

# COVID-19 and the forward-looking stock-bond return relationship

Xiaojing Cai<sup>ab</sup>, Yingnan Cong<sup>c</sup>, Ryuta Sakemoto<sup>ad</sup>

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<sup>a</sup>*Graduate School of Humanities and Social Sciences, Okayama University, 3-1-1, Tsushima-naka, Kita-ku, Okayama 700-8530, Japan. Email: caicai@okayama-u.ac.jp*

<sup>b</sup>*Graduate School of Economics, Kobe University, 2-1, Rokkodai, Nada-Ku, Kobe 657-8501, Japan.*

<sup>c</sup>*Business School, China University of Political Science and Law, 25 Xitucheng Lu, Haidian District, Beijing, 100088, China.*

<sup>d</sup>*Keio Economic Observatory, Keio University, Minato-ku, Tokyo, 108-8345, Japan.*

## Abstract

This study analyzes the relationship between the forward-looking stock-bond return correlations and the number of COVID-19 cases using a quantile approach that is beneficial to explore non-linear relationships. It shows that there are heterogeneous responses across regions and countries. Specifically, the negative stock-bond correlations weaken as the number of confirmed cases in the regions of North America (the U. S. and Canada) and Asia-Pacific (Australia and Japan) increases. These findings suggest that uncertainty triggered by COVID-19 impacts the financial markets more significantly than the actual confirmed cases. Our result also highlights that this pattern is not observed in European countries.

JEL: C32; G01; G15

Keywords: Forward-looking stock-bond correlations; COVID-19; DCC-GARCH

## 1. Introduction

The World Health Organization (WHO) declared that the reported coronavirus disease (COVID-19) cases surpassed 61 million, and the total number of deaths was over 1 million globally by December 1, 2020.<sup>1</sup> The outbreak of COVID-19 has a great impact upon economic activities and burgeoning studies are exploring the impact of the pandemic on financial markets.<sup>2</sup> For instance, Baker et al. (2020) report that the COVID-19 pandemic raised stock market volatility, which was not observed in the previous influenza pandemics. Ramelli and Wagner (2020) highlight that stock prices of firms exposed to international trade risk underperformed at the beginning of the outbreak. Gormsen and Kojen (2020) show that a forecast of annual growth in dividends significantly declined since January 2020.

In this study, we focus on stock and bond correlations during the COVID-19 pandemic. Previous studies have shown that a negative correlation between stock and bond returns becomes stronger with high market uncertainty and illiquidity periods (Connolly et al., 2005, 2007; Baele et al., 2010, 2020). The COVID-19 outbreak causes high market uncertainty and may influence the stock and bond correlations. Papadamou et al. (2020) present empirical evidence that an increase in the confirmed COVID-19 cases results in negative stock and bond correlations. We extend the works of Connolly et al. (2005, 2007) and Papadamou et al. (2020) to investigate the responses of stock-bond correlations during the COVID-19 pandemic across international markets. Our study contributes to the literature in the following manner.

Firstly, the study focuses on forward-looking correlations during the COVID-19 pandemic. Connolly et al. (2005, 2007) highlight that market uncertainty leads to more frequent revisions of expected returns for investors, resulting in negative stock and bond correlations. The empirical evidence provided by Giglio et al. (2021) and Samels (2021) supports our hypothesis that the market crash triggered by the pandemic changes investors' expectations. Giglio et al. (2021) use data from the survey of Vanguard investors and reveal that investors perceive a more pessimistic outlook of the stock market after the market crash triggered by the pandemic. Samels (2021) deploys Google search volume for "coronavirus" and reports that the search volume is negatively linked to stock market returns.

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<sup>1</sup> See [Weekly epidemiological update - 1 December 2020 \(who.int\)](https://www.who.int/news-room/weekly-epidemiological-update-1-december-2020).

<sup>2</sup> For example, Liu et al. (2021) measure the dynamic network strength during the coronavirus pandemic, Albulescu (2021) investigates how official announcements regarding new cases of COVID-19 impacted the financial markets, Zaremba et al. (2020) explore the relationship between policy response to the COVID-19 pandemic and stock market volatility, and Goodell (2020) summarizes the economic impact of COVID-19.

Secondly, the study explores the heterogeneity of responses across various countries based on the studies presenting the variation in responses of financial markets by region and social structure. Zhang et al. (2020) explore international stock market correlations and observe that Asian markets were more segmented than European and North American markets. Erdem (2020) uses the political freedom index provided by Freedom House and finds that countries receiving high scores suffered more severe stock market downturns.

Finally, the study's approach explores a non-linear relationship between market uncertainty and correlations. Adrian et al. (2019) highlight that an increase in expected returns in the stock market is associated with a moderate, but not an extreme, rise in market uncertainty. Accordingly, we do not employ a linear regression model, as done by Papadamou et al. (2020),<sup>3</sup> and adopt a quantile approach instead.

The study showed that an increase in the number of confirmed COVID-19 cases mitigates a negative relationship between stock and bond returns in the markets in North America (the U.S. and Canada) and Asia-Pacific (Australia and Japan). Our finding is related to gradual information diffusion (Hong and Stein, 1999). Investors do not have sufficient information to evaluate how the pandemic affects stock markets, thus, demanding safe Treasury bonds; i.e., they sell risky stocks and buy safe Treasury bonds at the beginning of the pandemic, while they obtain more information about the pandemic and adjust the risk level of their portfolios.

## **2. Data and methodology**

This study investigates whether changes in the COVID-19 pandemic influence the forward-looking stock-bond correlations. The daily confirmed cases of the COVID-19 are obtained from <https://ourworldindata.org> (Roser et al., 2020). This dataset presents statistics on the COVID-19 pandemic for all countries and is updated daily. Erdem (2020) uses this dataset to investigate the stock market performance in 195 countries during the COVID-19 outbreak.

We also employ the MSCI net total return local indices as stock market indices and the FTSE government bond local indices as bond market indices. These data are obtained from Bloomberg. The returns are calculated as the first difference in the logarithmic prices. This study's sample period is from February 3, 2020, to December 3, 2020. This start date is chosen because the first positive case was observed in Italy on January 30, 2020, and on January 31, 2020, in the U.K. Twenty-one developed financial markets from 3 regions,

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<sup>3</sup> Cepoi (2020) also shows that relationships between stock market returns and COVID-19 news are not linear.

including North America (the U.S. and Canada), Asia Pacific (Australia, New Zealand, and Japan), and Europe (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherland, Norway, Portugal, Spain, Sweden, Switzerland, and the U.K.) are selected. Table A1 in the Online Appendix presents the descriptive statistics for all data series.

We first estimate the dynamic correlations between stock and bond returns for each country using the dynamic conditional correlation – generalized autoregressive conditional heteroskedasticity (DCC-GARCH) model (Engle, 2002). Our interest is to understand how the expected returns on stocks and bonds are updated. The DCC-GARCH provides time-varying correlations using the information of up to  $t - 1$ . Considering  $r_t$  as a vector of asset returns with the information set  $\mathfrak{I}_{t-1}$ , the DCC-GARCH process is described as

$$r_t | \mathfrak{I}_{t-1} \sim N(\mu, D_t R_t D_t) \quad (1)$$

where  $D_t$  is a diagonal matrix of the standard deviations of returns on the diagonal, and  $R_t$  is the conditional correlation matrix of the standardized residuals of returns, given by

$$R_t = \text{diag}(Q_t)^{-1/2} Q_t \text{diag}(Q_t)^{-1/2}. \quad (2)$$

It is assumed that  $Q_t$  is an autoregressive process given by

$$Q_t = (1 - a - b)\bar{Q} + bQ_{t-1} + a\varepsilon_{t-1}\varepsilon'_{t-1}, \text{ with } a \geq 0, b \geq 0, a + b < 1 \quad (3)$$

where  $\bar{Q}$  is the unconditional correlation coefficient matrix, and  $\varepsilon_{t-1}$  is the lagged function of standardized residuals of returns. Thus, the conditional correlation coefficient in a bivariate case is obtained by

$$\rho_{12,t} = \frac{q_{12,t}}{\sqrt{q_{11,t}q_{22,t}}} \quad (4)$$

where  $q_{ij,t}$  is the  $ij$  element of  $Q_t$  in Equation (3).

Forward-looking correlations are evaluated for three different time horizons. A daily change in the correlations is calculated from the daily conditional correlations from  $t$  to  $t+1$ . Similarly, a weekly (monthly) change in the correlations was obtained from daily conditional correlations from  $t$  to  $t+5$  ( $t+22$ ). Papadamou et al. (2020) explore stock-bond correlations during the pandemic. However, they focus on contemporaneous correlations. As investors may update their expected returns on stocks and bonds when they obtain new information about the pandemic, and we use the forward-looking stock-bond correlations (Connolly et al., 2005, 2007). The mean and standard deviation of the forward-looking correlations are calculated following the average value of the confirmed cases in the previous week (from  $t-4$  to  $t$ ).

### 3. Empirical results

This section presents the means and standard deviations of the forward-looking correlations following the given quantile values of confirmed COVID-19 cases. Table 1 presents the empirical results for North America (the U.S. and Canada), Asia-Pacific (Australia, New Zealand, and Japan). The data shows that all forward-looking stock-bond correlations are negative. Connolly et al. (2005, 2007) report that the forward-looking stock-bond correlations vary over time and take negative values with high market uncertainty states. The negative stock-bond correlations observed in our study indicate that the market uncertainty is high during the pandemic, and investors prefer safe Treasury bonds to risky stocks (flight-to-safety). Furthermore, the means of the daily and weekly forward-looking correlations are lowest in all countries, except for New Zealand, where the confirmed COVID-19 cases are below their 30% percentile. Notably, the forward-looking correlations rise with the increase in the confirmed cases in North America (the U.S. and Canada) and the Asia-Pacific (Australia and Japan). Investors in these regions are less risk averse as the pandemic worsens. This finding relates to the gradual information diffusion model in that information regarding the market is revealed to investors gradually (Hong and Stein, 1999). Investors sold risky stocks and bought safe Treasury bonds at the beginning of the pandemic because they could not collect sufficient information about how the pandemic would impact the financial markets, while they adjusted the risk level of their portfolio as they obtained more information. Another point to note from Table 1 is that the positive relationship between the forward-looking correlations and the confirmed COVID-19 cases is less clear for the monthly results, suggesting that the flight-to-safety period is short-lived, as reported by Baele et al. (2020).

Table 2 shows the results in Europe. We observe that all forward-looking stock-bond average correlations are negative for countries in Panel A, while the average correlations are positive for those in Panel B when the COVID-19 case levels are below their 30% percentile. Panel B includes Greece, Ireland, Italy, Portugal, and Spain. The Treasury bonds of these countries are riskier than those issued by the countries in Panel A. The risky Treasury bonds positively comove with the stocks (Dufour et al., 2017). The country-specific factors played a more important in the bond markets during the market turmoil, observed in the euro bond market crisis (Pozzi and Wolswijk, 2012; Christiansen, 2014; Sakemoto, 2018). More importantly, the forward-looking average correlations in Europe do not change with an increase in the number of confirmed COVID-19 cases, contradicting the results observed for North America and the Asia-Pacific.

Figure 1 provides the evolution of the dynamic correlations and infection cases during our sample period for four countries (the U.S., Australia, Germany, and Italy). The straight

black line indicates the dynamic correlations, the values of which are reported by the left vertical axis. The dashed red line indicates the weekly average values of the confirmed COVID-19 cases, the values of which are reported by the right vertical axis. We confirm that the negative stock-bond correlations weaken as the numbers of cases increase for the U.S. and Australia. Contrastingly, no clear pattern is observed for Germany and Italy, consistent with the empirical results presented in Tables 1 and 2.

In summary, the results in Tables 1 and 2 present empirical evidence that the response of the stock-bond correlations observed during the COVID-19 pandemic is heterogeneous across various regions and countries.

#### **4. Conclusion**

This paper investigated whether the forward-looking stock-bond return correlations varied as the COVID-19 cases increased during the pandemic. We estimated the correlations using the DCC-GARCH model for 21 financial markets from 3 regions. We focused on a non-linear relationship between the market states and the forward-looking correlations proposed by Connolly et al. (2005, 2007). We found that a heterogeneous relationship across regions and countries. Specifically, the negative forward-looking stock-bond correlations weakened with the increase in the confirmed COVID-19 cases in North America (the U.S. and Canada) and the Asia-Pacific (Australia and Japan). However, no clear relationships were observed between the confirmed COVID-19 cases and the stock-bond correlations in European countries. The positive relationship was particularly strong for the U.S. The results were explained by the gradual information diffusion model (Hong and Stein, 1999). Uncertainty triggered by the COVID-19 pandemic had a stronger impact on investors than the actual number of confirmed cases. As investors lacked sufficient information, they became risk-averse, leading to flight-to-safety and strong negative stock-bond correlations. Investors adjusted their expected returns on the stocks and the bonds as information was revealed, mitigating the negative stock-bond correlations.

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Table 1

Confirmed COVID-19 cases and stock-bond return correlation in North American (the U.S. and Canada), and the Asia Pacific (including Australia, New Zealand, and Japan)

Case level	Mean	Mean	Mean	Mean	Mean
	(SD)	(SD)	(SD)	(SD)	(SD)
	U.S.	Canada	Australia	New Zealand	Japan
t+1					
0~30%	-0.407 (0.022)	-0.356 (0.017)	-0.24 (0.103)	-0.094 (0.009)	-0.357 (0.084)
30%~70%	-0.394 (0.040)	-0.331 (0.030)	-0.23 (0.083)	-0.096 (0.005)	-0.338 (0.072)
70%~100%	-0.29 (0.016)	-0.312 (0.016)	-0.213 (0.070)	-0.097 (0.005)	-0.326 (0.081)
t+5					
0~30%	-0.407 (0.023)	-0.355 (0.018)	-0.242 (0.114)	-0.094 (0.010)	-0.36 (0.089)
30%~70%	-0.397 (0.038)	-0.333 (0.03)	-0.233 (0.093)	-0.096 (0.006)	-0.342 (0.076)
70%~100%	-0.289 (0.018)	-0.31 (0.016)	-0.206 (0.084)	-0.097 (0.007)	-0.321 (0.088)
t+21					
0~30%	-0.411 (0.016)	-0.363 (0.012)	-0.235 (0.123)	-0.095 (0.008)	-0.338 (0.089)
30%~70%	-0.406 (0.032)	-0.335 (0.028)	-0.245 (0.086)	-0.095 (0.005)	-0.355 (0.068)
70%~100%	-0.298 (0.017)	-0.302 (0.016)	-0.188 (0.086)	-0.098 (0.006)	-0.321 (0.083)

Notes: This table presents the means, and standard deviations (SD) of the forward-looking correlations for North American and the Asia Pacific regions following the given quantile values of the average number of confirmed COVID-19 cases from  $t-4$  to  $t$ . The standard deviations are reported in parentheses.

Table 2

Confirmed COVID-19 cases and stock-bond return correlation in Europe.

Case level	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Panel A	Austria	Belgium	Denmark	Finland	France	Germany	Netherlands	Norway	Sweden	Switzerland	U.K.
t+1											
0~30%	-0.253 (0.058)	-0.122 (0.014)	-0.145 (0.132)	-0.325 (0.151)	-0.076 (0.027)	-0.366 (0.201)	-0.292 (0.130)	-0.45 (0.071)	-0.323 (0.097)	-0.216 (0.053)	-0.315 (0.046)
30%~70%	-0.277 (0.021)	-0.125 (0.004)	-0.139 (0.103)	-0.321 (0.081)	-0.08 (0.011)	-0.368 (0.130)	-0.299 (0.084)	-0.497 (0.036)	-0.318 (0.064)	-0.219 (0.046)	-0.324 (0.033)
70%~100%	-0.289 (0.036)	-0.126 (0.006)	-0.137 (0.082)	-0.32 (0.063)	-0.08 (0.009)	-0.363 (0.096)	-0.285 (0.071)	-0.496 (0.032)	-0.318 (0.050)	-0.215 (0.021)	-0.319 (0.031)
t+5											
0~30%	-0.253 (0.062)	-0.122 (0.016)	-0.144 (0.174)	-0.321 (0.170)	-0.076 (0.032)	-0.373 (0.230)	-0.290 (0.146)	-0.450 (0.073)	-0.326 (0.119)	-0.216 (0.074)	-0.316 (0.052)
30%~70%	-0.276 (0.024)	-0.126 (0.004)	-0.142 (0.136)	-0.328 (0.100)	-0.081 (0.013)	-0.372 (0.153)	-0.304 (0.099)	-0.496 (0.038)	-0.318 (0.089)	-0.217 (0.065)	-0.325 (0.035)
70%~100%	-0.291 (0.040)	-0.126 (0.008)	-0.13 (0.105)	-0.318 (0.086)	-0.08 (0.011)	-0.351 (0.153)	-0.28 (0.085)	-0.497 (0.034)	-0.315 (0.075)	-0.216 (0.031)	-0.317 (0.038)

Notes: See page 12.

Table 2

Continued

	Austria	Belgium	Denmark	Finland	France	Germany	Netherlands	Norway	Sweden	Switzerland	U.K.
t+21											
0~30%	-0.268 (0.034)	-0.121 (0.017)	-0.118 (0.149)	-0.317 (0.184)	-0.073 (0.035)	-0.351 (0.224)	-0.273 (0.123)	-0.429 (0.061)	-0.32 (0.120)	-0.213 (0.053)	-0.313 (0.056)
30%~70%	-0.277 (0.025)	-0.126 (0.004)	-0.15 (0.138)	-0.325 (0.102)	-0.081 (0.014)	-0.385 (0.156)	-0.311 (0.092)	-0.505 (0.034)	-0.323 (0.089)	-0.222 (0.062)	-0.331 (0.033)
70%~100%	-0.277 (0.018)	-0.124 (0.004)	-0.118 (0.100)	-0.307 (0.089)	-0.079 (0.011)	-0.331 (0.150)	-0.262 (0.091)	-0.478 (0.031)	-0.305 (0.072)	-0.214 (0.049)	-0.307 (0.038)

Notes: See page 12.

Table 2

Continued

Panel B	Greece	Ireland	Italy	Portugal	Spain
t+1					
0~30%	0.431 (0.074)	0.095 (0.010)	0.308 (0.013)	0.201 (0.023)	0.09 (0.050)
30%~70%	0.243 (0.062)	-0.055 (0.047)	0.284 (0.008)	0.186 (0.011)	0.047 (0.035)
70%~100%	0.162 (0.043)	0.011 (0.040)	0.278 (0.009)	0.185 (0.019)	-0.012 (0.048)
t+5					
0~30%	0.43 (0.077)	0.098 (0.101)	0.308 (0.013)	0.201 (0.025)	0.089 (0.051)
30%~70%	0.25 (0.062)	-0.056 (0.049)	0.285 (0.009)	0.185 (0.012)	0.049 (0.036)
70%~100%	0.162 (0.046)	0.008 (0.042)	0.278 (0.009)	0.186 (0.020)	-0.007 (0.048)
t+21					
0~30%	0.454 (0.055)	0.047 (0.067)	0.312 (0.010)	0.202 (0.026)	0.11 (0.035)
30%~70%	0.248 (0.052)	-0.062 (0.051)	0.285 (0.007)	0.184 (0.012)	0.049 (0.031)
70%~100%	0.177 (0.028)	-0.007 (0.038)	0.28 (0.007)	0.192 (0.012)	0.015 (0.011)

Notes: This table presents the means, and standard deviations (SD) of the forward-looking correlations for European countries following given quantile values of the average number of confirmed COVID-19 cases from  $t-4$  to  $t$ . The standard deviations are reported in parentheses.

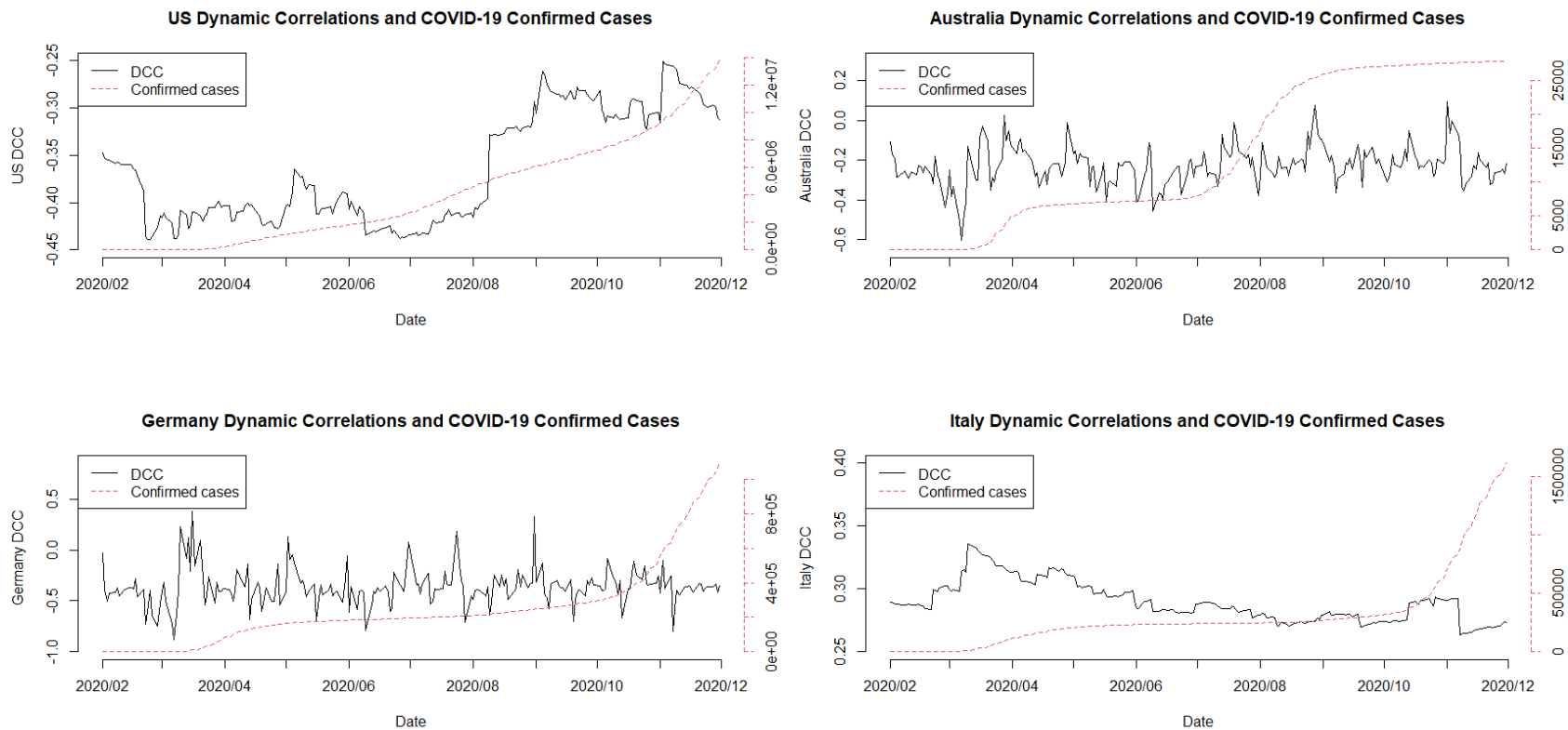


Fig. 1. Dynamic correlations (left vertical axis and the straight black line) and confirmed COVID-19 cases (right vertical axis and dashed red line) from February 3, 2020, to December 3, 2020.

# **COVID-19 and the forward-looking stock-bond return relationship**

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Xiaojing Cai, Yingnan Cong and Ryuta Sakemoto

## **Online Supplement, Not for Publication**

This material provides additional results not reported in the main text. Table A1 presents the descriptive statistics. Figure A1 shows the evolution of dynamic correlations and the number of confirmed COVID-19 cases from February 3 to December 3, 2020, for Canada, New Zealand, Japan, Austria, Belgium, Denmark, Finland, France, the Netherlands, Norway, Sweden, Switzerland, the U.K., Greece, Ireland, Italy, Portugal, and Spain.

Table A1

Descriptive statistics for MSCI total net return index, FTSE government bond index, and confirmed COVID-19 cases.

OECD countries	Obs.	Mean	SD	Skewness	Kurtosis
Panel A: MSCI total net return index					
U.S.	218	0.001	0.023	-0.864	10.199
Canada	218	0	0.023	-1.113	16.206
Australia	218	0	0.021	-0.967	8.185
New Zealand	199	0	0.015	0.274	5.456
Japan	218	0	0.015	-0.001	6.787
Austria	202	0	0.029	-0.844	8.464
Belgium	217	-0.001	0.025	-1.761	12.446
Denmark	162	0.001	0.015	-1.157	8.054
Finland	180	0	0.02	-0.926	8.052
France	180	-0.001	0.023	-1.259	9.978
Germany	218	0	0.021	-1.089	11.923
Greece	215	-0.002	0.03	-0.993	8.414
Ireland	198	0.001	0.022	-1.186	8.54
Italy	218	0	0.024	-2.622	21.992
Netherlands	208	0	0.018	-1.08	9.423
Norway	201	0	0.018	-0.896	6.738
Portugal	214	0	0.021	-0.823	11.77
Spain	218	-0.001	0.023	-1.252	12.482
Sweden	218	0	0.019	-1.079	8.798
Switzerland	202	0	0.016	-1.193	11.816
U.K.	218	0	0.02	-0.964	9.869

Notes: SD stands for standard deviation.

Table A1  
Continued

OECD countries	Obs.	Mean	SD	Skewness	Kurtosis
Panel B: FTSE government bond index					
U.S.	218	0	0.004	-0.32	10.359
Canada	218	0	0.003	0.657	9.038
Australia	218	0	0.003	-0.753	10.161
New Zealand	199	0	0.005	1.247	19.924
Japan	218	0	0.002	-1.292	14.347
Austria	202	0	0.005	-0.767	7.429
Belgium	217	0	0.004	-0.961	8.212
Denmark	162	0	0.003	0.05	6.909
Finland	180	0	0.003	-0.832	7.577
France	180	0	0.004	-0.734	7.457
Germany	218	0	0.003	-0.582	7.762
Greece	215	0	0.013	2.675	49.22
Ireland	198	0	0.004	-0.479	7.043
Italy	218	0	0.005	-0.365	11.542
Netherlands	208	0	0.003	-0.875	8.105
Norway	201	0	0.002	0.82	6.349
Portugal	214	0	0.004	0.091	12.902
Spain	218	0	0.004	0.039	10.549
Sweden	218	0	0.002	-0.411	9.674
Switzerland	202	0	0.001	-1.523	11.294
U.K.	218	0	0.008	1.414	20.24

Notes: SD stands for standard deviation.



Table A1  
Continued

OECD countries	Obs.	Mean	SD	Skewness	Kurtosis
Panel C: COVID-19 confirmed cases					
U.S.	218	4,085,739	3,795,376	0.764	2.622
Canada	218	113,634.70	94,253.05	0.947	3.669
Australia	218	14,151.35	10,704.42	0.155	1.345
New Zealand	199	1,483.79	538.967	-1.755	5.283
Japan	218	43,033.53	42,352.24	0.822	2.483
Austria	202	46,054.46	66,358.33	2.415	7.909
Belgium	217	121,193.20	160,818.90	1.899	5.244
Denmark	162	12,634.43	7,537.18	0.49	3.336
Finland	180	5,450.74	3,366.31	-0.498	1.972
France	180	204,875.50	172,742.70	1.139	4.317
Germany	218	252,978.10	243,573	1.88	6.397
Greece	215	23,109.38	36,773.68	1.878	5.155
Ireland	198	29,848.91	19,161.11	0.677	3.001
Italy	218	323,815.60	354,321.30	2.292	7.845
Netherlands	208	132,993.70	166,949.90	1.607	4.181
Norway	201	11,532.11	8,050.33	1.483	5.078
Portugal	214	90,747.43	103,750	1.664	4.546
Spain	218	452,006.30	459,217.90	1.291	3.578
Sweden	218	66,203.82	59,366.84	1.206	4.633
Switzerland	202	64,220.24	80,855.95	2.201	6.656
U.K.	218	387,526.60	412,997.10	1.671	5.04

Notes: SD stands for standard deviation.

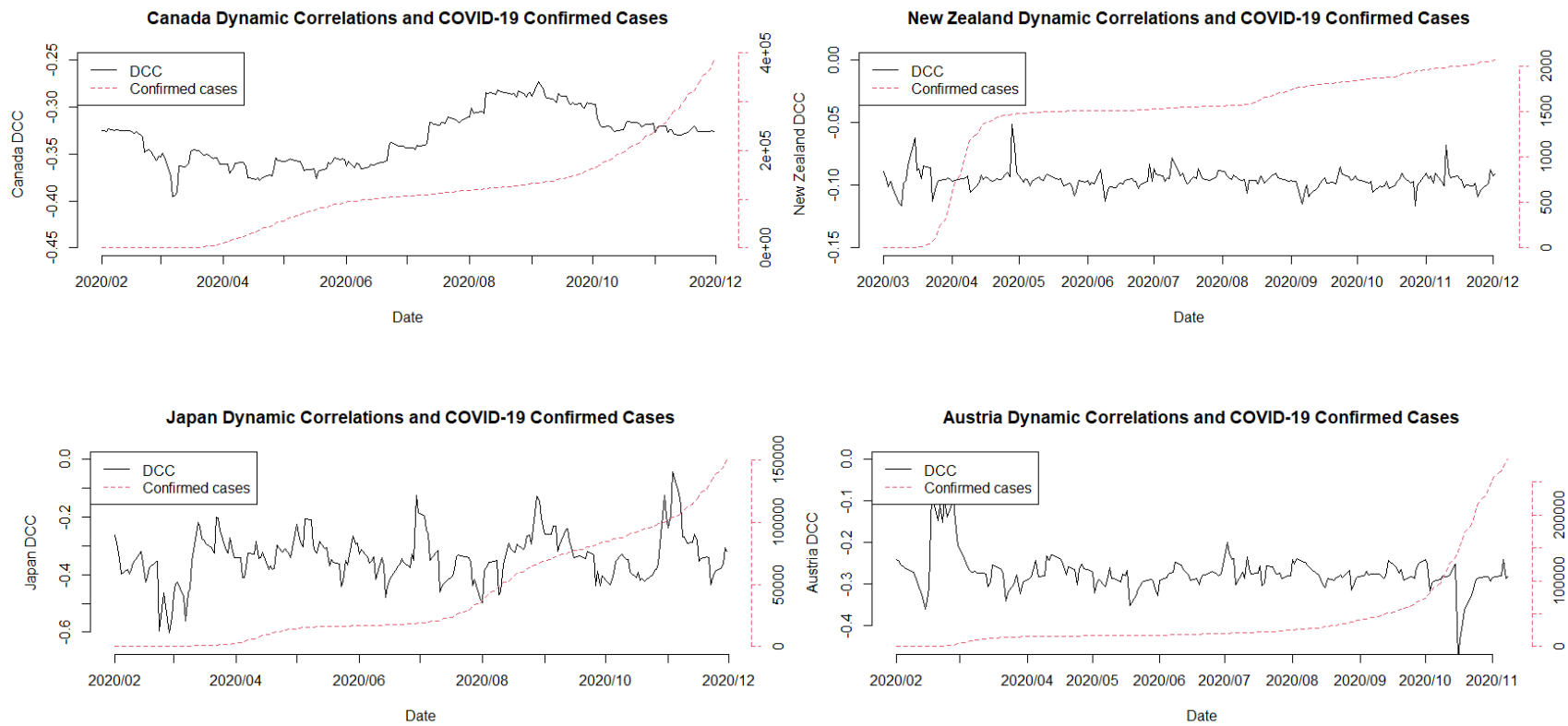


Fig. A1. The dynamic correlations (left vertical axis and the straight black line) and the number of confirmed COVID-19 cases (right vertical axis and dashed red line) in North America, the Asia Pacific, and Europe from February 3, 2020, to December 3, 2020.

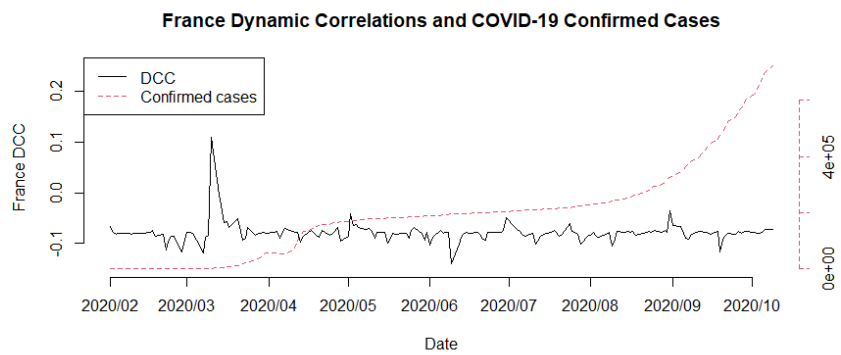
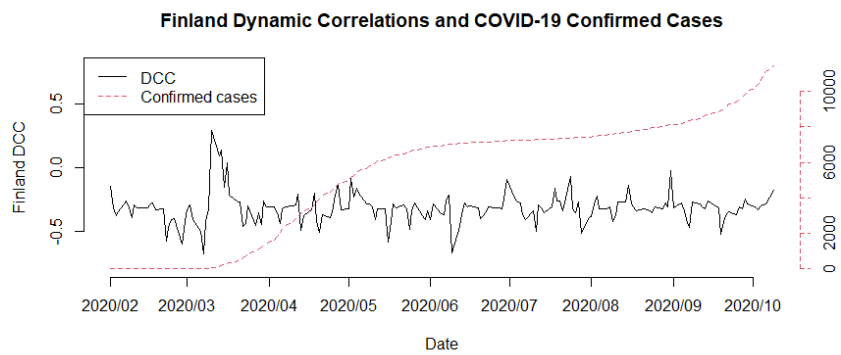
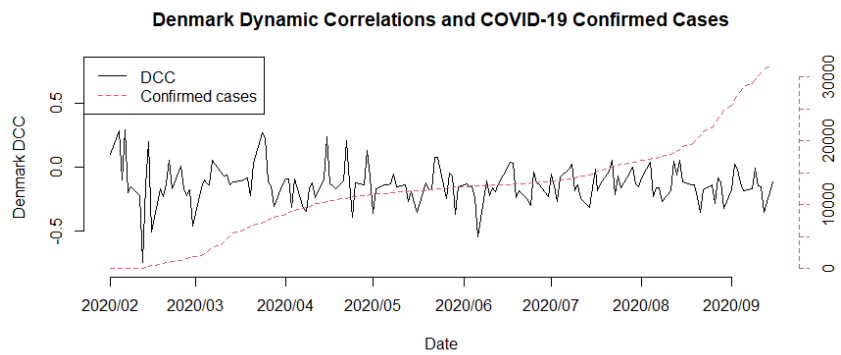
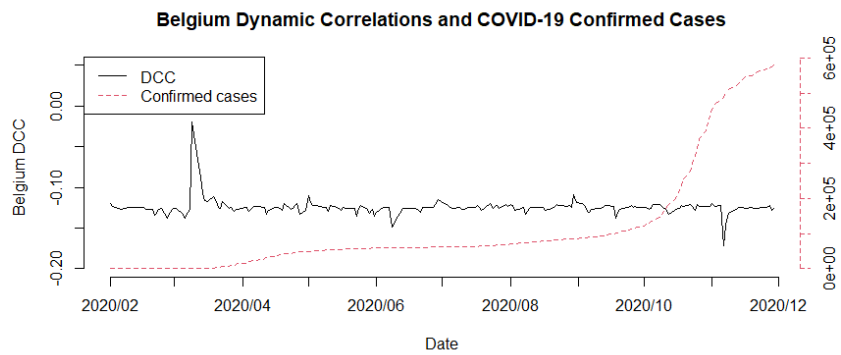
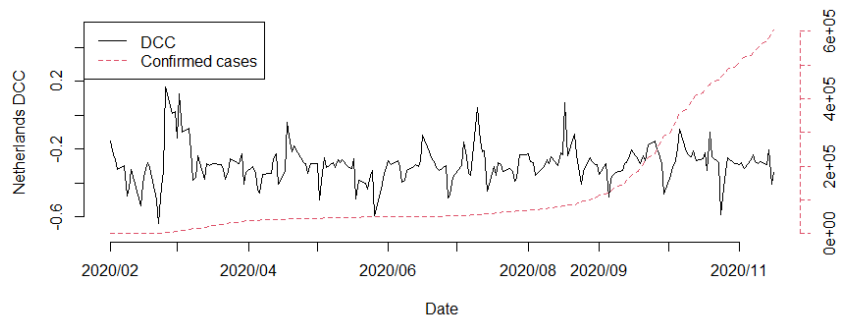
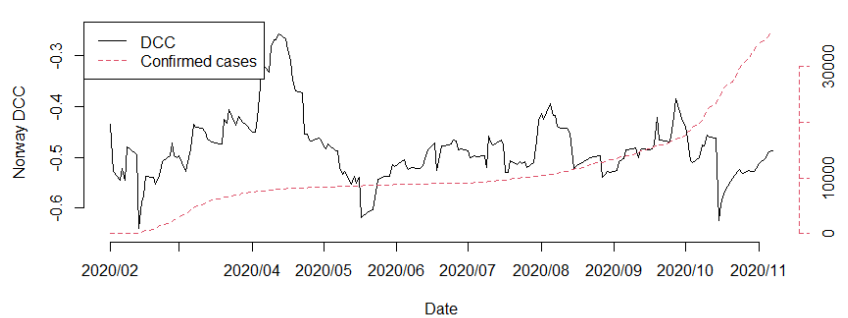


Fig. A1. Continued.

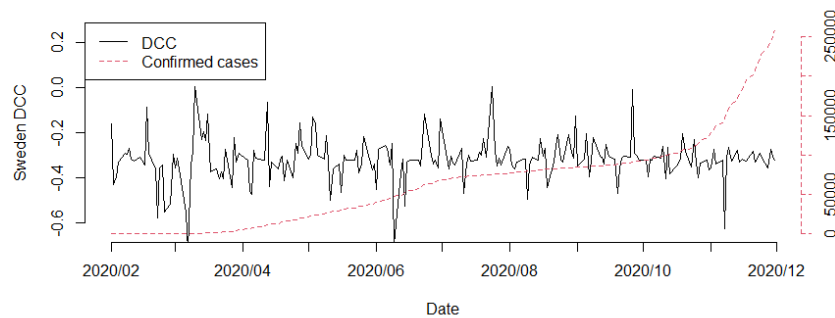
**Netherlands Dynamic Correlations and COVID-19 Confirmed Cases**



**Norway Dynamic Correlations and COVID-19 Confirmed Cases**



**Sweden Dynamic Correlations and COVID-19 Confirmed Cases**



**Switzerland Dynamic Correlations and COVID-19 Confirmed Cases**

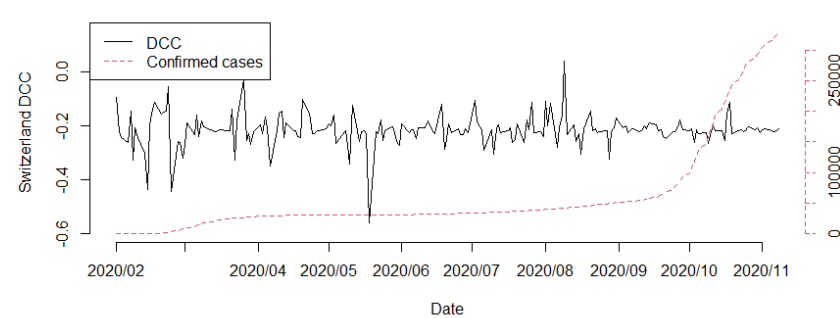


Fig. A1. Continued.

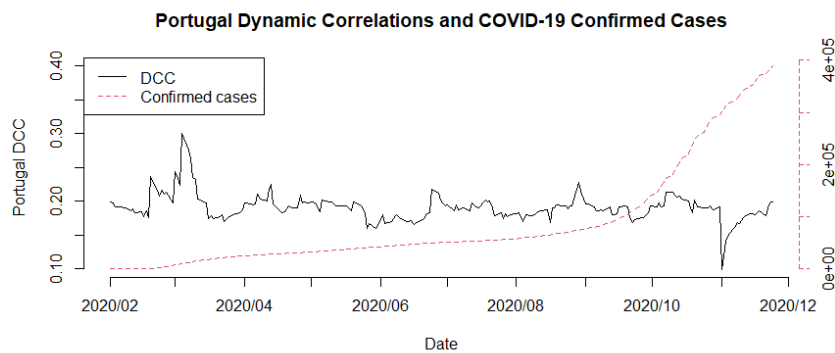
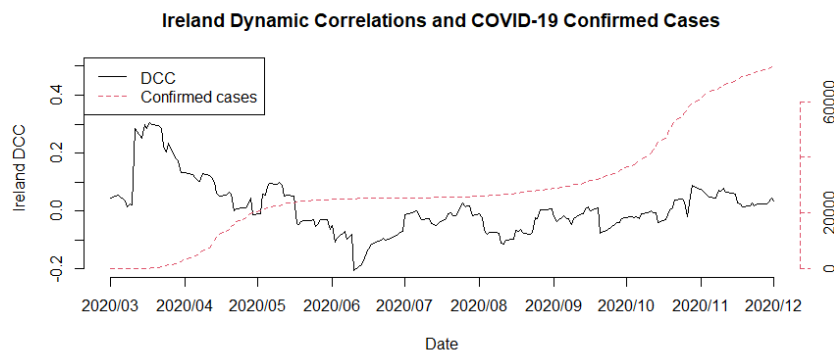
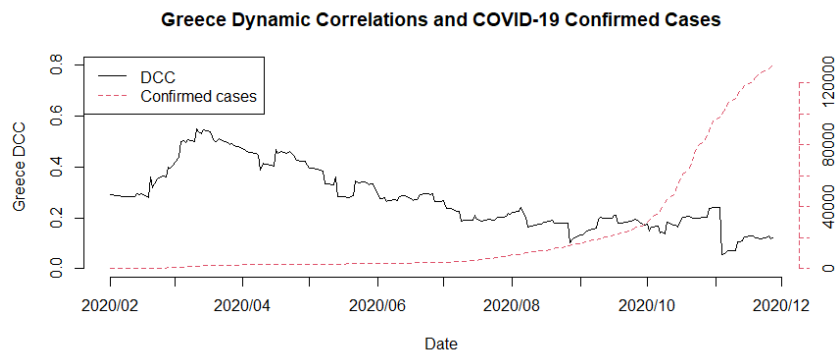
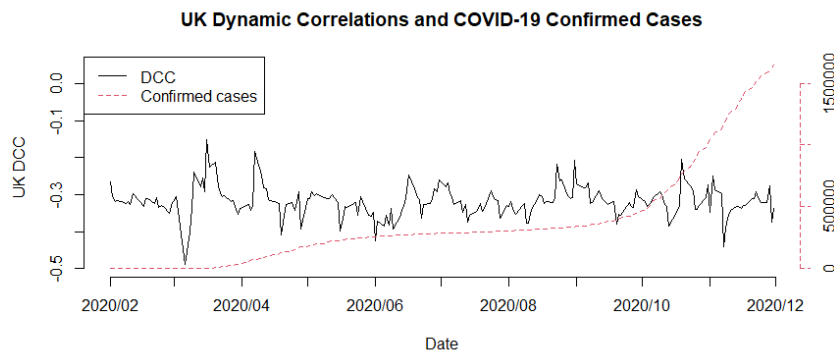


Fig. A1. Continued.

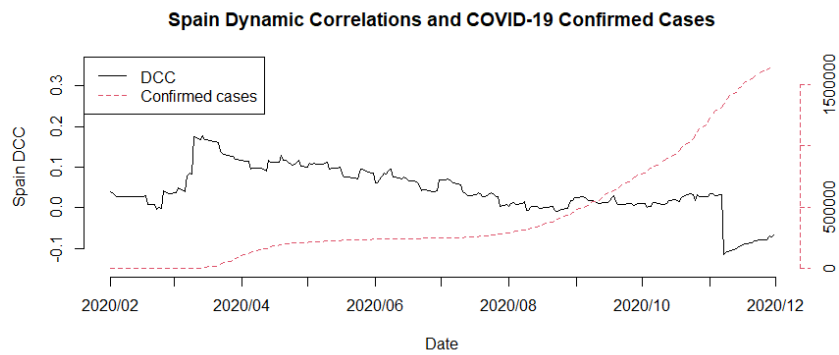


Fig. A1. Continued.