

FINANCIAL CONTAGION BETWEEN THE US AND EMERGING MARKETS: COVID-19 PANDEMIC CASE

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Abstract: *To realise how crises are disseminated is relevant for policy makers and regulators in order to take appropriate measures to prevent or contain the propagation of crises. This study aims to analyse the financial contagion in the six main markets of Latin America (Argentina, Brazil, Chile, Colombia, Mexico and Peru) and the USA, in the period 2015-2020. Different approaches have been undertaken to carry out this analysis in order to consider the following research question, namely whether: (i) the global pandemic COVID-19 has accentuated the contagion between Latin American financial markets and the US? The results of the autocorrelation tests are totally coincident with those obtained by the BDS test. The rejection of the null hypothesis, i.i.d., can be explained, among other factors, by the existence of autocorrelation or by the existence of heteroscedasticity in the stock market index series, in which case the rejection of the null hypothesis is explained by non-linear dependence on data, with the exception of the Argentine market. However, significant levels of contagion were expected to occur between these regional markets and the US as a result of the global pandemic (Covid-19), which did not happen. These results may indicate the implementation of efficient diversification strategies. The authors consider that the results achieved are relevance for investors who seek opportunities in these stock markets, as well as for policy makers to carry out institutional reforms in order to increase the efficiency of stock markets and promote the sustainable growth of financial markets.*

Keywords: *COVID-19; Contagion effects; Region LAC; Portfolio diversification.*

1. INTRODUCTION

Until the 1980s, crises in emerging markets, particularly in Latin American countries, with their long history of enormous external debts, successive devaluations, banking crises and deep economic recessions, were attributed to inconsistent domestic policies. Financial crises were considered as events that occurred in individual markets, without a systemic character, and therefore deserved little attention to the possibility of transmitting shocks between countries. (Bejarano-Bejarano, Gómez-González, Melo-Velandia, and Torres-Gorron, 2015; Wagan and Ali, 2014).

The scenario changed throughout the 1990s as a series of serious financial crises unfolded: the European Exchange Rate Mechanism crisis in 1992, the crisis in Mexico in 1994-1995, the crisis in South East Asia in 1997-1998, the crisis in Russia in 1998, the crisis in Brazil in 1999, the Dot-com crisis in 2000, the crisis in Argentina in 2001-2002, the subprime crisis in 2008, the sovereign debt crisis in 2010, and the stock market crash in China in 2015. The negative

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consequences associated with the episodes of instability and uncertainty were not limited to the countries of origin but were transmitted quickly to various markets with very diverse structures and dimensions throughout the world, constituting what has come to be described in the literature as contagion effects (Gunay, 2020; Kanno, 2020; Yuan, Wang, and Zhuang, 2020).

This paper aims to study financial contagion in the six main Latin American markets (Argentina, Brazil, Chile, Colombia, Mexico and Peru) and the US, in the period 2015-2020. Different approaches have been undertaken to carry out this analysis in order to investigate the following research question, namely whether: (i) has the global pandemic accentuated the contagion between Latin American financial markets and the US? The results show persistence in these regional markets. The rejection of the null hypothesis, i.i.d., may be explained, among other factors, by the existence of autocorrelation or by the existence of heteroscedasticity in the stock market index series, in which case the rejection of the null hypothesis is explained by non-linear dependence on data. However, it was expected to verify significant levels of contagion between these regional markets and the US, resulting from the global pandemic (Covid-19), which did not occur.

This research adds contributions to the literature, especially in the study on financial contagion in Latin American and US financial markets. According to our information, this is the first study that examines these financial markets during the pandemic (Covid-19). However, there are recent studies that have analysed risk diversification in other financial markets during the global pandemic, namely the authors Liu, Manzoor, Wang, Zhang and Manzoor (2020) and Zeren and Hizarci (2020). However, the approach was quite different from that followed in this study.

In terms of structure this paper is organised in 5 sections. Section 1 is represented by the current introduction. Section 2 presents a literature review on articles concerning contagion in financial markets. Section 3 describes the data and methodology. Section 4 contains the results. Finally, Section 5 presents the main conclusions.

2. LITERATURE REVIEW

The literature describes many ways in which financial crises spread among countries. The transmission of shocks in periods of crisis has been one of the main topics of study. While there are many definitions of financial contagion that are adapted to the specific nature of each study, we will follow the definition of Forbes e Rigobon (2002) for contagion „... This is a significant increase in links between markets after a shock in one country (or group of countries) ...”. In practical terms, there is financial contagion when the correlation between the yields of two markets increases statistically significantly after an unexpected event. This line of research is the one that is considered the most appropriate and is adopted in this study.

Luchtenberg and Vu (2015), Cho, Hyde and Nguyen (2015), Antonakakis, Breitenlechner and Scharler (2015), Bejarano-Bejarano, Gómez-González, Melo-Velandia, and Torres-Gorron (2015) examined the risk in financial markets, in the context of contagion. Luchtenberg and Vu (2015) concluded that the North American market contaminated all the markets examined, except for China, Japan and Germany. The evidence indicates a significant change in the behaviour of institutional investors in relation to risk at the beginning of the 2008 financial crisis. These outcomes are in accordance with the study of Kenourgios (2014), on the issue that there is greater risk aversion on the part of institutional investors. Cho, Hyde e Nguyen (2015) ana-

lysed 30,838 shares corresponding to thirty-one markets between 1973 and 2011, demonstrating that the subprime financial crisis has contaminated the markets globally, while the impact of the Mexican and Asian crises was smoother and limited to the region of the country of origin. Antonakakis, Breitenlechner e Scharler (2015) suggest that the subprime crisis has led to unprecedented shocks, particularly in the real estate and stock market. Additionally, the contagion gave rise to uncertainty in economic and monetary policy, with considerable impact on the real economy. Bejarano-Bejarano, Gómez-González, Melo-Velandia, and Torres-Gorron (2015) reveal two episodes of contagion among Latin American financial markets to shocks originating in the United States and Europe. The first corresponds to the time of the subprime crisis, while the second corresponds to the period of the sovereign debt crisis in Europe.

Karanasos, Yfanti e Karoglou (2016), Shahzad, Ferrer, Ballester e Umar (2017) have studied the impact of the 2008 financial crisis on several financial markets. Karanasos, Yfanti e Karoglou (2016) argue that the markets have been abruptly affected by the 2008 financial crisis compared to the Asian financial crisis. Shahzad, Ferrer, Ballester e Umar (2017) suggest that Islamic financial markets have been affected, such as the developed markets under review. The authors argue that Islamic markets, by not being immune to global contagion, make it difficult for institutional investors to operate when they want to diversify their investment portfolios, particularly in periods of financial crisis.

BenSaïda (2017) suggest financial contagion from more developed markets to peripheral markets in the Eurozone, demonstrating that the level of turbulence has remained high since the 2008 financial crisis. Fortunato, Martins, and de Lamare Bastian-Pinto (2020) have studied the financial markets in Latin America, and they demonstrate global commodity market shocks in these regional markets.

In summary, this paper aims to contribute to providing information to investors and regulators in Latin American stock markets, where individual and institutional investors seek diversification benefits, as well as to help promote the implementation of policies that contribute to the efficiency of these markets. Therefore, the context of this work is to examine financial accounting in the context of the global pandemic (Covid-19).

3. DATA AND METHODOLOGY

The closing price data for the financial markets of Argentina, Brazil, Chile, Colombia, Peru, Mexico and the US were obtained from the Thomson Reuters platform. The stock prices are daily and comprise the period from 1 July 2015 to 29 June 2020 and were split into two sub-periods pre and during Covid-19. Stock prices are in local currency to mitigate exchange rate distortions.

Table 1. The name of countries and their indices used in this paper

| Country / Region name | Index |
|----------------------------|-----------|
| Argentina / América Latina | MERVAL |
| Brasil / América Latina | BOVESPA |
| Chile / América Latina | IPSA |
| Colombia / América Latina | COLCAP |
| Peru / América Latina | BVLAC |
| Mexico / América Latina | BOLSAA.MX |
| US / America | DJI |

Source: Own elaboration

The development of research has taken place in several stages. The characterization of the sample used was carried out through descriptive statistics, the adherence test of Jarque and Bera (1980). The persistence of the yields will be tested through the following tests: Ljung-Box (with the squares of the yields); ARCH-LM (Engle, 1982) and BDS (Brock e De Lima, 1996). The importance of studying the level of autocorrelation in contagion research is due to the existence of volatility clusters. According to Mandelbrot (1963) and Engle (1982) if the volatility is high (low), in a certain period, it tends to continue to be so in the following period, because the new information that arrives in the market is correlated in time. In order to understand if the generalized increase in the correlations had statistical significance, the t-t test of heteroscedasticity of two samples Forbes and Rigobon (2002), will be applied. This type of correlations requires transformation through Fisher's method. This test will show the results on the existence or not of contagion between the financial markets of the LAC Region and the USA.

4. RESULTS

Figure 1 illustrates the evolution of the markets, in first differences, under analysis. The sample comprises the time span from July 1, 2015 to June 29, 2020, which is a very complex period due to the understanding of the outbreak of the global pandemic (VIDOC-19). The yields clearly reveal the instability experienced in these markets in February, March and April.

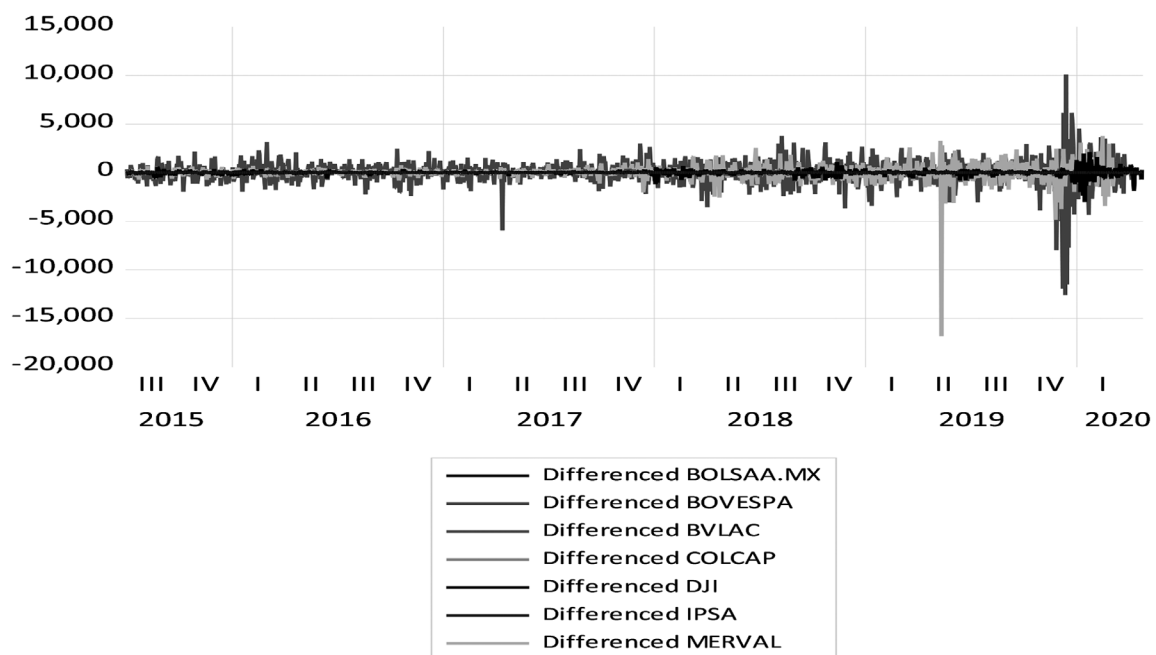


Figure 1. Evolution, in first differences, of the 7 financial markets analysed

Source: Own elaboration

Table 2 presents the main descriptive statistics of the seven indices, referring to the complete sample period. The average is positive for most stock market indices, except for Chile and Colombia. The Argentine market presents the highest standard deviation. The results achieved show that the yield series propose deviations from the normality hypothesis. This result emerges through the test of Jarque and Bera (1980) which made it possible to reject the null hypothesis of normality (H_0) in favour of the alternative (H_1 – non-normality), for a significance level of 1%. Additionally, the asymmetry and kurtosis coefficients are statistically different from those of a normal distribution. The analysed series are leptokurtic and asymmetric.

Table 2. Descriptive statistics, in yields, of the 7 financial markets

| | BOLSAA MX | BOVESPA | BVLAC | COLCAP | DJI | IPSA | MERVAL |
|--------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Mean | 0.000341 | 0.000485 | 0.000184 | -0.000354 | 0.000296 | -9.84E-05 | 0.000986 |
| Std. Dev. | 0.019598 | 0.017721 | 0.010191 | 0.012433 | 0.012794 | 0.010873 | 0.027853 |
| Skewness | 0.737319 | -1.270587 | -0.986542 | -2.100000 | -1.143581 | -2.808352 | -4.300342 |
| Kurtosis | 14.68516 | 19.39696 | 20.85103 | 51.84137 | 27.88837 | 50.61238 | 73.62126 |
| Jarque-Bera | 7259.546 | 14408.30 | 16880.25 | 125763.2 | 32690.66 | 120287.4 | 264876.5 |
| Observations | 1256 | 1256 | 1256 | 1256 | 1256 | 1256 | 1256 |

Source: Own elaboration

With the purpose of testing the persistence of the yields we will estimate the following methodologies: Ljung-Box (with the squares of the yields); ARCH-LM (Engle, 1982) and BDS (Brock e De Lima, 1996). The results obtained, through the Ljung-Box test, applied to the index yields, as well as to the square yields, are presented in table 3. We have verified that all the indexes suggest autocorrelation, in the considered lags (12), with the exception made to the Argentine market.

Table 3. Results of the Ljung-Box tests applied to the daily index returns series, in the period considered in the study

| | MERVAL | BOVESPA | IPSA | BVLAC | COLCAP | BOLSAA MX | DJI |
|----------------------|---------------|-----------|-----------|-----------|-----------|-----------|------------|
| LB (12) | 13.662 | 83.363*** | 67.563*** | 40.500*** | 97.956*** | 62.124*** | 311.73*** |
| LB ² (12) | 10.618 | 1566.3*** | 571.08*** | 269.89*** | 796.64*** | 668.15*** | 1.644.4*** |

Note: ***, ** represent the significance at 1% and 5% respectively

Source: Own elaboration

To analyse the presence of the phenomenon of conditioned heteroscedasticity in financial series, it is usual to use the Lagrange Multiplier test (ARCH-LM test)(Engle, 1982). The ARCH-LM tests were applied to the residues of first order autoregressive processes and, for lag 10. In table 4 it can be observed that the residues of autoregressive processes in the financial markets under analysis exhibit conditioned heteroscedasticity, corroborating this characteristic often present in financial assets. The Ljung-Box tests, applied to the square of the yields (table 3), for lag 12, corroborate the evidence of the ARCH-LM test, reinforcing the evidence of presence of ARCH effects in time series.

Table 4. ARCH-LM test to the residues of the autoregressive process applied to the yields, in the full period

| MERVAL | BOVESPA | IPSA | BVLAC | COLCAP | BOLSAA MX | DJI |
|----------------|-----------|----------|----------|----------|-----------|-----------|
| 5.327** | 528.17*** | 47.25*** | 47.25*** | 26.34*** | 254.61*** | 304.03*** |

Note: The LM test was applied to the residues of a first order autoregressive process of each series. ***, ** represent the significance at 1% and 5% respectively.

Source: Own elaboration

The BDS test rejects the hypothesis that returns are i.i.d. with the results showing statistical significance, from dimension 2 onwards, reinforcing the idea that stock market index returns have a non-linear nature or have a significant non-linear component, with the exception of the Argentine market, which was expected due to the results of the Ljung-Box (with the squares of the returns) and ARCH-LM tests. According to Taylor (1986), the significant presence of a higher autocorrelation between the squares of yields than between the original values of yields is also an indication of the presence of nonlinearity. Table 3 presents the results of the autocorrelation tests of the squares of the yields for lag 12 and all indexes reject the null hypothesis, identifying autocorrelation in series. The results of the autocorrelation tests are totally coincident with those obtained by the BDS test. The rejection of the null hypothesis, i.i.d., can be explained, among

other factors, by the existence of autocorrelation or by the existence of heteroscedasticity in the stock market index series, in which case the rejection of the null hypothesis is explained by non-linear dependence on the data. These results are in line with the studies of the authors Ferreira and Dionísio (2016), Aggarwal (2018), Pernagallo and Torrisi (2019), which evidence the existence of persistence and memories in the stock market indices.

Table 5. BDS Test Statistics, full period

| | ARG | BRA | CHI | PER | COL | MEX | US |
|---------------|--------|-----------|-----------|-----------|-----------|-----------|------------|
| Dimension (2) | -0.028 | 7.217*** | 8.490*** | 7.188*** | 7.908*** | 8.867*** | 14.934*** |
| Dimension (3) | -0.038 | 8.962*** | 9.937*** | 8.608** | 10.951** | 9.089*** | 18.057*** |
| Dimension (4) | -0.045 | 9.894*** | 10.631*** | 10.085*** | 13.300*** | 9.1435*** | 20.592*** |
| Dimension (5) | -0.052 | 10.586*** | 11.718*** | 10.990*** | 14.973*** | 9.174*** | 22.826*** |
| Dimension (6) | -0.058 | 11.323*** | 12.240*** | 11.586*** | 16.503*** | 9.205*** | 25.3112*** |

Notes: The first column concerns the *embedding dimension*. The method considered in the BDS test was the fraction of pairs, for a value of 0.7. The values presented in the table refer to the z-Statistic. ***, ** represent the significance at 1% and 5% respectively.

Source: Own elaboration

In order to estimate the occurrence of financial contagion between the financial markets of the LAC Region and the U.S., the unconditional correlations were estimated, and the statistical significance examined. One method of testing the statistical significance of the correlation coefficient is to apply the t -test, that follows the distribution t_{n-2} , with $n-2$ degrees of freedom, where r is the correlation coefficient between two series and n is the number of observations.

To test if the correlation coefficient matrix is globally different from the identity matrix, the verisimilitude ratio test is used, proposed by Pindyck and Rotemberg (1990). The null hypothesis of this test assumes that there is no correlation between the various markets of the sample. The statistics of the test are given by $-N \cdot \ln |R|$, which is proved to follow a Chi-square distribution, with $0,5p(p-1)$ degrees of freedom, in which $|R|$ is the determinant of the correlations matrix, N is the number of observations of the common sample and p is the number of series analysed in the test.

Table 6 presents the unconditional correlation coefficient of the t -statistic for the pre-Covid subperiod. As we can see all the coefficients are significant at 1%, that is, the Latin American markets and the USA present robust correlation coefficients.

Table 6. Non-conditional correlation coefficients, in the Pre-Covid period

| Correlation | BOLSAA MX | BOVESPA | BVLAC | COLCAP | DJI | IPSA | MERVAL |
|-------------|-----------|----------|----------|----------|----------|----------|--------|
| BOLSAA_ | ***** | | | | | | |
| MX | | | | | | | |
| BOVESPA | 0.826452 | ***** | | | | | |
| BVLAC | 0.845146 | 0.903175 | ***** | | | | |
| COLCAP | 0.802287 | 0.840090 | 0.899658 | ***** | | | |
| DJI | 0.832249 | 0.932512 | 0.937698 | 0.845853 | ***** | | |
| IPSA | 0.779933 | 0.813341 | 0.936881 | 0.840480 | 0.908348 | ***** | |
| MERVAL | 0.810014 | 0.939341 | 0.913974 | 0.833162 | 0.934985 | 0.883293 | ***** |

Source: Own elaboration

Table 7 presents the unconditional correlation coefficients for the Covid period. As we can see all the correlation coefficients, they have decreased in a very significant way.

Table 7. Non-conditional correlation coefficients, in the period Covid

| Correlation | BOLSAA MX | BOVESPA | BVLAC | COLCAP | DJI | IPSA | MERVAL |
|-------------|------------------|-------------|--------------|-----------------|--------------|--------------|--------|
| BOLSAA_ | ***** | | | | | | |
| MX | | | | | | | |
| BOVESPA | -0.001424 | ***** | | | | | |
| BVLAC | 0.239068*** | 0.758758*** | ***** | | | | |
| COLCAP | -0.222915*** | 0.642907*** | 0.609330*** | ***** | | | |
| DJI | 0.405436*** | 0.558996*** | 0.903947*** | 0.471105*** | ***** | | |
| IPSA | -0.352050*** | 0.479263*** | 0.496683*** | 0.832843*** | 0.378162*** | ***** | |
| MERVAL | 0.044687 | 0.219725*** | -0.215788*** | 0.032303 | -0.299853*** | -0.175876*** | ***** |

Note: ***, ** represent the significance at 1% and 5% respectively

Source: Own elaboration

Table 8a and 8b presents the t-test results, to the contagion effect between the pre-Covid and Covid subperiods. The results indicate the existence of interdependencies and not contagion, this was due in part to the significant decrease in correlations between these regional markets and the US, in the Covid period. These results suggest possible portfolio diversification.

Table 8a. Results of the contagion effect between the pre-Covid / Covid subperiods

| Markets | t-Statistic | Results | Markets | t-Statistic | Results |
|---------------------|-------------|---------------------|--------------------|-------------|---------------------|
| BOLSAA MX / BOVESPA | -4.61 | No Contagion | COLCAP / BOLSAA MX | -1.89 | No Contagion |
| BOLSAA MX / BVLAC | -4.69 | No Contagion | COLCAP / BOVESPA | -2.09 | No Contagion |
| BOLSAA MX / COLCAP | -4.56 | No Contagion | COLCAP / BVLAC | -2.21 | No Contagion |
| BOLSAA MX / DJI | -4.66 | No Contagion | COLCAP / DJI | -2.17 | No Contagion |
| BOLSAA MX / IPSA | -4.57 | No Contagion | COLCAP / IPSA | -2.04 | No Contagion |
| BOLSAA MX / MERVAL | -4.62 | No Contagion | COLCAP / MERVAL | -2.13 | No Contagion |
| BOVESPA / BOLSAA MX | -1.93 | No Contagion | DJI / BOLSAA MX | -1.88 | No Contagion |
| BOVESPA / BVLAC | -2.27 | No Contagion | DJI / BOVESPA | -2.08 | No Contagion |
| BOVESPA / COLCAP | -2.04 | No Contagion | DJI / BVLAC | -2.19 | No Contagion |
| BOVESPA / DJI | -2.24 | No Contagion | DJI / COLCAP | -1.97 | No Contagion |
| BOVESPA / IPSA | -2.09 | No Contagion | DJI / IPSA | -2.03 | No Contagion |
| BOVESPA / MERVAL | -2.19 | No Contagion | DJI / MERVAL | -2.12 | No Contagion |
| BVLAC / BOLSAA MX | -1.55 | No Contagion | IPSA / BOLSAA MX | -2.33 | No Contagion |
| BVLAC / BOVESPA | -1.76 | No Contagion | IPSA / BOVESPA | -2.52 | No Contagion |
| BVLAC / COLCAP | -1.65 | No Contagion | IPSA / BVLAC | -2.62 | No Contagion |
| BVLAC / DJI | -1.84 | No Contagion | IPSA / COLCAP | -2.42 | No Contagion |
| BVLAC / IPSA | -1.71 | No Contagion | IPSA / DJI | -2.59 | No Contagion |
| BVLAC / MERVAL | -1.79 | No Contagion | IPSA / MERVAL | 2.54 | No Contagion |

Notes: Critical values correspond to a one-tailed significance on the right, 2.7638 (1%), 1.8125 (5%) and 1.3722 (10%).

Source: Own elaboration

Table 8b. Results of the contagion effect between the pre-Covid / Covid subperiods

| Markets | t-statistic | Results |
|--------------------|-------------|---------------------|
| MERVAL / BOLSAA MX | -5.58 | No Contagion |
| MERVAL / BOVESPA | -5.61 | No Contagion |
| MERVAL / BVLAC | -5.67 | No Contagion |
| MERVAL / COLCAP | -5.60 | No Contagion |
| MERVAL / DJI | -5.64 | No Contagion |
| MERVAL / IPSA | 5.58 | No Contagion |

Notes: Critical values correspond to a one-tailed significance on the right, 2.7638 (1%), 1.8125 (5%) and 1.3722 (10%)

Source: Own elaboration

5. CONCLUSION

The general conclusion to be retained and, supported by the results obtained, through tests performed with econometric models, demonstrates that the global pandemic has a significant impact on the memory properties of financial market indices in Latin America. The markets exhibit strong evidence of persistence in yields. However, significant contagion levels were expected to occur between these regional markets and the US, a fact that was not verified. In conclusion, we believe that these evidences are relevant for policy makers and investors in relation to regional development policies and portfolio diversification strategies in the LAC region's financial markets.

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