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NO CONTAGION, ONLY VOLATILITY: U.S. EQUITY CORRELATIONS DURING COVID-19

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ABSTRACT

Purpose-During the COVID-19 crisis, correlations between U.S. equity returns and those of its three primary trading partners—Canada, China, and Mexico—rose sharply. In particular, the average correlation climbed from 0.56 in 2019 to 0.83 in 2020, the peak year. This study investigates whether this nearly 48% surge signals a contagion effect stemming from COVID-19.

Methodology-Price data of ADRs for Canada, China, and Mexico, traded on the New York Stock Exchange were collected and returns on equally weighted portfolios for each country were computed. Using the returns on the country portfolios of ADRs and the US equity stock index S&P 500, cross-country correlations between the U.S. and each of its major trading partner countries were computed. These estimates were revised by applying the volatility adjustment procedure recommended by Forbes and Rigobon (2002). The revised estimates of correlations were tested whether they differed from the stable period values.

Findings-During the pandemic, unadjusted Correlations between U.S. equities and each of its major trading partners increased. These estimates were then adjusted for the increased volatility. The revised correlations were not found to be significantly different from their pre-pandemic values.

Conclusion-Estimates of correlations between U.S. equity and its major trading partner countries increased dramatically during the pandemic, implying possible contagion. This conclusion would be premature and incorrect as volatility changes are ignored in the estimation process. When corrected for it, the revised estimates of correlations do not support the presence of contagion effect.

Keywords: COVID-19, pandemic, correlations, contagion, ADR
JEL Codes: G10, G11, G15

1. INTRODUCTION

The COVID-19 pandemic stands among the most disruptive events in modern history. As Taylor (2021) notes in The New York Times, the virus quickly spread worldwide, infecting over 76 million people and causing more than 1.6 million deaths by the end of 2020. The World Health Organization (2021) declared COVID-19 a global public health emergency, and the Centers for Disease Control and Prevention deemed 2020 the deadliest year in American history.

Countries responded differently and in varying degrees to COVID-19. Regardless of how countries responded to the pandemic, the disruption to life within the countries was significant and widespread. The impact affected local economies as well as trade between countries. As financial markets reflect economic conditions, the pandemic could have had its impact in the domestic as well as international financial markets with important consequences for investors.

Investors seek opportunities to improve the risk-return tradeoff of investments. Investing internationally helps achieve that objective through lower correlations of securities. However, as Solnik and McLeavey (2009) observe, correlations between countries have been increasing over the past few decades. They attribute the increase in correlations to the steady increase in international trade and opening of financial markets for foreign investment. Nevertheless, they found correlations have been low enough for investors to benefit from global investment. But the investment environment could change when counties are

affected by political upheavals and economic and health crises. These crises could affect several countries and disrupt the correlation structure of equity returns, upsetting portfolio allocations and planned diversification of risk. Solnik and McLeavey (2009) note that such sudden spikes in correlations hurt diversifying internationally when diversification is needed most.

The COVID-19 pandemic is considered to be one of the major international crises, affecting almost all countries. This study examines whether the pandemic resulted in contagion in the equity markets. Estimates of correlations of U.S. equity returns with the returns of its major trading partner countries (Canada, China, and Mexico) increased substantially during the COVID-19 pandemic. The average correlation increased from the pre-pandemic value of 0.56 in 2019 to 0.83 in 2020 (the year in which the epidemic was at its peak). The nearly 48% increase in the average correlation in one year may signify contagion. However, during the same time period, average standard deviation of the equity securities in the four countries (including U.S.) increased by about 160%. Using the procedure suggested by Forbes and Rigobon (2002), hereafter FR, it is shown that, if the estimates of correlations are adjusted for volatility increases, the average correlation is 0.50—much lower and closer to the pre-pandemic level. Therefore, even with the devastation caused by the pandemic, its impact on cross-market correlations of the U.S. equity was not significant. The pandemic did not cause "contagion" from one country to another.

The rest of the paper is organized as follows. Section 2 provides a review of the related literature. Section 3 describes the data, and the methodology used in the study. The findings of the data analysis are discussed in Section 4. Conclusions of the study are provided in Section 5.

2. LITERATURE REVIEW

Several studies have examined the effect of the COVID-19 pandemic on the lives of people, economies, and the financial markets. This study examines change in international investment opportunities for U.S. investors during the COVID-19 pandemic. It is done by examining the correlation between U.S. equity securities and those of its major trading partner countries. The first section of the literature survey summarizes results of studies that examine how equity markets responded to COVID-19 related news, including changes in volatility. The second section of literature survey summarizes the main results of the studies on ADRs that justify using the ADR returns to represent the return on foreign equity for U.S. investors. The third section of the literature survey briefly discusses the Forbes and Rigobon (2002) study (FR) which is used in the present study as the main framework to analyse the data.

2.1. COVID-19 and Equity Market Reactions

Several studies examine the impact of COVID-19 on national stock index returns. Ftiti, et al. (2021) examine the Shanghai stock market index's price reaction to health news such as daily confirmed cases and deaths due to the outbreak. Xu (2021) examines how stocks in Canada and the U.S. responded to unanticipated changes in the COVID-19 related cases published by the World Health Organization. Using a GARCH model, the study finds a negative relationship between stock price response and the number of Covid related cases published. Kusumahadi and Permana (2021), using a TGARCH model, found COVID-19 news affected the volatility of stock returns, and negative shocks had a greater impact than positive shocks. Li et al. (2022) applied GARCH model on the U.S. and foreign stock indexes and demonstrate that volatility of stock price was linked to COVID-19 fear among the public.

Cepoi (2020) investigates the stock market's reaction to coronavirus news in the U.S., U.K., Germany, France, Spain, and Italy. Employing a panel quantile regression model, he shows that the stock markets present asymmetric dependencies with COVID-19 related information such as fake news, media coverage, media hype, sentiment, sovereign CDs, gold returns, and financial contagion. Hong et al. (2021), using ARCH model, examine the relationship between COVID-19 and the instability of both stock return predictability and price volatility in the U.S. Using structural break tests, they show that a single break occurred in mid-late February 2020, for both S&P 500 and DJIA return prediction models.

A few studies examine the impact of COVID-19 related issues at sector level. Mazur et al. (2021) find that, during the month of March 2020, which was the height of the pandemic, some industries such as natural gas, food, healthcare, and software, did well, whereas petroleum, real estate, entertainment, and hospitality industries did poorly. The industries that did poorly also had higher volatility of stock prices. Lee et al. (2023) examine the impact of COVID-19 epidemic on hospitality stock returns in China, and Chien et al. (2021) examine the impact of the pandemic on energy price**s** and stock market return.

Some studies examine the impact of COVID-19 at regional level within a country because the state level policies differ from state to state. For example, Pham et al. (2021) examine the impact on stock returns of the companies and the release of COVID-19 related news such as number of people infected and hospitalized, number of people died in that state, etc. and equity returns of companies headquartered in those states. They find significant negative price change the day following the news. Chang et al. (2021) investigates the effect of governments' actions on stock index return, using a panel data of 20 countries. They show that

the overall government response, containment and health, and stringency indices have a significant effect on stock market returns.

Cultural differences were also found to have had an effect in stock returns to COVID-19 related news. Fernandez-Perez et al. (2021) find that market participants' response to COVID-19 related news varied based on national culture. The stock price response to the news was higher in cultures that have lower individualism and higher uncertainty avoidance.

At a (more micro) company level, the study by Ding et al. (2021) shows that the effect of adverse COVID-19 related news on companies depends on the characteristics of the companies also. Their study indicates that companies with strong corporate characteristics are affected less by COVID-19 related bad news.

2.2. American Depositary Receipts and Foreign Equity Markets

The main objective of the present study is to quantify the changes in the correlations of U.S. equity with the equities of its major trading partner countries during the COVID-19 pandemic and check whether there was contagion in the equity markets. To perform the investigation, however, the equity returns of the respective country's indexes during the pre-pandemic (normal) period and the returns during the pandemic (crisis) period are needed. Further, the returns on foreign equities must be aligned with the domestic U.S. equity returns. International investing makes it difficult to obtain these returns due to the different time zones of the location and operations of the foreign financial markets and the resulting non-synchronous trading with U.S. markets. Further, foreign exchange rate issues make converting the foreign equity returns into returns commensurable with U.S. equity returns a complex task. However, American Depositary Receipts (ADRs) provide an alternative. ADRs trade in the U.S. equity markets and the price is quoted in U.S. dollars. While ADRs offer a practical proxy for U.S. investors, it is worth noting that they may not fully capture the entire breadth of each country's equity market, especially if only larger or internationally oriented firms issue ADRs. Still, ADR returns are a convenient, although approximate, way to circumvent the problems encountered in obtaining foreign equity returns for U.S. investors. As discussed below, empirical studies on ADRs support it.

Kabir et al. (2011) show the substitutability between ADRs and country indices. They analyze whether U.S. investors can achieve diversification benefits from ADRs, beyond what is achievable through investing directly in country indices. Using monthly data for the 1981-2001 period, and equally weighted portfolios of ADRs, they show that ADRs are reasonable substitutes for country stock indexes. Wahab and Lashgari (1993) show that U.S. investors can achieve international diversification benefits by investing in ADRs—compared to direct investment in foreign securities—and thereby avoid issues such as taxation by foreign countries, restrictions on capital flows, and exchange rate risk. Wang and Yang (2004) find that U.S. investors can obtain international diversification by investing in the ADRs issued by Taiwanese companies. They also show that, as the ADRs price the foreign exchange risk, investing and portfolio construction process is simplified by investing in ADRs. The present study uses returns on portfolios of ADRs to represent returns from foreign equity investing.

2.3. Volatility Adjustments in Estimating Correlation

This study examines the cross-market correlations of U.S. equity with the major trading partner countries of the U.S. As Forbes and Rigobon (2002) indicate, these correlations, estimated from returns for different time periods, are important from an investment perspective. During pandemics, correlations of equity between countries that are economically linked tend to go up. However, FR cautions that the estimates must take into consideration the accompanying changes in volatility of the equity. Not doing so could lead to incorrect conclusions and attribute the increased correlations to contagion. FR also provide a procedure to reduce the bias in the estimates and apply their proposed methodology to examine three major crises—the 1997 Hong Kong Crash, the 1994 Mexican crisis, and the 1987 U.S. crash. They show that, contrary to existing belief, these crises were not contagion, although the estimates of cross-market correlations substantially increased during the crises. FR claim that the increase in the estimated correlations was primarily due to changes in the volatility of the sample during the periods of crises. After the correction, the estimates of the correlations were lower and found not statistically significant to indicate contagion.

FR categorizes empirical studies that examine propagation of shocks across financial markets into four groups. These are: (1) ARCH and GARCH models that examine time-series data, (2) cointegration methods, (3) direct estimation of the propagation, and (4) the approach that examines cross-market correlations. Of the four methods used for examining the transmission of shocks, FR claims that tests based on cross-market correlations are the most straightforward for testing contagion and use the approach in their study. The present study applies the procedure suggested by FR to examine whether the cross-market equity correlations of the U.S. with its major trading partner countries changed significantly during the pandemic period. The next section describes the data, and the methodology used in this study.

3. DATA AND METHODOLOGY

3.1. Data

This study examines the changes in cross-market correlations of the U.S. with its major trading partners. The major trading partners of the U.S. were identified from the U.S. Census Bureau publications. In the year 2021, fifteen countries accounted for about 75% of the U.S.'s total foreign trade. Of all trading partners of the U.S., the top three countries (Canada, China, and Mexico) accounted for about 43% of the total foreign trade. Further, all three had roughly the same amount of trade (14.5%, each) with the U.S. making them equally important as trading partners of the U.S. The three countries that ranked high on foreign trade with the U.S. also ranked high on the number of ADRs they had on the NYSE: Canada (71), China (35), and Mexico (10) – number of ADRs are in the parentheses. The fourth ranked country, Japan, accounted for only 4.6% of U.S.' foreign trade. Other countries had much lower trade with the U.S. This study restricts the analysis to the top three trading partners of the U.S. because the high trade volume of these countries with the U.S. might align with the fundamental causes of transmission of contagion, such as integrated supply chain and other business relationships. Further, these three countries also had the largest number of ADRs making them more representative of the opportunities for international investment for U.S. investors. Cross-market correlations were estimated using equally weighted portfolios of the ADRs of Canada, China, and Mexico, and the S&P 500 stock index for U.S. equity.

This study compares the cross-market correlations during the pandemic (crisis) period with the correlations during the pre-pandemic (normal) period. Therefore, the normal period and the crisis period must be identified. For the COVID-19 pandemic, the beginning of 2020 provides a clear turning point in the economic activities and relationships. It is widely believed that most of the countries were affected by COVID-19 in 2020, although indications of the onset were noticed as early as January of 2020. Newspapers and other media accounts indicate that the spreading of the pandemic became widely known, very quickly, at the beginning of the year 2020 (Taylor, 2021). The effect of the pandemic was felt over a two-year period, starting in 2020, and tapered off in 2021. The World Health Organization declared the end of the pandemic by December 2021. Therefore, the years 2020 and 2021 can be used for choosing a sample to represent the COVID-19 period returns. However, as the severe impact of the pandemic was in the year 2020, we use the returns in the year 2020 for estimating correlations during the pandemic period. Including 2021 data might offer a fuller picture, but the present study focuses on the most acute phase of the pandemic.

Studies that examined the stock price response to COVID-19 have used daily, weekly, and monthly data. The choice of the data was driven by the nature of the investigation and availability of data. Daily data was more common among studies that quantified response to COVID-19 related news. Such investigations also used ARCH and GARCH techniques to estimate changes in volatility. Empirical studies investigating the benefits from investing on ADRs have used monthly data. The present study uses weekly returns for estimation of correlations and volatility. Monthly data would make the sample size too small, whereas weekly data provide fifty-two observations, making the sample size sufficiently large. Weekly data has been used in a comprehensive, COVID-19 related study by Ding, et al. (2021) to show that a company's ability to resist the impact of COVID-19 depended on the company's financial as well as non-financial characteristics.

Data on closing prices of Stocks and ADRs traded on the New York Stock Exchange are available in the Yahoo.finance database. Xu (2021) uses this data source in their investigation of stock returns in Canada and the U.S. during the COVID-19 pandemic. For the present study, stock index data and ADR price data were collected from yahoo.Finance.

To construct the equally weighted ADR returns of country portfolios, historical price data of ADRs of Canada, China, and Mexico traded on the New York Stock Exchange were obtained from yahoo.finance. To extract the data from yahoo.finance, an open-source computer software "tidyquant" made available in Dancho and Valghan (2021) was used. Using R, tidyquant and BatchGetSymbols packages, weekly ADR data included ticker symbols, dates, and adjusted closing prices were retrieved. With the data of individual ADRs, equally weighted country portfolios for Canada, China, and Mexico were formed.

3.2. Methodology

First, the correlations between the S&P 500 (U.S. stock index) returns and the equity (ADR portfolio) returns of each of the major trading partner countries, namely Canada, China, and Mexico were estimated. It was done separately for the normal and the pandemic periods. Then the volatility (standard deviation) for each country's equity for normal and pandemic periods were estimated. Using the volatility estimates, the estimates of correlations during the pandemic period were adjusted. Then the volatility-adjusted pandemic period cross-market correlations were tested for the difference from the corresponding stable period correlations.

The procedure for volatility adjustment recommended by FR is as follows. Let r_p indicate the estimated correlation during the pandemic period between U.S. equity and the equity of another country. Let SD_p and SD_n indicate the standard deviation

(volatility) of U.S. equity returns during the pandemic period and the normal period, respectively. FR show that the volatility adjusted pandemic-period correlation coefficient r'_p can be found as shown below.

$$r'_p = \frac{r_p}{\sqrt{(1+d(1-r_p^2))}} \quad (1)$$

$$\text{where } d = \left(\frac{SD_p}{SD_n}\right)^2 - 1 \quad (2)$$

The present study used the FR method to estimate the volatility adjusted correlations r'_p during the pandemic period and tested whether they were significantly different from the correlations during the normal period r_n. To test for the difference in correlations, the correlations had to be transformed using Fisher's Z transformation. If r is the correlation coefficient, and ln represents natural logarithm, the Fisher Z transformation of r is as shown below.

$$Z = 0.5 \times \ln[(1+r)/(1-r)] \quad (3)$$

Z values were computed for the normal period (Z_n) and for the pandemic period (Z_p) and tested for the difference in correlation by using the statistic d (shown below). The statistic d is distributed approximately as a standard normal.

$$d = (Z_p - Z_n)/s \quad (4)$$

$$\text{where} \quad s = \sqrt{\frac{1}{N_p - 3} + \frac{1}{N_n - 3}} \quad (5)$$

In the above equation, N_p and N_n are the sizes of the samples used for estimating the correlations during the pandemic period and the normal period, respectively. In the data analysis, the sample size is fifty-two for the stable as well as the pandemic periods (years 2019 and 2020, respectively) as weekly returns are used.

4. FINDINGS AND DISCUSSIONS

Results of the analysis, if volatility adjustments are not made, are provided first. Table 1 below shows the estimates of the cross-market correlations between the U.S. and each of the three countries (Canada, China, and Mexico). The table also shows the estimates of volatilities (standard deviation) during the normal period and the pandemic period. The cross-market correlations shown in Table 1 indicate that the unadjusted correlations during the pandemic period were much higher than the correlations during the normal period. Correlations of U.S. equity and Canadian ADR equity portfolio increased from 0.5699 in the pre-pandemic year to 0.8703 in the pandemic year. Similarly, correlation of U.S. equity and China ADRs increased from 0.5058 to 0.7624, and the correlation of U.S. equity with Mexico increased from 0.5942 to 0.8442. The average of correlations during the stable period was 0.5566 and the average of the unadjusted correlations during the pandemic period was 0.8257—an increase of approximately 48%. The table also shows that there was a substantial increase in volatility (standard deviation) during the pandemic period.

Table 1: Correlations during stable period (2019) and unadjusted correlations during the pandemic period (2020)

	Normal period		COVID-19 Pandemic period			
Trading Partner Country	**Volatility (percent)**	**Correlation with U.S.**	**Volatility (percent)**	**Change in volatility (%)**	**(Unadjusted) Correlation with U.S. Equity**	**Test statistics (d)**
U. S.	1.4898		4.3582	193		
Canada	1.6631	0.5699	6.0601	264	0.8703	3.3999*
China	2.8274	0.5058	4.9616	75	0.7624	2.2025*
Mexico	2.5265	0.5942	6.7559	167	0.8442	2.7303*

* Significant at 5%

To check if the increase in correlations of U.S. equity with each of the three countries were statistically significant, the test statistic "d" (described earlier) was constructed. This statistic is distributed as standard normal. Results of the tests are reported in the last column in Table 1. Figures indicate that the increase in correlations during the pandemic was significant at 5% level (value of d greater than 1.645) for the U.S. with each of the three countries. The significantly higher correlations during the pandemic could be interpreted as the existence of contagion during the COVID-19 pandemic period. However, when the correlations are adjusted for changes in volatility, data lead to different conclusions. Results using volatility adjusted correlations are presented in Table 2.

Table 2: Volatility adjusted Correlation of U.S. equity with major trading partner countries

Major Trading Partner country	Normal Period correlations with U.S.	Pandemic Period correlations with U.S. equity			Test statistics for change in correlation using the volatility	
		Correlations unadjusted for volatility changes	Correlations adjusted using the volatility of			
			U.S.	Trading country	U.S. equity	Trading country
Canada	0.5699	0.8703	0.5170	0.4363	-0.3721	-0.8896
China	0.5058	0.7624	0.3736	0.5575	-0.8139	0.3568
Mexico	0.5942	0.8442	0.4741	0.5075	-0.8356	-0.6173

The cross-market correlations shown in Table 2 shows volatility adjusted correlations of U.S. equity with its major trading partner countries. Volatility adjustments were made in two ways. For the first, the change in volatility of U.S. equity was used to revise the estimates of correlations. The standard deviation of U.S. equity index increased from 1.4898% in the pre-pandemic period to 4.3582% in the pandemic period, which is an increase of 193%. When the volatility of U.S. equity is used for adjusting the estimate of the correlation coefficients, a significant decrease in the correlations can be noticed. Using U.S. volatilities for volatility adjustments, the revised estimates of correlations of U.S. equity during the pandemic period were 0.5170, 0.3736, and 0.4741 with Canada, China, and Mexico, respectively. The revised estimates are much lower than the estimates obtained when unadjusted for the increase in volatility. It can also be noted that the revised estimates of correlations during the pandemic were lower than the correlations during the pre-pandemic, normal, year. However, the tests for the difference indicate that the changes are not significant even at the 10% level.

For the second set of adjustments, the respective partner country's volatility was used for adjusting the estimated correlation of U.S. equity with that country's equity. As shown in Table 2, if Canada's volatility is used for adjustment, the correlation of the U.S. with Canada will be 0.4363. Similar estimations resulted in 0.5575 as the correlation with China and 0.5075 as the correlation with Mexico. As the pandemic affected all the countries at about the same time, there is a possibility of endogeneity in the transmissions of the pandemic that could affect estimations. However, as Forbes and Rigobon (2002) point out, existing techniques do not provide a way to handle endogeneity. While more advanced methods may partially address endogeneity, they lie beyond our current scope. Therefore, the correlations were estimated using the volatility of U.S. equity as well as the major trading partner countries of the U.S. Regardless of which volatility is used for adjusting the estimates of correlations during the pandemic period, the revised estimates are not statistically different from their pre-pandemic levels.

5. CONCLUSION AND IMPLICATIONS

The COVID-19 pandemic posed an unprecedented global crisis, warranting close examination of its financial effects. Although our initial findings suggest that correlations between U.S. equities and those of its top trading partner countries rose sharply during 2020, volatility also escalated significantly. After adjustments are made for the heightened volatility, the revised correlations no longer support the conclusion that COVID-19 triggered contagion. By highlighting the importance of volatility adjustments, this study also (like FR) underscores the need for a more nuanced interpretation of cross-country correlation spikes during global crises. A practical implication of the result from our study could be that investors should avoid reacting to raw correlation spikes during crises. By doing so they may sacrifice international diversification prematurely.

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