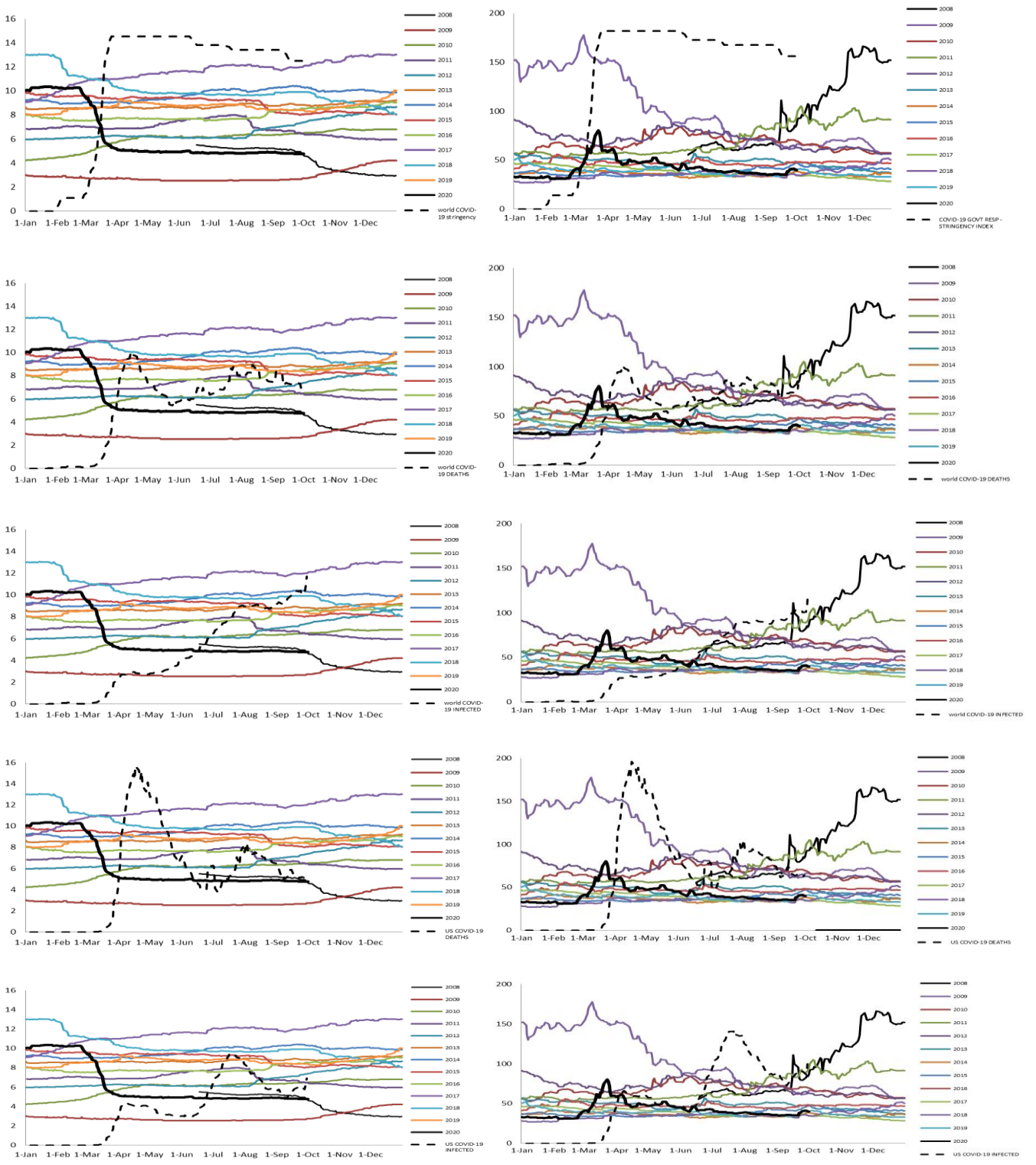

Figure 1. US Corporate Credit Risk and Covid-19 Levels in from 2008 to 2020. The panels on the left show the daily average distance to default, presented year-by-year from January to December, and the panels on the right show the corresponding daily average CDS spreads. Each of the five panels shows identical credit risk graphs but with the five different Covid-19 measures (levels). From top to bottom; the Covid-19 government response stringency index, the number of Covid-19 deaths in the world, the number of Covid-19 infections in the world, the number of Covid-19 deaths in the US, and the number of Covid-19 infections in the US. The dashed line shows the Covid-19 measure (5-day moving average and normalized, January to September 2020) and the bold black line shows the corresponding credit risk measure over the same time period.

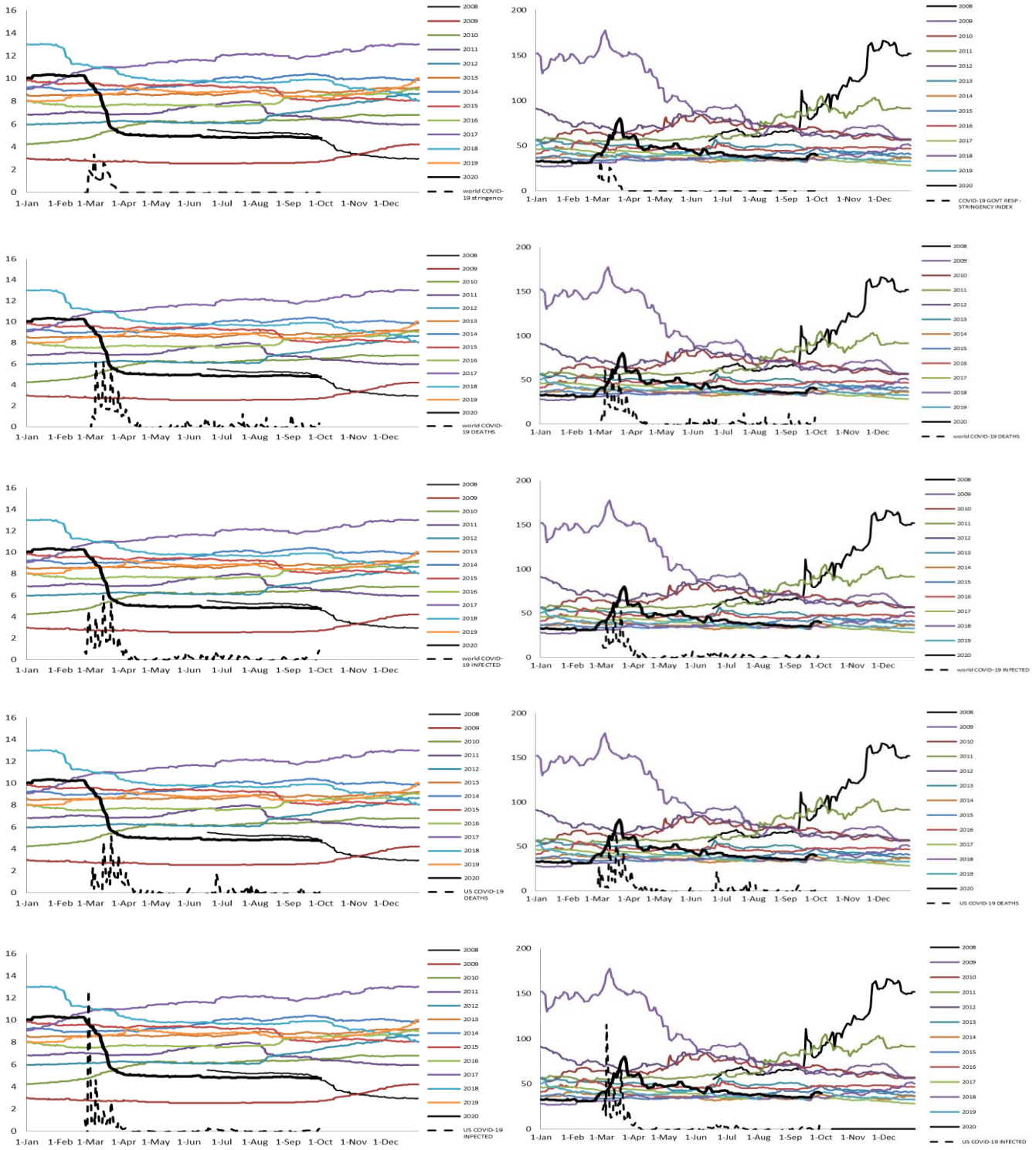

Figure 2. US Corporate Credit Risk and Covid-19 Changes from 2008 to 2020. The panels on the left show the daily average distance to default, presented year-by-year from January to December, and the panels on the right show the corresponding daily average CDS spreads. Each of the five panels shows identical credit risk graphs but with the five different Covid-19 measures (changes). From top to bottom; the Covid-19 government response stringency index, the number of Covid-19 deaths in the world, the number of Covid-19 infections in the world, the number of Covid-19 deaths in the US, and the number of Covid-19 infections in the US. The dashed line shows changes in the Covid-19 measure (5-day moving average and normalized, January to September 2020) and the bold black line shows the corresponding credit risk measure over the same time period.

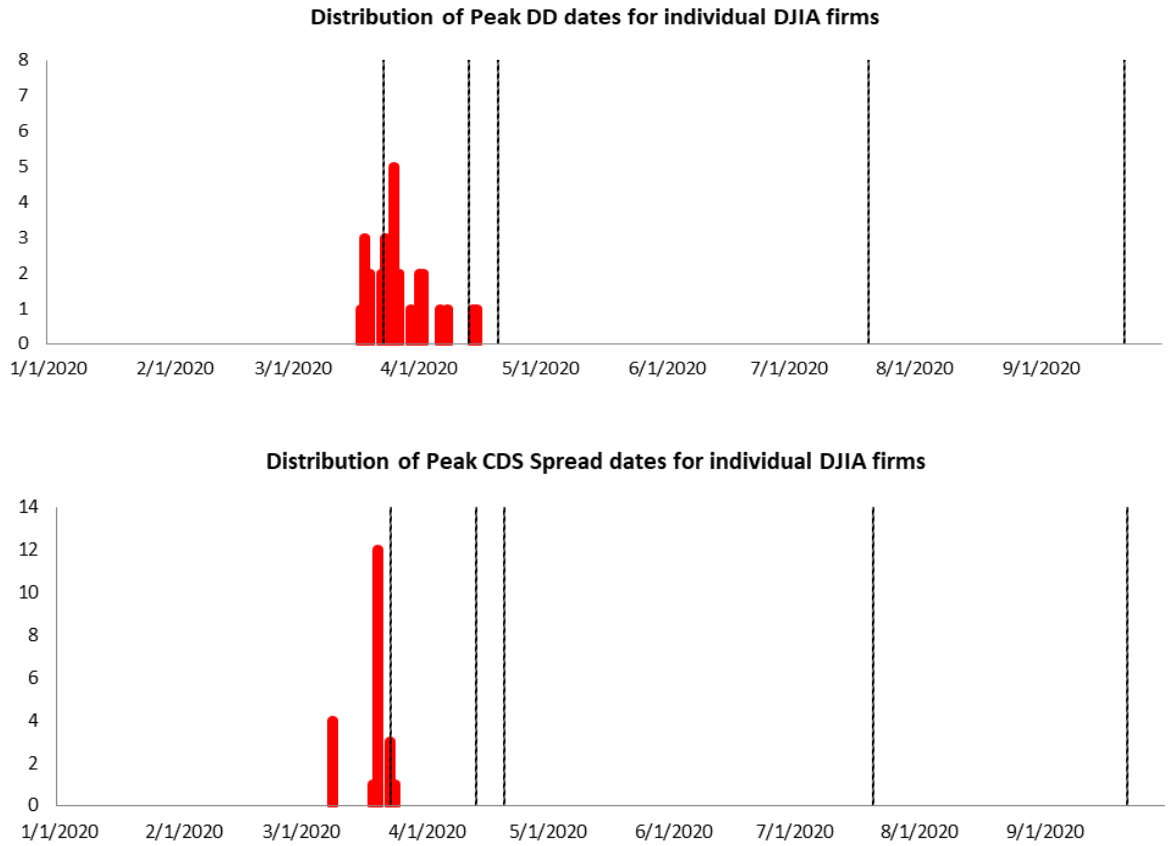

Figure 3. Peaks in Individual Firms' Credit Risk and Peaks in Covid-19. The figure shows the histogram, i.e. the distribution, of the number of individual DJIA firms' credit risk levels peaking a certain date. The y-axis indicates the number of firms at a certain date and the higher the fat (red) bars, the more common it is that the credit risk peaks this particular day. The upper panel shows the peak-dates for the distance to default, and the lower panel shows the corresponding peak-dates for the CDS spread. The thin (black) bars indicate the dates when the different Covid-19 measures peak. They are, from left to right; the Covid-19 government response stringency index (March 23), the number of Covid-19 deaths in the world (April 13), the number of Covid-19 deaths in the US (April 20), the number of Covid-19 infections in the US (July 20) and the number of Covid-19 infections in the world (September 21).

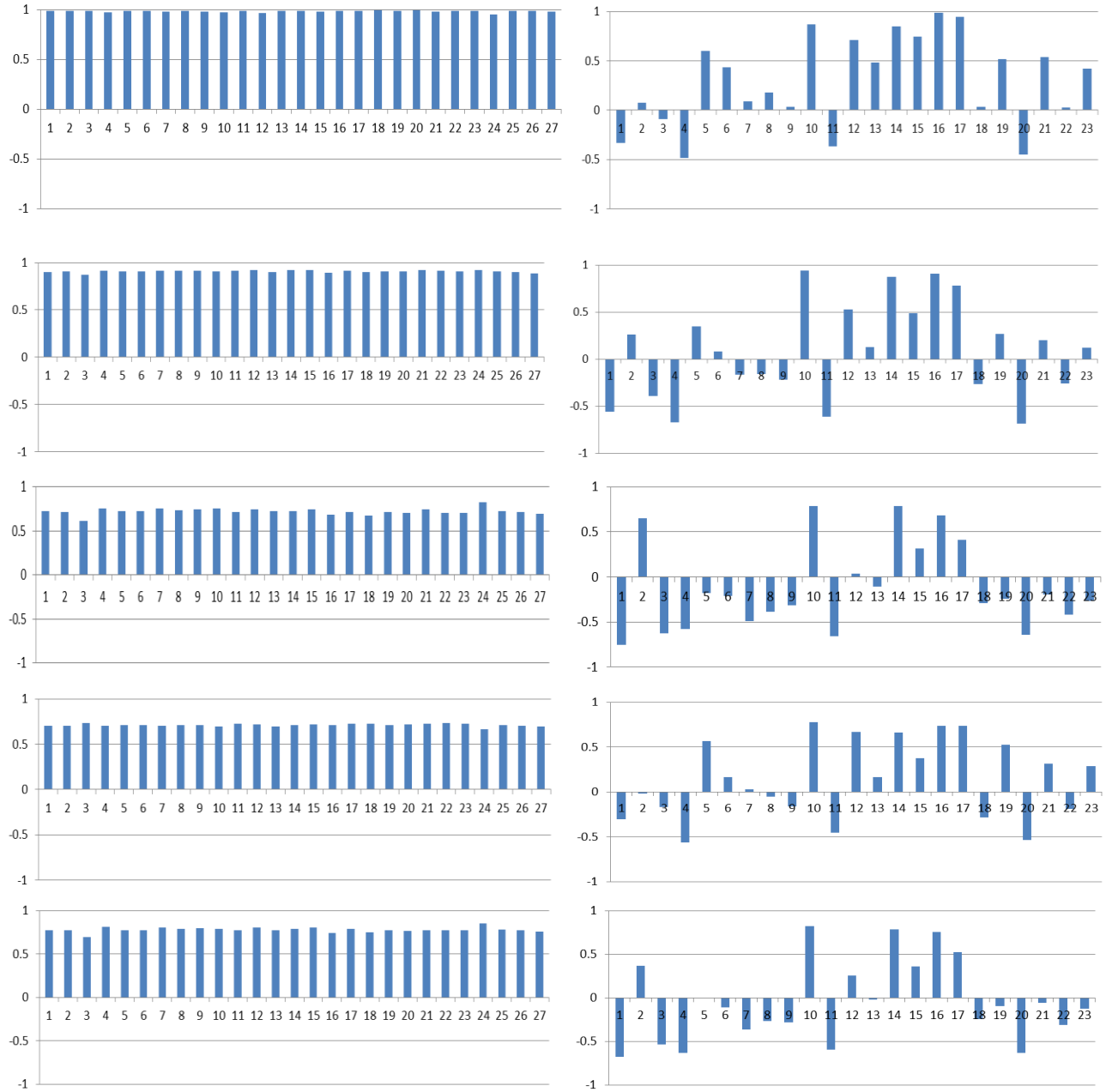

Figure 4. Correlations Between Individual Firms' Credit Risk and Covid-19 Levels. The figure shows correlations (ordinary Pearson correlation coefficients) between the various risk- and virus-measure levels. The panels on the left show the correlation between the individual DJIA firms' weekly distance to default levels and weekly virus-measure levels, and the panels on the right show the corresponding correlations for weekly CDS spread levels. Each of the five panels corresponds to one of the five different Covid-19 measures (levels). From top to bottom; the Covid-19 government response stringency index, the number of Covid-19 deaths in the world, the number of Covid-19 infections in the world, the number of Covid-19 deaths in the US, and the number of Covid-19 infections in the US. The firms in the left panel are (1-27, from left to right): AMERICAN EXPRESS, AMGEN, APPLE, CATERPILLAR, CISCO, CHEVRON, GOLDMAN SACHS, HONEYWELL, IBM, INTEL, JOHNSON & JOHNSON, COCA COLA, JP MORGAN CHASE, 3M, MERCK, MICROSOFT, NIKE, PROCTER & GAMBLE, TRAVELERS, UNITEDHEALTH, SALESFORCE, VERIZON, VISA, WALGREENS BOOTS, WALMART, WALT DISNEY and DOW CHEMICAL. The firms in the right panel are (1-23, from left to right): AMGEN, BOEING, CATERPILLAR, CISCO, CHEVRON, GOLDMAN SACHS, HOME DEPOT, HONEYWELL, IBM, INTEL, JOHNSON & JOHNSON, COCA COLA, JP MORGAN CHASE, 3M, MERCK, MICROSOFT, NIKE, PROCTER & GAMBLE, TRAVELERS, UNITEDHEALTH, VERIZON, WALMART and DOW CHEMICAL.

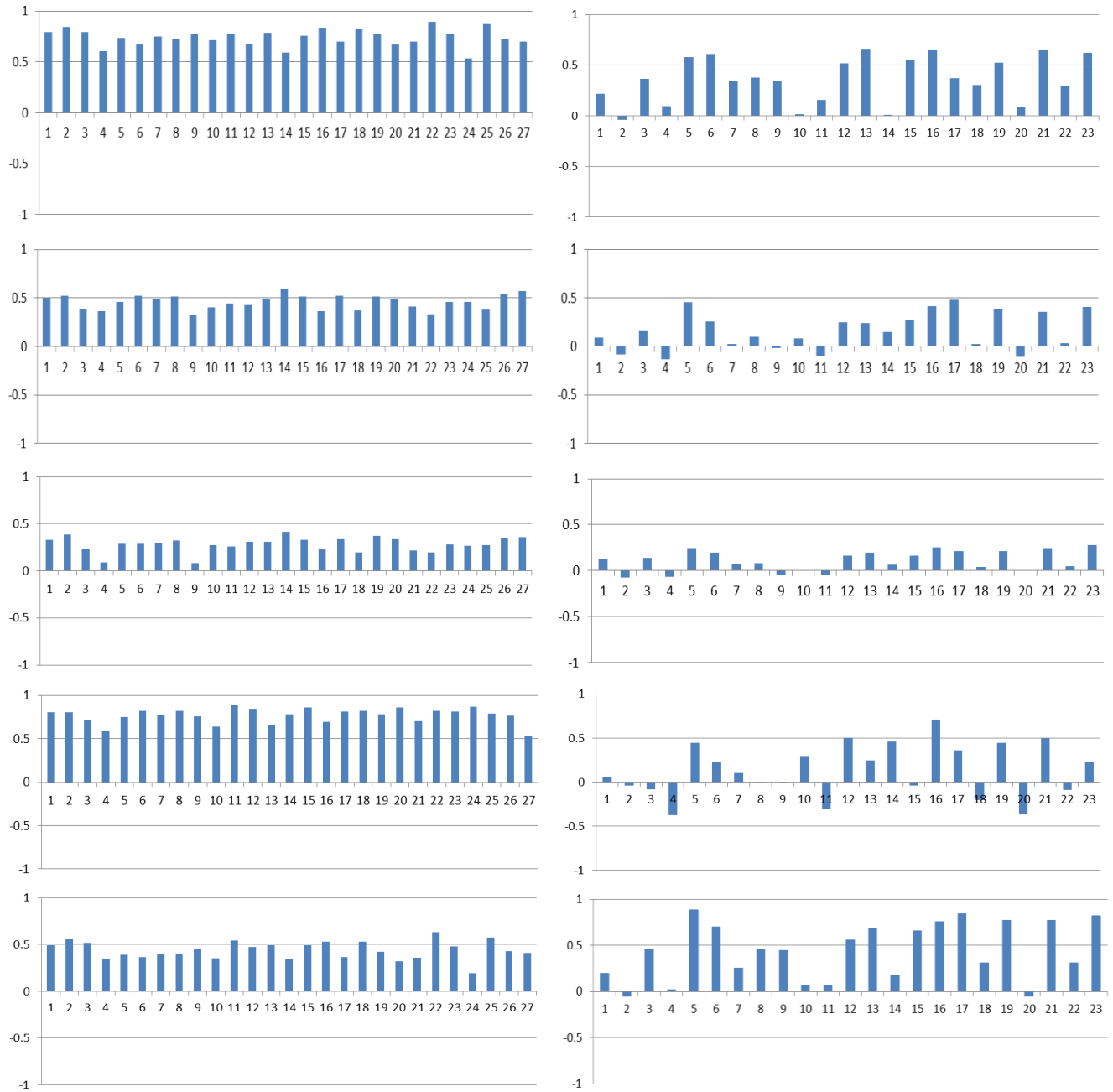

Figure 5 Correlations Between Individual Firms' Credit Risk and Covid-19 Changes. The figure shows correlations (ordinary Pearson correlation coefficients) between the various risk- and virus-measure changes. The panels on the left show the correlation between the individual DJIA firms' weekly distance to default changes and weekly virus-measure changes, and the panels on the right show the corresponding correlations for weekly CDS spread changes. Each of the five panels corresponds to one of the five different Covid-19 measures (changes). From top to bottom; the Covid-19 government response stringency index, the number of Covid-19 deaths in the world, the number of Covid-19 infections in the world, the number of Covid-19 deaths in the US, and the number of Covid-19 infections in the US. The firms in the left panel are (1-27, from left to right): AMERICAN EXPRESS, AMGEN, APPLE, CATERPILLAR, CISCO, CHEVRON, GOLDMAN SACHS, HONEYWELL, IBM, INTEL, JOHNSON & JOHNSON, COCA COLA, JP MORGAN CHASE, 3M, MERCK, MICROSOFT, NIKE, PROCTER & GAMBLE, TRAVELERS, UNITEDHEALTH, SALESFORCE, VERIZON, VISA, WALGREENS BOOTS, WALMART, WALT DISNEY and DOW CHEMICAL. The firms in the right panel are (1-23, from left to right): AMGEN, BOEING, CATERPILLAR, CISCO, CHEVRON, GOLDMAN SACHS, HOME DEPOT, HONEYWELL, IBM, INTEL, JOHNSON & JOHNSON, COCA COLA, JP MORGAN CHASE, 3M, MERCK, MICROSOFT, NIKE, PROCTER & GAMBLE, TRAVELERS, UNITEDHEALTH, VERIZON, WALMART and DOW CHEMICAL.

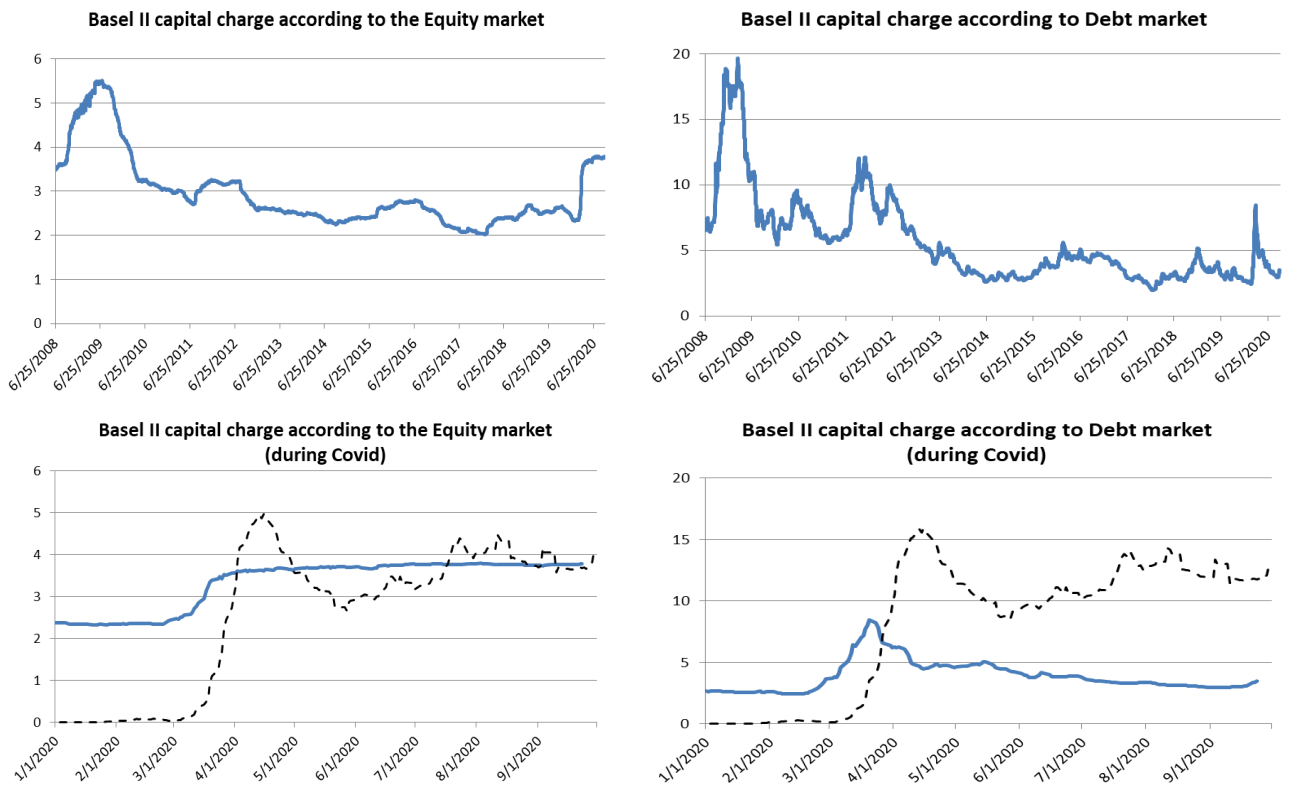

Figure 6. Basel II Capital Charge, according to the Equity market and the Debt market The figure shows the daily DJIA portfolio credit risk, i.e. the Basel II capital charge, according to the equity- and debt market, respectively. The panels on the left show the capital charge according to the equity market, and the panels on the right show the corresponding capital charge according to the debt market. The upper panels show the entire sample period 2008 – 2020 while the lower panels show the development of the capital charge during the Covid-19 pandemic (the dashed curve is the daily Covid-19 world deaths numbers).