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## COVID–19 and oil price risk exposure

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### ABSTRACT

This study investigates oil price risk exposure of financial and non-financial industries around the world during the COVID–19 pandemic. The empirical results show that oil supply industries benefit from positive shocks to oil price risk in general, whereas oil user industries and financial industries react negatively to positive oil price shocks. The COVID–19 outbreak appears to moderate the oil price risk exposure of both financial and non-financial industries. This brings important implications in risk management of energy risk during the pandemic.

### 1. Introduction

This study presents a comprehensive analysis of oil price exposure across financial and non-financial sectors during the COVID–19 pandemic around the world. The COVID–19 pandemic is a “once-in-a century pathogen we’ve been worried about” (CNBC, 2020).<sup>1</sup> The world has been experiencing an economic catastrophe since the onset of the pandemic. Global financial markets had the worst turmoil since 1930 and more pervasive than the global financial crisis (GFC) in terms of the number of countries affected (IMF, 2020). IMF projects global growth at –4.4% in 2020. To combat the pandemic, governments across the globe announced fiscal measures estimated at USD 11 trillion, resulting in a fiscal deficit of 14% of GDP in 2020, up 10% points from 2019 (IMF, 2020).

Since the onset of the COVID–19 crisis, academic literature and industry reports on the effect of the pandemic have been growing on a fast pace (e.g., Akhtaruzzaman et al., 2020; International Energy Agency, 2020). Most of the studies focus on the effects of the COVID–19 on the aggregate financial markets and financial assets such as gold, cryptocurrencies (e.g., Akhtaruzzaman, Boubaker, et al., 2020; Baker et al., 2020; Bissoondoyal-Bheenick et al., 2020; Chiah and Zhong, 2020; Corbet et al., 2020a; Corbet, et al., 2020b; Yarovaya et al., 2020; Zhang et al., 2020). However, there has been little attention paid to oil price risk exposure of financial and non-financial industries and their roles as oil suppliers, users and infrastructure providers during the COVID–19 pandemic. Also, the

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E-mail address: [stage.sboubaker@em-normandie.fr](mailto:stage.sboubaker@em-normandie.fr) (S. Boubaker).<sup>1</sup> As of June 28th, 2020, there are 9,782,197 COVID–19 confirmed cases and 494,421 deaths from 216 countries and territories (WHO, 2020).

energy sector is severely affected by the COVID–19 pandemic (International Energy Agency, 2020). Countries in full (partial) lockdown experienced a decline of 25% (18%) in energy demand per week through mid-April (International Energy Agency, 2020).

In the context of such an economic crisis and unprecedented drop in energy demand, our study aims at exploring a research question: How do financial and non-financial industries across different regions expose to the change in oil price during the COVID–19?<sup>2</sup> A number of studies examine the oil price risk exposure of industries during the non-COVID–19 period.<sup>3</sup> Our study contributes to the literature by investigating the impact of the COVID–19 pandemic on the relationship between changes in oil price and financial and non-financial stock returns across regions around the world.<sup>4</sup> Our paper also speaks to the important literature (Batten et al., 2017, 2018, 2019) on the implication of the relation between oil price and stock prices in risk management, asset pricing and portfolio theory. The comovement between oil price changes and stock returns, is a significant factor that helps decide on how to hedge energy risk. Studying the impact of pandemic on the nexus between oil price and stock returns provides fruitful insights into the consideration of health-related crisis in the design of hedging strategies of energy risk.

The empirical results provide interesting findings. First, across all times, among non-financial industries, oil suppliers such as oil crude production, integrated oil & gas benefit most from an increase in oil price. Industries that are users of oil, such as home improvement retailers, multi utilities, recreational services, and waste & disposal services benefit most from a decline in oil price. Second, COVID–19 appears to moderate the oil price exposure of both financial and non-financial industries. Among non-financial industries, weaker positive (negative) exposure to oil price risk is documented in oil supply (demand) industries during COVID–19.<sup>5</sup> In a similar vein, financial industries (e.g., banks) experience a weakened negative exposure to oil price during COVID–19. Third, the oil price risk exposure of financial and non-financial industries remains robust across regions and even when using an alternative asset pricing framework.

The rest of the paper is organised as follows. Section 2 presents data and methodology. Section 3 presents the results and Section 4 concludes.

## 2. Data and methodology

### 2.1. Data

This paper explores oil price exposure of different industries with a special focus on the COVID–19 outbreak period. The full sample period is from January 1st, 2018 to April 30th, 2020. The pre-COVID–19 period starts January 1st, 2018 to not overlap with prior financial crises and ends January 22nd, 2020.<sup>6</sup> The COVID–19 period is from January 23rd, 2020 to April 30th, 2020. We choose January 23rd, 2020 as the starting point of the period, as the Chinese government imposed a lockdown on Wuhan on that day.

We obtain daily returns of Datastream industry classification of level six (subsector level) for three regions: Americas (North and South American countries), Asia, and Europe. In total, our dataset contains 216 industries for Americas, 206 industries for Asia, and 216 industries for Europe. We further divide the industries into financial and non-financial sectors. There are 39 financial industries and 177 non-financial industries for Americas. Asia (Europe) comprises 29 (35) financial and 177 (181) non-financial industries. We conduct analysis for all industries and present the top and bottom 25 industries in terms of oil price exposure in each region. To further analyse the sensitivity of different industries to oil price risk exposure, we also consider their roles as oil demand, supply and infrastructure provider industries.

We classify oil & gas producers as oil suppliers based on the Industrial Classification Benchmark (ICB)-Datastream Level 4.<sup>7</sup> Similarly, we classify oil equipment & services as an oil infrastructure industry. Following Elyasiani et al. (2011), industries such as airlines, container & packaging, defence, and pharmaceuticals are considered as oil demand industries. We calculate daily returns from the USD denominated return series for each industry subsector. We obtain the daily Fama and French (2015) five risk factors from Kenneth French's website.<sup>8</sup> Oil price is obtained from the daily returns on the West Texas Intermediate (WTI) in USD per barrel.

### 2.2. Methodology

The Fama and French (2015) five-factor model has been widely used as an asset pricing model in the literature (Barillas and Shanken, 2018; Fama and French, 2017; Hou et al., 2020; Stambaugh and Yuan, 2017). Given the oil price is an input in the production

<sup>2</sup> Oil price risk refers to the sensitivity of stock returns to the changes in oil prices.

<sup>3</sup> For instance, Elyasiani et al. (2011) investigate the oil price risk exposure of US industries during the non-COVID–19 period. Yun and Yoon (2019) look at oil price risk exposure of the airline industry in China and South Korea. Narayan and Sharma (2011) examine how oil price affects firms differently depending on their industries.

<sup>4</sup> Changes in crude oil prices have had a significant effect on the economic and financial activities (e.g., Cologni and Manera, 2008; Gisser and Goodwin, 1986; Gogolin et al., 2018; Hamilton, 1983; Jones and Kaul, 1996; Lau et al., 2017) and on stock returns through several channels including higher production cost (Jones et al., 2004), decrease in the discretionary income (Gogineni, 2010), higher equity risk premium (Hamilton and Herrera, 2004; Demirer et al., 2015), higher inflation rates and uncertainties leading to lower economic growth (Friedman, 1977).

<sup>5</sup> Elyasiani et al. (2011) classify industries into oil-substitute, oil-related, and oil user.

<sup>6</sup> Global financial crisis in 2007–2009, European debt crisis in 2010–2012 (Akhtaruzzaman et al., 2019), Russian financial crisis in 2014–2015 (Viktorov and Abramov, 2020), Chinese stock market crash in 2014–2015 (Jian et al., 2018).

<sup>7</sup> <https://www.ftserussell.com/files/support-document/icb-structure-definitions>.

<sup>8</sup> [http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data\\_library.html](http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html).

cost and valuation model (Hamilton and Herrera, 2004; Jones et al., 2004), prior literature uses the oil risk factor within a multifactor asset pricing framework (Azimli, 2020; Narayan and Sharma, 2011; Shaeri et al., 2016). In our baseline model, we augment the Fama and French (2015) five-factor model with oil price return in our baseline model:

$$R_{i,t} = \alpha_i + \beta_i MKT_t + \tau_i SMB_t + \gamma_i HML_t + \theta_i RMW_t + \mu_i CMA_t + \sigma_i Oil_t + \omega_i Oil_{t-1} + \delta_i D_t + \varepsilon_{i,t} \quad (1)$$

where  $MKT_t$ ,  $SMB_t$ ,  $HML_t$ ,  $RMW_t$ , and  $CMA_t$  are the market risk premium, size factor, value factor, profitability factor and investment factor for a region on day  $t$ , respectively;  $Oil_t$  and  $Oil_{t-1}$  are the oil price return on day  $t$  and  $t-1$ , respectively;  $R_{i,t}$  is the excess return for each industry subsector;  $D_t$  is a dummy variable that is equal to one if day  $t$  is within the COVID-19 period and zero otherwise.  $\varepsilon_{i,t}$  is the error term on day  $t$ . Oil price risk exposure is reflected by the slope coefficient ( $\sigma_i$ ) on  $Oil_t$ . The loading on the COVID-19 dummy ( $D_t$ ) illustrates the relative performance of subsector  $i$  in the pandemic. We also include the lagged oil return to account for return autocorrelation.

To investigate oil price risk exposure in the COVID-19 outbreak, we include an interaction term between oil price return and the COVID-19 dummy in Eq. (2):

$$R_{i,t} = \alpha_i + \beta_i MKT_t + \tau_i SMB_t + \gamma_i HML_t + \theta_i RMW_t + \mu_i CMA_t + \sigma_i Oil_t + \omega_i Oil_{t-1} + \delta_i D_t + \varphi_i Oil_t * D_t + \varepsilon_{i,t} \quad (2)$$

### 3. Empirical results

Table 1 presents summary statistics of the industries in each region.<sup>9</sup> We only present the top and bottom 25 industries in terms of oil exposure in each region. Panel A (Table 1) presents the non-financial industries with the most positive oil price risk exposure captured by  $\sigma_i$  in Eq. (1) during the sample period (2018–2020) for Americas. Not surprisingly, the crude oil production subsector and other supplier industries has the highest positive exposure to oil price risk. Interestingly, the average returns of most industries in this panel are negative. In particular, oil and gas industries such as crude oil production, oil equipment and services, oil, gas, and coal generate negative mean return with higher economic magnitude. This is reflective of the fact that energy sectors perform the worst during the COVID-19 (Kwan and Mertens, 2020). For instance, Alternative Fuels industry has the highest mean return as well as the highest variation proxied by standard deviation.<sup>10</sup> Panel B (Table 1) portrays results for the non-financial industries with the most negative oil price risk exposure, which also resemble the definition of oil users and infrastructure providers. The airlines industry has the highest negative exposure to oil price risk indicating that it benefits from lower oil prices. All the industries except the household equipment production have a positive mean return.

Panel C (Table 1) presents 25 financial industries with the highest exposure to the oil price risk. Most financial industries have positive mean returns during the sample period. We conduct the Augmented Dicky-Fuller test to detect the presence of a unit root. The tests are all statistically significant, indicating the rejection of the null hypothesis of a unit root. The Jarque-Bera test statistic is significant in all industries, indicating that the returns do not follow a normal distribution. The Box-Pierce-Ljung portmanteau test indicates the presence of autocorrelation in returns. We observe significant Q (10) statistic in a large number of industries, indicating autocorrelation in daily returns, which is consistent with Jegadeesh (1990). The pattern in the summary statistics is similar to Shaeri et al. (2016).

Table 2 reports the regression output of Eq. (2) in the Americas. For the sake of brevity, we only report the key variables of interest of the top and bottom 25 industries ranked by their exposure to oil price risk in Eq. (1). Panel A (B) reports the top 25 non-financial industries with the highest positive (negative) exposure to oil price return, whereas Panel C reports the results for the financial industries. Oil supply industries such as oil crude production, integrated oil & gas, oil, gas & coal are among the top 5 industries with the highest positive exposure to oil price risk, which is consistent with prior literature (e.g., Elyasiani et al., 2011; Nandha and Faff, 2008). Oil infrastructure providers such as oil equipment & services and pipelines are among the top 10 industries with the highest positive exposure to oil price risk. Equally, oil-substitute industries such as alternative energy, alternative fuels, energy, and renewable energy equipment have positive exposure to oil price risk, and the magnitude of the sensitivity is much lower than those of oil supply and infrastructure provider industries. The oil demand industries such as airlines, defense, home improvement retailers, multi utilities, recreational services, and waste & disposal services are negatively exposed to oil price return. This is an intuitive result. Oil demand industries are heavy users of oil, and hence they benefit from lower oil prices.<sup>11</sup> The varying exposures of suppliers and users of oil indicate that different risk management measures should be put in place to hedge energy risk (Batten et al., 2019).

Consistent with the literature, most financial industries are negatively exposed to oil price risk (Elyasiani et al., 2011). Financial industries are not heavy users of oil or not directly involved with oil production. However, their association with oil occurs mainly through their lending and investment portfolios to firms which have exposure to oil price risk. The breakdown of bank loan portfolios shows that the majority of loans go to individuals and industries other than oil and gas industry (Forbes, 2018). The relative higher exposure to oil-user industries leads to the negative exposure of financial industries to oil price risk. Retail REITs has the highest exposure, while investment bank broker has the lowest exposure. The magnitude of the sensitivity of financial industries to the oil price risk is considerably lower than that of non-financial industries. The diverse lending and investment portfolios of financial industries may have effects on lowering the magnitude of the sensitivity to the oil price risk. Elyasiani et al. (2011) and Shaeri et al. (2016) find

<sup>9</sup> Table A5 (Appendix) presents additional summary statistics to those in Table 1.

<sup>10</sup> The higher moments (standard deviation, kurtosis and skewness) are similar across the 25 industries.

<sup>11</sup> We report all slope coefficients in Table A6 (Appendix).

**Table 1.**

Descriptive statistics: Americas.

This table reports the summary statistics of returns by sector in the Americas region. The top 25, bottom 25 non-financial and financial industries are presented in Panels A, B and C, respectively. The industries are ranked based on the slope coefficient on oil price return in Eq. (1). The sample period is from 1 January 2018 to 30 April 2020.

Panel A: Non Financial Industries (Positive Exposure)				Panel B: Non Financial Industries (Negative Exposure)				Panel C: Financial industries (Top 25)			
Subsector	Mean	Standard-deviation	Skewness	Subsector	Mean	Standard Deviation	Skewness	Subsector	Mean	Standard Deviation	Skewness
Oil Crude Production	-0.0005	0.0212	-3.9315	Airlines	0.0001	0.0201	-1.4138	Mortgage Finance	-0.0001	0.0178	-2.6706
Oil Equipment & Services	-0.0007	0.021	-2.2949	Household Equipment Products	-0.0002	0.0228	-2.3311	Investment Companies	0.0002	0.0139	-2.2092
Oil, Gas, Coal Energy	-0.0003	0.0166	-2.3314	Drug Retailers	0.0002	0.0129	-0.5938	Closed End Investments	0.0002	0.0139	-2.2093
	-0.0003	0.0163	-2.4415	Misc Consumer Staple	0.0007	0.0161	-0.6856	Real Estate Holding & Development	-0.0004	0.0156	-4.2495
Integrated Oil & Gas	-0.0002	0.0155	-1.9247	Toys	0.0004	0.0166	-0.5898	Real Estate Investment Services	-0.0001	0.0134	-2.0404
Pipelines	0.0001	0.0165	-2.3768	Defense	0.0007	0.0121	-0.7699	Financial Data Providers	0.0008	0.0118	-0.8845
General Mining	-0.0006	0.0232	-0.2502	Multi utilities	0.0003	0.0116	-0.7412	Hotel, Lodge REIT	-0.0002	0.0178	-1.4911
Chemicals Synthetic Fibers	-0.0006	0.0217	-0.5401	Apparel Retailer	0.0002	0.0152	-1.7931	Diversified Financial Services	0.0001	0.013	-1.0266
Copper	-0.0004	0.0211	-0.0539	Health Care Services	0.0005	0.0116	-0.6675	Financial Credit Services	0.0006	0.0126	-1.0795
Marine Transport	-0.0002	0.0198	-1.1811	Recreational Services	0.0002	0.0172	-1.7174	Mortgage REITs: Commercial	0.0003	0.0193	-0.0707
Plastics	-0.0007	0.0216	-0.3120	Drug/Grocery Stores	0.0003	0.0091	-0.3145	Mortgage REITs: Residential	0	0.0167	-2.3501
Nonferrous Metal	-0.0004	0.0187	-0.1094	Container & Packaging	0.0003	0.0116	-0.7981	Real Estate Services	0.0002	0.0153	-0.8405
Industrial Metal, Mining	-0.0003	0.0176	-0.3726	Delivery Service	0.0002	0.013	-0.4022	Divers REITs	-0.0002	0.0142	-3.4817
Alternative Energy	0.0002	0.0253	1.3737	Soft Drinks	0.0003	0.0098	-1.2410	Mortgage REITs	0	0.0153	-2.4288
Alternative Fuels	0.0012	0.0461	1.6098	Tobacco	0.0001	0.0124	-1.1848	Insurance Brokers	0.0007	0.0127	2.3233
Precious Metal, Mining	-0.0001	0.0197	-0.1230	Home Improvement Retailers	0.0007	0.0145	-2.3500	Health Care REIT	0	0.017	-3.0946
Basic Resources	-0.0002	0.0149	-0.4749	Waste & Disposal Services	0.0005	0.0103	-1.0171	Retail REITs	-0.0002	0.0155	-4.1248
Gold Mining	-0.0001	0.0234	-0.1451	Distillers Vintners	0.0005	0.0119	-2.0522	Financial Services	0.0004	0.013	-1.0387
Commercial Vehicle Lease	0.0003	0.0207	-0.8013	Aero/Defence	0.0004	0.0131	-1.1644	Infrastructure REITs	0.0006	0.0135	-0.3040
Platinum Precious Metal	0.0000	0.0253	-0.2479	Pharmaceuticals	0.0004	0.0105	-0.1937	Full Line Insurance	0	0.0141	-1.9592
Renewable Energy Equipment	0.0002	0.0256	1.4486	Pharmaceuticals & Biotech	0.0005	0.0113	-0.1573	Investment Bank, Broker	0.0004	0.0132	-0.9555
Building & Plumbing	0.0000	0.0259	-0.6331	Nondurable Household Products	0.0005	0.0102	0.7155	Banks	0.0001	0.0133	-1.1297
Oil Refinery Marketing	0.0001	0.0179	-1.1464	Biotechnology	0.0006	0.0152	-0.1591	Consumer Lending	0.0004	0.0156	-1.1074
Electronic Office Equipment	0.0001	0.0212	-1.1810	Conventional Electricity	0.0003	0.0108	-0.6414	Asset Managers	0.0003	0.0141	-0.8874
Machinery Constructions	0.0002	0.0167	-0.6380	Water	0.0002	0.0128	-0.5126	Life Insurance	0.0001	0.0149	-1.3421

Table 2

. Oil Exposures for Americas (1 Jan 2018–30 April 2020). This table reports the regression output of Eq. (2) in the Americas region. The top 25, bottom 25 non-financial and financial industries are presented in Panels A, B and C, respectively. The industries are ranked based on the slope coefficient on oil price return in Eq. (1). Sector returns are regressed on the five asset pricing factors of Fama and French (2015), as well as oil price returns and COVID-19 dummy. The sample period is from 1 January 2018 to 30 April 2020. Bolded figures indicate statistical significance at 10% level at least.

Panel A: Non Financial Industries (Positive Exposure)				Panel B: Non Financial Industries (Negative Exposure)				Panel C: Financial industries (Top 25)			
Subsector	Oil	COVID19	Oil* COVID19	Subsector	Oil	COVID19	Oil* COVID	Subsector	Oil	COVID19	Oil* COVID
Oil Crude Production	<b>0.3062</b>	0.0012	-0.0186	Airlines	<b>-0.1279</b>	-0.0037	<b>0.1077</b>	Mortgage Finance	-0.0086	0.0027	0.1549
Oil Equipment & Services	<b>0.2639</b>	0.0001	-0.0091	Household Equipment Products	-0.0324	0.0005	-0.0247	Investment Cos.	-0.0067	0.0020	0.1257
Oil, Gas, Coal	<b>0.2259</b>	0.0011	-0.037	Drug Retailers	-0.0340	-0.0009	-0.0084	Closed End Inv.	-0.0067	0.0020	0.1257
Energy	<b>0.2142</b>	0.0011	-0.0263	Misc Consumer Staple	-0.0276	0.0007	-0.0165	Real Est.Hold,Dv	0.0139	-0.0018	0.0736
Integrated Oil & Gas	<b>0.1745</b>	0.0003	-0.0071	Toys	-0.0031	-0.0041	-0.0408	Real Est.Inv.Svs	0.0184	0.0004	0.0441
Pipelines	<b>0.1586</b>	0.0015	0.0209	Defense	<b>-0.0360</b>	-0.0009	0.0259	Fin. Data Prov.	0.0021	0.0013	<b>0.0691</b>
General Mining	<b>0.1859</b>	0.0011	-0.0516	Multi utilities	<b>-0.0445</b>	-0.0009	<b>0.0487</b>	Hotel,Lodge REIT	-0.0124	-0.0010	0.0926
Chemicals Synthetic Fibers	<b>0.1152</b>	-0.0021	0.0125	Apparel Retailer	-0.0141	0.0013	-0.0023	Div. Fin. Svs	0.0059	-0.0007	<b>0.0537</b>
Copper	<b>0.2018</b>	0.0037	<b>-0.1570</b>	Health Care Services	-0.0072	0.0003	-0.0138	Fin. Credit Svs	-0.0049	0.0013	<b>0.0717</b>
Marine Transport	<b>0.1363</b>	0.0012	-0.0346	Recreational Services	<b>-0.0738</b>	0.0011	<b>0.1139</b>	Mge REITs: Comm.	-0.0367	0.0001	0.1306
Plastics	<b>0.1018</b>	-0.0008	0.0082	Drug/Grocery Stores	<b>-0.0206</b>	-0.0011	0.0165	Mge REITs: Resid	<b>-0.0360</b>	-0.0002	0.1228
Nonferrous Metal	<b>0.214</b>	0.0029	<b>-0.2060</b>	Container & Packaging	<b>-0.0236</b>	0.0009	0.0234	Real Est.Service	0.0160	0.0021	0.0249
Industrial Metal, Mining	<b>0.1613</b>	0.0022	<b>-0.1226</b>	Delivery Service	-0.0019	0.0002	-0.0161	Divers REITs	-0.0152	-0.0009	0.0793
Alternative Energy	<b>0.1198</b>	0.0033	-0.0513	Soft Drinks	<b>-0.0268</b>	-0.0013	<b>0.0314</b>	Mortgage REITs	<b>-0.0318</b>	0.0000	0.0998
Alternative Fuels	<b>0.1036</b>	0.0044	-0.0221	Tobacco	<b>-0.0261</b>	-0.0013	0.0314	Insur Brokers	<b>-0.0200</b>	0.0003	0.0738
Precious Metal, Mining	<b>0.1237</b>	0.0039	-0.0600	Home Improvement Retailers	<b>-0.0462</b>	0.0025	<b>0.0693</b>	Health Care REIT	<b>-0.0551</b>	-0.0008	0.1393
Basic Resources	<b>0.1274</b>	0.0026	<b>-0.0743</b>	Waste & Disposal Services	<b>-0.0379</b>	-0.0003	<b>0.0561</b>	Retail REITs	<b>-0.0603</b>	-0.0013	0.1470
Gold Mining	<b>0.0946</b>	0.0035	-0.0164	Distillers Vintners	<b>-0.0224</b>	-0.0004	0.0284	Fin. Services	-0.0114	0.0013	0.0535
Commercial Vehicle Lease	<b>0.0726</b>	0.0031	0.0227	Aero/Defence	<b>-0.0238</b>	-0.0013	0.0312	Infrastr. REITs	<b>-0.0183</b>	-0.0002	0.0654
Platinum Precious Metal	<b>0.1280</b>	0.0037	-0.0814	Pharmaceuticals	<b>-0.0275</b>	-0.0006	<b>0.0391</b>	Full Line Insur	-0.0122	-0.0005	0.0507
Renewable Energy Equipment	<b>0.1200</b>	0.0037	<b>-0.0678</b>	Pharmaceuticals & Biotech	<b>-0.0246</b>	-0.0003	<b>0.0342</b>	Inv. Bank,Broker	<b>-0.0141</b>	0.0011	<b>0.0525</b>
Building & Plumbing	<b>0.0523</b>	0.0034	0.0568	Nondurable Household Products	-0.0117	-0.0002	0.0104	Banks	-0.0097	0.0013	<b>0.0427</b>
Oil Refinery Marketing	<b>0.0490</b>	0.001	0.0620	Biotechnology	-0.0196	0.0006	0.0257	Consumer Lending	-0.0204	0.0000	0.0547
Electronic Office Equipment	<b>0.0373</b>	-0.0023	0.0830	Conventional Electricity	<b>-0.0381</b>	-0.0011	<b>0.0608</b>	Asset Mngr, Cust	-0.0039	0.0032	0.0226
Machinery Constructions	<b>0.1166</b>	0.001	<b>-0.0684</b>	Water	<b>-0.0232</b>	-0.0011	0.0348	Life Insurance	-0.0063	0.0021	0.0258

similar results for US financial and non-financial industries, whereby non-financial industries are more sensitive to oil price risk than their financial counterparts are. The exposure of financial and non-financial industries to oil price risk appears to be similar across the three regions.

Compared to non-financial sectors, financial industries have higher loadings on the market risk premium that are above 1. The loadings on the market risk premium of the non-financial sectors tend to be around 0.8. Non-financial industries appear to have lower loadings on the size (SMB) and investment (CMA) factors for those with high exposure to oil price, while the opposite is true for industries with low exposure to oil price return. Industries with high exposure to oil price risk tend to load negatively on RMW and positively on other factors. This pattern is reversed in part for the industries with negative exposure to oil price risk, suggesting that oil price exposure is an important force in driving firm profitability.

An interesting finding emerges in the variable of interest, i.e., the interaction between COVID-19 dummy and oil price return. The interaction terms for part of the 25 industries with oil positive exposures in Panel A (Table 2) are negative and statistically significant, indicating that industries such as copper, nonferrous metal, basic resources, industrial metals, renewable energy equipment, and construction machinery exhibit less pronounced positive exposure to the oil price risk during the COVID-19 outbreak compared to other non-financial industries. The interaction terms for 25 industries with highest oil negative exposures differ in Panel B of Table 2. The top 12 industries appear to be negatively associated with oil price risk exposure in COVID-19. The results suggest that the negative oil exposures for industries such as airlines, multi utilities, recreational services, soft drinks, home improvement retailers, waste & disposal services, pharmaceuticals, pharma & biotech, and conventional electricity were moderated during the COVID-19. This is potentially a result of lower oil prices and less reliance on oil in COVID-19. Likewise, Panel C (Table 2) shows that the negative oil exposure of financial industries such as banks, financial data providers, diversified financial services, financial credit services, and investment bank broker decreases during the COVID-19. This is potentially related to their systemic importance in the economic system. Interestingly, industries in Asia and Europe do not respond to oil price risk differently in COVID-19.<sup>12,13</sup>

#### 4. Conclusion

COVID-19 has exerted a dramatic impact on the health and economic systems around the world. This paper investigates the impact of COVID-19 on exposure to oil price risk of both financial and non-financial sectors around the world. In general, oil supply (user) industries suffer (benefit) most when there is a decrease in oil prices. The COVID-19 pandemic moderates the relationship between changes in oil prices and stock returns around the world. Oil supply and infrastructure provider industries exhibit weaker positive exposure to oil price risk during the COVID-19 outbreak compared to the non-COVID-19 period. Oil demand industries and financial industries display weakened negative exposure to oil price risk during the COVID-19. Our results are robust to alternative asset pricing frameworks. They are of particular importance for investors, portfolio managers, and policymakers in mitigating oil price risk. We believe that there is more scope of research on COVID-19 and oil price factor for the industries of developed versus emerging/frontier countries and/or oil-importing versus oil-exporting countries. The time-varying comovement between oil price changes and industry stock returns during the pandemic provides fruitful insights to the literature on management of energy risk (Batten et al., 2018). It appears that hedging strategies designed for normal times should be re-considered in health-related crises and the associated economic turbulence. Future research would benefit from developing hedging strategies of energy risk that considers pandemic situations.

#### Authors statement

**Md Akhtaruzzaman:** Conceptualization, Methodology, Formal Analysis, Investigation, Writing-Original Draft, Writing-Review & Editing

**Sabri Boubaker:** Conceptualization, Writing-Review & Editing, Supervision, Resources, Validation

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#### Supplementary materials

Supplementary material associated with this article can be found, in the online version, at [doi:10.1016/j.frl.2020.101882](https://doi.org/10.1016/j.frl.2020.101882).

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<sup>12</sup> For the sake of brevity, the detailed results for Asia and Europe are provided in Internet Appendix.

<sup>13</sup> Eqs. (1) and (2) are also estimated using the Capital Asset Pricing Model and the Fama and French (1993) three-factor model. The results remain qualitatively similar.

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