APPLIED FINANCE LETTERS

VOLUME 13, 2024

INFECTIOUS DISEASE AND ASYMMETRIC INDUSTRIAL VOLATILITY

MUHAMMAD TAHIR SULEMAN[1], BURCU KAPAR[2*] , FAISAL RANA[3]

1. University of Otago, New Zealand
2. University of Wollongong in Dubai, UAE
3. University of Wollongong in Dubai, UAE

* Corresponding Author: Burcu Kapar, Faculty of Finance and Accounting, University of Wollongong in Dubai, UAE
☎ +971 (0) 4 278 19 00 ✉ burcukapar@uowdubai.ac.ae

Abstract

We examine the time-varying effect of stock market volatility due to infectious diseases on industrial sectors in the US from 2012 to 2021 in three sub-periods: the whole sample till COVID-19, during COVID-19 period before and after the Pfizer and Biontech vaccine announcement, respectively. We extend the current literature by exploring the diverse impact of infectious disease equity market volatility index (EMV-ID) on market index and various industrial sectors and decomposing industrial volatility into good and bad volatility to quantify how good and bad components vary in response to the transmission of shocks due to infectious diseases. The results show that the transmission of volatile shocks from the stock market strongly enhances the bad components of industrial volatility before the outbreak of COVID-19 but the good component of industrial volatility during COVID-19 before the Pfizer and Biontech vaccine announcement. The positive transmission of volatile shocks from EMV-ID towards the industrial volatility strengthens and gains momentum as the industrial volatility transits from bearish (lower quantiles) towards the bullish (higher quantiles) conditions irrespective of the period considered. We conclude that the relationship between infectious disease equity market volatility and industrial volatility depends on the good and bad volatile components and their respective conditions at different quantiles.

Keywords: Infectious disease equity market volatility, good volatility, bad volatility, S&P 500, vaccine announcement

1. Introduction

The global spread of the coronavirus (COVID-19) and accompanying containment measures enhanced uncertainties in the global economy and international financial markets at an unprecedented level. With the expanding impact of the pandemic, a growing number of studies have investigated the influence of the pandemic on stock markets. Towards this end, numerous studies have established that the pandemic has caused extreme volatility in the stock markets of affected countries (Topcu and Gulal, 2020; Acharya et al., 2021; Al-Awadhi et al., 2020; Baek et al., 2020; Engelhardt et al., 2021; Kapar et al., 2021; Kucher et al., 2021; Rouatbi et al., 2021). These pandemic-induced equity market disturbances are found to be more severe than previous outbreaks of infectious diseases such as SARS, MERS, Swine flu and Ebola virus (Baker et al., 2020; O'Donnell et al., 2021, Bai et al., 2021). Similarly, compared to the global financial crisis (GFC) in 2008, the evidence suggests that COVID-19 has more intensified impact across countries and stock market sectors (Choi, 2020; Shehzad et al., 2020).

Although global stock markets are adversely affected by the pandemic, the impact is found to be asymmetric across sectors (Mazur et al., 2021; Kapar et al., 2022; Gräb et al., 2021; He et al., 2020; Bradley and Stumpner, 2021). For instance, Gräb et al. (2021) show that stock market sectors that hit the hardest by the pandemic gained more in response to positive vaccine-related announcements. Bradley and Stumpner (2021) estimate that the spread between the best and worst-performing sectors widened from 27 percentage points to 80 percentage points within the year of the outbreak of the COVID-19 pandemic. Some industries, such as airline, travel, banking, insurance, and energy witnessed considerable losses, whereas industries like airfreight, household appliances, computers and electronics benefited from the pandemic.

Understanding how different pandemic-induced shocks impact industrial sectors is crucial for investors and businesses to make optimal investment and hedging decisions. This requires an in-depth analysis at the industrial level, which is presently lacking in literature. We fill this gap in the literature and investigate the effect of equity market volatility due to infectious diseases on industrial volatility (IV hereafter). This study, therefore, broadens our understanding of the diverse impact of infectious diseases on industrial sectors in the US.

To better capture the impact of infectious diseases on industrial sectors, we use the newly developed Infectious Disease Equity Market Volatility Index (EMV-ID hereafter) constructed by Baker et al. (2020), which tracks US equity market volatility caused by infectious diseases. EMV-ID has been widely employed in recent empirical studies to explore the impact of equity market volatility due to infectious diseases on numerous factors, such as commodity returns (Long and Guo, 2022), stock market returns (Ozkan et al., 2022; Gohar et al., 2022), Islamic stocks (Salisu and Sikiru, 2020), energy market (Salisu and Adediran, 2020), sports economy (Guo et al., 2022), public sentiment (Meng et al., 2021), corporate activities (Suleman and Yaghoubi, 2022) and others.

We contribute to the literature by employing this newly developed EMV-ID index to examine its heterogeneous effect on the volatility of ten industrial sectors in the US (i.e., consumer services, financials, health care, industrials, materials, oil and gas, real estate, technology, telecommunication, and utilities) and general market index. Further, we extend the literature by exploring the impact of infectious diseases on various industrial sectors as well as market index and decomposing industrial volatility into good and bad volatility to quantify how good and bad components vary in response to the transmission of shocks due to infectious diseases. Our motivation to study the good and bad volatility of spillovers among stock sectors is due to the evidence suggesting that volatility in financial markets is highly sensitive to good and bad returns. Moreover, this helps to identify whether a specific sector is more prone to infectious disease volatility that will be useful for investors, portfolio managers and regulators. Finally, to better understand the interrelationship between EMV-ID and IV, we examine the association at different quantiles using quantile regression.

Hence, the aim of this study is to examine the time-varying effect of stock market volatility due to infectious diseases on industrial sectors in the US from 2012 to 2021 in three sub-periods: the whole sample till COVID-19, during COVID-19 period before and after the Pfizer and Biontech vaccine announcement, respectively. We find that the transmission of volatile shocks from the stock market more strongly enhances the bad components of industrial volatility before the outbreak of COVID-19 but the good component of industrial volatility during COVID-19 before the vaccine announcement. The positive transmission of volatile shocks from the EMV-ID towards the industrial volatility is stronger when the industrial volatility transits from bearish (lower quantiles) towards the bullish (higher quantiles) conditions irrespective of the period considered. Overall, we conclude that the relationship between EMV-ID and IV depends on the good and bad volatile components and their respective conditions at different quantiles.

The rest of the paper is organized as follows. Section 2 presents the data, Section 3 the methodology, and Section 4 the findings. Finally, a conclusion is provided in Section 6.

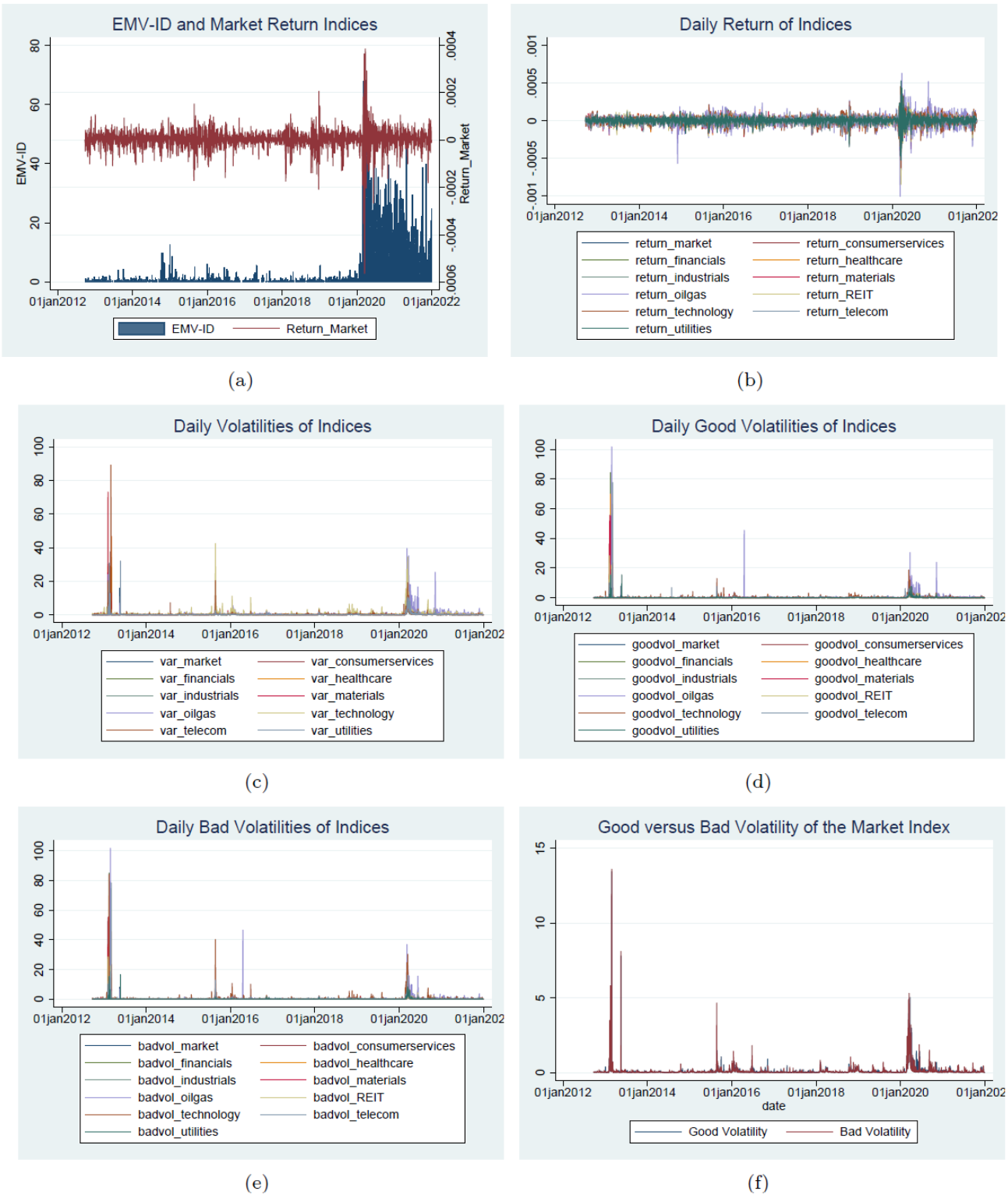
2. Data

This paper examines the time-varying effects of infectious disease equity market volatility on S&P 500 general market and sectoral indices volatility. Daily Infectious Disease Equity Market Volatility Tracker (EMV-ID) is constructed by Baker et al. (2019) to quantify the effect of infectious diseases on U.S. stock market volatility. They first specify terms in four sets: E: (economic, economy, financial), M: (stock market, equity, equities, Standard & Poor's), V: (volatility, volatile, uncertain, uncertainty, risk, risky) and ID: (epidemic, pandemic, virus, flu, disease, coronavirus, MERS, Sars, Ebola, H5N1, H1N1). Second, they count the daily number of newspaper articles containing at least one term in each category, E, M, V and I.D., representing the raw EMV-ID counts. Third, they scale the raw EMV-ID counts by the number of articles on the same day. Finally, they multiplicatively rescale these series to match the mean value of the VIX since 1985. We utilize high-frequency stock prices data (one second) of the overall USA market index and ten sectoral indices (Consumer Services, Financials, Health Care, Industrials, Materials, Oil and Gas, REIT, Technology, Telecommunication and Utilities) to construct volatility series from the Wharton Research Data Services (WRDS) from 21 September 2012 to 31 December 2021.

We apply the Wilcoxon Rank Sum Test to check the equality of the median between good and bad volatility of general market index and sectoral indices and report the findings in Table 7 in Section 4. The full sample findings indicate statistical differences in the median values in all series except Oil and Gas and Utilities. This strengthens our argument to separate the volatility into two components: good and bad volatility.

Figure 1 presents the graph of the EMV-ID index, the return series of different industries and different types of volatilities. During our sample period, five public health emergencies of international concern (PHEIC) are declared by World Health Organization (BBC, 2019; Wilder-Smith and Osman, 2020; WHO, 2016; WHO, 2019; WHO, 2020; WHO, 2022), Ebola (West African outbreak 2013–2015, outbreak in Democratic Republic of Congo 2018–2020), poliomyelitis (2014 to present), Zika (2016) and COVID-19 (2020 to present). EMV-ID index increases during these diseases, but the most significant effect is observed during the COVID-19 breakout in 2020 as presented in Figure 1.a. Figure 1.b. presents the return series of different industries. All indices experience high fluctuations during COVID-19 period, oil and gas industry experiencing the highest fluctuation. Figures 1.c, 1.d. and 1.e present the sectoral indices' volatility, good and bad volatility, respectively. Volatility increased during the 2011-2012 sovereign crisis, the oil price crash in 2016 and the breakout of COVID-19 in 2020.

Figure 1:



Note: This figure reports infectious disease equity market volatility tracker index (a), daily return series (b)and three types of S&P 500 industrial volatility series: daily volatility (c), daily good volatility (d), daily bad volatility(e).

Table 1 below presents the descriptive statistics of the sectoral indices' volatility, good volatility and bad volatility for the period from 21 September 2012 to 17 January 2020 until the outbreak of COVID-19. The technology index has the highest average volatility measure, followed by the oil and gas and telecommunication indices. The telecommunication industry has the highest standard deviation in all three measures. All volatility measures have positively skewed with high kurtosis, indicating fat tails in the distributions.

Table 1: Descriptive statistics of volatility measures for the whole sample before COVID-19 outbreak.

	Index	Obs	Mean	Std. Dev.	Median	Min	Max	Skewness	Kurtosis	Unit Root Test
					Volatility					
Sectoral Indices	Market Index	1841	0.149	0.823	0.0583	0.00392	27.04	24.78	717.6	-40.433
	Consumer Services	1841	0.147	0.894	0.0736	0.0154	34.19	32.89	1192	-29.219
	Financials	1840	0.159	0.765	0.0762	0.00744	24.29	22.80	625.7	-34.706
	Healthcare	1839	0.227	1.346	0.106	0.0155	46.68	28.76	908.4	-41.784
	Industrials	1841	0.117	0.420	0.0647	0.00903	14.38	25.53	782.6	-30.048
	Materials	1840	0.277	1.839	0.140	0.0264	73.11	34.75	1346	-42.106
	Oil and Gas	1839	0.440	1.232	0.244	0.0364	37.69	21.02	554.0	-37.446
	REIT	1841	0.144	1.119	0.0727	0.0158	44.29	35.00	1336	-42.602
	Technology	1841	0.495	1.355	0.226	0.0224	42.46	19.24	532.5	-30.583
	Telecom	1837	0.364	2.381	0.191	0.0492	89.16	31.08	1093	-30.645
	Utilities	1842	0.188	1.112	0.104	0.0187	32.02	25.20	686.6	-38.118
					Good Volatility					
Sectoral Indices	Market Index	1841	0.0744	0.406	0.0273	0.00215	13.44	25.02	732.0	-40.574
	Consumer Services	1841	0.0736	0.447	0.0353	0.00699	17.23	33.49	1226	-29.199
	Financials	1841	0.125	2.001	0.0359	0.00412	84.36	40.72	1709	-40.519
	Healthcare	1841	0.185	2.284	0.0535	0.00721	69.84	27.38	785.9	-42.097
	Industrials	1841	0.0584	0.207	0.0295	0.00447	7.190	25.88	815.9	-29.830
	Materials	1842	0.200	2.039	0.0645	0.0130	55.62	24.70	639.0	-41.108
	Oil and Gas	1841	0.298	2.661	0.114	0.0183	101.7	33.01	1195	-42.175
	REIT	1842	0.0871	0.859	0.0345	0.00658	28.26	28.46	856.3	-42.832
	Technology	1841	0.238	0.579	0.103	0.0124	13.04	11.79	203.1	-30.977
	Telecom	1838	0.223	2.165	0.0934	0.0246	77.74	30.11	993.7	-28.034
	Utilities	1842	0.0912	0.546	0.0501	0.00801	15.46	25.13	681.7	-38.054
					Bad Volatility					
Sectoral Indices	Market Index	1841	0.0750	0.429	0.0225	0.00160	13.60	22.95	629.9	-40.643
	Consumer Services	1842	0.103	1.358	0.0318	0.00636	55.04	37.10	1468	-41.311
	Financials	1841	0.125	2.016	0.0314	0.00332	84.95	40.65	1705	-40.494
	Healthcare	1841	0.186	2.299	0.0436	0.00800	69.62	26.92	765.7	-41.728
	Industrials	1841	0.0584	0.222	0.0260	0.00376	7.191	23.00	650.8	-31.278
	Materials	1842	0.197	2.044	0.0574	0.00872	55.49	24.63	635.0	-41.131
	Oil and Gas	1841	0.302	2.678	0.109	0.0143	101.8	32.60	1169	-42.252
	REIT	1842	0.0881	0.872	0.0317	0.00577	28.46	28.26	845.8	-42.864
	Technology	1842	0.302	2.246	0.0835	0.00956	83.93	31.27	1099	-42.195
	Telecom	1838	0.226	2.185	0.0870	0.0235	78.37	29.95	986.8	-28.182
	Utilities	1842	0.0969	0.569	0.0489	0.00911	16.56	24.93	678.5	-38.199
	Infectious Disease Equity Market Volatility Index(EMV-ID)									
	EMV-ID	2,335	3.78	8.33	0	68.37	3.18	15.31	-17.48	-31.486

Note: This table reports descriptive statistics of the variables. Data is obtained from Wharton Research Data Services (WRDS) for the period from 21 September 2012 to 17 January 2020. Critical values for Dickey Fuller Unit Root Test is -3.430, -2.860 and -2.570 for 1%, 5% and 10% significance level, respectively

We examine COVID-19 period in two subgroups. Kapar et al. (2022) explore how the US sectoral and sub-sectoral indices reacted to the news of a successful development of vaccine by Pfizer and Biontech on 9 November 2020. They find out that there are considerable inter and intra sectoral variations in the impact of the vaccine news. Due to different impact of vaccine announcement on sectoral indices, we split the COVID-19 period into two sub-periods by taking 9 November 2020 as the break point: Before Vaccine and After Vaccine announcement during COVID-19 period. Although Moderna announced the first COVID-19 vaccination on 23rd January 2020, we consider Pfizer and BioNTech vaccine announcement as the breakpoint since this vaccine candidate is the first one that succeeded the first interim analysis from the Phase 3 study to fight against COVID-19.

In Section 4, Table 5 presents the descriptive statistics of the different volatility measures during the COVID-19 period before the Pfizer and Biontech vaccine announcement for the period from 20 January 2020 to 6 November 2020 and Table 6 presents the descriptive statistics of volatility measures during the COVID-19 period after the vaccine announcement for the period from 9 November 2020 to 31 December 2021. As expected, all volatility measures increased with the outbreak of COVID-19 period but significantly decreased after the vaccine announcement. The oil and gas industry index has the highest volatility, followed by technology indices before and after the Pfizer and Biontech vaccine announcement during COVID-19. The Augmented Dickey-Fuller unit root tests support the rejection of the existence of a unit root at the 1% significance level, implying that all of the volatility series and EMV-ID series are stationary.

3. Methodology

In this study, we investigate the relationship between infectious disease equity market volatility tracker and S&P 500 market index and sectoral indices different volatility measures. Initially, we calculate the realized variance, good and bad volatility following Bollerslev et al. (2019), and then we estimate the quantile regression to understand the relation between infectious disease equity market volatility tracker and different volatility measures.

Let p_T denote the natural logarithmic price of an arbitrary asset on day T. The price is assumed to follow the generic jump diffusion process,

$$p_T = \int_0^T \mu_\tau \, d\tau + \int_0^T \sigma_\tau dW_\tau + J_T \tag{1}$$

where τ and σ denote the drift and diffusive volatility processes, respectively. W is a standard Brownian motion, J is a pure jump process, and the unit time interval corresponds to a trading day. We will assume that high-frequency intraday prices p_t,p_(t+1/N),…,p_(t+1) are observed at n+1 equally spaced times over the trading day [t,t+1]. We calculate the natural logarithmic discrete-time return over the ith time-interval on day t+1 as below:

$$r_{t+i/n} = p_{t+i/n} - p_{t+(i-1)/n} \tag{2}$$

The daily realized variance (RV) is then simply defined by the summation of these within-day high-frequency squared returns,

$$RV_t = \sum_{i=1}^{n} r_{t-1+i/n}^2 \tag{3}$$

As documented by Andersen et al.(2011) and Andersen et al. (2003), the realized variance converges (for n →∞) to the quadratic variation comprised of the separate components due to " continuous" and "jump" price increments,

$$RV_t = \int_{t-1}^{t} \sigma_s^2 ds + \sum_{t-1 \le \tau \le t} J_\tau^2$$

(4)

thus, affording increasingly more accurate ex post measures of the true latent total daily price variation for ever finer sampled intraday returns.

The realized variance measure in equation (3) does not differentiate between "good" and "bad" volatility. We decompose the total realized variation into separate components associated with the positive and negative high-frequency returns,

$$RV_t^+ = \sum_{i=1}^{n} r^2_{t-1+\frac{i}{n}} \mathbf{1}_{[r_t - \frac{1}{n}i > 0]}$$

$$RV_t^- = \sum_{i=1}^{n} r^2_{t-1+\frac{i}{n}} \mathbf{1}_{[r_t - \frac{1}{n}i < 0]}$$

(5)

The good and bad volatility measures obviously add up to the total daily realized variation, $RV_t = RV_t^+ + RV_t^-$

As a second step, we estimate quantile regression between volatility measures and infectious disease equity market volatility tracker. In the context of financial time series, according to Koenker and Xiao (2006) quantile regression is an ideal technique as it is robust to conditional heteroskedasticity, skewness and leptokurtosis. Therefore, we use this technique to estimate different quantile autoregressive models for each of our volatility series separately:

$$q_t(R_t|M_t) = \alpha_\tau + \beta_\tau M_t$$

(6)

where $\alpha \in (0,1)$, R_t is the any volatility series and M_t is the infectious disease equity market volatility tracker. The estimates of α_t and β_t in Equation 7 are defined as the solutions to:

$$min_{\alpha_\tau, \beta_\tau} \sum_{t=1}^{T} \rho_\tau(R_t - \alpha_\tau - \beta_\tau M_t)$$

(7)

where $\rho_\tau(z)$ is the check function given by $\rho_\tau(z) = z(\tau - \mathbf{1}_{|z \leq 0|})$, where $\mathbf{1}_{|z \leq 0|}$ is the indicator function taking only two values: 1 if $z \leq 0$ and 0 otherwise. As explained in Koenker and Hallock (2001), the function $\rho_\tau(z)$ imposes different weights on positive and negative residuals depending on the value of τ; when $\tau = 0.5$, his is the median estimator. We estimate the interrelationship between volatility series and infectious disease volatility tracker at different quantiles (0.05, 0.10, 0.20, 0.30, 0.40, 0.50, 0.60, 0.70, 0.80, 0.90, 0.95). Thus, it provides a broader picture in helping us examine the relation.

4. Empirical Results

This study analyses the relationship between industrial uncertainty and US equity market volatility caused by infectious disease in the US from 2012 to 2021 in three sub-periods: the whole sample till COVID-19, during COVID-19 period before and after the Pfizer and Biontech vaccine announcement, respectively.

In Table 2, we analyse the transmission of volatility shocks from the US infectious equity market volatility index (EMV-ID) towards industrial volatility (IV) at different quantiles to see the differences in bearish and bullish conditions.

Table 2: Descriptive statistics of volatility measures during COVID-19 period before the Pfizer and Biontech vaccine announcement.

	Index	Obs.	Mean	Std. Dev.	Median	Min	Max	Skewness	Kurtosis	Unit Root Test
					Volatility					
Sectoral Indices	Market Index	204	0.708	1.190	0.248	0.0246	6.946	3.173	13.92	-5.779
	Consumer Services	204	0.870	1.899	0.265	0.0503	15.42	4.515	27.32	-5.440
	Financials	204	0.993	1.560	0.368	0.0237	9.774	2.836	12.16	-7.548
	Healthcare	204	0.640	1.212	0.205	0.0468	7.799	3.667	17.84	-5.203
	Industrials	204	0.686	1.069	0.271	0.0211	5.935	2.750	10.78	-7.533
	Materials	204	1.225	2.332	0.455	0.0582	21.50	5.111	37.43	-8.382
	Oil and Gas	204	3.560	5.860	1.193	0.119	39.45	3.080	14.56	-6.850
	REIT	204	0.898	1.451	0.275	0.0273	8.042	2.672	10.56	-6.871
	Technology	204	2.277	4.598	0.785	0.115	34.50	4.446	25.17	-6.772
	Telecom	204	1.262	2.464	0.413	0.0804	19.22	4.135	23.62	-6.137
	Utilities	204	0.981	1.839	0.298	0.0379	10.59	3.213	13.61	-5.496
					Good Volatility					
Sectoral Indices	Market Index	204	0.348	0.636	0.118	0.00884	5.025	4.014	23.31	-7.553
	Consumer Services	204	0.407	0.829	0.128	0.0233	6.301	4.234	24.44	-5.376
	Financials	204	0.515	1.014	0.146	0.0115	8.843	4.358	28.66	-9.351
	Healthcare	204	0.316	0.597	0.0959	0.0221	4.661	3.919	22.34	-6.951
	Industrials	204	0.348	0.679	0.113	0.0110	5.407	4.282	25.46	-9.635
	Materials	204	0.601	1.334	0.195	0.0275	14.44	6.716	62.05	-10.385
	Oil and Gas	204	1.804	3.410	0.505	0.0502	30.43	4.196	28.24	-8.096
	REIT	204	0.444	0.844	0.118	0.0153	6.038	3.553	18.21	-9.076
	Technology	204	1.008	1.911	0.384	0.0428	18.76	5.510	43.78	-8.200
	Telecom	204	0.587	1.056	0.203	0.0358	6.203	3.369	15.11	-6.578
	Utilities	204	0.485	0.988	0.129	0.0194	7.597	4.423	27.92	-7.491
					Bad Volatility					
Sectoral Indices	Market Index	204	0.359	0.770	0.0885	0.00884	5.300	4.135	22.34	-9.364
	Consumer Services	204	0.463	1.287	0.108	0.0214	12.54	6.259	50.24	-9.297
	Financials	204	0.477	1.017	0.123	0.0103	7.482	4.167	22.75	-11.178
	Healthcare	204	0.324	0.785	0.0867	0.0159	6.012	4.853	29.43	-8.528
	Industrials	204	0.338	0.717	0.0845	0.0102	4.331	3.902	19.18	-11.017
	Materials	204	0.624	1.718	0.155	0.0278	19.81	7.725	79.60	-12.171
	Oil and Gas	204	1.757	3.848	0.514	0.0634	36.80	5.389	41.02	-10.932
	REIT	204	0.453	1.006	0.0982	0.0112	6.553	4.039	21.07	-10.582
	Technology	204	1.269	3.533	0.290	0.0392	30.29	5.775	39.90	-10.894
	Telecom	204	0.675	1.682	0.189	0.0365	16.15	5.798	44.89	-9.081
	Utilities	204	0.496	1.164	0.114	0.0146	8.268	4.383	24.3	-8.530
					Infectious Disease Equity Market Volatility Index(EMV-ID)					
	EMV-ID	204	21.56	13.56	19.05	0	68.37	0.970	4.037	-5.542

Note: This table reports descriptive statistics of the variables during COVID-19 Period before the Pfizer and Biontech Vaccine Announcement. Data is obtained from Wharton Research Data Services (WRDS) for the period from 20 Jan 2020 to 6 November 2020. Critical values for Dickey Fuller Unit Root Test is -3.430, -2.860 and -2.570 for 1%, 5% and 10% significance level, respectively.

For example, according to the findings of total volatility, during bearish ($\tau = 0.05$) IV conditions, the EMV-ID volatility causes a more appreciative impact on the IV of financials, oil and gas and telecom. This means that when the IV falls below the normalized region, EMV-ID puts upward pressure on the IV and may provide investment incentives for risk-taking long- term investors. However, at bullish ($\tau = 0.95$) IV conditions, only industrials, oil and gas and technology react significantly to EMV-ID.

During the whole sample until COVID-19, EMV-ID significantly affects almost all good volatility measures irrespective of industry and quantile. However, the effect is only pronounced at high quantiles of bad volatility in some industries such as consumer services, financials, healthcare,

industrials, materials, technology, telecom, and utilities. However, when the effect of magnitude is compared, the effect on bad volatilities is at a greater magnitude than on good volatilities. This means that bad volatility is much more sensitive to economic uncertainty shocks than good volatility. This could be explained with investor's behaviour. When uncertainty increases in the markets, investors tend to reduce their long positions in financial assets, decreasing prices and enhancing bad volatility (Lyu et al., 2021). Further bullish shifts in sentiment lead to downward revisions in the volatility of returns and are associated with higher future excess returns, which signifies the investor's attitude in explaining the formation of volatility (Lee et al., 2002).

Apparently, the significant impact of EMV-ID on the oil and gas industry's total, good and bad volatility is observed at all quantiles before the COVID-19. Interestingly, bad volatility of oil and gas industry is the only industry that reacts EMV-ID at all quantiles significantly compared to other industries. This indicates that oil and gas industry is the most sensitive industry to equity market volatility associated with infectious disease. Similarly, Bouri et al. (2020) also examines the predictive power of EMV-ID index for oil-market volatility and document that incorporating EMV-ID into a forecasting setting significantly improves the forecast accuracy of oil realized volatility at short-, medium-, and long-run horizons.

Overall, we have also observed that before the COVID-19 period, the relationship between EMV-ID and IV depends not only on the industrial volatility conditions but also on the good and bad volatile components and their respective conditions at lower (τ = 0.05, 0.10) and higher quantiles (τ = 0.90, 0.95). As presented in Figure 1.b., during the COVID-19 and before the vaccine announcement, uncertainty was very high in the financial markets and EMV-ID reached its highest level. Moreover, as presented in Table 2, the volatility of each industry increased significantly with the outbreak of COVID-19 as also documented by Baker et al. (2020) and Baek et al. (2020). However, once the shock has been absorbed, the total volatility exhibits a significant fall with the quick recovery of financial markets as also claimed by Basuony et al. (2021).

As seen in Table 3, the vaccine announcement mitigated the volatility in financial markets (Nguyen To et al., 2023).

Table 3: Descriptive statistics of volatility measures during COVID-19 period after the Pfizer and Biontech vaccine announcement.

	Index	Obs.	Mean	Std. Dev.	Median	Min	Max	Skewness	Kurtosis	Unit Root Test
					Volatility					
Sectoral Indices	Market Index	289	0.126	0.131	0.0812	0.0136	0.867	2.399	9.923	-11.636
	Consumer Services	289	0.137	0.146	0.111	0.0373	2.165	9.747	132.1	-25.078
	Financials	289	0.228	0.296	0.149	0.0392	3.437	6.231	57.76	-19.058
	Healthcare	289	0.126	0.135	0.0910	0.0239	1.799	7.348	85.18	-20.605
	Industrials	289	0.165	0.196	0.104	0.0221	2.173	4.948	42.53	-17.180
	Materials	289	0.304	0.323	0.210	0.0598	4.084	6.414	68.02	-20.845
	Oil and Gas	289	0.947	1.598	0.605	0.146	25.33	12.51	189.3	-35.725
	REIT	289	0.140	0.195	0.0983	0.0276	2.878	10.03	135.3	-25.919
	Technology	289	0.448	0.428	0.285	0.0747	2.223	1.998	6.795	-9.735
	Telecom	289	0.211	0.213	0.151	0.0473	2.407	5.235	45.52	-16.161
	Utilities	289	0.157	0.197	0.114	0.0313	2.993	10.71	151.2	-27.971
					Good Volatility					
Sectoral Indices	Market Index	289	0.126	0.131	0.0812	0.0136	0.867	2.399	9.923	-11.636
	Consumer Services	289	0.137	0.146	0.111	0.0373	2.165	9.747	132.1	-25.078
	Financials	289	0.228	0.296	0.149	0.0392	3.437	6.231	57.76	-19.058
	Healthcare	289	0.126	0.135	0.0910	0.0239	1.799	7.348	85.18	-20.605
	Industrials	289	0.165	0.196	0.104	0.0221	2.173	4.948	42.53	-17.180
	Materials	289	0.304	0.323	0.210	0.0598	4.084	6.414	68.02	-20.845
	Oil and Gas	289	0.947	1.598	0.605	0.146	25.33	12.51	189.3	-35.725
	REIT	289	0.140	0.195	0.0983	0.0276	2.878	10.03	135.3	-25.919
	Technology	289	0.448	0.428	0.285	0.0747	2.223	1.998	6.795	-9.735
	Telecom	289	0.211	0.213	0.151	0.0473	2.407	5.235	45.52	-16.161
	Utilities	289	0.157	0.197	0.114	0.0313	2.993	10.71	151.2	-27.971
					Bad Volatility					
Sectoral Indices	Market Index	289	0.0605	0.0869	0.0288	0.00559	0.657	3.420	17.33	-14.646
	Consumer Services	289	0.0663	0.0577	0.0496	0.0160	0.552	3.702	23.56	-14.276
	Financials	289	0.101	0.150	0.0569	0.0188	1.290	4.947	32.76	-16.734
	Healthcare	289	0.0581	0.0615	0.0380	0.0103	0.481	3.624	19.78	-14.708
	Industrials	289	0.0735	0.117	0.0365	0.00942	0.920	4.295	24.20	-16.493
	Materials	289	0.138	0.187	0.0771	0.0253	1.408	4.069	22.14	-16.278
	Oil and Gas	289	0.424	0.473	0.275	0.0704	3.627	3.544	18.87	-16.016
	REIT	289	0.0616	0.0748	0.0386	0.0120	0.748	5.037	37.65	-15.971
	Technology	289	0.223	0.283	0.116	0.0306	1.788	2.917	12.77	-12.790
	Telecom	289	0.105	0.120	0.0661	0.0222	1.288	4.841	38.77	-13.239
	Utilities	289	0.0697	0.0551	0.0545	0.0161	0.444	2.963	15.51	-12.536
	Infectious Disease Equity Market Volatility Index (EMV-ID)									
	EMV-ID	289	12.63	7.36	11.61	0	47.59	1.19	5.28	-11.399

Note: This table reports descriptive statistics of the variables during COVID-19 Period after the Pfizer and Biontech Vaccine Announcement. Data is obtained from Wharton Research Data Services (WRDS) for the period from 9 November 2020 to 31 December 2021. Critical values for Dickey Fuller Unit Root Test is -3.430, -2.860 and -2.570 for 1%, 5% and 10% significance level, respectively.

Grab et al. (2021) and Kapar et al. (2022) analyse the effect of vaccine announcements on the stock return of different industries. They suggest that the stock market sectors hit hardest by the pandemic benefited the most from positive vaccine news. When we analyse the effect of vaccine announcement on the volatility in Table 6, except bearish conditions of consumer services, financials, health care, industrials, real estate and utilities and bullish conditions of financials, health care, materials, real estate, all other industrial volatilities are affected from EMV-ID. In terms of the magnitude, the impact of EMV-ID on good or bad volatility depends on the industry. In financials, health care and materials, the impact is more pronounced on good components. In contrast, in consumer services, industrials, real estate, telecom and utilities, the impact is more noticeable in bad components. The findings of the Wilcoxon Rank Sum Test in Table 7 also indicate that there are no statistical differences between good and bad volatility of consumer services, oil and gas, telecom and utilities industries on the reaction for EMV-ID at the median level.

Table 4 presents the results for the entire sample until the COVID-19 outbreak.

Table 4: The Relation between industry volatilities and infectious disease equity market volatility index for the whole sample before COVID-19 outbreak.

	Quantiles	(0.05)	(0.10)	(0.20)	(0.30)	(0.40)	(0.50)	(0.60)	(0.70)	(0.80)	(0.90)	(0.95)
						Total Volatility						
Sectoral Indices	Market Index	0.0003	0.0012*	0.0017**	0.0018*	0.0044***	0.0061***	0.0075***	0.0110***	0.0218***	0.0485***	0.0561*
	Consumer Services	0.0003	0.0000	0.0010	0.0021**	0.0017	0.0021	0.0048**	0.0059*	0.0085*	0.0351***	0.0325*
	Financials	-0.0015**	0.0011	0.0016*	0.0012	0.0012	0.0022	0.0049*	0.0072**	0.0093*	0.0310**	0.0147
	Health Care	0.0012	0.0027**	0.0049***	0.0053***	0.0087***	0.0091***	0.0109***	0.0119**	0.0373***	0.0503***	0.0633
	Industrials	0.0010	0.0012*	0.0018**	0.0025**	0.0029**	0.0042**	0.0044*	0.0107***	0.0174***	0.0318***	0.0393**
	Materials	0.0023*	0.0015	0.0015	0.0055***	0.0083***	0.0140***	0.0137***	0.0227***	0.0289***	0.0535***	0.0317
	Oil and Gas	0.0060***	0.0136***	0.0170***	0.0189***	0.0335***	0.0523***	0.0603***	0.0817***	0.1103***	0.2194***	0.3917***
	REIT	-0.0009	0.0006	0.0012	0.0005	0.0009	0.0013	0.0006	0.0052*	0.0059	0.0059	0.0021
	Technology	0.0004	0.0030	0.0034	0.0050	0.0105**	0.0136**	0.0191*	0.0377***	0.0764***	0.1662***	0.2968**
	Telecom	0.0035**	0.0030	0.0014	-0.0001	-0.0010	0.0005	-0.0016	0.0037	0.0129	0.0482**	0.0501
	Utilities	-0.0003	0.0003	0.0016	0.0006	0.0030	0.0050**	0.0058**	0.0099***	0.0127***	0.0135	0.0281
						Good Volatility						
Sectoral Indices	Market Index	0.0003***	0.0004***	0.0006***	0.0009***	0.0012***	0.0018***	0.0026***	0.0036***	0.0052***	0.0059***	0.0090***
	Consumer Services	0.0003***	0.0003***	0.0005***	0.0007***	0.0009***	0.0014***	0.0020***	0.0025***	0.0039***	0.0051***	0.0055***
	Financials	0.0002***	0.0005***	0.0007***	0.0010***	0.0012***	0.0015***	0.0024***	0.0036***	0.0045***	0.0069***	0.0082***
	Health Care	0.0002**	0.0005***	0.0009***	0.0013***	0.0016***	0.0019***	0.0025***	0.0043***	0.0049***	0.0056***	0.0086***
	Industrials	0.0003***	0.0003***	0.0006***	0.0007***	0.0009***	0.0015***	0.0018***	0.0025***	0.0036***	0.0050***	0.0067***
	Materials	0.0006***	0.0009***	0.0013***	0.0019***	0.0024***	0.0030***	0.0037***	0.0045***	0.0064***	0.0096***	0.0107***
	Oil and Gas	0.0026***	0.0029***	0.0047***	0.0065***	0.0079***	0.0100***	0.0119***	0.0164***	0.0201***	0.0271***	0.0782***
	REIT	0.0001**	0.0002***	0.0004***	0.0005***	0.0006***	0.0009***	0.0011***	0.0016***	0.0031***	0.0038***	0.0065***
	Technology	0.0006***	0.0007***	0.0013***	0.0016***	0.0028***	0.0040***	0.0063***	0.0107***	0.0158***	0.0226***	0.0282***
	Telecom	0.0002	0.0004***	0.0009***	0.0013***	0.0017***	0.0021***	0.0024***	0.0035***	0.0046***	0.0063***	0.0048
	Utilities	0.0004***	0.0004***	0.0007***	0.0010***	0.0015***	0.0016***	0.0017***	0.0018***	0.0023***	0.0024***	0.0017
						Bad Volatility						
Sectoral Indices	Market Index	-0.0001	0.0001	0.0004	0.0008**	0.0011*	0.0021***	0.0061***	0.0070***	0.0184***	0.0377***	0.0480**
	Consumer Services	0.0005	0.0002	0.0004	0.0002	0.0018***	0.0030***	0.0041***	0.0046**	0.0094***	0.0206***	0.0252*
	Financials	-0.0001	-0.0002	-0.0005	-0.0001	-0.0002	0.0017*	0.0029**	0.0083***	0.0107***	0.0232***	0.0327**
	Health Care	0.0001	0.0006	0.0008	0.0026***	0.0035***	0.0047***	0.0095***	0.0132***	0.0308***	0.0591***	0.0932***
	Industrials	0.0004	0.0004*	0.0003	0.0005	0.0007	0.0019**	0.0045***	0.0048***	0.0079***	0.0239***	0.0280**
	Materials	0.0011*	0.0014**	0.0012*	0.0010	0.0024**	0.0022	0.0074***	0.0084**	0.0131**	0.0335***	0.0235
	Oil and Gas	0.0042***	0.0052***	0.0101***	0.0101***	0.0110***	0.0239***	0.0292***	0.0605***	0.0699***	0.1582***	0.1378***
	REIT	-0.0002	0.0001	0.0003	0.0000	0.0002	0.0002	0.0012	0.0002	-0.0023	0.0087*	0.0059
	Technology	-0.0017*	-0.0005	0.0004	0.0041***	0.0040**	0.0037	0.0061	0.0180**	0.0560***	0.1461***	0.2620***
	Telecom	-0.0002	0.0010	0.0010	0.0008	0.0024**	0.0023	0.0049**	0.0075**	0.0086*	0.0293**	0.0444
	Utilities	0.0001	0.0001	-0.0000	0.0019***	0.0016*	0.0015	0.0013	0.0043**	0.0091***	0.0217***	0.0180*

*Note: This table reports the estimates by regressing industrial total, good and bad volatility on infectious disease equity market volatility index (EMV-ID) using a quantile regression model at different quantiles (0.05, 0.10, 0.20, 0.30, 0.40, 0.50, 0.60, 0.70, 0.80, 0.90, 0.95) during the sample period from 21 September 2012 to 17 January 2020. *, **, *** represents significancy at the 10%, 5% and 1% levels, respectively.*

Tables 5 and 6 present the results for the COVID-19 period before and after the Pfizer and Biontech vaccine announcement, respectively. The first part of Tables 4, 5 and 6 demonstrates how the US equity market volatility index (EMVI) affects the overall industrial volatility (IV) at different quantiles.

According to Table 5, during this period, the appreciative impact of EMV-ID is significant for all industries, irrespective of the quantile condition and volatility measures.

Table 5: The Relation between industry volatilities and infectious disease equity market volatility index during the COVID-19 period before Pfizer and Biontech vaccine announcement.

	Quantiles	(0.05)	(0.10)	(0.20)	(0.30)	(0.40)	(0.50)	(0.60)	(0.70)	(0.80)	(0.90)	(0.95)
							Total Volatility					
Sectoral Indices	Market	0.0035***	0.0049***	0.0065***	0.0122***	0.0158***	0.0223***	0.0347***	0.0411***	0.0596***	0.0831***	0.1004***
	Consumer Services	0.0023***	0.0033***	0.0068***	0.0108***	0.0142***	0.0190***	0.0375***	0.0591***	0.0769***	0.0949***	0.1430**
	Financials	0.0041***	0.0064***	0.0135***	0.0178***	0.0238***	0.0320***	0.0537***	0.0617***	0.0754***	0.1317***	0.1554***
	Health Care	0.0016**	0.0033***	0.0055***	0.0089***	0.0112***	0.0181***	0.0263***	0.0417***	0.0552***	0.0646***	0.1005***
	Industrials	0.0027***	0.0046***	0.0100***	0.0126***	0.0150***	0.0264***	0.0317***	0.0376***	0.0438***	0.0958***	0.1032***
	Materials	0.0052***	0.0073***	0.0143***	0.0220***	0.0301***	0.0356***	0.0493***	0.0687***	0.0712***	0.1422***	0.1713***
	Oil and Gas	0.0138***	0.0217***	0.0348***	0.0512***	0.0867***	0.1628***	0.1916***	0.2387***	0.3146***	0.4237***	0.4932***
	REIT	0.0039***	0.0055***	0.0123***	0.0148***	0.0241***	0.0353***	0.0527***	0.0572***	0.0713***	0.1161***	0.1356***
	Technology	0.0078***	0.0101***	0.0146***	0.0236***	0.0304***	0.0459***	0.0767***	0.1109***	0.1384***	0.2539***	0.4382***
	Telecom	0.0013	0.0061***	0.0114***	0.0163***	0.0237***	0.0417***	0.0525***	0.0692***	0.0960***	0.1443***	0.1610**
	Utilities	0.0033***	0.0051***	0.0099***	0.0137***	0.0178***	0.0324***	0.0516***	0.0755***	0.0863***	0.1097***	0.1837***
							Good Volatility					
Sectoral Indices	Market	0.0012***	0.0014***	0.0027***	0.0037***	0.0066***	0.0121***	0.0161***	0.0255***	0.0299***	0.0391***	0.0898***
	Consumer Services	0.0006**	0.0014***	0.0027***	0.0045***	0.0075***	0.0100***	0.0123***	0.0219***	0.0533***	0.0624***	0.1229***
	Financials	0.0021***	0.0038***	0.0051***	0.0081***	0.0126***	0.0178***	0.0283***	0.0357***	0.0476***	0.0693***	0.0935***
	Health Care	0.0012***	0.0017***	0.0031***	0.0041***	0.0047***	0.0073***	0.0147***	0.0222***	0.0338***	0.0481***	0.0774***
	Industries	0.0013***	0.0022***	0.0028***	0.0050***	0.0063***	0.0151***	0.0182***	0.0230***	0.0333***	0.0446***	0.0537***
	Materials	0.0014***	0.0029***	0.0056***	0.0062***	0.0104***	0.0192***	0.0264***	0.0370***	0.0455***	0.0627***	0.1256***
	Oil and Gas	0.0086***	0.0118***	0.0227***	0.0362***	0.0489***	0.0836***	0.1152***	0.1555***	0.1847***	0.2146***	0.3724***
	REIT	0.0011***	0.0027***	0.0039***	0.0052***	0.0065***	0.0171***	0.0237***	0.0320***	0.0453***	0.0584***	0.0830***
	Technology	0.0027***	0.0039***	0.0055***	0.0067***	0.0090***	0.0162***	0.0324***	0.0505***	0.0693***	0.1183***	0.2075***
	Telecom	0.0004	0.0022***	0.0054***	0.0091***	0.0094***	0.0157***	0.0223***	0.0372***	0.0629***	0.0699***	0.1202***
	Utilities	0.0013***	0.0016***	0.0040***	0.0046***	0.0086***	0.0135***	0.0288***	0.0362***	0.0469***	0.0809***	0.0732***
							Bad Volatility					
Sectoral Indices	Market	0.0009***	0.0014***	0.0027***	0.0038***	0.0056***	0.0075***	0.0128***	0.0199***	0.0251***	0.0447**	0.0842***
	Consumer Services	0.0009***	0.0013***	0.0023***	0.0041***	0.0059***	0.0072***	0.0148***	0.0265***	0.0345***	0.0593***	0.0985**
	Financials	0.0020***	0.0026***	0.0039***	0.0056***	0.0073***	0.0121***	0.0183***	0.0221***	0.0299***	0.0566***	0.0844***
	Health Care	0.0005**	0.0012***	0.0021***	0.0032***	0.0046***	0.0071***	0.0104***	0.0169***	0.0215***	0.0389**	0.0905***
	Industrials	0.0011***	0.0014***	0.0021***	0.0034***	0.0048***	0.0068***	0.0120***	0.0149***	0.0215***	0.0328**	0.0723***
	Materials	0.0014***	0.0025***	0.0042***	0.0055***	0.0071***	0.0115***	0.0196***	0.0242***	0.0370***	0.0682**	0.1104**
	Oil and Gas	0.0079***	0.0103***	0.0203***	0.0260***	0.0333***	0.0493***	0.0602***	0.0915***	0.1251***	0.2096***	0.3016***
	REIT	0.0014***	0.0021***	0.0033***	0.0045***	0.0058***	0.0124***	0.0160***	0.0244***	0.0315***	0.0567**	0.0957***
	Technology	0.0027***	0.0041***	0.0064***	0.0081***	0.0128***	0.0186***	0.0312***	0.0461***	0.0677***	0.1253	0.3642***
	Telecom	0.0014***	0.0021***	0.0058***	0.0089***	0.0118***	0.0173***	0.0210***	0.0360***	0.0468***	0.0751***	0.1194***
	Utilities	0.0015***	0.0023***	0.0034***	0.0049***	0.0064***	0.0100***	0.0210***	0.0276***	0.0388***	0.0530***	0.0854**

*Note: This table reports the estimates by regressing industrial total, good and bad volatility on infectious disease equity market volatility index (EMV-ID) using a quantile regression model at different quantiles (0.05, 0.10, 0.20, 0.30, 0.40, 0.50, 0.60, 0.70, 0.80, 0.90, 0.95) during the sample period from 20 January 2020 to 6 November December 2020 to see the relation during COVID-19 period before the Pfizer and Biontech vaccine announcement. *, **, *** represents significancy at the 10%, 5% and 1% levels, respectively.*

Table 6: The Relation between industry volatilities and infectious disease equity market volatility index during the COVID-19 period after the Pfizer and Biontech vaccine announcement.

	Quantiles	(0.05)	(0.10)	(0.20)	(0.30)	(0.40)	(0.50)	(0.60)	(0.70)	(0.80)	(0.90)	(0.95)
							Total Volatility					
Sectoral Indices	Market	0.0002	0.0005**	0.0011***	0.0020***	0.0030***	0.0033***	0.0039***	0.0045***	0.0062***	0.0084*	0.0124**
	Consumer Services	0.0005	0.0009***	0.0020***	0.0024***	0.0030***	0.0030***	0.0033***	0.0042***	0.0051***	0.0074**	0.0074*
	Financials	0.0006	0.0013**	0.0018***	0.0028***	0.0031***	0.0044***	0.0048***	0.0073***	0.0087***	0.0114	0.0177
	Health Care	0.0001	0.0008**	0.0009**	0.0009**	0.0012**	0.0015**	0.0013*	0.0018*	0.0042**	0.0054*	0.0061
	Industrials	0.0005	0.0007**	0.0017***	0.0023***	0.0026***	0.0042***	0.0054***	0.0073***	0.0097***	0.0128**	0.0165*
	Materials	0.0013**	0.0019**	0.0023**	0.0029***	0.0035***	0.0060***	0.0053**	0.0056*	0.0149***	0.0155**	0.0127
	Oil and Gas	0.0049**	0.0044*	0.0054	0.0150***	0.0132***	0.0256***	0.0292***	0.0380***	0.0467***	0.0667***	0.1015***
	REIT	0.0002	0.0005*	0.0011***	0.0017***	0.0020***	0.0019***	0.0024***	0.0032***	0.0051**	0.0079**	0.0082
	Technology	0.0025***	0.0027***	0.0033***	0.0054***	0.0073***	0.0091***	0.0094***	0.0136***	0.0252***	0.0358***	0.0390***
	Telecom	0.0010*	0.0006	0.0007	0.0019***	0.0024***	0.0026***	0.0026**	0.0039**	0.0043	0.0097*	0.0151*
	Utilities	0.0006	0.0004	0.0018***	0.0027***	0.0030***	0.0034***	0.0042***	0.0043***	0.0080***	0.0090***	0.0179***
							Good Volatility					
Sectoral Indices	Market	-0.0001	0.0001	0.0005***	0.0004**	0.0004	0.0007*	0.0015***	0.0026***	0.0047***	0.0062***	0.0087**
	Consumer Services	-0.0001	0.0001	0.0002	0.0004*	0.0008***	0.0010***	0.0013***	0.0022***	0.0023***	0.0043***	0.0030
	Financials	0.0002	0.0003	0.0004*	0.0010***	0.0017***	0.0020***	0.0021***	0.0030***	0.0055***	0.0127***	0.0206
	Health Care	-0.0001	0.0002	0.0006***	0.0005***	0.0006***	0.0007***	0.0012***	0.0020***	0.0022***	0.0038**	0.0054
	Industrials	0.0001	0.0002	0.0006***	0.0006***	0.0007**	0.0007*	0.0017***	0.0022**	0.0044***	0.0100***	0.0099
	Materials	0.0006***	0.0006***	0.0011***	0.0012***	0.0013**	0.0026***	0.0042***	0.0048***	0.0101***	0.0171***	0.0139
	Oil and Gas	0.0010	0.0012	0.0026**	0.0032**	0.0098***	0.0123***	0.0133***	0.0222***	0.0260***	0.0548***	0.0450
	REIT	0.0000	0.0002	0.0003**	0.0005***	0.0008***	0.0007**	0.0014***	0.0028***	0.0034***	0.0071***	0.0065
	Technology	0.0002	0.0001	0.0004	0.0014**	0.0009	0.0013	0.0050***	0.0064***	0.0093***	0.0182***	0.0164*
	Telecom	0.0005**	0.0006***	0.0005***	0.0007**	0.0013***	0.0017***	0.0021***	0.0030***	0.0041***	0.0077***	0.0058
	Utilities	-0.0000	-0.0000	0.0003*	0.0007***	0.0007***	0.0009***	0.0016***	0.0027***	0.0045***	0.0049**	0.0158**
							Bad Volatility					
Sectoral Indices	Market	0.0002	0.0003***	0.0002**	0.0006***	0.0008***	0.0009***	0.0018***	0.0030***	0.0046***	0.0067***	0.0057
	Consumer Services	0.0002	0.0003**	0.0005**	0.0009***	0.0011***	0.0012***	0.0018***	0.0021***	0.0030***	0.0027	0.0060
	Financials	0.0000	0.0000	0.0001	0.0005**	0.0005	0.0006	0.0020***	0.0028***	0.0045***	0.0099***	0.0104
	Health Care	0.0002	0.0002*	0.0003*	0.0005**	0.0006***	0.0006**	0.0010***	0.0021***	0.0027***	0.0034	0.0068*
	Industrials	0.0002**	0.0003***	0.0005***	0.0006***	0.0006**	0.0011***	0.0023***	0.0036***	0.0053***	0.0055**	0.0075
	Materials	0.0002	0.0005**	0.0007***	0.0010***	0.0013***	0.0022***	0.0039***	0.0051***	0.0061***	0.0068	0.0201
	Oil and Gas	0.0002	0.0002	0.0021	0.0037***	0.0058***	0.0072***	0.0114***	0.0162***	0.0285***	0.0538***	0.0388
	REIT	0.0001	0.0002	0.0005***	0.0006***	0.0009***	0.0014***	0.0017***	0.0023***	0.0021***	0.0037*	0.0053
	Technology	0.0003	0.0009***	0.0012***	0.0020***	0.0023***	0.0032***	0.0038**	0.0075**	0.0178***	0.0185**	0.0192
	Telecom	0.0005***	0.0006***	0.0005**	0.0007***	0.0011***	0.0020***	0.0023***	0.0043***	0.0038**	0.0054	0.0041
	Utilities	0.0002	0.0003	0.0005***	0.0011***	0.0012***	0.0013***	0.0021***	0.0028***	0.0037***	0.0034***	0.0040

*Note: This table reports the estimates by regressing industrial total, good and bad volatility on infectious disease equity market volatility index (EMV-ID) using a quantile regression model at different quantiles (0.05, 0.10, 0.20, 0.30, 0.40, 0.50, 0.60, 0.70, 0.80, 0.90, 0.95) during the sample period from 9 November December 2020 to 31 December 2021 to see the relation during COVID-19 period after the Pfizer and Biontech vaccine announcement. *, **, *** represents significancy at the 10%, 5% and 1% levels, respectively.*

As the findings of the Wilcoxon Rank Sum Test suggest in Table 7, there are statistical differences in the median values of good and bad volatility in all indices except the Oil and Gas and Utilities sectors. Due to this statistical difference, we demonstrate the results by decomposing volatility into good and bad components in the second and third parts of Tables 4, 5 and 6.

Table 7: Wilcoxon Rank Sum Test

		Whole Sample until COVID-19		During COVID-19 before the vaccine announcement		During COVID-19 after the vaccine announcement		Whole Sample	
		z value	Probability	z value	Probability	z value	Probability	z value	Probability
Sectoral Indices	Market Index	5.463	0.0000	1.816	0.0693	3.597	0.0003	6.087	0.0000
	Consumer Services	3.749	0.0002	1.122	0.2620	0.588	0.5565	3.546	0.0004
	Financials	3.710	0.0002	0.767	0.4433	2.754	0.0059	3.774	0.0002
	Health Care	5.509	0.0000	1.259	0.2079	2.577	0.0100	5.994	0.0000
	Industrials	4.080	0.0000	1.580	0.1141	4.059	0.0000	4.949	0.0000
	Materials	3.391	0.0007	1.820	0.0687	3.750	0.0002	4.362	0.0000
	Oil and Gas	1.918	0.0551	-0.023	0.9819	1.473	0.1407	1.525	0.1273
	REIT	3.639	0.0003	0.974	0.3301	3.197	0.0014	4.182	0.0000
	Technology	5.318	0.0000	1.898	0.0577	2.530	0.0114	5.563	0.0000
	Telecom	2.236	0.0254	0.768	0.4423	1.406	0.1597	2.553	0.0107
	Utilities	0.416	0.6771	0.544	0.5864	1.509	0.1314	0.937	0.3486

Note: Wilcoxon Rank Sum Test is applied to check the equality of the medians of the two samples (good volatility versus bad volatility).

Hence, we empirically verify that economic uncertainty shocks can significantly and persistently increase industrial volatility during COVID-19 until the vaccine announcement. Bad volatility is associated with declines in prices, and good volatility is associated with increases in prices. After the outbreak of COVID-19, economic uncertainty shocks initially caused an increase in bad volatility due to significant price decreases with the outbreak of COVID-19. However, once the shock has been absorbed, the stock market recovers with big price jumps and good volatility increases, as presented in Figure 1.f. The findings of the Wilcoxon Rank Sum Test in Table 7 also support this inference. During the COVID-19 period before the vaccine announcement, there is no statistical difference between good and bad volatility in their reaction to a change in the EMV-ID index. As price decreases with the shocks followed by a recovery, we observe that both good and bad volatility of industry indices are affected by infectious disease economic uncertainty. Hence, during COVID-19 period, all volatility measures are affected from uncertainty irrespective of the quantile condition.

To conclude, according to Tables 2, 3 and 4, it is evident that the positive transmission of volatile shocks from the EMV-ID towards the IV strengthens and gains momentum as the IV volatility transits from bearish (lower quantiles) towards the bullish (higher quantiles) condition irrespective of the period considered. Interestingly, during the COVID-19 period before the vaccine announcement and bearish IV conditions, the appreciative impact of EMV-ID is more significant for all industries compared with the other periods. This is supported by Kundu and Paul (2022), who examine the effect of economic policy uncertainty on stock market volatility for the seven countries in differential market conditions such as bull and bear markets. The estimation results suggest that the impact of EPU is significant in the bear market. Finally, the magnitudes of the effect of EMV-ID uncertainty on industrial volatility across the three subsample periods are significantly different from each other, indicating that the effects of economic uncertainty shocks on industrial volatilities vary significantly under different macroeconomic conditions as documented by Lyu et al. (2021) for the oil market.

5. Robustness Analysis

To investigate the sensitivity of our findings, we also estimate the quantile regression with bootstrapped standard errors (Tables 8, 9 and 10) and robust standard errors (Tables 11, 12 and 13) as a robustness check. Our results are robust to different estimation types and indicate a similar relation between U.S. industrial volatility resulting from infectious disease and different industrial volatility measures.

Table 8: The Relation between industry volatilities and infectious disease equity market volatility index for the whole sample before COVID-19 outbreak.

	Quantiles	(0.05)	(0.10)	(0.20)	(0.30)	(0.40)	(0.50)	(0.60)	(0.70)	(0.80)	(0.90)	(0.95)
						Total Volatility						
Sectoral Indices	Market Index	0.0003	0.0012*	0.0017**	0.0018	0.0044**	0.0061*	0.0075	0.0110*	0.0216**	0.0475**	0.0446*
	Consumer Services	0.0003	0.0000	0.0010	0.0021	0.0017	0.0021	0.0048	0.0059	0.0085	0.0356***	0.0325
	Financials	-0.0015	0.0011	0.0014	0.0017	0.0012	0.0022	0.0049	0.0083*	0.0092**	0.0309**	0.0146
	Health Care	0.0010	0.0026	0.0049***	0.0053***	0.0087***	0.0090***	0.0109*	0.0115	0.0372**	0.0485	0.0626***
	Industrials	0.0010	0.0012	0.0018**	0.0025	0.0029	0.0042**	0.0044	0.0106	0.0174**	0.0318**	0.0393
	Materials	0.0020	0.0015	0.0014	0.0055	0.0083**	0.0140***	0.0137**	0.0226**	0.0287*	0.0534**	0.0311
	Oil and Gas	0.0060	0.0134***	0.0170***	0.0189***	0.0335**	0.0523***	0.0603***	0.0817***	0.1103***	0.2194**	0.3917***
	REIT	-0.0009	0.0006	0.0012	0.0005	0.0009	0.0013	0.0006	0.0052	0.0060*	0.0059	0.0021
	Technology	0.0004	0.0030	0.0034	0.0050	0.0105	0.0136	0.0191	0.0377	0.0764**	0.1662	0.3004
	Telecom	0.0035	0.0030***	0.0014	-0.0001	-0.0010	0.0006	-0.0016	0.0037	0.0129	0.0482*	0.0493
	Utilities	-0.0003	0.0003	0.0016	0.0006	0.0030	0.0050***	0.0058**	0.0099**	0.0127**	0.0135	0.0281*
						Good Volatility						
Sectoral Indices	Market Index	0.0003***	0.0004***	0.0006***	0.0009***	0.0012***	0.0018***	0.0026***	0.0036***	0.0052***	0.0059***	0.0089***
	Consumer Services	0.0003***	0.0003***	0.0005***	0.0007***	0.0009***	0.0014***	0.0020***	0.0025***	0.0039***	0.0051***	0.0055***
	Financials	0.0002	0.0005***	0.0007***	0.0010***	0.0012***	0.0015***	0.0024***	0.0036***	0.0045***	0.0069***	0.0082***
	Health Care	0.0002*	0.0005***	0.0009***	0.0013***	0.0016***	0.0019***	0.0025***	0.0043***	0.0049***	0.0056***	0.0085***
	Industrials	0.0003***	0.0003***	0.0006***	0.0007***	0.0009***	0.0015***	0.0018***	0.0025***	0.0036***	0.0050***	0.0067***
	Materials	0.0006***	0.0009***	0.0013***	0.0019***	0.0024***	0.0030***	0.0037***	0.0045***	0.0064***	0.0096***	0.0107***
	Oil and Gas	0.0026***	0.0029***	0.0047***	0.0065***	0.0079***	0.0100***	0.0119***	0.0164***	0.0201***	0.0271***	0.0782
	REIT	0.0001*	0.0002	0.0004***	0.0005***	0.0006***	0.0009***	0.0011***	0.0016***	0.0031***	0.0038***	0.0065*
	Technology	0.0006**	0.0007***	0.0013***	0.0016***	0.0028***	0.0040***	0.0063***	0.0107***	0.0158***	0.0226***	0.0282*
	Telecom	0.0002	0.0004**	0.0009***	0.0013***	0.0017***	0.0021***	0.0024***	0.0035***	0.0046***	0.0063***	0.0048
	Utilities	0.0004***	0.0004***	0.0007***	0.0010***	0.0015***	0.0016***	0.0017***	0.0018***	0.0023***	0.0024***	0.0017
						Bad Volatility						
Sectoral Indices	Market Index	-0.0001	0.0001	0.0004	0.0008	0.0011	0.0021	0.0061***	0.0070	0.0183***	0.0376**	0.0478
	Consumer Services	0.0005**	0.0002	0.0004	0.0002	0.0018	0.0030**	0.0041**	0.0046	0.0094*	0.0206***	0.0252
	Financials	-0.0001	-0.0002	-0.0005	-0.0001	-0.0001	0.0017	0.0029	0.0083***	0.0107	0.0233***	0.0327*
	Health Care	0.0001	0.0006*	0.0008	0.0026**	0.0035***	0.0047**	0.0095**	0.0132**	0.0308***	0.0590***	0.0890**
	Industrials	0.0004	0.0004	0.0003	0.0005	0.0007	0.0019	0.0043*	0.0048*	0.0079	0.0239**	0.0280
	Materials	0.0011	0.0014***	0.0012***	0.0010	0.0024**	0.0022	0.0074*	0.0084**	0.0131	0.0335**	0.0235
	Oil and Gas	0.0042*	0.0052**	0.0101***	0.0101***	0.0114**	0.0239***	0.0292**	0.0605***	0.0699***	0.1582***	0.1378*
	REIT	-0.0002	0.0001	0.0003	0.0000	0.0002	0.0002	0.0012	0.0002	-0.0023	0.0087	0.0059
	Technology	-0.0005	0.0004	0.0041	0.0040	0.0037	0.0061	0.0180*	0.0560	0.1461*	0.2620***	
	Telecom	-0.0002	0.0010**	0.0011	0.0008	0.0025*	0.0023	0.0049*	0.0075	0.0090	0.0293	0.0447**
	Utilities	0.0001	0.0001	-0.0000	0.0019	0.0016*	0.0015	0.0013	0.0043	0.0091	0.0217***	0.0180**

*Note: This table reports the estimates by regressing industrial total, good and bad volatility on infectious disease equity market volatility index (EMV-ID) using a quantile regression model at different quantiles (0.05, 0.10, 0.20, 0.30, 0.40, 0.50, 0.60, 0.70, 0.80, 0.90, 0.95) with bootstrapped standard errors during the sample period from 21 September 2012 to 17 January 2020. *, **, *** represents significancy at the 10%, 5% and 1% levels, respectively.*

Table 9: The Relation between industry volatilities and infectious disease equity market volatility index during the COVID-19 period before the Pfizer and Biontech vaccine announcement.

	Quantiles	(0.05)	(0.10)	(0.20)	(0.30)	(0.40)	(0.50)	(0.60)	(0.70)	(0.80)	(0.90)	(0.95)
							Total Volatility					
Sectoral Indices	Market	0.0035**	0.0049***	0.0065***	0.0122***	0.0158***	0.0223***	0.0347***	0.0411***	0.0596***	0.0831***	0.1004***
	Consumer Services	0.0023***	0.0033***	0.0068***	0.0108**	0.0142***	0.0190**	0.0375**	0.0591***	0.0769***	0.0949***	0.1430***
	Financials	0.0041**	0.0064***	0.0135***	0.0178***	0.0238***	0.0320**	0.0537***	0.0617***	0.0754***	0.1317***	0.1554***
	Health Care	0.0016	0.0033***	0.0055***	0.0089***	0.0112***	0.0181***	0.0263***	0.0417***	0.0552***	0.0646***	0.1005***
	Industrials	0.0027*	0.0046***	0.0100***	0.0126***	0.0150***	0.0264***	0.0317***	0.0376***	0.0438***	0.0958***	0.1032***
	Materials	0.0052***	0.0073***	0.0143***	0.0220***	0.0301***	0.0356***	0.0493***	0.0687***	0.0712***	0.1422***	0.1713***
	Oil and Gas	0.0138**	0.0217***	0.0348***	0.0512*	0.0867***	0.1628***	0.1916***	0.2387***	0.3146***	0.4237***	0.4932***
	REIT	0.0039***	0.0055***	0.0123***	0.0148***	0.0241***	0.0353***	0.0527***	0.0572***	0.0713***	0.1161***	0.1356***
	Technology	0.0078***	0.0101***	0.0146***	0.0236***	0.0304***	0.0459***	0.0767***	0.1109***	0.1384***	0.2539***	0.4382***
	Telecom	0.0013	0.0061*	0.0114***	0.0163**	0.0237**	0.0417***	0.0525***	0.0692***	0.0960***	0.1443***	0.1610***
	Utilities	0.0033***	0.0051***	0.0099***	0.0137***	0.0178*	0.0324**	0.0516***	0.0755***	0.0863***	0.1097***	0.1837***
							Good Volatility					
Sectoral Indices	Market	0.0012***	0.0014**	0.0027***	0.0037*	0.0066**	0.0121***	0.0161***	0.0255***	0.0299***	0.0391**	0.0898***
	Consumer Services	0.0006	0.0014	0.0027***	0.0045***	0.0075***	0.0100***	0.0123	0.0219	0.0533***	0.0624**	0.1229***
	Financials	0.0021***	0.0038***	0.0051***	0.0081***	0.0126***	0.0178***	0.0283***	0.0357***	0.0476***	0.0693**	0.0935**
	Health Care	0.0012***	0.0017***	0.0031***	0.0041***	0.0047***	0.0073*	0.0147***	0.0222***	0.0338***	0.0481**	0.0774***
	Industries	0.0013*	0.0022***	0.0028***	0.0050***	0.0063***	0.0151***	0.0182***	0.0230***	0.0333***	0.0446**	0.0537*
	Materials	0.0014***	0.0029*	0.0056***	0.0062***	0.0104**	0.0192***	0.0264***	0.0370***	0.0455***	0.0627	0.1256
	Oil and Gas	0.0086**	0.0118**	0.0227***	0.0362***	0.0489***	0.0836***	0.1152***	0.1555***	0.1847***	0.2146***	0.3724***
	REIT	0.0011	0.0027***	0.0039***	0.0052***	0.0065*	0.0171***	0.0237***	0.0320***	0.0453***	0.0584***	0.0830***
	Technology	0.0027*	0.0039***	0.0055***	0.0067**	0.0090***	0.0162	0.0324**	0.0505***	0.0693***	0.1183**	0.2075**
	Telecom	0.0004	0.0022**	0.0054**	0.0091***	0.0094**	0.0157***	0.0223**	0.0372***	0.0629***	0.0699***	0.1202***
	Utilities	0.0013***	0.0016	0.0040***	0.0046***	0.0086***	0.0135***	0.0288***	0.0362***	0.0469***	0.0809***	0.0732
							Bad Volatility					
Sectoral Indices	Market	0.0009**	0.0014***	0.0027***	0.0038***	0.0056***	0.0075***	0.0128***	0.0199***	0.0251***	0.0447***	0.0842***
	Consumer Services	0.0009***	0.0013***	0.0023**	0.0041***	0.0059***	0.0072	0.0148**	0.0265***	0.0345***	0.0593***	0.0985***
	Financials	0.0020***	0.0026***	0.0039***	0.0056***	0.0073***	0.0121***	0.0183***	0.0221***	0.0299***	0.0566***	0.0844***
	Health Care	0.0005	0.0012***	0.0021***	0.0032***	0.0046***	0.0071**	0.0104**	0.0169***	0.0215***	0.0389**	0.0905***
	Industrials	0.0011***	0.0014***	0.0021***	0.0034***	0.0048***	0.0068***	0.0120***	0.0149***	0.0215***	0.0328**	0.0723***
	Materials	0.0014**	0.0025***	0.0042***	0.0055***	0.0071	0.0115***	0.0196***	0.0242***	0.0370***	0.0682***	0.1104
	Oil and Gas	0.0079***	0.0103***	0.0203***	0.0260***	0.0333***	0.0493***	0.0602***	0.0915***	0.1251***	0.2096***	0.3016**
	REIT	0.0014***	0.0021***	0.0033***	0.0045***	0.0058***	0.0124***	0.0160***	0.0244***	0.0315***	0.0567***	0.0957***
	Technology	0.0027***	0.0041***	0.0064***	0.0081***	0.0128***	0.0186***	0.0312***	0.0461***	0.0677***	0.1253**	0.3642***
	Telecom	0.0014	0.0021	0.0058***	0.0089***	0.0118***	0.0173***	0.0210**	0.0360***	0.0468***	0.0751***	0.1194***
	Utilities	0.0015***	0.0023***	0.0034***	0.0049***	0.0064***	0.0100***	0.0210***	0.0276***	0.0388***	0.0530***	0.0854**

*Note: This table reports the estimates by regressing industrial total, good and bad volatility on infectious disease equity market volatility index (EMV-ID) using a quantile regression model at different quantiles (0.05, 0.10, 0.20, 0.30, 0.40, 0.50, 0.60, 0.70, 0.80, 0.90, 0.95) with bootstrapped standard errors during the sample period from 20 January 2020 to 6 November December 2020 to see the relation during COVID-19 period before the Pfizer and Biontech vaccine announcement. *, **, *** represents significancy at the 10%, 5% and 1% levels, respectively.*

Table 10: The Relation between industry volatilities and infectious disease equity market volatility index during the COVID-19 period after the Pfizer and Biontech vaccine announcement.

	Quantiles	(0.05)	(0.10)	(0.20)	(0.30)	(0.40)	(0.50)	(0.60)	(0.70)	(0.80)	(0.90)	(0.95)
							Total Volatility					
Sectoral Indices	Market	0.0035***	0.0049***	0.0065***	0.0122***	0.0158***	0.0223***	0.0347***	0.0411***	0.0596***	0.0831***	0.1004***
	Consumer Services	0.0023***	0.0033***	0.0068***	0.0108***	0.0142***	0.0190***	0.0375***	0.0591***	0.0769***	0.0949***	0.1430**
	Financials	0.0041***	0.0064***	0.0135***	0.0178***	0.0238***	0.0320***	0.0537***	0.0617***	0.0754***	0.1317***	0.1554***
	Health Care	0.0016**	0.0033***	0.0055***	0.0089***	0.0112***	0.0181***	0.0263***	0.0417***	0.0552***	0.0646***	0.1005***
	Industrials	0.0027***	0.0046***	0.0100***	0.0126***	0.0150***	0.0264***	0.0317***	0.0376***	0.0438***	0.0958***	0.1032***
	Materials	0.0052***	0.0073***	0.0143***	0.0220***	0.0301***	0.0356***	0.0493***	0.0687***	0.0712***	0.1422***	0.1713***
	Oil and Gas	0.0138***	0.0217***	0.0348***	0.0512***	0.0867***	0.1628***	0.1916***	0.2387***	0.3146***	0.4237***	0.4932***
	REIT	0.0039***	0.0055***	0.0123***	0.0148***	0.0241***	0.0353***	0.0527***	0.0572***	0.0713***	0.1161***	0.1356***
	Technology	0.0078***	0.0101***	0.0146***	0.0236***	0.0304***	0.0459***	0.0767***	0.1109***	0.1384***	0.2539***	0.4382***
	Telecom	0.0013	0.0061***	0.0114***	0.0163***	0.0237***	0.0417***	0.0525***	0.0692***	0.0960***	0.1443***	0.1610**
	Utilities	0.0033***	0.0051***	0.0099***	0.0137***	0.0178***	0.0324***	0.0516***	0.0755***	0.0863***	0.1097***	0.1837***
							Good Volatility					
Sectoral Indices	Market	0.0012***	0.0014***	0.0027***	0.0037***	0.0066***	0.0121***	0.0161***	0.0255***	0.0299***	0.0391***	0.0898***
	Consumer Services	0.0006**	0.0014***	0.0027***	0.0045***	0.0075***	0.0100***	0.0123***	0.0219***	0.0533***	0.0624***	0.1229***
	Financials	0.0021***	0.0038***	0.0051***	0.0081***	0.0126***	0.0178***	0.0283***	0.0357***	0.0476***	0.0693***	0.0935***
	Health Care	0.0012***	0.0017***	0.0031***	0.0041***	0.0047***	0.0073***	0.0147***	0.0222***	0.0338***	0.0481***	0.0774***
	Industries	0.0013***	0.0022***	0.0028***	0.0050***	0.0063***	0.0151***	0.0182***	0.0230***	0.0333***	0.0446***	0.0537***
	Materials	0.0014***	0.0029***	0.0056***	0.0062***	0.0104***	0.0192***	0.0264***	0.0370***	0.0455***	0.0627***	0.1256***
	Oil and Gas	0.0086***	0.0118***	0.0227***	0.0362***	0.0489***	0.0836***	0.1152***	0.1555***	0.1847***	0.2146***	0.3724***
	REIT	0.0011***	0.0027***	0.0039***	0.0052***	0.0065***	0.0171***	0.0237***	0.0320***	0.0453***	0.0584***	0.0830***
	Technology	0.0027***	0.0039***	0.0055***	0.0067***	0.0090***	0.0162***	0.0324***	0.0505***	0.0693***	0.1183***	0.2075***
	Telecom	0.0004	0.0022***	0.0054***	0.0091***	0.0094***	0.0157***	0.0223***	0.0372***	0.0629***	0.0699***	0.1202***
	Utilities	0.0013***	0.0016***	0.0040***	0.0046***	0.0086***	0.0135***	0.0288***	0.0362***	0.0469***	0.0809***	0.0732***
							Bad Volatility					
Sectoral Indices	Market	0.0009***	0.0014***	0.0027***	0.0038***	0.0056***	0.0075***	0.0128***	0.0199***	0.0251***	0.0447**	0.0842***
	Consumer Services	0.0009***	0.0013***	0.0023***	0.0041***	0.0059***	0.0072***	0.0148***	0.0265***	0.0345***	0.0593***	0.0985**
	Financials	0.0020***	0.0026***	0.0039***	0.0056***	0.0073***	0.0121***	0.0183***	0.0221***	0.0299***	0.0566***	0.0844***
	Health Care	0.0005**	0.0012***	0.0021***	0.0032***	0.0046***	0.0071***	0.0104***	0.0169***	0.0215***	0.0389**	0.0905***
	Industrials	0.0011***	0.0014***	0.0021***	0.0034***	0.0048***	0.0068***	0.0120***	0.0149***	0.0215***	0.0328**	0.0723***
	Materials	0.0014***	0.0025***	0.0042***	0.0055***	0.0071***	0.0115***	0.0196***	0.0242***	0.0370***	0.0682**	0.1104**
	Oil and Gas	0.0079***	0.0103***	0.0203***	0.0260***	0.0333***	0.0493***	0.0602***	0.0915***	0.1251***	0.2096***	0.3016***
	REIT	0.0014***	0.0021***	0.0033***	0.0045***	0.0058***	0.0124***	0.0160***	0.0244***	0.0315***	0.0567**	0.0957***
	Technology	0.0027***	0.0041***	0.0064***	0.0081***	0.0128***	0.0186***	0.0312***	0.0461***	0.0677***	0.1253	0.3642***
	Telecom	0.0014***	0.0021***	0.0058***	0.0089***	0.0118***	0.0173***	0.0210***	0.0360***	0.0468***	0.0751***	0.1194***
	Utilities	0.0015***	0.0023***	0.0034***	0.0049***	0.0064***	0.0100***	0.0210***	0.0276***	0.0388***	0.0530***	0.0854**

*Note: This table reports the estimates by regressing industrial total, good and bad volatility on infectious disease equity market volatility index (EMV-ID) using a quantile regression model at different quantiles (0.05, 0.10, 0.20, 0.30, 0.40, 0.50, 0.60, 0.70, 0.80, 0.90, 0.95) with bootstrapped standard errors during the sample period from 9 November December 2020 to 31 December 2021 to see the relation during COVID-19 period after the Pfizer and Biontech vaccine announcement. *, **, *** represents significancy at the 10%, 5% and 1% levels, respectively.*

Table 11: The Relation between industry volatilities and infectious disease equity market volatility index for the whole sample before COVID-19 outbreak.

	Quantiles	(0.05)	(0.10)	(0.20)	(0.30)	(0.40)	(0.50)	(0.60)	(0.70)	(0.80)	(0.90)	(0.95)
						Total Volatility						
Sectoral Indices	Market Index	0.0003	0.0012	0.0017*	0.0018	0.0044**	0.0061***	0.0075	0.0110***	0.0216***	0.0475	0.0446***
	Consumer Services	0.0003	0.0000	0.0010	0.0021	0.0017	0.0021	0.0048	0.0059	0.0085	0.0356***	0.0325***
	Financials	-0.0015	0.0011	0.0014	0.0017	0.0012	0.0022	0.0049	0.0083**	0.0092	0.0309***	0.0146***
	Health Care	0.0010	0.0026	0.0049***	0.0053***	0.0087**	0.0090***	0.0109***	0.0115	0.0372***	0.0485	0.0626***
	Industrials	0.0010	0.0012	0.0018*	0.0025	0.0029	0.0042*	0.0044	0.0106*	0.0174***	0.0318***	0.0393
	Materials	0.0020*	0.0015	0.0014	0.0055	0.0083**	0.0140**	0.0137**	0.0226***	0.0287***	0.0534***	0.0311***
	Oil and Gas	0.0060	0.0134**	0.0170***	0.0189***	0.0335*	0.0523***	0.0603**	0.0817*	0.1103***	0.2194**	0.3917
	REIT	-0.0009	0.0006	0.0012	0.0005	0.0009	0.0013	0.0006	0.0052**	0.0060*	0.0059	0.0021
	Technology	0.0004	0.0030	0.0034	0.0050	0.0105	0.0136*	0.0191	0.0377	0.0764	0.1662	0.3004***
	Telecom	0.0035***	0.0030**	0.0014	-0.0001	-0.0010	0.0006	-0.0016	0.0037	0.0129*	0.0482***	0.0493***
	Utilities	-0.0003	0.0003	0.0016	0.0006	0.0030	0.0050**	0.0058**	0.0099*	0.0127***	0.0135	0.0281***
						Good Volatility						
Sectoral Indices	Market Index	0.0003***	0.0004***	0.0006***	0.0009***	0.0012***	0.0018***	0.0026***	0.0036***	0.0052***	0.0059***	0.0089***
	Consumer Services	0.0003***	0.0003***	0.0005***	0.0007***	0.0009***	0.0014***	0.0020***	0.0025***	0.0039***	0.0051***	0.0055*
	Financials	0.0002*	0.0005***	0.0007***	0.0010***	0.0012***	0.0015***	0.0024***	0.0036***	0.0045***	0.0069***	0.0082**
	Health Care	0.0002*	0.0005***	0.0009***	0.0013***	0.0016***	0.0019***	0.0025***	0.0043***	0.0049***	0.0056***	0.0085***
	Industrials	0.0003***	0.0003***	0.0006***	0.0007***	0.0009***	0.0015***	0.0018***	0.0025***	0.0036***	0.0050***	0.0067***
	Materials	0.0006***	0.0009***	0.0013***	0.0019***	0.0024***	0.0030***	0.0037***	0.0045***	0.0064***	0.0096***	0.0107***
	Oil and Gas	0.0026***	0.0029***	0.0047***	0.0065***	0.0079***	0.0100***	0.0119***	0.0164***	0.0201***	0.0271***	0.0782***
	REIT	0.0001	0.0002*	0.0004***	0.0005***	0.0006***	0.0009***	0.0011***	0.0016***	0.0031***	0.0038***	0.0065***
	Technology	0.0006***	0.0007**	0.0013***	0.0016***	0.0028***	0.0040***	0.0063***	0.0107***	0.0158***	0.0226***	0.0282***
	Telecom	0.0002	0.0004*	0.0009***	0.0013***	0.0017***	0.0021***	0.0024***	0.0035***	0.0046***	0.0063***	0.0048***
	Utilities	0.0004**	0.0004***	0.0007***	0.0010***	0.0015***	0.0016***	0.0017***	0.0018***	0.0023***	0.0024***	0.0017***
						Bad Volatility						
Sectoral Indices	Market Index	-0.0001	0.0001	0.0004	0.0008	0.0011	0.0021	0.0061*	0.0070***	0.0183***	0.0376***	0.0478***
	Consumer Services	0.0005	0.0002	0.0004	0.0002	0.0018	0.0030***	0.0041	0.0046**	0.0094**	0.0206***	0.0252
	Financials	-0.0001	-0.0002	-0.0005	-0.0001	-0.0001	0.0017	0.0029	0.0083***	0.0107***	0.0233***	0.0327
	Health Care	0.0001	0.0006	0.0008	0.0026**	0.0035**	0.0047**	0.0095	0.0132***	0.0308***	0.0590***	0.0890**
	Industrials	0.0004*	0.0004*	0.0003	0.0005	0.0007	0.0019	0.0043	0.0048***	0.0079	0.0239***	0.0280**
	Materials	0.0011	0.0014***	0.0012**	0.0010	0.0024**	0.0022	0.0074	0.0084*	0.0131***	0.0335***	0.0235***
	Oil and Gas	0.0042**	0.0052*	0.0101***	0.0101***	0.0114***	0.0239**	0.0292***	0.0605***	0.0699	0.1582***	0.1378***
	REIT	-0.0002	0.0001	0.0003	0.0000	0.0002	0.0002	0.0012	0.0002	-0.0023**	0.0087	0.0059***
	Technology	-0.0017	-0.0005	0.0004	0.0041**	0.0040**	0.0037	0.0061	0.0180	0.0560	0.1461**	0.2620***
	Telecom	-0.0002	0.0010	0.0011	0.0008	0.0025*	0.0023	0.0049	0.0075*	0.0090	0.0293	0.0447***
	Utilities	0.0001	0.0001	-0.0000	0.0019***	0.0016**	0.0015**	0.0013	0.0043*	0.0091*	0.0217***	0.0180***

*Note: This table reports the estimates by regressing industrial total, good and bad volatility on infectious disease equity market volatility index (EMV-ID) using a quantile regression model at different quantiles (0.05, 0.10, 0.20, 0.30, 0.40, 0.50, 0.60, 0.70, 0.80, 0.90, 0.95) during the sample period from 21 September 2012 to 17 January 2020. *, **, *** represents significancy at the 10%, 5% and 1% levels, respectively.*

Table 12: The Relation between industry volatilities and infectious disease equity market volatility index during the COVID-19 period before the Pfizer and Biontech vaccine announcement.

	Quantiles	(0.05)	(0.10)	(0.20)	(0.30)	(0.40)	(0.50)	(0.60)	(0.70)	(0.80)	(0.90)	(0.95)
							Total Volatility					
Sectoral Indices	Market	0.0035***	0.0049***	0.0065***	0.0122***	0.0158***	0.0223***	0.0347***	0.0411***	0.0596***	0.0831***	0.1004***
	Consumer Services	0.0023*	0.0033***	0.0068***	0.0108***	0.0142***	0.0190***	0.0375**	0.0591***	0.0769***	0.0949***	0.1430***
	Financials	0.0041**	0.0064***	0.0135***	0.0178***	0.0238***	0.0320***	0.0537***	0.0617***	0.0754***	0.1317***	0.1554***
	Health Care	0.0016	0.0033***	0.0055***	0.0089***	0.0112***	0.0181***	0.0263***	0.0417***	0.0552***	0.0646***	0.1005***
	Industrials	0.0027*	0.0046***	0.0100***	0.0126***	0.0150***	0.0264***	0.0317***	0.0376***	0.0438***	0.0958***	0.1032***
	Materials	0.0052**	0.0073***	0.0143***	0.0220***	0.0301***	0.0356***	0.0493***	0.0687***	0.0712***	0.1422***	0.1713***
	Oil and Gas	0.0138**	0.0217***	0.0348***	0.0512***	0.0867***	0.1628***	0.1916***	0.2387***	0.3146***	0.4237***	0.4932***
	REIT	0.0039**	0.0055***	0.0123***	0.0148***	0.0241***	0.0353***	0.0527***	0.0572***	0.0713***	0.1161***	0.1356***
	Technology	0.0078**	0.0101***	0.0146***	0.0236***	0.0304***	0.0459**	0.0767***	0.1109***	0.1384***	0.2539***	0.4382***
	Telecom	0.0013	0.0061***	0.0114***	0.0163***	0.0237***	0.0417***	0.0525***	0.0692***	0.0960***	0.1443***	0.1610***
	Utilities	0.0033**	0.0051***	0.0099***	0.0137***	0.0178***	0.0324***	0.0516***	0.0755***	0.0863***	0.1097***	0.1837***
							Good Volatility					
Sectoral Indices	Market	0.0012	0.0014	0.0027***	0.0037***	0.0066	0.0121***	0.0161***	0.0255***	0.0299***	0.0391***	0.0898***
	Consumer Services	0.0006	0.0014	0.0027***	0.0045**	0.0075***	0.0100***	0.0123**	0.0219**	0.0533***	0.0624***	0.1229**
	Financials	0.0021**	0.0038***	0.0051***	0.0081***	0.0126***	0.0178***	0.0283***	0.0357***	0.0476***	0.0693***	0.0935**
	Health Care	0.0012*	0.0017**	0.0031***	0.0041***	0.0047***	0.0073***	0.0147***	0.0222***	0.0338***	0.0481**	0.0774***
	Industries	0.0013	0.0022***	0.0028***	0.0050***	0.0063***	0.0151***	0.0182***	0.0230***	0.0333***	0.0446*	0.0537***
	Materials	0.0014	0.0029*	0.0056***	0.0062***	0.0104	0.0192***	0.0264***	0.0370***	0.0455***	0.0627***	0.1256***
	Oil and Gas	0.0086***	0.0118***	0.0227***	0.0362***	0.0489***	0.0836***	0.1152***	0.1555***	0.1847***	0.2146***	0.3724**
	REIT	0.0011	0.0027***	0.0039***	0.0052***	0.0065***	0.0171***	0.0237*	0.0320***	0.0453***	0.0584***	0.0830
	Technology	0.0027	0.0039**	0.0055***	0.0067***	0.0090**	0.0162**	0.0324*	0.0505***	0.0693***	0.1183	0.2075***
	Telecom	0.0004	0.0022*	0.0054	0.0091***	0.0094***	0.0157***	0.0223***	0.0372***	0.0629***	0.0699***	0.1202***
	Utilities	0.0013*	0.0016	0.0040***	0.0046***	0.0086***	0.0135***	0.0288***	0.0362***	0.0469***	0.0809***	0.0732***
							Bad Volatility					
Sectoral Indices	Market	0.0009*	0.0014***	0.0027***	0.0038***	0.0056***	0.0075***	0.0128***	0.0199***	0.0251***	0.0447**	0.0842***
	Consumer Services	0.0009*	0.0013**	0.0023***	0.0041***	0.0059***	0.0072***	0.0148***	0.0265***	0.0345***	0.0593***	0.0985***
	Financials	0.0020***	0.0026***	0.0039***	0.0056***	0.0073***	0.0121***	0.0183***	0.0221***	0.0299***	0.0566***	0.0844***
	Health Care	0.0005	0.0012***	0.0021***	0.0032***	0.0046***	0.0071**	0.0104***	0.0169***	0.0215***	0.0389***	0.0905***
	Industrials	0.0011***	0.0014***	0.0021***	0.0034***	0.0048***	0.0068***	0.0120***	0.0149***	0.0215***	0.0328***	0.0723***
	Materials	0.0014*	0.0025***	0.0042***	0.0055***	0.0071***	0.0115***	0.0196***	0.0242***	0.0370***	0.0682***	0.1104
	Oil and Gas	0.0079***	0.0103***	0.0203***	0.0260***	0.0333***	0.0493***	0.0602***	0.0915***	0.1251***	0.2096***	0.3016***
	REIT	0.0014**	0.0021***	0.0033***	0.0045***	0.0058***	0.0124***	0.0160***	0.0244***	0.0315***	0.0567***	0.0957***
	Technology	0.0027*	0.0041***	0.0064***	0.0081***	0.0128***	0.0186***	0.0312***	0.0461***	0.0677***	0.1253***	0.3642***
	Telecom	0.0014	0.0021**	0.0058***	0.0089***	0.0118***	0.0173***	0.0210***	0.0360**	0.0468***	0.0751***	0.1194***
	Utilities	0.0015***	0.0023***	0.0034***	0.0049***	0.0064***	0.0100***	0.0210***	0.0276***	0.0388***	0.0530***	0.0854***

*Note: This table reports the estimates by regressing industrial total, good and bad volatility on infectious disease equity market volatility index (EMV-ID) using a quantile regression model at different quantiles (0.05, 0.10, 0.20, 0.30, 0.40, 0.50, 0.60, 0.70, 0.80, 0.90, 0.95) during the sample period from 20 January 2020 to 6 November December 2020 to see the relation during COVID-19 period before the Pfizer and Biontech vaccine announcement. *, **, *** represents significancy at the 10%, 5% and 1% levels, respectively.*

Table 13: The Relation between industry volatilities and infectious disease equity market volatility index during the COVID-19 period after the Pfizer and Biontech vaccine announcement.

	Quantiles	(0.05)	(0.10)	(0.20)	(0.30)	(0.40)	(0.50)	(0.60)	(0.70)	(0.80)	(0.90)	(0.95)
							Total Volatility					
Sectoral Indices	Market	0.0002	0.0005*	0.0011**	0.0020**	0.0030***	0.0033***	0.0039	0.0045***	0.0062***	0.0084***	0.0124*
	Consumer Services	0.0005	0.0009	0.0020***	0.0024***	0.0030***	0.0030***	0.0033***	0.0042***	0.0051***	0.0074***	0.0074**
	Financials	0.0006	0.0013*	0.0018*	0.0028***	0.0031**	0.0044***	0.0048***	0.0073***	0.0087**	0.0114*	0.0177
	Health Care	0.0001	0.0008***	0.0009**	0.0009**	0.0012*	0.0015**	0.0013*	0.0018	0.0042***	0.0054***	0.0061**
	Industrials	0.0005	0.0007	0.0017**	0.0023***	0.0026***	0.0042***	0.0054***	0.0073***	0.0097***	0.0128***	0.0165***
	Materials	0.0013	0.0019*	0.0023**	0.0029**	0.0035**	0.0060***	0.0053***	0.0056	0.0149***	0.0155	0.0127***
	Oil and Gas	0.0049**	0.0044*	0.0054	0.0150***	0.0132**	0.0256***	0.0292***	0.0380***	0.0467***	0.0667***	0.1015***
	REIT	0.0002	0.0005	0.0011*	0.0017***	0.0020***	0.0019***	0.0024**	0.0032**	0.0051***	0.0079**	0.0082***
	Technology	0.0025***	0.0027***	0.0033**	0.0054*	0.0073**	0.0091***	0.0094**	0.0136**	0.0252***	0.0358**	0.0390***
	Telecom	0.0010*	0.0006	0.0007	0.0019	0.0024**	0.0026**	0.0026**	0.0039*	0.0043**	0.0097	0.0151**
	Utilities	0.0006	0.0004	0.0018***	0.0027***	0.0030***	0.0034***	0.0042***	0.0043***	0.0080***	0.0090***	0.0179***
							Good Volatility					
Sectoral Indices	Market	-0.0001	0.0001	0.0005**	0.0004*	0.0004	0.0007	0.0015	0.0026	0.0047***	0.0062***	0.0087***
	Consumer Services	-0.0001	0.0001	0.0002	0.0004	0.0008*	0.0010***	0.0013	0.0022***	0.0023***	0.0043***	0.0030***
	Financials	0.0002	0.0003	0.0004	0.0010	0.0017***	0.0020***	0.0021***	0.0030	0.0055	0.0127***	0.0206***
	Health Care	-0.0001	0.0002	0.0006**	0.0005**	0.0006**	0.0007*	0.0012	0.0020*	0.0022***	0.0038	0.0054***
	Industrials	0.0001	0.0002	0.0006**	0.0006***	0.0007**	0.0007*	0.0017***	0.0022	0.0044*	0.0100***	0.0099
	Materials	0.0006	0.0006	0.0011**	0.0012**	0.0013*	0.0026**	0.0042***	0.0048*	0.0101***	0.0171***	0.0139***
	Oil and Gas	0.0010	0.0012	0.0026*	0.0032	0.0098***	0.0123***	0.0133***	0.0222***	0.0260***	0.0548***	0.0450***
	REIT	0.0000	0.0002	0.0003	0.0005*	0.0008**	0.0007*	0.0014	0.0028	0.0034***	0.0071***	0.0065***
	Technology	0.0002	0.0001	0.0004	0.0014	0.0009	0.0013	0.0050**	0.0064***	0.0093***	0.0182***	0.0164***
	Telecom	0.0005	0.0006***	0.0005*	0.0007*	0.0013**	0.0017**	0.0021*	0.0030***	0.0041***	0.0077***	0.0058***
	Utilities	-0.0000	-0.0000	0.0003	0.0007**	0.0007**	0.0009*	0.0016**	0.0027***	0.0045***	0.0049***	0.0158**
							Bad Volatility					
Sectoral Indices	Market	0.0002	0.0003**	0.0002	0.0006*	0.0008***	0.0009***	0.0018**	0.0030***	0.0046**	0.0067***	0.0057*
	Consumer Services	0.0002	0.0003**	0.0005**	0.0009**	0.0011***	0.0012***	0.0018***	0.0021***	0.0030***	0.0027**	0.0060***
	Financials	0.0000	0.0000	0.0001	0.0005	0.0005	0.0006	0.0020**	0.0028***	0.0045***	0.0099**	0.0104**
	Health Care	0.0002*	0.0002	0.0003	0.0005*	0.0006**	0.0006**	0.0010	0.0021***	0.0027***	0.0034***	0.0068*
	Industrials	0.0002	0.0003*	0.0005***	0.0006***	0.0006***	0.0011*	0.0023***	0.0036***	0.0053***	0.0055***	0.0075***
	Materials	0.0002	0.0005*	0.0007*	0.0010***	0.0013***	0.0022**	0.0039***	0.0051***	0.0061***	0.0068**	0.0201
	Oil and Gas	0.0002	0.0002	0.0021	0.0037*	0.0058***	0.0072***	0.0114***	0.0162***	0.0285***	0.0538***	0.0388**
	REIT	0.0001	0.0002	0.0005***	0.0006***	0.0009***	0.0014***	0.0017***	0.0023***	0.0021***	0.0037**	0.0053*
	Technology	0.0003	0.0009*	0.0012**	0.0020**	0.0023***	0.0032***	0.0038	0.0075*	0.0178***	0.0185***	0.0192
	Telecom	0.0005**	0.0006***	0.0005**	0.0007**	0.0011*	0.0020***	0.0023***	0.0043***	0.0038**	0.0054**	0.0041
	Utilities	0.0002	0.0003**	0.0005	0.0011***	0.0012***	0.0013***	0.0021***	0.0028***	0.0037***	0.0034***	0.0040***

*Note: This table reports the estimates by regressing industrial total, good and bad volatility on infectious disease equity market volatility index (EMV-ID) using a quantile regression model at different quantiles (0.05, 0.10, 0.20, 0.30, 0.40, 0.50, 0.60, 0.70, 0.80, 0.90, 0.95) during the sample period from 9 November December 2020 to 31 December 2021 to see the relation during COVID-19 period after the Pfizer and Biontech vaccine announcement. *, **, *** represents significancy at the 10%, 5% and 1% levels, respectively.*

6. Conclusion

The current study delves deeper into understanding the asymmetric impact of infectious diseases on industrial sectors in the US. Employing the Infectious Disease Equity Market Volatility Index (EMV- ID) constructed by Baker et al. (2020), we investigate the effect of equity market volatility due to infectious disease on industrial volatility from 2012 to 2021. We use ten industrial sector indices (i.e., consumer services, financials, health care, industrials, materials, oil and gas, real estate, technology, telecommunication, and utilities) and decompose industry volatility into good and bad components to examine how these components vary in response to equity market volatility index at different quantiles in sub-periods before COVID-19, during COVID-19 before and after the Pfizer and Biontech vaccine announcement.

The results show that the transmission of volatile shocks from the stock market strongly enhances the bad components of industrial volatility before the outbreak of COVID-19 and both components of industrial volatility during COVID-19 before the vaccine announcement. The positive transmission of volatile shocks from the EMV-ID towards industrial volatility enhances as industrial volatility transits from bearish to bullish conditions, irrespective of the period considered. We conclude that the relationship between infectious disease equity market volatility and industrial volatility depends on the good and bad volatile components and their respective conditions at different quantiles during different time frames.

Our findings have several important implications for investors, risk managers and regulators. Firstly, our paper suggests that the EMV-ID uncertainty shocks on good and bad volatility depend on the sector and the distribution. Investors and risk managers should consider the infectious economic uncertainty index as a risk factor and incorporate the EMV-ID index into a forecasting setting of the realized volatility of industries, especially in forecasting the realized volatility of the oil and gas industry. EMV-ID index should also guide investors in constructing a market timing strategy. Regulators can implement prudent policies to reduce economic uncertainty and prevent the volatility spillover between sectors, thereby maintaining the stability of all financial systems and the economy. As a future work, we believe the same analysis should be applied to stock markets of other regions to reveal the effect of uncertainty on the stock market volatility.

References

Acharya, V. V., Johnson, T., Sundaresan, S., & Zheng, S. (2020). *The value of a cure: An asset pricing perspective* (No. w28127). National Bureau of Economic Research.

Andersen, T. G., Bollerslev, T., Diebold, F. X., & Labys, P. (2003). Modeling and forecasting realized volatility. *Econometrica*, *71*(2), 579-625.

Andersen, T. G., Bollerslev, T., & Meddahi, N. (2011). Realized volatility forecasting and market microstructure noise. *Journal of Econometrics*, *160*(1), 220-234.

Al-Awadhi, A. M., Alsaifi, K., Al-Awadhi, A., & Alhammadi, S. (2020). Death and contagious infectious diseases: Impact of the COVID-19 virus on stock market returns. *Journal of behavioral and experimental finance*, *27*, 100326.

Baek, S., Mohanty, S. K., & Glambosky, M. (2020). COVID-19 and stock market volatility: An industry level analysis. *Finance research letters*, *37*, 101748.

Bai, L., Wei, Y., Wei, G., Li, X., & Zhang, S. (2021). Infectious disease pandemic and permanent volatility of international stock markets: A long-term perspective. *Finance research letters*, *40*, 101709.

Baker, S. R., Bloom, N., Davis, S. J., & Kost, K. J. (2019). *Policy news and stock market volatility* (No. w25720). National Bureau of Economic Research.

Baker, S. R., Bloom, N., Davis, S. J., Kost, K., Sammon, M., & Viratyosin, T. (2020). The unprecedented stock market reaction to COVID-19. *The review of asset pricing studies*, *10*(4), 742-758.

Basu, S., & Bundick, B. (2017). Uncertainty shocks in a model of effective demand. *Econometrica*, *85*(3), 937-958.

Basuony, M. A., Bouaddi, M., Ali, H., & EmadEldeen, R. (2022). The effect of COVID-19 pandemic on global stock markets: Return, volatility, and bad state probability dynamics. *Journal of Public Affairs*, *22*, e2761.

Bloom, N. (2009). The impact of uncertainty shocks. *econometrica*, *77*(3), 623-685.

Bollerslev, T., Li, S. Z., & Zhao, B. (2020). Good volatility, bad volatility, and the cross section of stock returns. *Journal of Financial and Quantitative Analysis*, *55*(3), 751-781.

Bouri, E., Demirer, R., Gupta, R., & Pierdzioch, C. (2020). Infectious diseases, market uncertainty and oil market volatility. *Energies*, *13*(16), 4090.

Bradley, C., & Stumpner, P. (2021). The impact of COVID-19 on capital markets, one year in. *McKinsey & Company. URL: https://www. mckinsey. com/business-functions/strategy-and-corporatefinance/our-insights/the-impact-of-covid-19-on-capital-markets-one-year-in (дата обращения 29.10. 2021)*.

Choi, S. Y. (2020). Industry volatility and economic uncertainty due to the COVID-19 pandemic: Evidence from wavelet coherence analysis. *Finance research letters*, *37*, 101783.

Engelhardt, B., Johnson, M., & Meder, M. E. (2021). Learning in the time of Covid-19: Some preliminary findings. *International Review of Economics Education*, *37*, 100215.

Gohar, R., Salman, A., Uche, E., Derindag, O. F., & Chang, B. H. (2023). Does US infectious disease equity market volatility index predict G7 stock returns? Evidence beyond symmetry. *Annals of Financial Economics*, *18*(02), 2250028.

Gräb, J., Kellers, M., & Le Mezo, H. (2021). Rotation towards normality–the impact of COVID-19 vaccine-related news on global financial markets. *Economic Bulletin Boxes*, *1*.

Guo, X., Wang, B., & Yongan, X. (2022). The asymmetric effect of infectious disease equity market volatility for the physical education economy: implication for a post-Covid world. *Economic research-Ekonomska istraživanja*, *35*(1), 7008-7021.

He, P., Sun, Y., Zhang, Y., & Li, T. (2020). COVID–19's impact on stock prices across different sectors—An event study based on the Chinese stock market. *Emerging Markets Finance and Trade*, *56*(10), 2198-2212.

Kapar, B., Buigut, S., & Rana, F. (2022). Global evidence on early effects of COVID-19 on stock markets. *Review of financial economics*, *40*(4), 438-463.

Koenker, R., & Hallock, K. F. (2001). Quantile regression. *Journal of economic perspectives*, *15*(4), 143-156.

Kucher, O., Kurov, A., & Wolfe, M. H. (2023). A shot in the arm: The effect of COVID-19 vaccine news on financial and commodity markets. *Financial Review*, *58*(3), 575-596.

Kundu, S., & Paul, A. (2022). Effect of economic policy uncertainty on stock market return and volatility under heterogeneous market characteristics. *International review of economics & finance*, *80*, 597-612.

Lee, W. Y., Jiang, C. X., & Indro, D. C. (2002). Stock market volatility, excess returns, and the role of investor sentiment. *Journal of banking & Finance*, 26(12), 2277-2299.

Long, S., & Guo, J. (2022). Infectious disease equity market volatility, geopolitical risk, speculation, and commodity returns: Comparative analysis of five epidemic outbreaks. *Research in international business and finance*, *62*, 101689.

Lyu, Y., Wei, Y., Hu, Y., & Yang, M. (2021). Good volatility, bad volatility and economic uncertainty: Evidence from the crude oil futures market. *Energy*, *222*, 119924.

Mazur, M., Dang, M., & Vega, M. (2021). COVID-19 and the march 2020 stock market crash. Evidence from S&P1500. *Finance research letters*, *38*, 101690.

Meng, J., & Xu, R. (2021). Epidemics, public sentiment, and infectious disease equity market volatility. *Frontiers in Public Health*, *9*, 686870.

Mensi, W., Nekhili, R., Vo, X. V., Suleman, T., & Kang, S. H. (2021). Asymmetric volatility connectedness among US stock sectors. *The North American Journal of Economics and Finance*, *56*, 101327.

O'Donnell, N., Shannon, D., & Sheehan, B. (2021). Immune or at-risk? Stock markets and the significance of the COVID-19 pandemic. *Journal of Behavioral and Experimental Finance*, *30*, 100477.

Özkan, O., Olasehinde-Williams, G., & Olanipekun, I. (2022). Predicting stock returns and volatility in BRICS countries during a pandemic: evidence from the novel wild bootstrap likelihood ratio approach. *Finance a Uver*, *72*(2), 124-149.

Rouatbi, W., Demir, E., Kizys, R., & Zaremba, A. (2021). Immunizing markets against the pandemic: COVID-19 vaccinations and stock volatility around the world. *International review of financial analysis*, *77*, 101819.

Salisu, A., & Adediran, I. (2020). Uncertainty due to infectious diseases and energy market volatility. *Energy Research Letters*, *1*(2), 14185.

Salisu, A. A., & Sikiru, A. A. (2020). Pandemics and the Asia-Pacific islamic stocks. *Asian Economics Letters*, *1*(1), 17413.

Shehzad, K., Xiaoxing, L., & Kazouz, H. (2020). COVID-19's disasters are perilous than Global Financial Crisis: A rumor or fact?. *Finance research letters*, *36*, 101669.

Suleman, M. T., & Yaghoubi, M. (2022). Infectious disease and corporate activities. *Economics Letters*, *212*, 110302.

Topcu, M., & Gulal, O. S. (2020). The impact of COVID-19 on emerging stock markets. *Finance research letters*, *36*, 101691.

Wilder-Smith, A., & Osman, S. (2020). Public health emergencies of international concern: a historic overview. *Journal of travel medicine*, *27*(8).

Web sources:

BBC, (2019). Ebola outbreak declared public health emergency. BBC News. 17 July 2019. Available from: https://www.bbc.com/news/health-49025298.

WHO, (2016). WHO Director-General summarizes the outcome of the Emergency Committee on Zika Archived. World Health Organization. 17 July 2019. Available from: https://www.who.int/en/news- room/detail/01-02-2016-who-director-general-summarizes-the-outcome-of-the-emergency-committee- regarding-clusters-of-microcephaly-and-guillain-barre-syndrome.

WHO, (2019). Ebola outbreak in the Democratic Republic of the Congo declared a Public Health Emergency of International Concern. World Health Organization. 17 July 2019. Available from: https://www.who.int/news-room/detail/17-07-2019-ebola-outbreak-in-the-democratic-republic- of-the-congo-declared-a-public-health-emergency-of-international-concern.

WHO, (2020). Statement on the second meeting of the International Health Regulations (2005) Emergency Committee regarding the outbreak of novel coronavirus (2019-nCoV). World Health Organization. 31 January 2020. Available from: https://www.who.int/news-room/detail/30-01-2020- statement-on-the-second-meeting-of-the-international-health-regulations-(2005)-emergency-committee- regarding-the-outbreak-of-novel-coronavirus-(2019-ncov).

WHO, (2022). Statement of the Thirty-second Polio IHR Emergency Committee. 24 June 2022. Available from: https://web.archive.org/web/20220723155355/https://www.who.int/news/item/24-06-2022-statement-of-the-thirty-second-polio-ihr-emergency-committee