DOI: 10.5902/1983465969467

CONNECTIVITY BETWEEN THE LATIN AMERICAN AND U.S. STOCK MARKETS IN THE PRESENCE OF THE COVID-19 PANDEMIC

Conectividade entre os mercados acionários da américa latina e dos EUA na presença da pandemia de Covid-19

Submission:09/03/2022
Accept: 02/08/2022

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ABSTRACT

Objective - This paper aims to revisit the relationship between the Latin American and U.S. stock markets during the Covid-19 pandemic.
Methodology- The dynamic connectivity between these markets was estimated by implementing the time-varying VAR model (TVP-VAR) for daily data from January 2010 to June 2021.
Results - There are three main results. First, although spillovers from each market accounted for most of their variance, exchanges were not entirely independent of each other. Second, the U.S. and Brazil were net transmitters of spillovers, while Argentina and Chile were net receivers. Finally, the magnitude of net spillovers is not high enough to characterize a contagion effect.
Practical implications - The inclusion of Latin American stock markets in the scope of Covid-19 studies is an important contribution to the literature that often neglects Latin American markets in its samples.
Originality - The study of the connection between markets in the presence of Covid-19 differs from most that focus exclusively on the impact of Covid-19. Understanding the relationship between Latin American and U.S. markets in the presence of a crisis unlike any that has occurred before can help investors in their investment strategies and policymakers, governments, and monetary authorities interested in the integration or disintegration between markets.

Keywords: Stock markets. Dynamic connectedness. COVID-19 pandemic. TVP-VAR model. Latin American.

RESUMO

Objetivo - Este artigo tem como objetivo revisitar a relação entre os mercados de ações da América Latina e dos Estados Unidos na presença da pandemia de Covid-19.
Metodologia - A conectividade dinâmica entre esses mercados foi estimada pela implementação do modelo VAR variável no tempo (TVP-VAR) para dados diários de janeiro de 2010 a junho de 2021.
Resultados - Existem três resultados principais. Em primeiro lugar, embora as repercussões de cada mercado fossem responsáveis pela maior parte de sua variação, as trocas não eram inteiramente independentes umas das outras. Em segundo lugar, os EUA e o Brasil foram os transmissores líquidos de *spillovers*, enquanto a Argentina e o Chile foram os receptores líquidos. Finalmente, a magnitude dos *spillovers* líquidos não é alta o suficiente para caracterizar um efeito de contágio.
Implicações práticas - A inclusão dos mercados de ações latino-americanos no escopo dos estudos da Covid-19 é uma importante contribuição para a literatura que muitas vezes negligencia esses mercados em suas amostras.
Originalidade - O estudo da conexão entre os mercados na presença da Covid-19 difere da maioria que se concentra exclusivamente no impacto da Covid-19. Compreender a relação entre os mercados da América Latina e dos EUA na presença de uma crise diferente de qualquer outra que tenha ocorrido antes pode ajudar os investidores em suas estratégias de investimento e formuladores de políticas, governos e autoridades monetárias interessados na integração ou desintegração entre os mercados.

Palavras-chave: Mercados de ações. Conectividade dinâmica. Pandemia de COVID-19. Modelo TVP-VAR. América Latina.

1 INTRODUCTION

In the first quarter of 2020, Corona Virus Disease, 2019 (COVID-19) escalated from a small marketplace in Wuhan, China, to cause the international social distancing and home isolation of over 1 billion people worldwide, causing social, political, and economic repercussions (Corbet, Hou, Hu, Lucey, & Oxley, 2021; Goodell, 2020; Sharif, Aloui, & Yarovaya, 2020). The extent of the recent global health crisis and the severe harmful consequences of contagion are characterized as the global financial crisis.

The unknown future situation of the pandemic, such as the patterns of dissemination and the mortality rate, leads to low expectations of cash flow, resulting in the stock market depreciation. In addition, efforts to contain this disease, such as quarantine, air and intercity travel restrictions, and labor mobility restrictions, are slowing down the world economy (Ashraf, 2020; Salisu; Vo, 2020). The economic activity came to a sudden and abrupt stop due to the suspension of the industrial activity, tourism, and other sectors that directly affect the stock index (Azimli, 2020). Moreover, the pandemic can impact financial systems through their enormous economic costs (Goodell, 2020).

Fan, Jamison, and Summers (2018) estimated the expected annual losses from potential pandemic risk to be approximately 500 billion U.S. dollars annually, or 0.6% of global income. In light of the costs of COVID-19, this seemingly large sum now seems greatly underestimated (Goodell, 2020). As a result, central banks, government agencies, and multilateral organizations have engaged in ongoing interventions in the financial market to stimulate economies. The International Monetary Fund (IMF) estimated that government stimulus packages adopted during the COVID–19 pandemic amounted to USD 3.3 trillion, and additional loans, equity injections, and guarantees amounted to USD 4.5 trillion (Akhtaruzzaman, Boubaker, & Sensoy, 2021).

Since the first case of coronavirus infection in the United States, identified in Washington State on January 20, 2020, more than 235,000 cases were identified in a little over two months (Guo et al., 2020). COVID-19 creates economic destruction on an unprecedented scale (see the $2.2 trillion bailout package in the U.S. versus the $ 750 billion bailout package during the global financial crisis) (Goodell, 2020). This crisis has resulted in depreciated stock indices, especially in countries with high infection rates. In addition, after the World Health Organization declared the coronavirus outbreak a global pandemic, the degree of uncertainty increased. As the pandemic caused by the coronavirus advances in America, countries like Brazil registered the first case in February 2020 and Argentina's first death from the infection in March. In April 2020, Brazil and Chile were classified as the most affected countries, with a high rate of cases resulting from the local transmission and fast contagion at the local level (Alvarez & Harris, 2020).

Although there is previous literature on how epidemics impact the financial markets, there are no records on pandemics until the spread of the coronavirus. This fact is observed due to the extensive literature that draws imperfect parallels from natural disasters (Goodell, 2020). Markets react to natural disasters, such as earthquakes, tsunamis, volcanoes (Cavallo, Galiani, Noy, & Pantano, 2013), air disasters (Bosch, Eckard, & Singal, 1998), and more recently, acts of terrorism (Karolyi & Martell, 2011). The effects of COVID-19 are compared with the 2008 Global Financial Crisis (Sharif et al., 2020), which has been extensively researched in the literature on interconnection, contagion, and spillover effect (Dimitriou, Kenourgios, & Simos, 2013). The fact that stock markets in different countries are correlated is, of course, not surprising in itself (King & Wadhwani, 1990). However, the implications regarding the pandemic's effect on stock markets exposed serious questions about the market's dynamics and connectedness (Youssef, Mokni, & Ajmi, 2021).

The outbreak of COVID-19, which triggered the crisis in the global financial economy, is of particular interest (Salisu & Vo, 2020). Many studies have analyzed the impact of Covid-19 on stock markets (Akhtaruzzaman; Boubaker; Sensoy, 2021; Ashraf, 2020; Hasan et al., 2021; Salisu; Vo, 2020; So; Chu; Chan, 2021; Youssef; Mokni; Ajmi, 2021). However, the focus is on the impact of the pandemic on equity markets, and fewer papers studied the connection between markets in the presence of Covid-19. Based on this context, we analyze the dynamic connection between the Latin American and U.S. stock markets in the presence of COVID-19 by implementing the time-varying VAR model (TVP-VAR). Latin America and the U.S. markets have unique characteristics such as trade and capital flows, cultural proximity, time zone, and macroeconomic effects (Cardona, Gutiérrez, & Agudelo, 2017; Marçal, Pereira, Martin, & Nakamura, 2011). These characteristics make the relationship between these markets attractive from a theoretical point of view. Some previous studies have already documented some level of interdependence between these markets (Chuliá, Guillén, & Uribe, 2017; Moretti, Vaz, & Mendes, 2005; Pimenta, 2004), or even evidence of abrupt contagion spreading abruptly from the U.S. to Brazil and Argentina during the global financial crisis (Davidson, 2020). However, there was no literature on the relationship between these markets in the presence of COVID-19.

The dynamic connectivity between Latin American and U.S. stock markets was estimated by implementing the time-varying VAR model (TVP-VAR) for daily data from January 2010 to June 2021. After estimating the TVP-VAR model, we found that: i) although the repercussions of each market accounted for most of its variation, the markets were not entirely independent of each other; ii) the U.S. and Brazil were the net transmitters of spillovers, while Argentina and Chile were the net receivers; and iii) the magnitude of the net spillovers is not high enough to characterize a contagion effect. Our results have some important implications and present some theoretical contributions to the preceding literature. First, we include Latin American stock markets in the scope of the Covid-19 studies. As far as we know, few researchers have included this region in their samples. Second, following a flow of existing literature, we re-evaluate the connection between these markets and the U.S. in a new context. Finally, considering that the connection between these markets is not so high, our results offer benefits for risk managers and stock market investors to investment and hedging strategies during crises like the one caused by COVID-19.

The remainder of this article is organized as follows. The second section presents the literature review. The third section presents the data and the methodology used. Finally, the fourth section presents the results and the discussion, and the last section, the concluding remarks.

2 LITERATURE REVIEW

In an internationally integrated economic space, a country's economic variations can influence the performance and well-being of other economies (Dornbusch, 1976; Silva, 2016). The financial crisis of 2008 has arguably been the first major global crisis since the Great Depression of 1929-32. While the crisis initially had its origin in the United States in a relatively small segment of the credit market, the subprime mortgage market, it rapidly spread across virtually all economies, both advanced and emerging, as well as across economic sectors. It also affected equity markets worldwide. Many countries experienced even sharper equity market crashes than the United States, making it an ideal laboratory to revisit the debate about the presence and sources of "contagion" in equity markets (Bekaert, Ehrmann, Fratzscher, & Mehl, 2011).

Financial crises have renewed interest in examining the connection, contagion, and correlations between stock markets using different econometric techniques during the past two decades. In general, financial crises have increased the market connection across all equity markets (Youssef et al., 2021). Bekaert et al. (2011) defined contagion as the co-movement above implied by the factor model, i.e., above and beyond what can be explained by fundamentals considering their natural evolution over time.

The relationship between financial markets exposes the degree of connection in periods of crisis, as already reported by studies on the global financial crisis (Bekaert et al., 2011; Dimitriou et al., 2013; King & Wadhwani, 1990). In addition, outbreaks and epidemics have also been studied to identify the connection between markets.

Macciocchi et al. (2016) studied the short-term economic impact of the Zika virus (ZIKV) outbreak on Brazil, Argentina, and Mexico. They showed that, except for Brazil, these three Latin American and Caribbean countries' market indices (LCR) did not show significant negative returns the day after each shock. Concerning ZIKV economic implications, the World Bank estimates that the short-term impact of the ZIKV outbreak for 2016 in the LCR is about US$3.5 billion. On the other hand, the fiscal impact (i.e., the estimated amount of revenues forecast caused by a reduction in revenues or income caused by the outbreak) would be limited to US$420 million.

Recently, researchers have turned their attention to the degree of connection in the period of the health crisis caused by the COVID-19 pandemic. Ashraf (2020) investigated stock markets' reaction to COVID-19. Using daily COVID-19 confirmed cases and deaths and stock market returns data from 64 countries from January 22, 2020, to April 17, 2020, he found that stock markets responded negatively to increases in COVID-19 confirmed cases. Salisu and Vo (2020) investigated the relevance of health news obtained through Google searches in expected stock returns using data from the top-20 most affected countries which reported the most deaths. They found that including health-related information in stock valuation improved forecast accuracy. Forecast performance was also improved by adjusting macroeconomic factors and accounting for the "asymmetry" effect of good and bad health news (Salisu; Vo, 2020; Youssef; Mokni; Ajmi, 2021).

The impacts of the COVID-19 pandemic on the connectedness of the Hong Kong financial market were studied by So, Chu, and Chan (2021). They constructed dynamic financial networks based on correlations and partial correlations of stock returns. Compared to other crises where the network density and clustering can be described by co-movement with market indices as in regular periods, both network density and clustering are higher in the partial correlation networks during the COVID-19 outbreak (So et al., 2021).

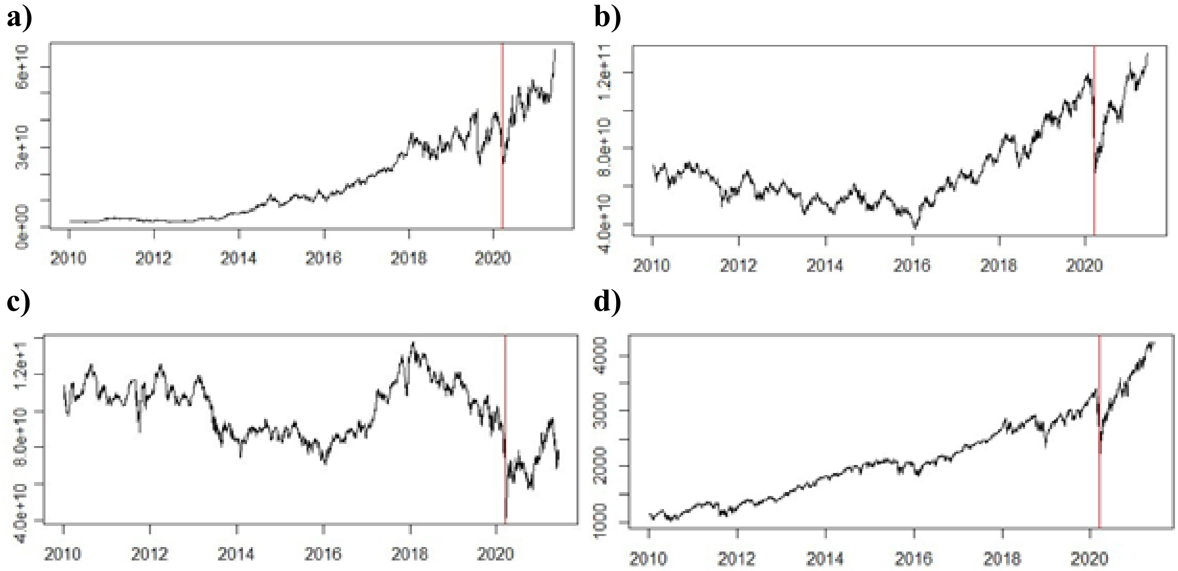
Akhtaruzzaman et al. (2021) examined how financial contagion occurs through financial and non-financial firms between China and G7 countries during the COVID–19 period. The author demonstrates that listed firms across these countries, financial and non-financial firms alike, experience a significant increase in conditional correlations between their stock returns. However, the magnitude of these correlations is considerably higher for financial firms during the COVID-19 outbreak, indicating the importance of their role in financial contagion transmission. The results also show that optimal hedge ratios increase significantly in most cases, implying higher hedging costs during the COVID-19 period. Hasan et al. (2021) empirically explored the effect of the COVID-19 pandemic on Islamic and conventional stock markets from a global perspective. The key results of wavelet-based multitemporal techniques on daily data from January 21 to November 27, 2020, indicated that the pandemic creates identical volatility in both stock markets. They also suggest that both markets were strongly associated and tended to move strongly during the period studied, refuting the hypothesis of decoupling the Islamic stock market from the conventional market.

Youssef et al. (2021) investigated the dynamic connection between stock indices and the effect of economic policy uncertainty in eight countries where COVID-19 was most widespread (China, Italy, France, Germany, Spain, Russia, the United States, and the United Kingdom). They used the implementation of the time-varying VAR model. They showed that stock markets were highly connected during the entire period. However, the dynamic spillovers reached unprecedented heights during the COVID-19 pandemic in the first quarter of 2020. Moreover, they found that the European stock markets (except Italy) transmitted more spillovers to all other stock markets than they received, primarily during the COVID-19 outbreak. This evidence suggests that the Covid-19 pandemic had significant negative impacts on stock markets. They also indicate that Covid-19 may have spillover effects across different sectors of the global economy, particularly in stock markets. These findings blaze a trail for new research.

3 DATA AND ECONOMETRIC FRAMEWORK

To carry out this study, we used daily data from stock indices in the United States (S&P500), Brazil (IBOVESPA), Argentina (MERVAL), and Chile (IPSA) from January 1, 2010, to June 5, 2021. We notice in Figure 1 that the stock market indices examined exhibited an abnormal decline near the onset of the COVID-19 pandemic. The American and Brazilian stock markets were the most affected by the spread of the new virus and registered unparalleled prices at the time of closing in the spot prices of their indices. For the U.S., the daily spot price index peaked above 3,300 points before the COVID-19 pandemic outbreak and dropped to less than 2,000 points when the new pandemic was announced by The World Health Organization. These results highlight the rapid response of stock markets to the COVID-19 pandemic outbreak.

Figure 1 - Daily closing quotes for the stock markets of: a) Argentina; b) Brazil; c) Chile; and d) the U.S. from January 1, 2010, to June 5, 2021, daily data.



Note. The red line indicates the onset of the covid-19 pandemic.

To correct the problem of non-stationarity typical of financial series, we transform stock indices into log returns and present, in Table 1, descriptive statistics, stationarity and unit root tests, and the correlation matrix. All markets have mean and medians close to zero, as is typical in log returns. Furthermore, as highlighted by the standard deviation, Argentina had the riskiest stock market, while Chile was the least risky. All countries' asymmetry values are skewed to the left of the mean, given their negative values. We also observed that all series presented kurtosis greater than 3, suggesting a leptokurtic distribution.

We also applied the Augmented Dickey–Fuller test ADF (Dickey & Fuller, 1981) and Kwiatkowski–Phillips–Schmidt–Shin tests (KPSS) (Kwiatkowski, Phillips, Schmidt, & Shin, 1992) tests to confirm the stationarity of the series. The ADF test statistics (t-stat) are greater than the critical value by 5% for all cases, and the KPSS test statistics (LM-stat) are less than the critical value by 5%. Therefore, the results of both tests confirm the stationarity of the log-return series.

Table 1 - Descriptive statistics and preliminary tests on the data (from January 1, 2010 to June 5, 2021, daily data).

	Argentina	Brazil	Chile	United States
Panel A - Descriptive statistic				
	Argentina	Brazil	Chile	United States
Mean	0.001	0.000	0.000	0.002
Median	0.001	0.000	0.000	0.000
Maximum	0.067	0.056	0.029	0.038
Minimum	-0.207	-0.069	-0.066	-0.055
Std. Dev.	0.010	0.007	0.004	0.005
Skewness	-2.970	-0.873	-1.694	-1.039
Kurtosis	56.385	14.682	28.106	18.495
Jarque-Bera	0.000	0.000	0.000	0.000
Panel B - Stationarity and unit root tests				
ADF (t-stat)	-51.315	-55.749	-29.309	-19.249
KPSS (LM-stat)	0.057	0.266	0.094	0.040
Panel C - Correlation matrix				
Argentina	1			
Brazil	0.465	1		
Chile	0.344	0.471	1	
United States	0.254	0.242	0.206	1

Note. Statistics based on 2590 observations. All return series present a non-normal behavior, which is perceived from the normality test of Jarque-Bera (1987), rejected at the level of 1% of the normality hypothesis, considered by p-values equal to zero. The appropriate delay length selections in the ADF tests are determined by the Akaike information criterion. To calculate the bandwidth for the KPSS test, the Andrew Bandwidth procedure was used. Critical values at the 5% level are as follows: ADF 5%, t-calc. = -2.862. 5% KPSS, t-calc. = 0.463.

During the sample period, all stock markets examined had low correlations. The most prominent associations were between Argentina and Brazil (0.465) and Chile and Brazil (0.471). Thus, the U.S market seems to be little connected to the Latin American markets. These results seem to suggest that the levels of interdependence between these markets were low in this period.

3.1 Estimation Strategy

To explore the time-varying connection between the stock markets of Latin American and U.S. in the presence of COVID-19, we followed the methodology of Antonakakis, Gabauer; and Gupta (2019), recently used by Youssef et al. (2021), who used the TVP-VAR methodology of Koop and Korobilis (2014), combined with the connection approach of Diebold and Yilmaz (2014). As in Y_t being a $(N\ X\ 1)$ vector of N stock market returns. The following set of equations can represent the TVP-VAR model:

$$Y_t = \Phi_t Y_{t-1} + u_t; u_t \backslash \Omega_{t-1} \sim N(0, S_t) \tag{1}$$

$$\Phi_t = \Phi_{t-1} + v_t; v_t \backslash \Omega_{t-1} \sim N(0, R_t) \tag{2}$$

Where, Y_{t-1} is a $(Np\ X\ 1)$ lagged vector of the dependent variables. Φ_t is a matrix of $(N\ X\ Np)$ coefficients, which is supposed to vary over time. u_t and v_t are two $(N\ X\ 1)$ vectors of the error terms. Ω_{t-1} is the set of information available in $t-1$. S_t and R_t are the time-varying variance-covariance matrices $(N\ X\ N)$ and $(Np\ X\ Np)$ of the error terms u_t and v_t. Antonakakis and Gabauer (2017) show that after estimating the TVP-VAR, time-varying coefficients and error covariances are used to estimate the generalized connectivity procedure of Diebold and Yılmaz (2014). This procedure is supported by generalized impulse response functions (GIRF) and generalized prediction error variance decompositions (GFEVD) developed by Koop et al. (1996) and Pesaran and Shin (1998), after transforming the VAR into its moving average vector representation (VMA). In this way, equation (3) can be transformed into:

$$Y_t = \Phi_t Y_{t-1} + u_t = A_t u_t \tag{3}$$

Where, $A_t = (A_{1,t}, A_{2,t}, \dots A_{p,t})'$ is an $(N\ X\ N)$ matrix of parameters checking $A_{1,t} = \sum_{k=1}^{p} \Phi_{1,t} A_{i-k,t} if\, i \neq 0$, and I_N otherwise, in this way, the GIRF defines the responses of all variables after a shock in variable i. According to Antonakakis and Gabauer (2017), it is possible to calculate the differences between a J-step ahead prediction once variable i is exposed to the shock. Once variable i is not exposed to the shock. As in J being the forecast horizon and $\delta_{j,t}$ the selection vector, the GIRF, denoted by $\psi_{j,t}^{g}(J)$, can be obtained by:

$$GIRF(J, \delta_{j,t}, \Omega_{t-1}) = E(Y_{t+J} \backslash u_{j,t} = \delta_{j,t}, \Omega_{t-1}) - E(Y_{t+J} \backslash \Omega_{t-1}) \tag{4}$$

$$\psi_{j,t}^{g}(J) = S_{jj,t}^{-\frac{1}{2}} A_{J,t} S_t u_{j,t} \tag{5}$$

In addition, the GFEVD for the J horizon, denoted by $\Pi_{j,t}^{g}(J)$, can be calculated by:

$$\Pi_{j,t}^{g}(J) = \frac{\sum_{t=1}^{J-1} \psi_{ij,t}^{2,g}}{\sum_{j=1}^{N} \sum_{t=1}^{J-1} \psi_{ij,t}^{2,g}} \tag{6}$$

$\Pi_{j,t}^{g}(J)$ can be interpreted as the share of variance that one variable has in others. GFEVD checks $\sum_{j=1}^{N} \Pi_{j,t}^{N}(J) = 1$ and $\sum_{i,j=1}^{N} \Pi_{j,t}^{N}(J) = N$. From GFEVD, it is possible to obtain some connection indices. The first is total connectivity and shows how a shock in one variable spreads to other variables. The second, called the total directional connectedness from others, shows the directional connectedness that a variable i receives from variables j. The third, called the total directional connectedness to others, shows the directional connectedness that one variable j transmits its shock to all other j variables. The fourth is the net total directional connectivity index obtained as the difference between the two later indices. These four connection indices are defined in Antonakakis and Gabauer (2017) as:

$$H_t^{g}(J) = \frac{\sum_{i,j=1, i\neq j}^{N} \Pi_{ij,t}^{g}(J)}{N} X\ 100 \tag{7}$$

$$H_{i\leftarrow j,t}^{g}(J) = \frac{\sum_{i,j=1, i\neq j}^{N} \Pi_{ji,t}^{g}(J)}{\sum_{j=1}^{N} \Pi_{ji,t}^{N}(J)} X\ 100 \tag{8}$$

$$H_{i\rightarrow j,t}^{g}(J) = \frac{\sum_{i,j=1, i\neq j}^{N} \Pi_{ji,t}^{g}(J)}{\sum_{j=1}^{N} \Pi_{ji,t}^{N}(J)} X\ 100 \tag{9}$$

$$H_{i,t}^{g}(J) = H_{i\rightarrow j,t}^{g}(J) - H_{i\leftarrow j,t}^{g}(J) \tag{10}$$

In (10), the influence of variable i on other variables is explored. If $H_{i,t}^{g}(J) > 0$ variable i influences others more than it is influenced by them. If $H_{i,t}^{g}(J) < 0$, variable i is more influenced by the others.

4 EMPIRICAL RESULTS

Table 2 summarizes the estimates of the average dynamic connectivity measures for each analyzed stock market generated by the TVP-VAR model. We observed that the country's own stock market spillovers explained most of the error variance. The total connectivity index (TCI) measured the average influence that all variables have on the variance of the forecast error of a variable over time. The TCI in all markets was 44.80%, indicating that international stock markets were not independent. The results showed that Brazil contributed to the forecast error variance of all other examined markets by transmitting the highest index of 52.25%, followed by the United States at 44.93%, Chile at 44.42%, and Argentina at 37.59%. Thus, although Brazil is the country that most contributes to the transmission of shocks to other countries, it also receives the most significant repercussions 48.32%. Furthermore, we observed the net spillovers for each country and discovered that Argentina and Chile were net receivers of spillovers from all others. At the same time, the U.S. and Brazil were transmitters for all the other countries analyzed.

Table 2 - Dynamic connectedness measures between stock returns

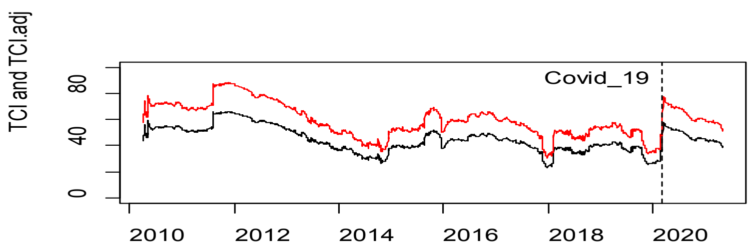
	United States	Argentina	Brazil	Chile	From
United States	55.49	12.30	17.22	14.99	44.51
Argentina	13.03	59.66	15.59	11.71	40.34
Brazil	16.71	13.89	51.68	17.72	48.32
Chile	15.18	11.40	19.44	53.98	46.02
Contribution to others	44.93	37.59	52.25	44.42	179.19
Contribution including own	100.42	97.25	103.93	98.40	TCI
Net spillovers	0.42	-2.75	3.93	-1.60	44.80

Note. The terms "Contribution to others" indicate the measure of the directional connectedness that a given variable *i* transmits its shock to all other variables *j*. The term "From" indicates the measure of the directional connectedness that a given variable *i* receives the shocks from all other variables *j*. "Net spillovers" means the difference between the two directional connectedness. TCI indicates total connectedness.

We estimated (Table 2) the different time-varying measures of connection to see how the connection between markets behaved over time and how it was affected by the COVID-19 pandemic. Figure 2 shows the trajectory of the TCI, and we observe that the evolution of the index shows large fluctuations over the period analyzed. For example, in mid-2015, 2018, and early 2020, TCI reached its lowest level at approximately 20%.

Youssef et al. (2021) also observed low values in the main world markets in 2015 and 2018. However, in 2020, total connectivity reached high levels during the COVID-19 outbreak, close to 60%. Similar levels have not been observed since 2013. Similar results were observed by Zhang, Hu and Ji (2020), Cepoi (2020), and Youssef, Mokni, and Ajmi (2021), who found an increase in the level of dependence between stock markets in different regions of the globe during the health crisis.

Figure 2 - Total connectedness measure.

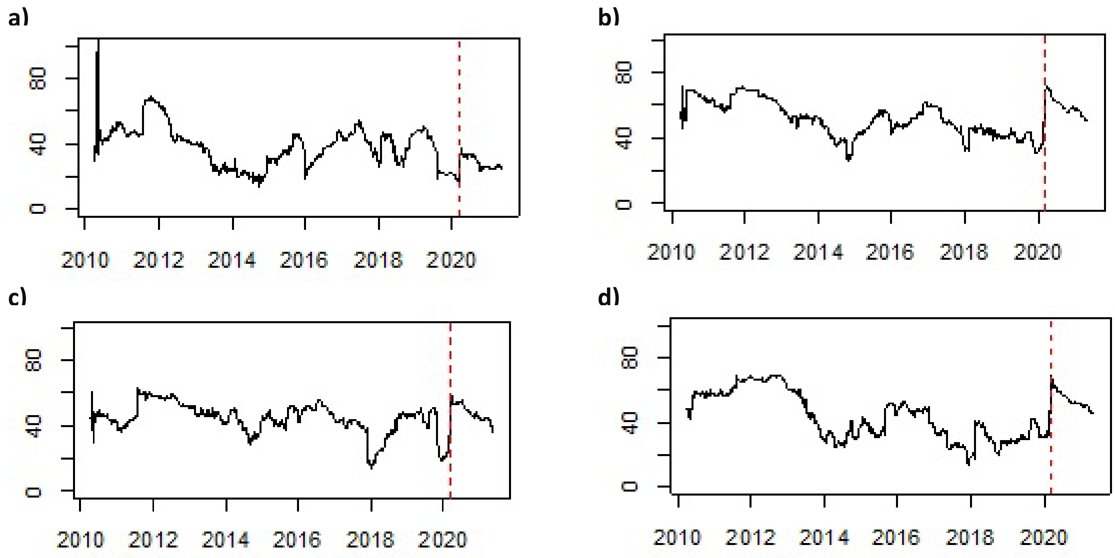


Note. The black line is the TCI, and the red line is the adjusted TCI. The vertical line is dashed over March 11, 2020, when the World Health Organization (WHO) determined the start of the Covid-19 pandemic.

The result is in line with theoretical expectations as it is widely documented that stock markets have some level of interdependence (King & Wadhwani, 1990; Pimenta, 2004). Moreover, these links tend to increase during periods of crisis and uncertainty (Ribeiro & Hotta, 2013). Therefore, we conjecture that this elevation is due to COVID-19. According to Youssef, Mokni and Ajmi (2021), the rapid spread of the coronavirus pandemic has reduced economic trends and caused changes in investor sentiment that may have driven investors into a state of pessimism, affecting their investment decisions and consequent depreciation of stock market prices. Bai (2014) and Baker et al. (2020) also corroborate this perspective and highlight that those investors may feel pessimistic about investment prospects in a given market, selling stocks in that market in an outbreak of infectious disease.

To further explore the connection between markets, we show in the Figures below the total dynamic spillovers for each country and all markets in each country. Figure 3 shows the number of spillovers received by each country from all other analyzed countries. We notice that all countries show a time-varying transmission behavior. For example, the transmission of spillovers to Brazil and the U.S. increased considerably during the COVID-19 pandemic. To Argentina and Chile, the impact on stock markets was significant because although the outbreak of the pandemic COVID-19 has high receiving spillovers, that level was equal to or less than periods that occurred in 2019. These results may occur because these countries were already facing an economic slowdown before the pandemic. Manzi and Viola (2020) emphasize that the world is still suffering from the effects of the strong economic slowdown in 2008, and the stagnation of the global economy may be due to structural factors or secular stagnation. As a result, stock markets were undergoing a decline and were no longer reacting to bad news related to the recent health crisis or the policies of different countries in response to the rapid spread of COVID-19.

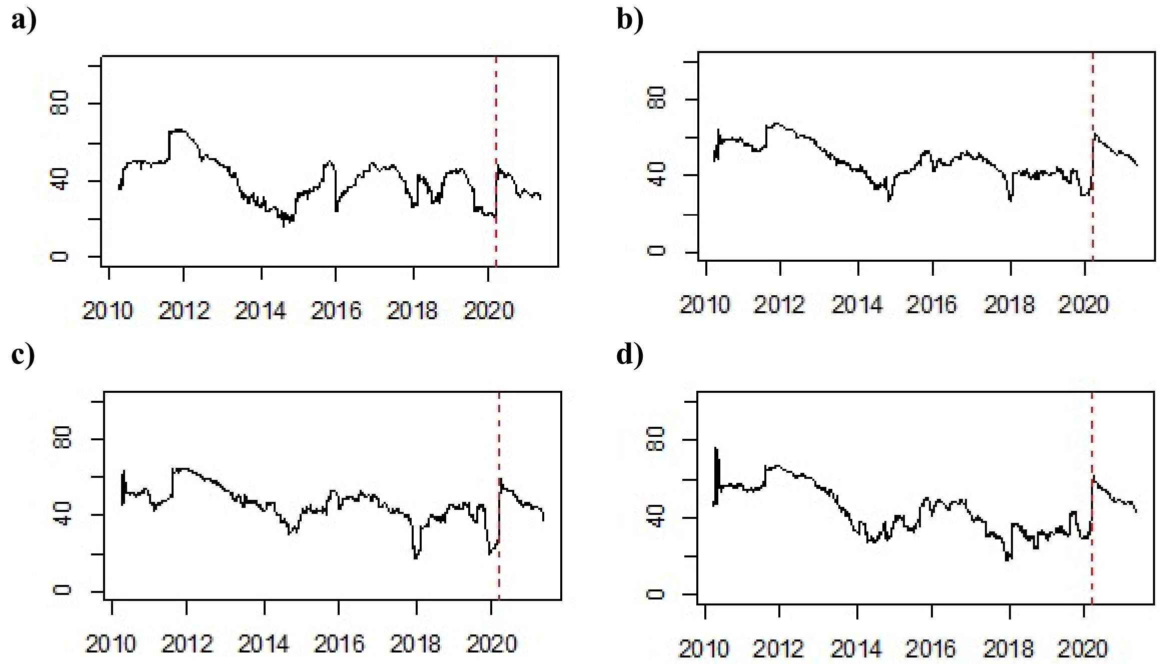
Figure 3 - Dynamic spillover to the stock market in each country. a) spillover dynamics for Argentina. b) spillover dynamics for Brazil; c) spillover dynamics for Chile; d) spillover dynamics for the U.S.



Note. The dashed line indicates the beginning of the covid-19 pandemic.

In Figure 4, we observe the spillover levels transmitted by each stock market to all other markets. In these countries, dynamic transmission patterns have varied over time. The dynamic spillovers from Brazil and U.S. behaved similarly in the analyzed period. They followed a homogeneous pattern of transmission to other stock markets that jumped from approximately 30% before the start of the pandemic to approximately 60% during the pandemic outbreak, corroborating the evidence that these markets were net transmitters. Dynamic transmission from Argentina and Chile to other equity markets also increased during the pandemic; however, the levels reached were similar to those recorded at the end of 2019.

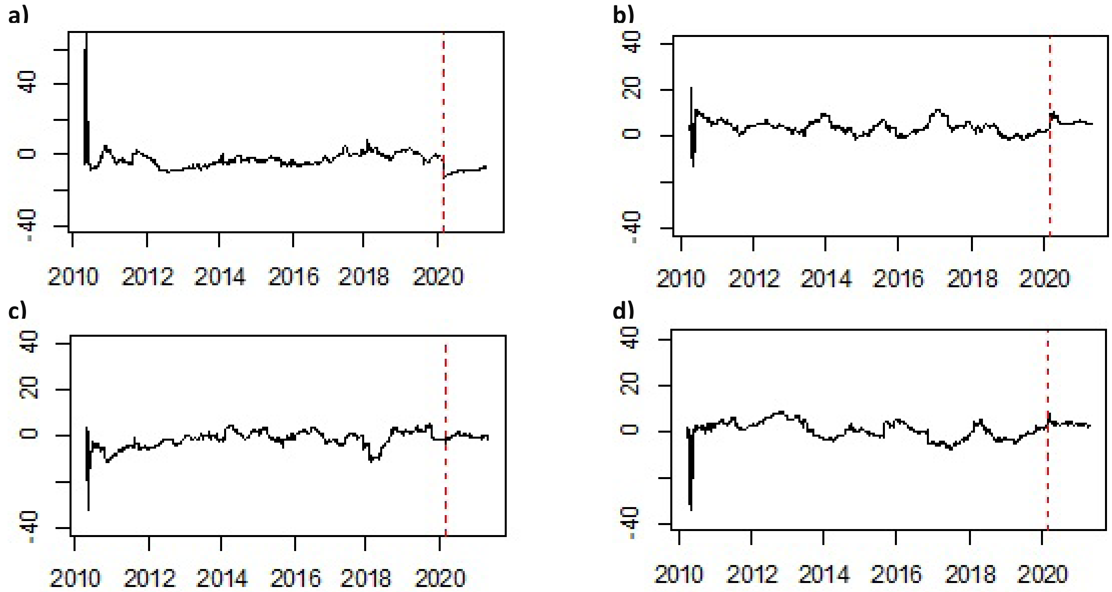
Figure 4 - Dynamic spillover from the stock market in each country. a) spillover dynamics from Argentina. b) spillover dynamics from Brazil; c) spillover dynamics from Chile; d) spillover dynamics from the U.S.



Note. The dashed line indicates the beginning of the Covid-19 pandemic.

An important piece of evidence that we observed is that, in all countries, the level of spillovers transmitted by these markets starts to reduce immediately after the COVID-19 outbreak. According to Yarovaya et al. (2020), the dynamics of spillover to and from other countries may differ from other financial episodes, such as the global financial crisis caused by different structural problems in the U.S. economy. COVID-19 was the single cause. Before its outbreak, there was no specific warning of a financial crisis. Finally, Figure 5 shows the total connection net of spillovers in the analyzed markets, that is, the difference between the two directional connections.

Figure 5 - Net dynamic spillover of the stock market in each country. a) net dynamic spillover from Argentina; b) net dynamic spillover from Brazil; c) net dynamic spillover from Chile; and the U.S.



Note. The dashed line indicates the beginning of the covid-19 pandemic.

Although the U.S. and Brazil were net transmitters of spillovers and Argentina and Chile were net receivers (see Table 2), all markets show a stationary behavior over time, suggesting that the net spillovers were not of great magnitude. The results suggest that Latin American stock markets were not as strongly connected with the U.S. stock market during the coronavirus pandemic as they were during the international financial crisis, as noted in Davidson (2020). Youssef, Mokni, and Ajmi (2021) have already found evidence that contradicts the U.S. leadership role in the economic system. In the research, the authors highlight that the U.S. was a receiver of repercussions from other countries during the Covid-19 pandemic. Some countries changed the functions of liquid transmitters to liquid spillover receivers. Among the possible explanations that can influence a country in the absorption or transmission of risk to other countries or regions is how the crisis is conducted, the characteristics of the economy, and the geographic proximity.

5 CONCLUDING REMARKS

In this study, we revisit the relationship between the Latin American and U.S. equity markets in the presence of COVID-19. The results coming from a TVP-VAR model showed that: i) although the spillovers of each market were responsible for most of its variance, the stock markets were not independent of each other; ii) USA and Brazil were net transmitters of spillovers, while Argentina and Chile were net receivers; and iii) the magnitude of net spillovers is not high enough to characterize a contagion effect. Based on these results, we conjecture that although there was a strong contagion effect during the global financial crisis (Davidson, 2020), the levels of dependence reduced to lower levels than before the crisis (Chuliá et al., 2017; Moretti et al., 2005; Pimenta, 2004) and have remained at these same levels in the presence of Covid-19.

The study contributes to the existing literature by investigating the dynamic connection between emerging markets in Latin America and the U.S. during a period that incorporated a significant health crisis. As the levels of dependence between the studied markets are moderate, even during a severe financial crisis, our results can be interesting for investors. They may consider the international diversification of their investment portfolio to minimize possible financial losses arising from the particular economic dynamics of each market. Finally, we think our results are significant for policymakers, governments, and monetary authorities to assess other countries' economic and financial integration strategies.

However, our research also has limitations. Due to the short period of the health crisis and the uncertain evolution of the coronavirus, we were unable to analyze the long-term effects of the COVID-19 outbreak on the dynamic connection between the affected countries' equity markets. Our results are also limited to a series of returns and do not include volatility and liquidity relationships. We suggest further research into these matters.

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2. Development of hypotheses or research questions (empirical studies)	√	√	
3. Development of theoretical propositions(theoretical work)	√	√	
4. Theoretical foundation/Literature review	√	√	
5. Definition of methodological procedures	√	√	√
6. Data collection	√		√
7. Statistical analysis	√	√	√
8. Analysis and interpretation of data	√	√	
9. Critical revision of the manuscript	√	√	
10. Manuscript writing	√	√	
11. Other (please specify)			

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Conflict of Interest

The authors have stated that there is no conflict of interest.

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