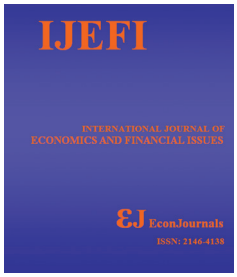

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The Impact of the Corona Crisis on the Worldwide Stock Markets: An Empirical Analysis with Cross National Event Study Approach

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ABSTRACT

The Corona Crisis led to a high drawdown in the stock markets in the whole world in March 2020. After that, infection rates, incidences, and dead people were published by many countries. Based on 11 stock price indices analyses according to volatility and correlation, we can conclude that only one event seems to be substantially affected by a Corona-related event not tied to specific countries. Therefore, in times of crisis, stock indices correlate highly positively. This leads us to a second step to our central research question: Do Corona dates significantly impact the stock price development? Therefore, we analyzed several events in Germany and the US with the event study approach. The main result is that only the March 2020 event significantly impacts the volatility and the returns. The following bad news but also the good news do not have any influence on the share prices and do not lead to abnormal returns. For example, the first approval of vaccinations had no apparent effect on the stock market, which was reflected in price movements comparable to those during the initial Lockdown.

Keywords: Covid-19, event study, abnormal returns, volatility, correlation
JEL Classification: G14

1. INTRODUCTION

The rising Covid pandemic implies a severe market reaction in February/March 2020. Along with the extreme market reaction, the susceptibility of the global financial markets to a pandemic became apparent for the first time. This is also distinguished from the previous pandemics, as these did not simultaneously trigger international market reactions. However, the market reactions cannot be traced to the initial outbreak in December 2019. The extreme market reactions observed only became apparent in March.

Many far-reaching pandemic politics could be observed in 2020 and parts in 2021. In addition to the Lockdown observed in a Western country for the first time internationally, there were often only minor effects on the stock market.

While an event study can document these comparatively short-term observations of potential pandemic-related influences on the stock market, the question of a structural break can also be examined relatively long-term.

Hence, the following academic aspects should be answered:

a. *In times of crisis, stock indices correlate highly positively* Based on our observations using the chart time series in March 2020, we analyze 11 different indices for their volatility and correlation over time. For this, we use the volatilities and correlations to focus the analysis of the 11 indices concerning

the events considered. This increases volatility, particularly in the case of tail events

b. *Do several Covid events significantly impact cumulative returns?* With a focus on the German and US stock markets, we can see different corona policies on the one hand. On the other hand, these markets show a high density of political pandemic decisions, which can be systematically compared to the stock market as part of an event study. Based on our findings from our event study on the US and Germany, we are expanding our investigation to include all 11 countries/indices for the significant events to examine the relevance for these countries.

The paper is structured as follows. Starting with the evolution of the Covid pandemic, we afterward focus on the current state of research. After this literature review, we express our used Data and Methodology. This includes the identification of relevant events in the US and Germany. Afterward, we describe and discuss our results. At least, we make conclusions based on our research and highlight the main aspects. Furthermore, we present the following research questions.

2. THE EVOLUTION OF COVID

According to media reports using unpublished data from the Chinese government, the first reported case of a person contracting Covid-19 dates back to November 17, 2019. However, the first official identification by international organizations such as the World Health Organization (WHO) was on December 31, 2019. On the last day of 2019, China reported multiple cases of pneumonia of unknown cause detected in Wuhan, Hubei Province, to the World Health Organization (WHO) for the 1st time. As a consequence of a globalized and interconnected world-initially induced by travelers to the affected region of Wuhan-the virus spread exponentially. A series of national lockdowns began on March 9 in Italy, initially becoming the western country's hardest hit. Shortly after that, on March 11, the WHO declared Covid-19 a pandemic.

On March 19, 2020, Italy reported more deaths than China for the 1st time. In mid-March 2020, most cases of infection were in China, Italy, Spain, Iran, Germany, France, and the US; only a few new infections were reported from China. At the end of March 2020, the number of corona infections in the US rose sharply; as a result, the United States became a focal point ("hotspot") of the global Covid-19 pandemic alongside Europe and China. There were many country-specific measures and lockdowns to slow the spread of the virus in the population and thus avoid overcrowding in hospitals and ultimately more deaths (AJMC, 2020; German Federal Ministry of Health, 2020; Allam, 2020; World Health Organization, 2020).

Global susceptibility to the pandemic was also due to worldwide networking and economic interdependence. The latter was expressed in particular by the observed worldwide market reactions. But aspects of daily life such as travel restrictions and (digital) collaboration have also changed significantly.

Governments have taken a variety of measures. Policy responses have varied in speed and severity, but they generally involved closure policies (e.g., school or restaurant closures), Covid-19 testing, bans on public gatherings, and travel restrictions. Subsequently, governments must introduce subsidy programs to deal with the economic consequences of such restrictions and help those who have lost income due to these interventions (Allam, 2020; World Health Organization, 2020).

3. CURRENT STATE OF RESEARCH

The sudden coronavirus outbreak surprised people worldwide and had a corresponding impact on the financial markets. Accordingly, several research papers deal with these effects, in particular with the influence of the pandemic on volatility (e.g., Albulescu, 2021; Bai et al., 2020; Bakry et al., 2022; Engelhardt et al., 2021; Haroon and Rizvi, 2020; Kusumahadi and Permana, 2021; Pyo, 2021; Zaremba et al., 2020; Zhang et al., 2020). For example, Zhang et al. (2020) point out volatility increased significantly after the WHO pandemic announcement on March 11. The stock correlations also show different patterns before and after the pandemic announcement. Albulescu (2021) examines the impact of global and US Covid-19 new infection and death rates on financial market volatility in the United States (US) and also shows that the health crisis increases realized volatility of the S&P 500. Bai et al. (2020) investigate the effects of the pandemic on the volatility of US, China, UK, and Japan stock markets and show that up to a 24-month lag, the pandemic has a significant impact on the permanent volatility of international stock markets. Pyo (2021) documents that the Covid-19 cases had an asymmetric effect on the regime of stock return volatility. When the stock return is in a low volatility regime, the probability of switching to the high volatility regime in the next trading day increases as the number of cumulative cases increases. Haroon and Rizvi (2020) analyze the relationship between sentiment generated by coronavirus-related news and stock market volatility. They note that an overwhelming panic caused by the news outlets is associated with increased volatility in the stock markets. Furthermore, Baig et al. (2021) show that an increase in confirmed corona cases and deaths is associated with a significant increase in market illiquidity and volatility.

In addition to volatility, the development of returns during the Covid-19 pandemic was also part of numerous studies (e.g., Bash, 2020; Cepoi, 2020; Corbet et al., 2021; Cox et al., 2020; Mazur et al., 2021; Singh and Shaik, 2021; Ashraf, 2020a; Ashraf, 2020b, Al-Awadhi et al., 2020). For example, Cepoi (2020) shows using a panel quantile regression model that stock markets exhibit asymmetric dependencies with Covid-19-related information. Corbet et al. (2021) pointed out that the corona pandemic mainly affects companies whose names are associated with the coronavirus, although these companies had no connection to the virus. The results of the panel data analysis by Al-Awadhi et al. (2020) document that the daily growth in the total number of confirmed cases and the total number of deaths caused by Covid significantly negatively impact the stock returns of all companies in the China stock market. Using pooled panel ordinary least squared regression models, Ashraf (2020a) points out that announcements of government social distancing measures have a direct negative impact on stock market returns due to their adverse effects on economic activity.

Conversely, government announcements of public awareness programs, testing and quarantine policies, and income support packages primarily drive positive market returns. In addition, Ashraf (2020b) shows that stock markets reacted negatively to the growth in confirmed Covid-19 cases. That means stock market returns fell as the number of confirmed cases increased. He also notes that stock markets reacted more proactively to the increase in the number of confirmed cases than the increase in the number of deaths. The analysis also suggests that the adverse market reaction was strong during the first few days of confirmed cases and between 40 and 60 days after the first confirmed cases.

Concerning our analyses, the event studies are particularly notable. Bash (2020) examines the impact of the first registered case of Covid-19 and a downward trend in cumulative abnormal returns for all considered indices, suggesting that Covid-19 negatively impacts index returns. Singh and Shaik (2021) examined the effect of six different WHO announcements, such as warning of Covid-19 as a potential pandemic or declaring coronavirus as a pandemic, pharmaceutical, healthcare, information stocks technology, hotel, and airline sectors in both areas of developed and emerging markets. Their findings suggest that Covid-19 is having a significant impact on global financial stock markets. However, the effect is different for industrialized and emerging countries. Khan et al. show that the growth rate of weekly new cases of Covid-19 negatively predicts stock market returns. The results show that investors are not reacting to the media news of Covid-19 in the early phase of the pandemic. However, after the human-to-human transmission was confirmed, all stock market indices responded negatively to the news in the short and long events window. Mazur et al. (2021) examine the development of the US stock market during the Covid-19-induced crash in March 2020. They find that natural gas, food, healthcare, and software stocks show high positive returns, while petroleum, real estate, entertainment, and hospitality stocks drop dramatically. Additionally, losing stocks exhibit extreme asymmetric volatility negatively correlated with stock returns.

So far, no study deals with the short-term effects of the corona-related political interventions on the financial markets. Accordingly, it is not analyzed yet whether the political measures have led abnormal returns and whether the nationally interventions have an international impact. In addition, no study deals with corona-related events after April 2021. We want to close this research gap with our analyses.

4. DATA AND METHODOLOGY

4.1. Relevant Stock Data

For our analyses, we have compiled a data set of stock market indices from Eastern and Central European countries (ATX (Austria), PX (Czech Republic), FTSE MIB (Italy), CAC (France), IBEX35 (Spain), DAX (Germany) and FTSE100 (Great Britain)). To analyze whether the lockdown measures have a substantial impact on stock market returns, we expand the data set to include countries (Bovespa (Brazil), DJI (US), KOSPI (South Korea), and AOR (Australia)) that reacted very differently to the local outbreaks, especially in the early phase of the corona pandemic. For example, the US and Brazil were added to the dataset because of their relatively mild Covid-19 management despite high infection rates, South Korea because of their good case tracking, and Australia because of their early Lockdown and special geographic location. We use the MSCI World Index as a market index. We obtain daily stock index data from stooq.com and Morgan Stanley Capital International (MSCI). Two restricting aspects have to be mentioned at this point: First, it should be noted that not all indices are adjusted for dividend payments. However, the effect should be negligible anyway since our significant events are not in the dividend season. Second, all indices are modelled in their local currency. Whenever performances of countries are summed up or correlations are modelled, the currency effect occurs. We think that the effect can be neglected as extreme movements in the share markets normally are not driven by the currency effect.

The registered cases and the number of deaths related to Covid-19 are obtained from Our World in Data (Ritchie et al., 2020). We have qualitatively compiled the German and US Covid-19 events via websites from the German federal ministry of health and the American Journal of Managed Care (AJMC, 2020; German Federal Ministry of Health, 2020). Since the Covid news are published without a timestamp, we used daily closing prices for our analysis.

4.2. Relevant Covid-Events

Considering the effect of various events on the stock markets based in the US and Germany, the relevant events have to be classified first. For this purpose, we have organized various positive and negative events from the timeline published by the federal government. Table 1 provides an overview of the relevant circumstances.

Like the German events derivation, we proceeded with the American events in Table 2. A smaller number of events also characterizes these. This can also be interpreted as a differently structured COVID crisis management.

4.3. Hypotheses

Based on the research questions, we operationalized three hypotheses and the relevant null hypotheses. In relation to the volatility and correlations we formulate the following hypothesis:

- Q1 – H0: Volatilities and correlations are not affected by the Corona crisis
- Q1 – H1: The volatilities and correlations are affected by the Corona crisis.

Regarding our research question, whether some corona events result in cumulative abnormal returns, we formulate the following hypothesis with a focus on the German and US stock markets:

- Q2 – H0: No abnormal returns can be found in the analyzed history
- Q2 – H1: There are events in our event dataset of political corona-related measures and other events in the early and late phase of the pandemic that lead to cumulative abnormal returns in Germany and the US.

Table 1: Relevant events for Germany

Date	Effect	Event
2020-01-27	▼	The first case in Germany
2020-03-09	▼	First Lockdown in Italy
2020-03-23	▼	The federal government passes two laws to combat COVID, including the first Lockdown
2020-04-15	▼	The federal government has decided to maintain contact restrictions until May 3
2020-05-04	▲	First lockdown ends
2020-06-15	▲	The federal government decides to relax the first corona lockdown
2020-06-25	▲	start of summer vacation
2020-07-24	▼	Corona testing obligation for travelers returning
2020-08-27	▼	Introduction of a 14-day quarantine obligation for travelers from so-called risk areas
2020-09-29	▼	Due to the increasing number of infections, the government has decided on new corona measures such as contact restrictions for gatherings of only a maximum of 25 people
2020-11-02	▼	Second lockdown "Light" announcement
2020-11-09	▲	Announcement of the vaccination sequence with the first vaccination of risk groups
2020-11-16	▼	Tightening of the lockdown "light"
2020-11-23	▲	The Federal Ministry of Health orders 5 million corona vaccine doses
2020-12-01	▲	BioNTech and Moderna have applied for approval of the vaccines
2020-12-13	▼	Extension of the second Lockdown
2020-12-18	▲	Decision on vaccination sequence
2020-12-21	▲	European Medicines Agency (EMA) has approved BioNTech's COVID-19 vaccine. The EU Commission then granted approval
2021-01-06	▲	The EU Commission has approved 2nd vaccine. Germany has secured 50 million doses of the Moderna vaccine
2021-01-11	▼	Extension and tightening of the second Lockdown. Now it seems to be a hard lockdown.
2021-01-12	▲	The first shipment of Moderna vaccine has arrived
2021-01-19	▲	Astra Zeneca has applied for approval of what will then be the third vaccine
2021-01-29	▼	Extension of the hard Lockdown until 14 February
2021-02-10	▲	The European Commission granted conditional marketing authorization (for people aged 18-64) to AstraZeneca's vaccine on Friday.
2021-02-16	▼	Hard Lockdown is extended until March 7, 2021
2021-02-24	▲	Johnson and Johnson has filed for approval
2021-02-26	▲	An announcement that the quick test is to be integrated into the test concept
2021-03-05	▲	Report of first vaccination successes in vaccination of risk groups
2021-03-11	▲	Announcement that all citizens will receive a free quick test once a week.
2021-03-15	▲	Involving medical practices in vaccinating the entire population to increase the rate of vaccination
2021-03-19	▲	The EU Commission approved the vaccine from the US company Johnson & Johnson on Thursday.
2021-03-22	▲	The federal government has suspended corona vaccinations with the vaccine from the manufacturer AstraZeneca due to health risks.
2021-03-24	▲	Vaccinations with AstraZeneca continue
2021-01-27	▼	Announcement of the so-called Easter peace as lockdown "very light"
2021-03-09	▲	Withdrawal of the Easter peace due to a wrong government decision

Source: German Federal Ministry of Health, 2020, ▲: Positive impact, ▼: Negative impact

Table 2: Relevant events for the US

Date	Effect	Event
2020-01-09	▼	WHO announces mysterious coronavirus-related pneumonia in Wuhan, China
2020-01-21	▼	Centers for Disease Control and Prevention (CDC) confirms the first US Coronavirus case
2020-02-25	▼	CDC says COVID-19 is heading toward the pandemic status
2020-03-02	▼	The first death in the US
2020-03-09	▼	First Lockdown in Italy
2020-03-30	▲	FDA authorizes the use of hydroxychloroquine
2020-04-08	▼	Troubles with the COVID-19 Cocktail
2020-04-29	▲	NIH trial shows early promise for Remdesivir
2020-05-28	▼	US COVID-19 deaths pass the 100,000 mark
2020-06-30	▼	Fauci warns new COVID-19 cases could hit 100,000 a day
2020-07-07	▲	The US Surpasses 3 million infections, began WHO withdrawal
2020-09-14	▲	Pfizer, BioNTech expand phase 3 trial
2020-10-02	▼	Trump and First Lady test positive for COVID-19; Trump enters the hospital
2020-10-05	▲	Trump leaves the hospital, continues receiving treatment
2020-11-18	▲	Pfizer, BioNTech Vaccine is 95% effective
2020-12-11	▲	FDA agrees to EUA for COVID-19 vaccine from Pfizer, BioNTech

Source: AJMC, 2020, ▲: Positive impact, ▼: Negative impact

Based on our findings from our event study on the US and Germany, we are expanding our investigation to all countries of our dataset:

- Q3 – H0: No abnormal returns can be found in the analyzed history for the relevant countries
- Q3 – H1: The events identified as significant for Germany and the US also lead to cumulative abnormal average returns for the extended data set - regardless of whether national measures are involved and whether the corona policy of the individual countries was conservative.

4.4. Methodology

For the volatility and correlation analyses, we first calculated the rolling 21-day volatility (monthly volatility) for every day in our observation period and then calculated the mean values for each month, specifically looking at November 2019 to July 2020. Based on this, we calculated the Pearson correlations to the world market (MSCI World Index). For this, we estimate the rolling correlation coefficient with a period of 254 days (annual correlation). We use arithmetic returns to calculate the index returns.

Based on the two preliminary analyses, we conducted an event study for the markets under investigation, Germany, and the US. We included other indices in our research to expand our event study on the US and Germany. Using different indexes, we also checked the significant events for Germany and the US. We calculate abnormal returns (AR) and cumulative abnormal returns (CAR) for each day in the event window. Our event window includes an anticipation period of 2 days and an adjustment period of 5 days after the event day. We evaluated the events for these different periods:

- The event day only.

- The event day and an adjustment period (day 0 to day five after the event)
- The entire event period (anticipation period of 2 days before the event, the event day, and the adjustment period).

We used a constant return approach/comparison period mean adjusted model and a market model to calculate the abnormal returns with an estimation period of 254 days (Brown and Warner, 1980; Fama, 1970; MacKinlay, 1997). The constant return or period mean model calculates the abnormal return $AR_{i,t}$ in the event window as the difference between the observed return i on day t and the average return of observation i in the estimation window, where T_0 is the oldest and T_1 the youngest day in the estimation period:

$$AR_{i,t} = R_{i,t} - \overline{R_i},$$

Where $\overline{R_i} = \frac{1}{T_1 - T_0} \sum_{t \in [T_0, T_1]} R_{i,t}$. In the market model, the abnormal return is calculated using a one-factor model and is quantified as follows:

$$AR_{i,t} = R_{i,t} - (\alpha_i + \beta_i R_{m,t})$$

where $R_{m,t}$ is the return of the market index on day t. As with the analysis of the correlations, we used the MSCI World as a market portfolio R_m in the sense of the CAPM. The cumulative abnormal returns for the whole event period (adjustment period, event day, and anticipation period) are calculated as follows:

$$CAR_i = \sum_{T_1+1}^{T_2} AR_{i,t}$$

Where T_1 is the youngest day of the estimation period and T_2 the last day of the adjustment period.

We analyzed individual events for our event study for Germany and the US (Tables 2 and 3).

Based on the analysis of the individual events in Germany and the US, the complete country set was checked for the events 1st case, 1st death, and Lockdown in Italy. For this purpose, we calculate the abnormal average returns and cumulative average abnormal returns of all countries:

$$AAR = \frac{1}{N} \sum_{i=1}^{N} AR_{i,t} \text{ and } CAAR = \frac{1}{N} \sum_{i=1}^{N} CAR_i$$

Where N is the sample size. We tested the significance of the hypothesis that the expected value of the cumulative abnormal returns is 0 H_0:E(CAR)=0 for the individual events using a CAR t-test, which represents a standard test for individual event analysis. The significance of the hypothesis that the expected value of the cumulative average abnormal returns is 0 H_0:E(CAAR)=0 for the event sample of our whole country dataset was tested using a cross-sectional t-test and the nonparametric Corrado rank test, which was extended by Campbell and Wesley (1993) to multi-day event periods. In contrast to the cross-sectional t-test, the Corrado rank test is robust against cross-correlation and volatility changes. Therefore, it is a good supplement to the parametric test.

5. RESULTS AND DISCUSSION

5.1. Volatility and Correlation Analysis

The mean values of the 21-day volatility are shown in Table 4. It has to be stated that the mean values of the volatility increase for all indices from February 2020. The increase in March is particularly evident. In the further course, but at the latest in May 2020, the 21-day volatility decreases significantly. No significant changes in volatility are noticeable as the period under review progresses. In this respect, there is a particular focus on the early Covid events. It is also worth mentioning that although some countries were not yet very severely affected by Covid cases in March/April 2020, there was also a significant increase in volatility for these indices. Our analysis of volatilities can also be condensed for the subsequent event study as follows. Almost all indices show a significantly increased volatility at the beginning of the pandemic, especially in March and April 2020. With regard to our first hypothesis, it can

Table 3: Monthly average of volatility

Monath and Year	MSCI World (%)	Australia AOR(%)	Brazil Bovespa (%)	France CAC (%)	Germany DAX (%)	US DJI (%)	Italy FTSE MIB (%)	Spain IBEX35 (%)	South Korea KOSPI (%)	Czech PX (%)	GB FTSE100 (%)	Austria ATX(%)
November 2019	0.37	0.55	0.86	0.48	0.57	0.46	0.64	0.64	0.68	0.56	0.58	0.78
December 2019	0.42	0.85	0.72	0.71	0.70	0.52	0.81	0.80	0.79	0.44	0.80	0.64
January 2020	0.44	0.74	0.97	0.64	0.78	0.58	0.81	0.66	0.85	0.49	0.67	0.62
February 2020	0.78	0.73	1.41	1.09	1.17	1.01	1.39	1.05	1.33	0.96	1.00	0.95
March 2020	3.51	3.10	5.67	3.43	3.30	4.55	4.30	3.68	2.63	2.64	3.08	3.84
April 2020	3.64	3.81	5.40	3.59	3.63	4.69	3.67	3.50	3.45	2.99	3.37	4.25
May 2020	1.55	1.67	2.55	2.08	2.19	1.77	2.03	2.00	1.23	1.39	1.89	2.52
June 2020	1.40	1.50	1.79	2.00	2.13	1.95	1.89	2.13	1.53	1.43	1.71	2.30
July 2020	1.11	1.35	1.43	1.41	1.49	1.55	1.54	1.72	1.40	1.04	1.37	1.54

Table 4: Monthly average of correlation to the MSCI world

Month and Year	Australia AOR	Brazil Bovespa	France CAC	Germany DAX	US DJI	Italy FTSE MIB	Spain IBEX35	South Korea KOSPI	Czech PX	GB FTSE100	Austria ATX
Januray 2019	0.285	0.371	0.623	0.601	0.928	0.509	0.591	0.412	0.350	0.506	0.568
February 2019	0.294	0.345	0.629	0.614	0.929	0.509	0.583	0.421	0.375	0.513	0.578
March 2019	0.271	0.330	0.642	0.624	0.927	0.521	0.591	0.417	0.406	0.514	0.606
April 2019	0.263	0.328	0.663	0.637	0.923	0.549	0.599	0.415	0.400	0.541	0.626
May 2019	0.264	0.328	0.684	0.655	0.927	0.574	0.616	0.415	0.405	0.563	0.648
June 2019	0.270	0.337	0.696	0.670	0.931	0.603	0.628	0.422	0.400	0.570	0.663
July 2019	0.278	0.340	0.699	0.674	0.930	0.609	0.627	0.415	0.411	0.567	0.662
August 2019	0.274	0.373	0.708	0.685	0.932	0.633	0.635	0.402	0.425	0.589	0.672
September 2019	0.254	0.403	0.719	0.693	0.936	0.664	0.642	0.382	0.414	0.596	0.680
October 2019	0.234	0.433	0.722	0.699	0.936	0.689	0.651	0.335	0.427	0.598	0.672
November 2019	0.229	0.436	0.729	0.709	0.930	0.696	0.648	0.326	0.444	0.604	0.656
December 2019	0.209	0.436	0.757	0.723	0.927	0.706	0.653	0.307	0.428	0.636	0.658
January 2020	0.153	0.474	0.799	0.761	0.925	0.728	0.695	0.288	0.398	0.686	0.661
February 2020	0.162	0.497	0.808	0.777	0.932	0.741	0.730	0.293	0.388	0.707	0.665
March 2020	0.558	0.742	0.824	0.796	0.966	0.766	0.813	0.400	0.636	0.817	0.744
April 2020	0.667	0.853	0.834	0.820	0.970	0.791	0.848	0.433	0.718	0.845	0.734
May 2020	0.669	0.840	0.832	0.820	0.969	0.791	0.843	0.438	0.726	0.830	0.734
June 2020	0.666	0.830	0.834	0.818	0.967	0.795	0.841	0.435	0.732	0.829	0.738
July 2020	0.645	0.824	0.831	0.818	0.966	0.796	0.835	0.420	0.727	0.825	0.743
August 2020	0.644	0.820	0.825	0.812	0.965	0.792	0.825	0.419	0.721	0.818	0.738
September 2020	0.630	0.810	0.818	0.807	0.964	0.789	0.814	0.410	0.719	0.809	0.733
October 2020	0.623	0.802	0.811	0.799	0.963	0.783	0.807	0.410	0.712	0.803	0.728
November 2020	0.619	0.804	0.802	0.800	0.962	0.784	0.791	0.418	0.702	0.801	0.719
December 2020	0.623	0.809	0.798	0.798	0.961	0.783	0.785	0.418	0.694	0.798	0.716
January 2021	0.627	0.808	0.797	0.796	0.960	0.780	0.779	0.416	0.688	0.793	0.713
February 2021	0.628	0.808	0.796	0.795	0.960	0.779	0.776	0.418	0.694	0.791	0.711
March 2021	0.487	0.702	0.758	0.767	0.937	0.749	0.705	0.373	0.620	0.728	0.660
April 2021	0.341	0.524	0.701	0.720	0.907	0.701	0.611	0.289	0.494	0.637	0.638
May 2021	0.286	0.523	0.672	0.688	0.896	0.675	0.576	0.271	0.454	0.623	0.604
June 2021	0.238	0.545	0.619	0.649	0.881	0.628	0.507	0.255	0.376	0.578	0.542
July 2021	0.247	0.540	0.614	0.638	0.875	0.618	0.486	0.270	0.358	0.570	0.516
August 2021	0.269	0.545	0.633	0.655	0.880	0.635	0.517	0.268	0.350	0.588	0.527
September 2021	0.345	0.557	0.639	0.655	0.871	0.633	0.523	0.302	0.364	0.602	0.537
October 2021	0.368	0.575	0.659	0.671	0.865	0.650	0.534	0.298	0.366	0.603	0.543
November 2021	0.366	0.489	0.647	0.615	0.847	0.603	0.508	0.260	0.354	0.557	0.530
December 2021	0.351	0.475	0.651	0.624	0.855	0.601	0.511	0.261	0.385	0.558	0.524

be stated that volatilities increase significantly at the beginning of the pandemic, but already decrease again in May 2020.

If we now look at the correlations of the individual indices to the MSCI World as a market portfolio in Table 5, the correlations skyrocket in February and early March. This is particularly evident in the case of the indices, which otherwise tend to have a lower correlation to the MSCI. This includes, for example, Austria, the Czech Republic, and Brazil. Even in the already highly correlated countries such as Germany, France, and the US, a significant increase in correlations can be seen. However, this increase does not occur to the same extent as in the otherwise low-correlated countries. It is also worth noting that 1-year correlations are used, so a noticeable increase in correlations requires a systematic increase over several observations.

As a conclusion it has to be stated that both volatilities and correlations only offer significant movements in March 2020. According to the now following event study it can be deducted that only this event leads to significant abnormal and/or cumulated abnormal returns. Hypothesis Q_1–H_0 thus has to be rejected. Otherwise, the general diversification effect cannot be neglected as e.g. sovereign bonds diversified a portfolio as expected in times of crisis.

5.2. Event Study Germany

Starting with the event study for Germany, Table 5 sums up the main results of the tested dates. It can be stated that the constant return model shows more significant abnormal returns than the market model overall. However, sometimes only the abnormal return on the day of the event is statistically significant.

The first Covid case in Germany (2020-01-27) as the first event is significant on a significance level of 1% and 5% for the event date and the adjustment period in the constant return model. However, the entire event period is only on a 10% level significant. A possible reason for this could be the sudden appearance of the first case of illness, which hit the market unexpectedly. In contrast, the Lockdown in Italy (2020-03-09) is significant over the entire event period on a 1% significance level. As well, the total event period as well as the event and adjustment period are statistically significant for the lockdown announcement in Germany (2020-03-23) on a 1% significance level. The individual event day, on the other hand, has no statistical significance.

Table 5: Hypothesis test of Event Study Germany (DAX)

Date	Constant return model						Market model					
	Event [0]		Event and adjustment [0.5]		Total [−2.5]		Event [0]		Event and adjustment [0.5]		Total [−2.5]	
	t-stat	P-value	t-stat	P-value	t-stat	P-value	t-stat	P-value	t-stat	P-value	t-stat	P-value
2020-01-27	−3.393	0.001***	−2.163	0.032**	−1.747	0.082*	−1.927	0.055*	−1.537	0.126	−0.624	0.534
2020-03-09	−8.635	0.000***	−11.861	0.000***	−12.109	0.000***	−2.078	0.039**	−3.834	0.000***	−3.845	0.000***
2020-03-23	−1.361	0.175	2.838	0.005***	3.870	0.000***	0.548	0.584	0.588	0.557	3.582	0.000***
2020-04-15	−2.272	0.024**	−0.743	0.458	−0.370	0.712	−1.980	0.049**	−1.035	0.302	−0.971	0.332
2020-05-04	−2.074	0.039**	−0.007	0.995	0.137	0.892	−1.324	0.187	−0.196	0.845	−0.367	0.714
2020-06-15	−0.176	0.861	0.541	0.589	−0.431	0.667	−0.546	0.586	0.167	0.868	−0.048	0.962
2020-06-25	0.361	0.718	0.893	0.373	0.518	0.605	0.146	0.885	0.854	0.394	0.788	0.432
2020-07-24	−1.062	0.290	−1.336	0.183	−1.260	0.209	−1.259	0.209	−2.238	0.026**	−1.945	0.053*
2020-08-27	−0.390	0.697	−0.266	0.791	−0.074	0.941	−0.518	0.605	−0.086	0.932	−0.112	0.911
2020-09-29	−0.182	0.856	0.043	0.966	0.404	0.687	−0.076	0.939	−0.104	0.917	−0.219	0.827
2020-11-02	1.005	0.316	2.579	0.011**	2.244	0.026**	0.752	0.453	1.701	0.090*	1.651	0.100*
2020-11-09	2.384	0.018**	1.066	0.288	1.150	0.251	3.066	0.002***	0.736	0.463	0.459	0.647
2020-11-16	0.229	0.819	0.076	0.940	−0.117	0.907	−0.508	0.612	−0.003	0.997	−0.294	0.769
2020-11-23	−0.039	0.969	0.232	0.817	0.117	0.907	−0.226	0.822	−0.036	0.971	−0.117	0.907
2020-12-01	0.330	0.742	−0.022	0.983	−0.014	0.989	−0.137	0.891	−0.616	0.539	−0.431	0.667
2020-12-13	0.512	0.609	0.291	0.772	0.155	0.877	0.807	0.421	0.655	0.513	0.225	0.822
2020-12-18	−0.132	0.895	0.135	0.892	0.505	0.614	0.048	0.961	0.231	0.818	0.567	0.571
2020-12-21	−1.388	0.166	0.125	0.901	0.189	0.850	−1.694	0.092*	0.072	0.942	0.111	0.912
2021-01-06	0.841	0.401	0.402	0.688	0.261	0.794	1.016	0.311	0.147	0.883	0.026	0.980
2021-01-11	−0.401	0.689	−0.308	0.759	−0.080	0.936	−0.016	0.987	0.010	0.992	−0.157	0.875
2021-01-12	−0.048	0.962	−0.195	0.845	−0.215	0.830	−0.151	0.880	−0.246	0.806	−0.219	0.827
2021-01-19	−0.126	0.900	0.012	0.991	−0.167	0.867	−0.672	0.502	−0.323	0.747	−0.320	0.750
2021-01-29	−0.845	0.399	0.537	0.592	0.203	0.840	−0.040	0.968	0.318	0.751	0.278	0.781
2021-02-10	−0.282	0.779	−0.161	0.873	−0.199	0.842	−0.480	0.632	−0.353	0.725	−0.603	0.547
2021-02-16	−0.160	0.873	−0.359	0.720	−0.230	0.818	−0.184	0.854	−0.069	0.945	−0.102	0.919
2021-02-24	0.384	0.702	0.295	0.768	0.094	0.925	0.336	0.737	1.088	0.278	0.860	0.391
2021-02-26	−0.342	0.733	0.032	0.975	0.036	0.971	0.352	0.725	0.506	0.613	0.752	0.453
2021-03-05	−0.515	0.607	0.550	0.583	0.474	0.636	−1.366	0.173	−0.020	0.984	0.604	0.547
2021-03-11	0.055	0.957	0.218	0.827	0.352	0.725	−0.637	0.525	0.237	0.813	0.029	0.977
2021-03-15	−0.211	0.833	0.061	0.951	−0.042	0.967	−0.636	0.525	0.283	0.777	−0.140	0.889
2021-03-19	−0.727	0.468	−0.328	0.744	−0.060	0.953	−0.759	0.449	−0.241	0.810	0.483	0.630
2021-03-22	0.029	0.977	0.040	0.968	−0.008	0.993	−0.216	0.829	0.265	0.791	0.612	0.541
2021-03-24	−0.333	0.739	0.265	0.791	0.200	0.842	0.304	0.762	0.514	0.608	0.609	0.543

Statistical significance at the 1%, 5% and 10% level are represented by ***, ** and *

The market model shows similar results. Only for the lockdown announcement in Italy are all intervals of the event period statistically significant. Although the entire event period is statistically significant for the lockdown announcement in Germany, the individual intervals of the event period (the individual event day as well as the event & adjustment period) are not significant. The significance can be traced back to the anticipation period. Nevertheless, there is much to suggest that after the significant lockdown announcement in Italy, the market has already priced in further events and lockdowns so that there are no significant abnormal returns in the market model. The end of the first lockdown in Germany (2020-04-15) shows a significant abnormal return on the event day (constant return and market model). The event & adjustment and total period are not statistically significant. However, the result shows the relevance of the lockdowns for the financial market.

Overall, it appears that the lockdown announcements, and particularly the lockdown imposed in Italy, have unsettled the market enough to lead to abnormal returns. In this respect, the other events do not show significant abnormal returns (in all intervals of the event window). Hypothesis $Q_2 - H_0$ has to be rejected for the lockdown events but cannot be rejected for the other events.

5.3. Event Study US (DJI)

Based on the Event Study Germany findings, further events in the US can now be included in the investigation, Table 6. There are slightly different results for the constant return and the market model. In the constant return model are the events "Pandemic Status According to Disease Control and Prevention Claims" (02/25/2020), the first death in the US (02/03/2020) and the lockdown in Italy (03/09/2020) statically significance for all intervals of the event period on a significance level of 1%.

As in Germany, only a few other sporadic event intervals, such as the trouble with the Covid cocktail on April 8, 2020, show statistical significance. For example, the event "Trouble with the Covid cocktail" show a statically significance at a significance level of 5% in the constant return model for the total event period. On the other hand, the cumulative abnormal returns of the event day and the adjustment period have no statistical significance. In addition, this event is not significant in any interval in the market model.

According to the hypothesis $Q_2 - H_0$ it has to be stated it must be rejected for the events the first death in the US and the lockdown in Italy, but it cannot be rejected for the other events, similar to the German market.

5.4. Event Study for all Countries/Indices of the Dataset

Relating to hypothesis $Q_3 - H_0$ we also carried out an event study analysis for our complete dataset of 11 countries/indices. Based on our findings that only a few events cause significant abnormal returns, we have examined the 1st Covid case and the 1st death in the respective country and the Lockdown in Italy. We focus the analysis on these three events because our research has shown that country-specific events usually did not lead to significant (cumulative) abnormal returns. This assumption results, among other things, from the fact that the other significant events-like 2020-02-25 (CDC says Covid-19 is heading toward the pandemic status) in the US-were only significant in the constant return model. The market model suggests that the further developments of the Covid pandemic have been priced in by the market and does not show any significant events in the further course for Germany and the US. For Germany, there is the peculiarity that the first death and the Lockdown in Italy are on the same day and, therefore, cannot be considered separately.

The comparison of the cumulative average abnormal returns of the country set show high abnormal returns, especially for the Lockdown in Italy, Table 7. The constant return model shows a cumulative average abnormal return of −32.34%, the market model of 11.61%. The first Covid case, on the other hand, shows a cumulative average abnormal return of −1.61% in the market model and −3.96% in the constant return model. The cumulative average abnormal returns are clearly lower than for the event Lockdown in Italy.

The hypothesis tests confirm the observation that the lockdown in Italy in particular resulted in significant cumulative abnormal average returns. All intervals of the event period were only significant for the Lockdown in Italy in both the constant return and market model for both tests, Table 8. This can be explained by the great uncertainty of the market, even before the Lockdown in Italy. However, when comparing all events and also the entire country set, the Lockdown in Italy seems to be the market-influencing event. In contrast, the other events mean less significant abnormal returns.

Tables 9 and 10 focus on the Lockdown in Italy and sum up the cumulative average abnormal returns for this event. In the constant return model show all countries/indices straightforward negative cumulative average abnormal returns. In the market model, all countries show negative abnormal returns except for the US. This different observation for the US can be explained by the high correlation between the DJI and the MSCI world since most stocks in the index also come from the US.

Table 6: Hypothesis test of Event Study US (DJI)

Date	Constant return model						Market model					
	Event [0]		Event and adjustment [0.5]		Total [−2.5]		Event [0]		Event and adjustment [0.5]		Total [−2.5]	
	t-stat	P-value	t-stat	P-value	t-stat	P-value	t-stat	P-value	t-stat	P-value	t-stat	P-value
2020-01-09	0.831	0.407	0.716	0.475	0.602	0.548	0.536	0.593	0.248	0.804	0.290	0.772
2020-01-21	−0.811	0.418	−1.445	0.150	−1.247	0.214	−0.857	0.392	−0.160	0.873	−0.417	0.677
2020-02-25	−4.378	0.000***	−4.342	0.000***	−5.910	0.000***	−0.679	0.498	0.088	0.930	−0.101	0.920
2020-03-02	6.188	0.000***	−3.271	0.001***	−5.458	0.000***	4.607	0.000***	2.595	0.010***	2.462	0.015**
2020-03-09	−8.371	0.000***	−10.471	0.000***	−10.771	0.000***	2.667	0.008***	4.287	0.000***	4.313	0.000***
2020-03-30	1.643	0.102	1.073	0.284	1.322	0.187	7.659	0.000***	1.065	0.288	0.242	0.809
2020-04-08	1.693	0.092*	0.838	0.403	2.020	0.045**	0.941	0.348	−0.408	0.683	−0.783	0.434
2020-04-29	1.042	0.298	−0.128	0.898	0.129	0.898	−1.269	0.206	−0.864	0.389	−1.305	0.193
2020-05-28	−0.258	0.797	0.551	0.582	1.189	0.235	−2.218	0.027**	−1.232	0.219	−0.315	0.753
2020-06-30	0.382	0.703	0.221	0.825	0.105	0.916	−0.983	0.327	−1.755	0.081*	−1.265	0.207
2020-07-07	−0.668	0.505	0.258	0.796	0.504	0.615	−0.603	0.547	0.781	0.435	0.549	0.584
2020-09-14	0.513	0.608	−0.360	0.720	−0.471	0.638	−0.417	0.677	0.211	0.833	0.413	0.680
2020-10-02	−0.216	0.829	0.482	0.630	0.620	0.536	0.767	0.444	−0.354	0.724	−0.112	0.911
2020-10-05	0.731	0.465	0.721	0.472	0.564	0.573	−0.672	0.502	−1.064	0.288	−0.951	0.343
2020-11-18	−0.515	0.607	0.028	0.978	0.175	0.862	−0.667	0.506	−0.661	0.509	−0.746	0.456
2020-12-11	0.056	0.955	0.074	0.941	−0.034	0.973	0.797	0.426	−0.574	0.566	−0.431	0.667

Statistical significance at the 1%, 5% and 10% level are represented by ***, ** and *

Table 7: Cumulative abnormal average returns of all indices of the dataset

Event window	Constant return model (%)			Market model (%)		
	First case	First death	Lockdown Italy	First case	First death	Lockdown Italy
−2	−0.47	0.55	−1.81	−0.19	0.19	−0.09
−1	−1.60	−1.69	−5.05	−0.72	−0.10	−1.82
0	−2.45	−3.37	−13.50	−0.89	−0.62	−4.70
1	−2.24	−5.27	−13.09	−0.65	−2.22	−6.36
2	−2.23	−6.36	−15.64	−0.73	−2.38	−5.93
3	−2.59	−8.41	−27.66	−0.77	−2.90	−10.13
4	−3.41	−12.34	−24.05	−1.61	−4.27	−10.79
5	−3.96	−14.00	−32.34	−1.61	−5.27	−11.61

Table 8: Hypothesis test of the event samples: First case, First death and Lockdown Italy

Event	Window	Constant return model				Market model			
		Cross-sectional t-test		Corrado rank test		Cross-sectional t-test		Corrado rank test	
		t-stat	P-value	t-stat	P-value	t-stat	P-value	t-stat	P-value
First case	[0]	−1.691	0.122	−1.078	0.282	−0.606	0.558	−0.882	0.378
	[0.5]	−2.094	0.063**	−1.165	0.245	−1.646	0.131	−0.442	0.674
	[−2.5]	−2.786	0.019***	−2.631	0.009***	−2.400	0.037**	−1.714	0.09*
First death	[0]	−0.989	0.346	−1.207	0.229	−0.846	0.417	−0.977	0.329
	[0.5]	−3.738	0.004***	−5.154	0.000***	−3.199	0.010***	−3.706	0.000***
	[−2.5]	−3.556	0.005***	−5.849	0.000***	−2.341	0.041**	−3.850	0.000***
Lockdown Italy	[0]	−11.206	0.000***	−2.388	0.018**	−3.952	0.003***	−2.663	0.008***
	[0.5]	−15.135	0.000***	−3.012	0.003***	−4.913	0.001***	−2.787	0.006***
	[−2.5]	−13.601	0.000***	−3.904	0.000***	−4.922	0.001***	−3.384	0.001***

Statistical significance at the 1%, 5% and 10% level are represented by ***, ** and *

Table 9: Cumulative abnormal returns Lockdown Italy for each country/index: Constant return model

Country	Event window (%)							
	−2	−1	0	1	2	3	4	5
Australia: AOR	1.14	−1.76	−9.45	−6.52	−10.03	−17.54	−13.54	−23.55
Austria: ATX	−2.77	−6.68	−16.08	−16.83	−19.17	−33.81	−33.30	−44.32
Brazil: Bovespa	−4.82	−9.10	−22.13	−15.28	−23.27	−39.31	−26.34	−41.38
Czech: PX	−1.63	−4.45	−9.69	−9.74	−12.79	−20.92	−19.75	−27.80
France: CAC	−1.93	−6.17	−14.95	−16.49	−17.07	−30.18	−28.38	−34.32
Germany: DAX	−1.54	−4.99	−13.28	−14.72	−15.09	−28.16	−27.41	−32.88
Greate Britain: FTSE100	−1.61	−5.28	−13.26	−13.33	−14.73	−26.22	−23.78	−27.85
Italy: FTSE MIB	−1.82	−5.41	−17.28	−20.64	−20.34	−38.90	−32.05	−38.37
South Korea: Kospi	1.28	−0.88	−5.13	−4.69	−7.49	−11.42	−14.88	−18.10
Spain: IBEX35	−2.57	−6.16	−14.44	−17.68	−18.00	−33.14	−29.46	−37.65
US: DJI	−3.66	−4.67	−12.79	−8.03	−14.08	−24.62	−15.69	−29.55
CAAR	−1.81	−5.05	−13.50	−13.09	−15.64	−27.66	−24.05	−32.34

Table 10: Cumulative abnormal returns Lockdown Italy for each country/index: market model

Country and Index	Event window (%)							
	−2	−1	0	1	2	3	4	5
Australia: AOR	1.57	−0.96	−7.26	−4.85	−7.61	−13.17	−10.23	−18.38
Austria: ATX	−1.01	−3.39	−7.10	−9.96	−9.25	−15.90	−19.75	−23.13
Brazil: Bovespa	−3.03	−5.76	−13.02	−8.32	−13.22	−21.17	−12.62	−19.92
Czech: PX	−0.71	−2.72	−4.98	−6.14	−7.59	−11.54	−12.65	−16.69
France: CAC	0.26	−2.08	−3.78	−7.95	−4.74	−7.93	−11.55	−8.00
Germany: DAX	0.62	−0.95	−2.28	−6.30	−2.94	−6.25	−10.83	−6.96
Greate Britain: FTSE100	0.22	−1.86	−3.92	−6.20	−4.43	−7.63	−9.72	−5.85
Italy: FTSE MIB	0.35	−1.35	−6.22	−12.18	−8.12	−16.87	−15.38	−12.31
South Korea: Kospi	2.28	0.99	−0.02	−0.79	−1.85	−1.23	−7.18	−6.05
Spain: IBEX35	−0.60	−2.48	−4.43	−10.03	−6.96	−13.21	−14.38	−14.08
US: DJI	−0.89	0.51	1.31	2.75	1.48	3.46	5.55	3.66
CAAR	−0.09	−1.82	−4.70	−6.36	−5.93	−10.13	−10.79	−11.61

6. CONCLUSION AND OUTLOOK

6.1. Summing up the Main Results

Summing up the main result, we achieve deep insights into several events and their impact on capital markets. Relating to our first research aspect we see a noticeable increase of the volatility in March 2020. In the further course, but at the latest in May 2020, the 21-day volatility decreases. As well the correlations increase substantially in February and early March, so that the stock indices correlate highly positive during the beginning of the corona crisis.

Regarding our research question whether several Covid events significantly impact cumulative returns, it could be stated that the Lockdown in Italy could be characterized as the most important event for the capital markets worldwide. Even capital markets in Australia, South Korea, and Brazil are affected by the first Lockdown in a western state. All other events mostly show no abnormal returns. While the constant return model sometimes identifies significant individual events with abnormal returns for the US and Germany, the market model does not show any other significant returns. From this, it can be concluded that abnormal returns can be observed, especially in times of great uncertainty at the beginning of the pandemic. As the pandemic progressed, the market priced further developments immediately after the Lockdown in Italy and generally no longer showed any significant events. This also goes hand in hand with our volatility studies, which only showed a sharp rise in volatility

for a brief period. As the year progressed, volatilities returned to their original level.

6.2. Limitations of the Analysis

Finally, the limits of our study should also be presented. Intraday changes cannot be examined by looking at closing prices. Nevertheless, the main events did not show any significant characteristics. Along with a not fully transparent information situation, it can nonetheless be stated that-also due to the time differences-there is overlapping information and the use of intraday data only appears advantageous for index-specific events. It was also shown that there are many different events, some of which followed one another directly or even dated to the same day. In this respect, concerning the dynamic situation of the global pandemic, an event could have been identified almost every day. In this respect, our analysis is also limited to our event selection. Finally, the general model weaknesses of the Efficient Markets Theory in event studies should be mentioned. At last, it has to be stated that the development of the indices was modelled in the relevant currency. As exchange rate is not neutralized in this analysis, currency effects and index price effects blur.

6.3. Further Research

Looking ahead to research questions linked to our research, these can be divided into the further analysis of the capital market on the one hand and the application of the findings on the other hand. Concerning the further capital market analysis, our results can also be checked for futures markets. In connection with this, the effects on the formation of liquidity in the markets and the changes in the implied volatilities can also be checked. The impact of particular sentiments, such as the healthcare industry or aviation, can also be considered in more detail. In this way, the event study can also be used for sentiment indices or individual stocks and provide more in-depth insights into the capital markets. But also, the consideration of the consequences, i.e., effects on diversification decisions, investment decisions, and banks' risk management, can be mentioned. Behavioral finance should also be mentioned. In-depth research is also available in this regard. In addition to the herd behavior at individual events, representativeness heuristics or sharing the blame effects can also be tested for the events.

6.4. Data Availability

The data used is publicly available and can be downloaded on the websites www.stooq.com, https://www.who.int/emergencies/diseases/novel-coronavirus-2019/interactive-timeline and https://www.bundesgesundheitsministerium.de/coronavirus/chronik-coronavirus.html.

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