RISK TRANSMISSION AMONG STOCK MARKETS IN LAC REGION: FINANCIAL CRISES IMPACT

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Abstract: *The main goal of this research work is to analyse risk transmission, in a dynamic context, between stock markets of the Latin American Countries (LAC) region, in the context of the subprime and European sovereign debt crises. Specifically, we intend to evaluate the volatility transmission between markets, as well as the respective asymmetric effect. For this purpose, we use a volatility measure based on opening, closing, maximum and minimum daily prices. We intend to answer the following questions: do Latin American stock markets show higher levels of volatility resulting from the financial crises of 2008 and 2010? The results suggest there is a risk transmission resulting from the subprime crisis. However, the empirical evidence points to a decrease in risk during the sovereign debt crisis of 2010, i.e. the high volatility during the subprime crisis tends to decrease in the period 2010-2012.*

Keywords: *Volatility, Stock markets, GARCH models.*

1. INTRODUCTION

Since the pioneering work of Markowitz (1952) volatility has been one of the main focuses in financial studies, playing a crucial role in risk analysis and decision-making processes concerning financial assets. Thus, predicting and estimating volatility has been a subject of great relevance in empirical and theoretical research in the financial area, since anticipating the future behaviour of asset volatility will certainly help in reformulating tight investment strategies.

Market volatility is a key element in the extension of financial theory and markets, which has attracted the attention of researchers and practitioners. Campbell, Lo and MacKinlay (1997) argue that what differentiates the financial economy is the central role played by market uncertainty, because in the absence of uncertainty, the dilemmas of financial economy are reduced to "elementary microeconomics exercises." A clear fact involving volatility, regardless of the perspective analysed, is that it is related to the instability and turbulence of financial markets and investors' behaviour. Thus, correct analysis of volatility estimation will be important, not only in outlining a good asset management strategy, but also to understand moments of uncertainty in financial markets.

Some recent studies have analysed the impact of the 2008 financial crisis on foreign exchange markets (Baba and Packer, 2009) and on stock markets, particularly Syllignakis and Kouretas (2011), Ben Rejeb and Arfaoui (2016) and so many others. Specifically, these studies argued that

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volatility is present in financial markets, and is high during periods of financial crisis, especially during the subprime crisis.

The objective of this research is to study the risk transmission among the main stock markets in the LAC region, because of the subprime and European sovereign debt crises. The purpose of this analysis is to answer two questions: (i) do Latin American stock markets show high levels of volatility resulting from the financial crises of 2008 and 2010? (ii) when the asymmetrical effect occurs, through the occurrence of potential losses, can the diversification of portfolios be questioned? This research presents an important contribution to the existing literature. This contribution is related to the study of dynamic volatility in these regional markets, in the context of the financial crises of 2008 and 2010. As far as we know, recent studies analysing these regional markets in the context of the subprime crisis were by Gamba-Santamaria et al. (2017), Cardona, Gutiérrez and Agudelo (2017), Chuliá, Guillén and Uribe (2017) and Güloğlu, Kaya and Aydemir (2016). In our approach we construct a measure of volatility that focuses on opening, closing, maximum, and minimum daily prices. Additionally, we analyse a sample period with two sub-periods of financial crisis and a sub-period of rising stock markets.

We should also refer the importance of these emergent markets in the financial context. According to Mensah and Premaratne (2014), with the elimination of barriers to investment in recent years, many countries have undergone the process of economic and financial integration. This leads to the benefits of international diversification, mainly because of the various financial crises that have led to significant changes in financial markets around the world. In this context, and considering the large inflows of capital, it is important to understand the volatility between Latin American markets. Understanding how market volatility is transmitted could help in implementing efficient diversification strategies.

This paper is organized in 6 sections: Section 2 presents the literature review on market volatility. Section 3 describes the methodology used. Section 4 presents the data description and Section 5 the results. Finally, Section 6 concludes.

2. LITERATURE REVIEW

Volatility is a very important topic in the study of financial markets, although it is not directly observable, with the respective estimation process being subjective and controversial. The risk/return binomial is a very relevant topic for certain investors, particularly when they are risk averse. This relationship becomes a problem when the purpose is to estimate and predict risk as well as the profitability of investments. In the early 1990s, some researchers made an important contribution to modelling the interactions among stock markets. In more recent studies, Kotkatvuori-Örnberg, Nikkinen and Äijö (2013) analysed 50 stock markets, considering two major banking events, namely the acquisition of the investment bank Bear Stearns by the JP Morgan Chase group and the collapse of Lehman Brothers Holding Inc. The authors argue that conditional dynamic correlations increased significantly over the period 2007-2009, leading to volatility shocks between markets. Yarovaya, Brzeszczyński and Lau (2016) examined 10 developed markets and 11 emerging markets in Asia, America, Europe and Africa, from 2005 to 2014. The authors claim that markets are more susceptible to national volatility and region-specific shocks than those of interregional volatility. Given these results, and regarding the regional markets analysed, portfolio diversification could be a strategy for international investors.

Similarly, Ben Rejeb and Arfaoui (2016) studied the volatility between markets in Latin America, Asia and the US and Japan from 1993 to 13 October 2010. The authors show that volatility transmission is directly linked to the regional integration of markets, especially during the subprime crisis. The authors also suggest the existence of asymmetric integration between markets, especially between the regional markets of Asia and Latin America, which could promote effective diversification strategies. Todea (2016) examined the volatility and financial integration of 20 emerging markets during the period 1999-2013. The author shows that volatility is persistent and that this is related to the integration of financial markets. Specifically, this analysis indicates that the persistence of long memories is directly related to the financial crisis of 2008, especially after 2005, suggesting that portfolio diversification could be questioned. Güloğlu, Kaya and Aydemir (2016) analysed volatility among the five largest Latin American stock markets in the period of the 2008 financial crisis. The results suggest that market volatility is not consistent, and Brazil influences all sample markets, suggesting that diversification strategies are feasible. Similarly, Gamba-Santamaria, Gomez-Gonzalez, Hurtado-Guarin and Melo-Velandia (2017) analyzed the markets of Brazil, Chile, Colombia, Mexico and the US during the subprime financial crisis. The results show that Brazil is the largest market in Latin America and transmits volatility to its regional peers. The authors point out that the most critical period of risk transmission occurred in the years 2008-2012, increasing the difficulty of implementing efficient diversification strategies Cardona, Gutiérrez and Agudelo (2017) analysed the six largest markets in Latin America and the United States. The authors suggest that the US market transmitted volatility to Latin American markets, suggesting some precautions regarding risk diversification. Chuliá, Guillén and Uribe (2017) examined the 6 main markets in Latin America and the US market. The authors found reduced volatility between the US and Latin American stock markets, suggesting that portfolio diversification strategies may be feasible.

3. METHODOLOGY

In this study, the first step in econometric analysis is to evaluate the time series stationarity. This analysis becomes essential since such characteristics are fundamental for the data generator process modelling (Lütkepohl and Krätzig, 2004).

To study the short-term relationships between financial markets in the LAC Region, as well as the direction of influence between them, we will use the autoregressive vector (VAR) methodology developed by Sims (1980). The impulse-response functions (IRF) methodology, with Monte Carlo simulations, provides a dynamic analysis (variable over time), performed from the VAR model estimates, allowing to study the causal relationships found, even when not previously detected., causal relations to Granger between variables (Lütkepohl and Saikkonen 1997). Several studies, including Hassan and Malik (2007), Weber (2013), Kotkatvuori-Örnberg, Nikkinen and Äijö (2013), Yarovaya, Brzeszczyński and Lau (2016), Brzeszczyński and Lau (2016), Ben Rejeb and Boughrara (2015), and Corber et al. (2018) have focused on volatility behaviour, namely the stylized fact of volatility clusters.

The sum of the ARCH coefficients with the GARCH gives us a measure of the impact permanence of a shock on volatility, being called the persistence of the GARCH model. To describe the asymmetric behaviour in the volatility of most financial series, Nelson (1991) suggested the exponential GARCH model or EGARCH (Exponential Generalized Autoregressive Conditional Heteroskedasticity Model). Asymmetric behaviour in volatility motivated Zakoian (1994) and Glosten, Jagannathan, and Runkle (1993) to suggest the Threshold ARCH (TARCH) model, also called GJR-GARCH, as an alternative to the ARCH model. The model of dynamic condi-

tional correlation (DCC-GARCH), suggested by Engle (2002) and Tse and Tsui (2002), is distinguished from other models, such as the constant conditional correlation proposed by Bollerslev (1990) in that the conditional correlation matrix changes over time.

4. DATA DESCRIPTION

This paper aims to study the transmission of dynamic risk among the main stock markets in the LAC region, due to the subprime and European sovereign debt crises. Specifically, we intend to evaluate the volatility of price returns between the main regional markets of the LAC region, as well as the asymmetric effect. These emerging markets included LAN region (Latin American North) and LAS (Latin American South) markets, including the stock markets of Argentina, Brazil, Chile, Peru and Mexico. Data about index prices: opening, closing, maximum, and minimum daily prices of the various markets, were obtained from the DataStream platform, and all prices are in US dollars.

The volatilities of returns are daily and include the period between January 3, 2005 and April 30, 2012 (1911 observations). We chose to divide the sample into three sub-periods, one of pre-crisis, which we call the calm period corresponding to January 3, 2005 to July 31, 2007. The subprime crisis period is from August 1, 2007 to December 7, 2009; and the European sovereign debt crisis (SDC) period from December 8, 2009 to April 30, 2012.

Table 1. Main indices of Latin American markets

Index	Code.	City/Country
São Paulo Stock Exchange Index	BRA	São Paulo / Brazil
Buenos Aires Stock Exchange Merval Index	ARG	Buenos Aires / Argentina
Lima Stock Exchange General Index	PER	Lima / Peru
Santiago Stock Exchange IGPA Index	CHI	Santiago / Chile
Mexico Stock Market Index	MEX	Mexico City / Mexico

Note: Volatility measure of Rogers, Satchell e Yoon (1994).
DataStream: Base 100, 1911 observations.

5. RESULTS

In the presence of correlation between the volatility and, simultaneous, the occurrence of significant stock market losses, the relationship is defined by an asymmetric effect (or leverage effect). To analyse the asymmetric effect, we will estimate the EGARCH model (Exponential Generalized Autoregressive Conditional Heteroscedasticity) and TARCH (Threshold Autoregressive Conditional Heteroscedasticity) from volatility returns. The selection of the p and q parameters is based on the SBIC (Schwarz Bayesian information criterion).

When the asymmetric coefficient has a negative sign, positive shocks cause less volatility than negative shocks of a similar size. From analysis of the estimates of the EGARCH (1,1), it is suggested that all the coefficients show a negative sign, revealing the presence of an asymmetric effect. In addition, these coefficients were statistically different from zero except for the Peruvian market in the calm sub-period.

According the TARCH (1.1) model, performed on price volatility, the results suggest that all coefficients ϒ present a negative sign, identifying the presence of an asymmetric effect. In addition, these coefficients were statistically different from zero, except for the Peruvian market in the Calm sub-period, which is not significant.

The results of the Ljung-Box tests of the residuals of the EGARCH (1,1) and TARCH (1,1) models allow us to conclude for the non-rejection of the null hypothesis and, consequently, to accept the absence of correlation in the standardized residuals. These results were corroborated by the ARCH-LM test which suggests a bleaching of the residuals from the data series under analysis. To analyse shocks between Latin American regional markets, we used a VAR model based on the volatility measure of Rogers, Satchell and Yoon (1994). The optimal lag was selected based on the information criteria of AIC and SIC. With the lags determined by the information criteria, the residuals of the estimated VAR models evidence autocorrelation. In this sense, we increased the number of lags in order to correct that problem. Thus, the number of lags for each VAR was 4, 8 and 4 (for the three subperiods, respectively).

The Monte Carlo simulated impulse response (IRF) functions for the calm subperiod, calculated based on the autoregressive vector model, identified significant movements among some stock markets. Mexico is the market with the higher number of movements (22), causing the largest number of reactions in the Peruvian market (8 out of 10 possible). The Chile, Argentina, Brazil and Peru stock markets caused 21, 19, 18 and 17 shocks to their peers, respectively. Mexico is the market that receives more from its peers (26). The Argentina-Chile, Peru-Argentina, Peru-Brazil pairs do not show significant movements.

During the subperiod of the 2008 financial crisis, the relationships between the stock markets under study were generally significant. Mexico was the market with the most shocks from its regional peers (28), causing 8 shocks of 10 possible in the Peruvian market. The markets of Peru, Chile, Argentina and Brazil caused 21, 20, 16 and 15 shocks, respectively, in the remaining markets. In this period of severe crisis, the Mexican and Argentinean markets were the markets that absorbed the most shocks from their regional peers.

Like the previous two subperiods, there were significant reactions between the markets in this crisis period. Mexico was the market that caused the most reactions, namely 26, of which 10 in the Argentina stock market (10 out of 10 possible). Argentina caused 25 shocks in its regional peers, with a greater emphasis on the Mexican market (9 out of 10 possible). Additionally, the markets of Chile, Peru and Brazil generated 18, 15, and 9 shocks in their peers, respectively. Mexico and Argentina were the markets with the most shocks from their regional peers, 26 and 23, relatively. The Brazil-Peru, Chile-Peru, Peru-Brazil, Mexico-Peru pairs did not have significant movements.

The number of statistically significant shocks in the three subperiods was 97,100 and 97 respectively, reason for concluding that the financial crises of 2008 and 2010 did not increase the shocks between the main markets of Latin America in a significant way.

In order to analyse the links between the different markets and the possible occurrence of dynamic risk transmission between them, we used the DCC-GARCH model suggested by Engle (2002) and Tse and Tsui (2002). In addition, the estimated model shows that the relation is respected. This means that the method of generating stock market volatility is stable and allows us to conclude about the existence of persistence.

The results of the t homoscedastic test, for the dynamic risk transmission effect, between the calm sub-period and the subprime financial crisis. The results suggest the existence of 9 pairs rejecting the null hypothesis and identifying dynamic risk transmission between markets (in 20 possible

cases). However, in the remaining pairs the null was not rejected. These results corroborate that the Brazilian Stock Exchange is the largest market in Latin America and its shocks are transversal to the other markets in the LAC Region. Our results are in line with Gamba-Santamaria et al. (2017), Cardona et al. (2017), Güloğlu, Kaya and Aydemir (2016), who argue that the transmission of volatility was more intense during the financial crisis of 2008. The results of the t homoscedastic test, from the subprime to European sovereign debt crises point to the non-rejection of the null hypothesis. As suspected, volatility declines significantly in the main Latin American markets. Concluding, we can suggest that in the period 2010-2012 these markets tend towards equilibrium, allowing for portfolio diversification strategies. These remarks are corroborated by Güloğlu et al. (2016), Chuliá et al. (2017), Ben Rejeb and Arfaoui (2016) and Yarovaya, Brzeszczyński and Lau (2016).

6. CONCLUSION

In terms of a general conclusion, we can confirm higher levels of volatility during the sub-prime crisis period. However, when focusing on the sub period resulting from the European sovereign debt crisis, we find the level of volatility has dropped considerably. Considering this evidence, we consider there has been a readjustment in these regional markets from the year 2010, which may be a good sign for portfolio diversification strategies by international investors. As for future research, we consider it important to use intraday data, with the intention of improving the analysis of volatility. The inclusion of macroeconomic and financial variables would be important to explain the phenomenon of volatility transmission between markets, especially in emerging markets.

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